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INTRODUCTION

INTER-FACE, the second International Conference on Live Interfaces, was dedicated to problematizing convergences and divergences between different understandings of performance technology. It sought to expose a variety of motivations and approaches, and discuss how specific understandings of 'liveness', 'immediacy', 'timing' or 'flow' manifest in performance with digital media.

Computers are tabula rasa. Software mediates physical action through code, and code embeds theories informed by specific purposes and criteria. For example, interfaces may apply the study of mechanisms through which we naturally perceive the world, because the interface brings a sense of immediate interaction. At the same time, interfaces may require effort, in a way that conveys expression. The problem is, theories embedded in software are too often taken for granted. In everyday life we are used to handling computers as magic black boxes that save us labour. When the black box works, its origins are forgotten; the more science and technology succeed, the more opaque and obscure they become, and the more distant we become of computation as creative material. Furthermore, collaborations between artists, designers, programmers and engineers can become frustrating when individual motivations are unclear.

INTER-FACE gathered paper presentations, performances, interactive installations, poster demonstrations and workshops. It happened in Lisbon, Portugal, at the Fine Arts Faculty of the University Lisbon (FBAUL); the School of Music of the National Conservatorium (EMCN); ZDB; the National Museum for Contemporary Arts (MNAC) and the Institute of Art, Design and Enterprise (IADE).

The Conference is biannual, and these Proceedings are published a year after the conference itself. The authors had the opportunity to strengthen their work after the presentation at the conference, benefitting from the feedback of the other participants and the editorial peer-review.

The Conference included two round-tables, "Problematizing Foundations" and "Further Directions". These moments were extremely useful to outline a common ground of discussion, and we wanted the proceedings to include a general dimension as well. This is the purpose of the following interview, which developed as a collaborative online discussion after the conference itself.

LIVE INTERFACES: SEEDS OF DEBATE

A discussion with:

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ADRIANA SA: Each person in this discussion develops and performs with digital systems, and some also make systems for audience interaction. I'll ask a few questions that I find important to consider, and clarify, when we use terms such performative expression, embodiment, immediacy and liveness, or when we discuss a system's transparency/ opacity to audience.

ADRIANA SA TO JOEL RYAN: You are composer, inventor and scientist; and you pioneered the application of digital signal processing to acoustic instruments. Your contribution to the first roundtable was titled *"Knowing When"*. What sort of knowledge do you mean, and why the quotes?

JOEL: The fact is I know when. Before it happens, I know when a beat should come, I know after, when it didn't. This knowledge is not something you can necessarily explain in words. It is something you demonstrate in playing but also listening, in enjoying music. It is the knowledge of how to make time. The proof is that with practice you get there on time, again and again.

When I first began making music with computers, I tried to make the software do all of the work. The idea at the time was to be able to program a complete work. Though I was already committed to performance, I still self-consciously avoided touching what I had coded as if it were cheating. But, as I kept painfully discovering, my programs never really worked well enough making time, never went far enough. So gradually, discreetly, I began letting my hands fix what was wrong. In the end I realized this wasn't cheating but the solution. Once touch was liberated, I began to understand my relation to time in music.

Time in music derives from performative knowledge. Systems of representation are capable of rendering many parts of this, but rendered via rigid symbol systems for discursive thinking, which moves more slowly than music. A performer has to revisit and revise his experiment everyday. More generality (down to logic itself) doesn't help but hinders the moment.

Local Time. The time referred to here is not the objective, uniform time inferred by physics or fashioned by technology, but another, local time. It is not a supplement or embellishment nor is it a primitive or schematic time but the time we make, enacted time, dense and polyvalent, the most elaborate aspect of time in music.

Knowing when implies a sense of Quantity. We have various perceptions of quantity both discrete and continuous: counts and measures and durations of intensity, quantities of force and weight, of acceleration and deceleration, degrees of speed and slowness in things we do and observe. Riding a bicycle leverages these capacities as does playing an instrument. We make time from the difference reveal in these Knowing when is articulate and arguably more precise and than musical representations of time. The time of performers is perhaps the most sophisticated demonstration of this human sense of *timing*, though it is present in the most everyday movements and gestures.

These are not qualities, but precise repeatable enactments and registrations of quantity. This might seem odd: to feel (sense) quantity like we feel quality, because quantities are supposed to be *calculated*, an aspect of rational mind.

So knowing when is innate, and performative i.e. not inferred via symbolic calculation. It consists of immediate enactments *now!, again like that, more than that, faster, enough*. Our time "sense" is neurological. It derives from the bodily capacities to make things happen "on time", originally locomotion etc, but now greatly elaborated in all aspects of action and perception. These begin in our actions but seem also to be the basis of how we register quantity outside our control as in listening to music and watching a dancer. In the past such sources of time have been deprecated in favor of descriptive/ symbolic theories.

Is this innate Q sense abstract? In playing music we digest and respond to relations among many simultaneous expressions of time both our own and others that we hear. Can we digest any posited relation of quantity or are the specifics of human experience and bodies folded in to music? E.g. is a drummer somehow a complex metronome capable of being *set to any tempo?* Or a heterogeneous entangled system of distinct temporal resonances both embodied and melded with those of his drums, tunable certainly, but not abstract like system of computation.

Building from representations alone loses the open empiricism of play, and its desire to go beyond itself. To universalize, representations make reductions. In music this is the *loss of detail*. Local knowledge, the local experiment, deprecated. (the specific character of materials, of human bodies and their histories).

The Problem: Computer music inclines towards pure representation. In the digital domain we can generate music via representation alone (code, calculation, scores, scripts) without further need of human intervention: "look ma no hands". This is unparalleled in music history: underestimating the contribution of musicians with their musically specific innate knowledge.

Music differs from science in that personal knowledge trumps the general. The idiomatic turns of a poet/musician create language not the other way around. Classical languages decay without the renewal of (local) dialects.

It would take too long to clarify here, but this isn't a rant against formal speculations in music. It is more a campaign to enlarge musical empiricism, an attempt to remind us of the many tacit ways we know when and to claim that this is an essential source of form in music of any kind.

ADRIANA TO JOEL: Your contribution to the second roundtable was titled *The Role of Effort in Music*. Would you say that some interfaces require that particular type of knowledge, and other interfaces do not? Must the interface be effortful for such knowledge to substantiate in music?

JOEL: When Michel Waisvisz and I were discussing the ideas that went into *Effort and Expression* it was not only resistance to the uncritical enthusiasm for effortlessness in computerland but shorthand for deeper questions about how music gets its form. Michel had run into big problems trying to carry over his discovery of electronic touch into the digital domain. In order to assimilate touch in a virtual world we had to discover what touch conducted, its intelligence. Effort became a reminder that in the material world, some notes are easy some are very rough (ask Tina Turner). The landscape of effort runs through human bodies, our habits and our history banging up against instruments and acoustic materials. To delete effort for some idea of convenience (making it easier to make music, or for the simplicity of representation, poverty of theory) is a way to remove context from music.

Effort is then a marker for the feedback between the world and our desire.

ADRIANA TO ANDREW MCPHERSON: On your webpage you explain that you integrate high-resolution sensors into acoustic instruments, so that performance gestures can be analysed in detail and correlations drawn with expressive intent. Can you tell us more about your notion of expression? Does your use of high-resolution sensors aim to maximize the performer's control over all the input variables, or are you more concerned with producing complex sonic behaviours? Do you seek to rule out unpredictability, or does it play a role in expression?

ANDREW: "Expression" is a difficult term to pin down, especially as it relates to designing instruments. To me, anyway, the term implies that there is a performer who seeks to express or communicate something using the instrument. As a designer, my job is to let the performer express their own ideas in their own way, without forcing them to conform to my artistic outlook. In other words, each performer playing on the instrument should sound like themselves; they shouldn't all sound alike because the technology has dictated what they can do. This is what we expect from familiar instruments: different guitarists may play similar instruments, but every player can craft a personal identity.

As for how that relates to sensor design, I'm much more interested in capturing subtlety than in trying to control as many simultaneous dimensions as possible. Timing precision seems to be a very important consideration here, as does being able to control slight variations in volume, pitch or timbre. The sensitivity to small changes may be at least as important as the overall range for any given control, provided the interaction is learnable and repeatable.

Complex sonic behaviours absolutely have a role in digital instruments, as they do in acoustic instruments (e.g. woodwind multiphonics, certain string articulations). I'm very interested in unexpected effects or playing techniques which the performer can discover and develop for themselves. On the other hand, I try to avoid overt large-scale randomness in my designs, as I think it moves control away from the performer and into the technology.

But an effect need not be random to be chaotic, where the slightest change in the input will produce a significant change in the output. These situations can be artistically rewarding, and the performer can learn to control them more precisely with practice, or to embrace the uncertainty on their own terms (rather than on my terms as the designer). I think it can be quite useful for an instrument to have regions of stable, straightforward sonic output punctuated by smaller regions of more complex or chaotic behaviour.

ADRIANA TO THOR MAGNUSSON: **You do live coding performances, creating drones with microtonal textures, often in collaboration with acoustic musicians. Potentially, live coding allows for human-computer interaction to happen at low level in the digital architecture, less mediated than if the software encapsulated a large amount of musical theory. But code typing also brings constraints with respect to timing. Does that lead you to dispense with a low level approach? Or would you say that live coders have a characteristic understanding of musical timing, different from that of acoustic musicians, who interact with their instruments in more immediate ways?**

THOR: There are many layers to this question; perhaps these can be mapped to the layers in which code is structured. Indeed, one could say that there is a direct relationship between the level of code and the potential for expression. The more low-level the language is, the more control you have over the hardware; the higher you get in this stratification, the more constrained you are by the abstractions defined by the system. But you gain speed: for a musician or an artist working with computers, the key question is at what level they want their constraints to be. We should note that time is always an important constraint as well.

Now, some software defines your music, some defines your work processes, and there is software that's so open you need to build your own systems to think and to express yourself. Different tools serve different people and purposes. Personally I am interested in coding at a high musical level – above synth building, signal routing, or pattern composition – and I have created two live coding systems: ixi lang and Threnoscope. Both of these are built on top of SuperCollider, and although they define their own methods and rules to the degree that they look very different from SuperCollider itself, the user is still able to code in the SuperCollider language. The aim with ixi lang was to be able to code quickly, to communicate the code to the audience through a simple notation system, but also to make the coding easy as I found nightclubs at two in the morning not exactly the right place to be debugging code.

It seems like musical performance and coding require two different types of focus and your points about immediacy and mediation are interesting in this context. There is almost a lived time and algorithmic time, the latter of which is so abstract that it has no duration. And to me these are two different experiences of flow. The live coder is constantly switching between the two, but the issues with timing you point to is the slowness of coding, the anticipation and lack of immediacy. Typing the code is of course an embodied and time-based action, but it is not a gesture that has one-to-one relationship with the sonic results, like we are accustomed to with acoustic instruments, so we can't talk about immediate gestures as we find with acoustic instruments.

Regarding timing in acoustic instruments, we could talk about the issue of latency (where some acoustic instruments have quite some latency, such as the church organ or bells). If we look at the live coder's actions and observe what they result in, we might say that live coding has almost no latency: the letters appear on the code document immediately after the key on the keyboard is hit! This is not a joke. Live coding is not just about the sound, it's a performance that's equally about the live composition. It doesn't make sense to separate the two words of performance and composition. So the issues of timing in live coding performances depend of course on the person who is playing, the music being performed and the system used. It is here that we can start to look at immediacy and mediation. Both of these words can differ in meaning depending on context, but in acoustic instruments we might say that immediacy is one of gestural immediacy, whilst in live coding we might refer to the time it takes from getting an idea to executing it. Same with mediation, where musical instruments mediate certain gestures into sound, whilst in live coding we might talk about mediation at many levels, for example how methods mediate through encapsulating complexity, how the language itself mediates through its semantics and syntax, or how live coders mediate their intentions. The live coding language is equally designed for talking to the computer as talking to audience members, and in this sense immediacy and mediation are highly relevant to the live coding performance.

ADRIANA TO THOR: You speak of Threnoscope as a graphic notation system, where sound and image represent each other. However, the cause-effect relationships may be not fully understandable, even for those who know SuperCollider very well – as you say, your code looks very different. To which extent is the understanding of the audio-visual relationship important to you?

THOR: There are many aspects of notation in the Threnoscope system: the code, the code score, the representational score (the visual system), and then you can write scores in linear or non-linear formats using timed arrays. I agree that the causal effects might not be understandable immediately, but that's fine: if people are interested they investigate, I think, and arrive at some conclusions, because it's all there. I don't think musical instruments should be necessarily easy to play or understand. We're not designing buttons in an elevator or a coffee machine where the affordances responding to the thing's function should be understood immediately.

If you're asking whether I think it's important that the audience understand the audio-visual relationship, the answer is no. I don't care whether they do or not, some people might even enjoy the music less if they understood everything. People are so different in this regard. However, I think the possibility for understanding should be there, and in addition I often answer questions afterwards or people can read a paper I wrote about the Threnoscope.

I have sometimes been asked to explain the instrument before I start playing. I've come to the conclusion that this focusses too much on the tool, and draws attention away from the music. How would you have listened to Miles in a concert if he'd started every gig explaining his trumpet and wah-wah pedal? So I don't do that unless playing for a room full of technophiles who really enjoy that kind of approach.

ADRIANA TO ATAU TANAKA: **When we met in 1995 you already performed with a system that captures neuron impulses resulting from muscle tension (EMG). You updated that earlier version, but the mode of interaction is the same. The biosignal is captured when you initiate physical gesture; we can say that actuation happens faster than with any acoustic instrument. Do semi-conscious muscle contractions bring certain unpredictability? Is that desirable in your sonic constructions, or do you endeavour to maximise deliberate control?**

ATAU: I think that there is a huge spectrum of possibility between unpredictability and control and that neither is interesting by itself. The neuron impulses that cause muscle tension are a stochastic pulse train. So it is not a periodic signal as most musical signals. But this does not mean the EMG signal is random or unpredictable. The stochastic signal does represent the number of muscle fibres firing to cause tension, and this is at some level related directly to the intensity of musical gesture.
At the beginning, in the 1990's, we were in a MIDI controller paradigm, and interested in the idea of "bio-control", as distinct from biofeedback. Biofeedback implied reading a signal that reflected the state of the body, where bio-control implied a form of volitional action. But control is, I think, a dangerous word. To control everything deterministically is not very interesting, and wouldn't give life in music. Ultimately, the muscle electromyogram signal is a very live, living signal that is organic and much more dynamic than any MIDI controller could produce.

Rather than control, I think the volitional aspect is interesting, and this is why I use the system on the forearms – these are the limbs we use for most musical instrument performance, and they are the limbs that are free from other duties of having to hold the body upright, so available to tense and relax freely. Volitional action implies reproducible. So this addresses to some extent the unpredictability issue. But the body is not a machine, the signal is a living signal. We can do the same gesture twice, but we can do it differently. Perhaps never the same way twice. The body can get energised depending on the situation, it can get tired with too much exertion. This is beyond our "control." So this gives a richness in the reproduction of gesture that creates variation – so ultimately more interesting than either unpredictable or totally predictable.

Volitional acts are intentional acts, and I think the EMG is the fastest sensor, closest to the body. Whereas other sensors report on the result of a movement, the biosignal is the signal the body is generating in order to produce a movement – so thought in this way, it is intention. Alongside this comes effort, and the restraint one needs to exercise not to over-extend. So intention, effort, and restraint, are three key qualities the EMG allows us to use musically.

ADRIANA TO EDWIN VAN DER HEIDE: **Your contribution to the first roundtable was titled *Audience and Space as Performers*. Nowadays you create installations, yet you used to perform on stage when we met in the 1990s. Joel spoke of performative skills, which the performer needs time to develop. That is obviously not what you mean in your title. So what does 'performing' mean here? Can we still think of performing in terms of 'expression'? What would that notion of expression entail?**

EDWIN: During my study at the conservatory I started focusing on controlling real-time generated sound with sensors in order to create a form of live, physical, control over the digitally computed sound. For most acoustic instruments physical control means a bidirectional form of control consisting of physical actions and physical reactions that are often inseparable (i.e. you touch a string and you feel it move). This means you do not only hear what you're doing but you also sense what you're doing in, for example, a tactile way. Furthermore with most acoustic instruments your body forms an intrinsic part of the sound generation system. However, the sensor-based interfaces that I was using were used to control parameters of algorithms in software but the sensors were not giving any physical feedback regarding what was going on within the algorithms. Another form of feedback that was there nevertheless was of course the live generated sound itself.

This brought two things to me as a performer:

I developed another awareness of my body. I learned to develop and memorize movements and gestures that are based more on the sense of proprioception instead of direct physical (i.e. tactile) feedback from the sound generation.

Because of the 'missing' physical feedback I focused even more on the generated sound.

Working with sensor-based instruments made me not only focus on the generated sound itself but also on the acoustic performance space. I realized that the space can form an intrinsic part of the resulting sound. I became interested in the following questions: How is the sound addressing the space and how is the space responding? And since the audience is inside and part of the space: how is the sound addressing audience and how are they responding? I realized that stage based performances are in the way of fully focusing on the (surrounding) space because of the predominant focus on the stage itself and the performer(s) on the stage. I became interested in the idea of creating environments and, as a consequence, a more active exploring audience. This doesn't mean that I think that listening is not active but I mean active in the sense that they are also taking action in space. Focusing on the space allows me to use and integrate specific aspects of the space in the composition/work. The role of the audience changes in that they have to explore the space by taking actions and relating themselves to the work. The audience is in a dialogue with their environment and, up to a certain extend, building their own order of events.

This is not a situation where the space or the audience take over the role of composer. The composer is the one creating and structuring the environment. But do the audience members become performers because they have a more active role? In my opinion the audience members do become performers but not performers in the sense of musical performers. They become performers because they perform actions in the space. They don't necessarily perform in a conscious way and wouldn't call themselves performers. They become performers because the work invites and steers them. The audience members let themselves being steered and they interact with the work within all the openness and closedness there is.

When we have an active moving audience they not only relate themselves to the sound but also to the space. Also the space is steering the audience. We get the following triangle: The sound is in a dialogue with the space, the audience is in a dialogue with the space, the audience is in a dialogue with the sound. The space is structured by the sound and the sound is structured by the space. This means it becomes a responsibility of the composer to structure, not only the sound but also the space (or at least, to structure how to use the space).

An interactive work is often seen as a work that reacts to the actions of the audience. I think this is a misconception. I believe a good interactive work is so well structured that it makes the audience do things.

ADRIANA: Interestingly, this seems to point out a possible convergence between interfaces meant for author interaction and user interaction: the term "composing an instrument" is frequent in NIME literature. For example, [Magnusson 2010] describes 'composing an instrument' as defining and limiting the boundaries of a musical space to be traversed in performance. The term is also extended in [Murray-Browne et al. 2011], which proposes an approach to instrument creation as an art form in itself, where instrument, mapping and music are an integrated part of a greater composition.

ADRIANA TO MICK GRIERSON: You developed interfaces meant for individual use as well interfaces for audience interaction. Can you point out basic similarities and divergences in interaction design? E.g., do you create greater amount of constraints when the system is meant for audience interaction than when it is meant for a specific performer? Is the interface less complex?

MICK: I'll try to answer this question simply, but it's not a simple question. Also, I respect the question so want to answer as truthfully and completely as possible.

Audiences. First I'd like to make clear that I haven't ever created instruments for audience interaction. As a composer/performer/content generator, I'm interested in one-way, non-inclusive experience generation, where I direct and create experiences for an audience in a space. As a musician and designer, I'm interested in creating interactive systems that allow people to play music together more easily, so we can all experience spontaneous music creation as a group. In the second scenario, we are all doing things to each other in a space, and nobody cares about the audience – the audience isn't relevant until you book a gig, and then we're all back to the first scenario. That's just how I see it.

I should add that the choice of title for my piece "Study for Film and Audience" was really meant as a joke about spectatorship and interactivity.

Complexity. I'm quite disinterested in having a long-term relationship with any instrument. I will more or less use anything. I get bored so easily that I need to constantly create new approaches for myself, and I'm happiest performing with something that I'm experiencing for the first time. I love playing other people's instruments, particularly when they are very badly made, or very simple, as they can be challenging and exciting. I learned this from an old friend. He could make a snapped-off piece of wood sound very compelling. So I don't think an interface or instrument has to be complex in order for it to be used to create interesting, meaningful, and complex expressive sound. You just have to understand what sound is, and be present in what you are doing. That's the skill of the musician in my view.

Furthermore, speaking as a musician who's reached a professional level of proficiency in a number of instruments, we spend a great deal of time practicing complex behaviour. This virtuosity has a tendency to infect musical and sonic style in a negative way. I can think of very few instances when this has resulted in music that expresses anything other than 'look how great I am'. This is a significant aesthetic problem that cuts across contemporary music and sound discourse just as it always has. Complex spaces of interaction and behaviour are great, but it is finite, specific interactions and behaviour that carry meaning. These don't require complexity at all.

Constraints. As a researcher and designer, I really care about creating tools for other people to use, as this seems like a harder and more interesting problem from my perspective than making instruments for myself. Most people have absolutely no interest in my approach to music and sound – they aren't going to be convinced by my friend and his broken stick, and I have no aesthetic interest in their approach to music making either. So there are all these kinds of expectations set up about sound, music, composition and meaning that although are totally worthless to me, I must accept are vitally important to others. These are examples of the constraints that I find myself working with, and I really enjoy understanding what it is that people want to do.

Other examples of constraints that I feel really matter include those made significant because of people's physical or mental abilities. I've created tools specifically for people to use just so I can play with those people, and make contact on a non-verbal, human level. They are definitely not an audience member. In this situation, we are in the second scenario, communicating through sound, and modulating it as a means of discussing our experience together. This experience is much more expressive, meaningful and powerful in my estimation than the homogeneity of contemporary musical culture. I also wonder if it's more important than the notion of composition, or the notion of performance altogether.

In this way I would argue that the constraints I am faced with when working with trained musicians who have what they consider to be culturally valuable affordance requirements are much greater than those I am faced with when working with those from outside contemporary music culture, and who have never or could never otherwise experience making music with another human being. Conversely, the design considerations and technical effort required in the second case is far far greater, as those requirements are beyond my understanding, whereas the requirements of musicians are more or less obvious to me.

ADRIANA: There are very compelling points of discussion here. A study conducted in an hospital environment showed that physical movements change from *exploratory* to *performatory* when a person becomes skilled in the execution of a specified task: movements become fluent, with a "focus on timing" [Kilborn and Isaksson 2007]. Personally I take a long time to develop my instruments, and I stick to each one for years. But I certainly don't find one type of movements more important than the other. To me, creating instruments entails the discovery and development of particular techniques, which combine performatory and exploratory movements: whereas the performatory aspect of the music entails fluency and focus on timing, the exploratory aspect makes the musical thread unrepeatable and unique. This seems close to Andrew's and Atau's thinking about the role of unpredictability and signal volatility. I feel that it is my great familiarity with the instrument that enables me to create interesting musical meaning upon unexpected events that could feel "wrong" within the musical logics. And the audience also has an influence upon the sonic construction. My playing is very sensitive to this empathic link; each performance is a common voyage.

I feel that there are fundamental differences between author-oriented design and user-oriented design. These are not that easy to pin down. One possible indicator is the level of challenge in the interaction, and consequently, the amount of time/ investment one needs to play the instrument/ system. This is a simplistic way to put it, but it touches important political/ economical issues, as for example research funding criteria.

Many designers seek methodologies for musical instruments/ systems to adapt to different types of users, while keeping all of them engaged. For example, Francois Pachet developed what he called *musical mirroring effects*, where, by construction, the level of challenge represented by the behaviour of the system always corresponds to the level of the user [Pachet 2004]. Another example are the *personal instruments* developed by Tod Machover and the MIT Media Lab, which the authors describe as musical tools that enable everyone to participate directly in music-making regardless of background [Machover 2009].

Alternatively, one can defend that an instrument requires great investment in playing, and that developing a new instrument is also developing a new musical language. For Michel Waisvisz, changing the algorithms that constitute the sound engine meant learning a new instrument, involving the re-incorporation of the conceptual understanding of the engine's functionality into bodily memory [Waisvisz 1999]. Joanne Cannon and Stuart Favilla also stressed that creating a new instrument must be accompanied with developing new skills to play the instrument; one does not learn to play an acoustic instrument in weeks, and that should also not be expected with digital instruments [Cannon and Favilla 2012].

ADRIANA TO MICK: Returning to your previous answer Mick, you use the term "culturally valuable", which is a very broad term. It brings the question if there are essentially different ways of understanding the cultural function of music. When trained musicians play together, human interaction is certainly fundamental; yet playing together is satisfactory or not depending on the sonic result – the musical logics, bound not only to the individuals involved, but also to their particular skills, and to the whole music history. I think that Joel explained that in a very clear way. Would you say that the value of a sonic construction can also be considered independently from the musical logics itself, i.e., do you think it can derive from the human value of personal interaction alone? Would you draw a distinction between "sound organisation" and "music"?

> **MICK:** Ok that's a great question. Before I answer, I should address why and how I used the term culturally valuable. I'm saying that musicians tend to have very strong ideas about what is culturally valuable and what is not. I'm saying that this is a constraint that affects the design process, and that it's a problem. A problem I'm fine with by the way!
>
> Fundamentally, coming to your actual question, it's really clear to me that when anybody plays music with anybody else, the sonic result is as important regardless of their skill, or self-identification as musicians. My point is that certain kinds of skills do not necessarily affect the sonic result. In fact, I think it's arguable (and I have argued) that skill often makes things sound much worse. Sonic results, certainly from a compositional perspective, have nothing to do necessarily with skill beyond the skills required for sonic construction. Take concrete music, for example: it's the sound that is primary. Musical interaction is actually not that useful in the context of sonic construction – only the sound is. Finally, I would state that great sonic results can be generated by a person using/working within a system that is designed to produce a specific sonic outcome, and that this is a fascinating political resource, and one that might invite and encourage all people to consider the value of very different types of sonic experience, regardless of preconceived or prejudiced notions of cultural value.
>
> And more directly, I don't really think there is a meaningful difference between sound and music in general. I think there are many different types of sound and music, and they are all beautiful. Currently enjoying listening to the air conditioning hum in my office, while people move chairs above me. Awesome.

ADRIANA TO MIGUEL CARVALHAIS: You have been interested in how the audience perceives a performer's interaction with their system. Once you told me that sometimes, performer and system are perceived as whole, and other times not. What do you think leads to one or the other?

MIGUEL: When thinking about interactive systems for performance – either when designing them or when studying them in other contexts – I find it extremely important to consider how the audience may interpret the interactions at any given point throughout the performance. Although these systems are interactive, they are commonly not designed to be experienced as such by the audience, but rather they're experienced as performance tools to which the audience has no direct access. Therefore, the audience relates to them in a manner similar to what Golan Levin describes as "vicarious interaction" (more about this in Levin's own writings or in Katja Kwastek's excellent *Aesthetics of Interaction in Digital Art*).

In any performance with interactive systems – and this includes both stage-performances as vicariously witnessing any other person directly interacting with a system – audience members will try to understand the affordances of the interactive system, will try to infer rules of causation or of transformation of the interactor's actions by the system, or to predict the system's actions and reactions throughout the performance. This of course happens in parallel with the more conventional aesthetic enjoyment of the work, but opens the door to two new levels of aesthetic enjoyment that we may identify as: 1) the aesthetics of interaction and, 2) the aesthetics of generative processes (particularly when the system is partially autonomous and not only responding linearly to the actions of the performer or interactor).

When witnessing a performance with an interactive system or instrument, or when interacting vicariously, one may perceive the aggregate of interactor + system (or interactors + systems) as a single entity, or one may read them individually, basing the interpretation of the human interactor on our own knowledge of physical mechanics and human psychology, and trying to predict possible responses and reactions from the system, thus developing a "theory of the system" that may help one to understand and predict the development of the performance.

I find this way of reading performances of the utmost importance for the enjoyment of this aesthetics of interaction. From this it follows that both the composer, the designer of the interactive system, and the performers, must be very aware of the necessity to give ongoing clues or affordances of the system's mechanics to the audience, so that it becomes possible for them to construct meaning from the observation of the performative act with the interactive system.

ADRIANA TO MIGUEL: Sensing causation is not necessarily the same than understanding the actual base cause-effect relationships. You use the term "clues", which raises the question: do you enjoy it more when you feel that you understand/ predict the cause-effect relationships, or, do

you like to be confounded, perhaps to the extent of quitting that logic understanding, and focus on the experience itself?

> **MIGUEL:** Sometimes the clues may lead to a logic understanding of the process, to a complete knowledge of how the system reacts to the interactor's input and, conversely, of how this reacts to the system. Sometimes they may simply lead to the identification of a number of cause-effect relationships that may barely allow one to understand that whatever is happening is not arbitrary, that there is a meaningful exchange going on even if we don't quite get it. In either case, this doesn't mean that all the details of the process are understood, but just that the audience is able to predict relationships and thus be surprised whenever either system or interactor deviate from the predicted outcomes. Both an understanding and accurate prediction of events as confusion may have their place in a performance, and they may both lead to its enjoyment.

ADRIANA: I can only agree with the importance of providing "cues", so that one gets a sense of causation – as a researcher, instrument designer, performer, or audience. However, personally I do not like to focus for too long on the mechanics of the instrument, and even less, to fully predict its mechanics. I suppose that is an aspect of subjective, aesthetic experience. But it may not be restricted to me as an individual. This actually motivated a study about perceiving causation without understanding the base cause-effect relationships [Sa et al. 2014].

ADRIANA TO ALEX MCLEAN: You do live coding, like Thor, and live coders project the computer screen so that audience members can see the code. Is there a political meaning to it?

> **ALEX:** Without projecting screens, people can't see any of the activity behind the performance. That's fine in a lot of cases, sometimes activity is a distraction, and code doubly so. However if you're on stage, and people are sitting in rows watching you, it's just a bit ridiculous that they can't see what you're actually up to.
>
> But yes, I think there are political reasons for projecting. Not too long ago the fashionable movement for creative coding was 'generative art', a fairly utopian movement looking for computational creativity in quite simple processes, sometimes mistaking arbitrary random selection for infinite, qualitative variety. Generative artists have endless discussions about authorship – if you program a computer to make art, is the author the programmer, or the computer? In my view this whole question of authorship is an intellectual cul-de-sac; humans have always thought through their tools, and followed lines through their materials. Thankfully live coding makes this question redundant, no-one can deny the human influence in such a performance.
>
> I think this reassertion of the humanity of computer language is political. At a time when there is much to fear from opaque software that governs our relationships and lives in general, making the authorship of code visible gives us a chance to reimagine code as social and communal. I don't think I'll ever meet a linguist who agrees, but my hunch is

that we are stepping towards making programming language more like natural language.

ADRIANA TO ALEX: You perform in clubs, and people may not understand programming language; anyway you like people to dance to your beats, rather than pay attention. To which extent is their understanding of your code important for you?

ALEX: Understanding code is not important to me, in fact in Slub we have sometimes purposefully obscured our code to make it more difficult to read, while still showing some of the activity of the edits. When I watch live coding performances, I don't read the code. Indeed even as a live coder I don't have top-down understanding of what my code is doing, I am just working with the code as a material, while listening to the output of the process it describes. I don't think the code holds any answers for me, it's just a step in a wider feedback loop. I changed my mind a bit about this though when a Deaf audience member let me know he got more from the music by reading the code, and was annoyed by the strobe that stopped him from being able to read it. So it's not important to me, but it seems to be crucial to some listeners, and inconsequential to others.

ADRIANA: Thank you all for your precious contributions to this discussion. Each topic can unfold in many directions. The fact is, with digital instruments physical action will always be mediated through code. The general purpose of this conference is to expose and discuss the principles governing interaction – that is the reason for the hyphen in INTER-FACE.

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PAPERS

PERFORMATIVE ARENA

"ART – DEAD OR ALIVE?"

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ABSTRACT

In our days, technological apparatuses, which are omnipresent even in traditional concerts, interfere with the spaces of musical listening. In traditional concerts this interference is generally limited to acoustic corrections, which aim to improve the listening situation. However, contemporary music often integrates technological means from the very beginning of the creative process. The composer's toolbox can include musical instruments, analogue and digital components, and other not specific equipment, designed for making music, such as computers.

Considering this framework, we will present some issues related to the use of "virtual instruments" in musical composition and performance. We will look at the idea of "hearing expectation", and elaborate on what kind of coherence or incoherence results from the relationship between the performer's physical gesture, and the sonic event generated by the machine. How can we specify the idea of performance expression in this context?

1. INTRODUCTION

Why does some art today claim itself as "live art"? The question may seem merely rhetorical given that no art form would want to appear as "dead" or as a thing of the past. On the contrary – all modern art claimed its inscription in the present, as the possibility of moving with the times and searching for the new. The art of our days actually claims the condition of pure contemporaneity, as an art form that is being made now, in the present, independently of any progress programme or historic rupture. Despite important differences, modern art and contemporary art equally claim an inscription in the here and now, be it understood at a historical level or, on the contrary, freed from history. The idea of "live art", which appeared in the past few decades, expresses a variation of this inscription in the here and now which resonates in all art from the 20th century. It invokes, in this case, an art that is immersed in the flux of life itself, that chooses actions and processes, bodies and gestures as its main media. It resumes a set of art forms that have gained a growing importance in the last few decades: performance, happening, action, relational art, and various other artistic practices mediated by computer systems in real time.

The inscription of art in the present is thus a transversal claim made by art from the last one hundred years. And yet, it has not always been this way. The mode of inscribing art in time has not always been the same even though Art History has unified it into a single narrative. Belonging to the universe of art ideally implied crossing the times and aspiration for eternity. The arts, as knowledge of the muses, were first and foremost arts of memory. Therefore, in past times art strived to be something eternal and not something that is topical or current. It wanted to present something that was timeless, that transcended the traces of time. Ideally, art should resist time and the contingency of the present.

Surviving (and not, "being alive") is the classical temporal claim of art. But that also implies the possibility of coming to the present in each new here and now, i.e., the possibility of works of art being continuously received in the present, despite coming from a distant past. Being made present in each (re)appearance is an ontological claim that implies condition that transcends time. The temporal structure of classical art is therefore a paradoxical structure: it is continuously being made present from a distant past through an ontological foundation that transcends all temporality.

Modern art, however, inverted this structure into a new paradox: in order to become unique and original, art should embrace actuality and allow itself to be marked by the ephemeral and transitory present as Baudelaire affirms in his notorious essay "The Painter of Modern Life" (1985 [1863]). To be modern is to embrace modernity by capturing that which is unrepeatable in the present. But that topicality is inscribed in the work of art as a destiny of death, just as the novelty of each fashion.

Originality or the unique character of each modern work of depends on the full assumption of temporality, as a species of negative ontology, an ontology of actuality that Michel Foucault proposes in "*Qu'est-ce que l'Iluminisme?*" (Foucault 1984), where he precisely comments on the vision of Baudelaire, who also speaks of the possibility of extracting the eternal out of the transitory itself.

The intrinsic ambivalence to the modernity of art therefore serves the same desire of transcendence and continuity, that justify the belief in the unique character of works of art and the need for their distinction and conservation, and that is why we continue to have things to place in museums, the homes of muses and memory. But what is "preserved" there no longer coincides with modernity of art itself, since that is, by definition, that which transitory and ephemeral. This ambivalence marked the tensional relation of modern art with the museum, expressed in a fundamental *aporia*, which was often discussed by artists, theorists and critics: modern art wishes to capture the present, the everyday life and the trivial, thus fighting its encapsulation in the museum. But at the same time it needs the frame of the museum to assure that the artistic meaning and status of its proposals do not get confused with the mere ordinary life.

The main question is therefore the mode of presence of the works of art and not just their claim of time or of eternity. What becomes present in art refers to a possibility of the art works manifesting a truth that transcends their specific existence. That transcendence would found the difference of the work of art in relation to all other things, and its necessity and origination would continuously manifest itself in it. Artistic value would thus be founded on the revelation of a truth whose model is ultimately metaphysical and theological. This transcendent mode of being has made art a part of the history of Being, namely in a phenomenological tradition. Some of the most influential philosophical approaches to art (from Hegel to Heidegger) establishes an absolute equivalence between the revelation of truth and artistic production (*poiesis*), as the very coming into being or appearance of truth in the form of work of art.

But this inscription of art in the history of being, as a sensible manifestation of truth, is precisely that which Hegel announced was coming to an end when, in his *Lectures on Aesthetics* (1835), he describes art as "something of the past". What tradition withholds as the vaticination of "the death of art" (Hegel 1975 [1835-1842]) is in fact described as the end of the appearance of truth in the form of a work of art. This particular conception of art is what Walter Benjamin critically summarized in his notion of "aura" (Benjamin 2008 [1935]), making us understand its metaphysical origin and its aesthetic modern extension. For him, also, this transcendent regime of art is about to end under the pressure of the technical reproducibility of the work of art. This end creates the possibility of a new (political) mode of existence for art, freed from onto-teological claims of originality and presence. As Odo Marquard so well put it, in *Aesthetica und Anasethetica* (1989) art would soon build a compensatory vision of its own "end" (Marquard 1998) or of the end of its ontological status. The modernity of art is already in fact that which compensates for the "end of art", for the "loss of aura" or for the loss of a pre-given truth supposed to be revealed in the work of art. From this phenomenological structure only the pure coming into being, the pure topicality of the artistic gesture are saved: the "here and now" now as an event of pure immanence, completely sovereign, with no pre-given truth nor historical destination.

Modern art celebrated this evenemental structure of art in two fundamental ways. On the one hand, the search of the new open it up to an almost infinite possibilities of being (namely those of not being art). On the other hand, it progressively reinforced the identification of the work of art with the actual event that interrupts the flux of history, with the irruption that challenges any art of presence, in the sense that every event challenges being, but also the mere passage of time without meaning (Badiou 1988). The event is what illuminates, in the present, the possibility of an appearance, of a self-positioning. The event coincides entirely with the here and now of its coming into effect. Its instant pays homage to the possible, not to the present. Art as evetn is, as stated by Deleuze and Guatari, of the "noncurrent" order. Art is the conservation of the happening (cf. Deleuze and Guatari 2003 [1991]) but only to the extent that it is consumed in it.

Since the mid-20th century, this evenemental structure of art, noticeable since the historical avant-garde, becomes entirely manifest in movements rooted in music, dance and theatre, which quickly merged with the performing arts, but also with the visual arts movements that tried to free themselves from object and presence. Through the incorporation of agency and spectatorship, space and time, situation and context, the frontiers between visual arts and performing arts become more and more porous and blurred. John Cage (1912-1992), Merce Cunningham (1919-2009), and Allan Kaprow (1927-2006) defend an "art with attitude and happening" that quickly emerged as "performance", "happening", "actionism", "situationism", "fluxus", "body art", etc. All of these art forms highlight their desire for agency and practical dimension, by giving a particular emphasis to the processes, namely to improvisations, adherence to the context, or on the contrary, to the construction of environments and action scenarios, and even detailed ritualizations.

Dematerialization and performance become the maim aspects of a progressive transformation of poiesis into praxis that affects a large part of what is done and presented as contemporary art. In The Man without Content (1994) Agamben describes this dislocation from *poiesis* to *praxis* as a modern transformation in course since the renaissance valorisation of the "*modus operandi*" over the operations themselves. As a consequence, many of the artistic practices of the 20th century cannot be framed within the notion of work (*ergon*) and production (*poiesis*). In fact, throughout the 20th century, artistic *activity* largely transcends artistic production. Art searches for a mode of presence in life that transcends the form of a finished work, as Adorno demonstrates in *Aesthetic Theory* (1970). Being alive is a revindication of art in tension with the condition of the work of art as a thing that is produced and separated from the event of its creation. As creatures, resulting from a poetic act, the works always present a kind of posterity. The idea of a living art is ultimately incompatible with the very idea of a "work of art". That is why art strove for a mode of existence that would allow it to mould itself completely to the flux of experience, to the axis of praxis and action, as opposed to the production of an *ergon* (the result of an act of production). There may be vestiges, remains or documents that allow us to refer back to it, but not works. The evenemental character of the performing arts allows them to coincide fully with the here and now of its live presence.[1]

The invocation of a "live art" represents the closure of the modern debate with the claim of atemporality and eternity of classical of art, but also the resolution of a tension within modern art itself: the tension between the here and now of artistic creation and the work of art as presence; the tension between event and being. The century has brought to light that the insistence in the "here and now" of creation can also redress the question of the "Origin of the Work of Art" (Heidegger2008 [1960]) into that of its dissolution. Moreover the claim of a "live art" may also be seen as a programme that resists or compensates the industrialization of culture, and the mass production and dissemination of aesthetical objects and experiences that threaten to dissolve the distinctive character of the work of art. This kind of interpretation, several times repeated after Benjamin, should nevertheless distinguish two moments of this industrialization process: 1) that of the mechanical and analogical means and their vocation for reproducibility, whereby the distinction between original and reproduction tends to disappear, threatening the survival of the value of the original; 2) that of the information and digital means and their vocation for the production of experiences in real time, which are always diverse and framed upon the here and now of the encounter between spectator and work.

In the first moment, and despite the entry of the technical image in the art scene, the resistance to the dissolution of aura imposes certain regimes of visibility and circulation of aesthetic objects (museums, concert halls, cinemas, etc.). These represent spaces and models for the production of specific modes of perception and experience, and even for the duration of contact with the objects in question that distinguish them from objets of common experience. This cultural apparatus surrounding the reception of the work of art (its regimes of attention,

1.Benjamin knew quite well that the practical and political value of art would only emerge at the price of its dissolution in life, a possibility that, according to Benjamin, was first expressed by the avant-garde and later confirmed by the technological condition of modern culture. (Benjamin 2008 [1935]).

judgement and experience) is just as relevant as the conditions for its production in establishing its distinctive mode of existence. In a second moment, however, that of the triumph of digital media, the cultural techniques surrounding the production and reception of aesthetical objects and experiences seem to respond to the many of the core ambitions of contemporary art, expressed all through the second half of the twentieth century: dematerialization, realtime responsive environments, interaction and participation, performative and processual art, happenings and evenemental art, etc…

2. CONCLUSION

From the caricature of the present staged by live television and reality shows, obsessed with real time performance and spectatorship, to interactive computational systems and digital networks, the new information and communication technologies seem perfectly able to host and also mould themselves to the living flux of experience, becoming the irresistible mediation of actuality. Moreover, in the age of the mathematical theory of information, all events are reducible to the entropy ratio of a stochastic process, through which cybernetic space and information processing becomes the widest and most plastic poetic space of all. Either within the field of classically-trained composers, or within the field of electronic and computer music, the evolution of technology seems to accompany all the whims of a live art: sound design, real-time sound synthesis and signal processing, tangible and adaptive interfaces, real-time computing and collaborative real-time editors, electronic and computational strategies of association between composition and performance, namely within the field of algorithmic composition, interactive sound installations, or laptop performances in the most diverse individual styles.

It is maybe interesting to remember that music was announced long ago (at least since the famous essay "The Poetics of the Open Work" by U. Eco, 1962) to be the most effective model for all kind of performance and interactive arts. In that essay, Umberto Eco takes contemporary music as the example, par excellence, of a new poetics and also of a new form of aesthetics. In fact, the encounter between music and information technologies for several decades now, as well as the lasting encounter between music and mathematics, is not by any chance a coincidence (Kittler 2005). Musical instruments are among the oldest "epistemic objects" made by humans. They are a kind of repository of a very rich and primary knowledge. They are agents of undefinable happenings, filled with the complexity of body performance and emotions, of its indescribable processes, nuances and expressiveness. Retracing and processing this kind of information and interacting with it, namely in real-time, has become one of the central challenges of computer art as live art. But perhaps at this point we should also recall that the ambition to merge art and life, and the development of art as performance and praxis, sprung out of 20th century avant-garde ambition to make art as close as possible to political praxis. It is also perhaps not by chance that we have most effectively approached this ambition through technological art, in the epistemic age of control and of biotechnology. Could this be a secondary conquest of what Foucault designated as "biopolitics" (Foucault 1994), the exercise of power and control applicable to life itself?

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MUSICAL VIRTUAL INSTRUMENTS AND AUDITORY PERCEPTION: SOME ISSUES

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ABSTRACT

In our days, technological apparatuses, which are omnipresent even in traditional concerts, interfere with the spaces of musical listening. In traditional concerts this interference is generally limited to acoustic corrections, which aim to improve the listening situation. However, contemporary music often integrates technological means from the very beginning of the creative process. The composer's toolbox can include musical instruments, analogue and digital components, and other not specific equipment, designed for making music, such as computers.

Considering this framework, we will present some issues related to the use of "virtual instruments" in musical composition and performance. We will look at the idea of "hearing expectation", and elaborate on what kind of coherence or incoherence results from the relationship between the performer's physical gesture, and the sonic event generated by the machine. How can we specify the idea of performance expression in this context?

KEYWORDS

Virtual Instruments, Sound Event, Technology, Sound Diffusion.

1.1. INTRODUCTION

A concert situation implies, in the majority of situations, an experience that is simultaneous auditory and visual. The evolution of sound diffusion and the development of music technology and electroacoustic music, including live sound manipulation in electronic music improvisation, altered the actual reality of the concert.

The traditional relationship of cause and effect between the gesture of the performer and the sound result expected by the listener is broken. On the one hand, the sound projected from a speaker, static and unimpressive, excludes perception of all relevant visual performative gesture. On the other hand, even when there is a performer on stage, the sound result does not correspond to the gesture of the performer. The performer who plays and improvises with a "virtual instrument" installed on a computer generally performs simple and unobtrusive gestures, using the keyboard, the mouse, or other interfaces. These gestures, often barely noticeable from a distance, can generate simple and understated gestures that can produce vivid sonic results, intense and rich in spatial movements.

This type of discord between performative activity (visually weak) and sonic result (diverse) generates a perceptual conflict in the listener: what the listener sees does not match what he hears.

Our personal creative strategies consider this perceptual discord as a shortcoming. We explore spacialization in accordance with musical assumptions, as a way to value the physical performance gesture. Spatial distribution can be a way to compensate for the lack of physical expressiveness.

The notion of space in music is quite complex, involving many variables and assumptions, which can be considered prior to sound diffusion. This paper elaborates on how space is considered at an early stage of composition, informing the choice of techniques, instrumentation and technical means.

2. ELECTROACOUSTIC MUSICAL LISTENING

2.1. EXTERNAL SPACE ISSUES

> "L'espace externe, lié aux conditions d'écoute à chaque fois particulières de l'œuvre: profil acoustique du lieu d'écoute; nombre, nature et disposition des haut-parleurs; utilisation ou non de filtres et de correcteurs en cours de concert; intervention à la régie du son d'un interprète humain ou d'un système automatique de diffusion."
> Chion 1991

The listening space is not neutral, and each listening situation involves specific conditions that must be analysed. "[…] parler de l'espace, c'est parler de l'interaction entre les caractéristiques acoustiques d'un lieu, sa disposition géographique, la configuration choisie pour les haut-parleurs dans le lieu […]" (Vande Gorne 2002)

Therefore, the space projection of electroacoustic music works has an influence on the perceived sonic result. This influence, which many researchers consider a phenomenon derived from the overlapping of acoustic sound areas, happen because, "[…] l'architecture physique d'une salle de théâtre s'ajoute à l'acoustique virtuelle d'une composition musicale pour bande."(Roads 1998) Indeed, since the 1950s, the writings about electroacoustic music concerts show a growing concern for the conditions of sound projection, related to the physical room or the equipment used.

When composition is informed by the characteristics of the physical space where there work will be experienced, the composer is well aware that the emitted sound differs from the heard. The compositional work extends to consider acoustic phenomena, spectral filtering, reflection, diffraction and absorbtion. Both composers and technicians seek to improve the conditions of listening, and respond to the challenges of each situation in musically satisfying ways. Many composers crate strategies for an increasingly effective conrtrol over the whole process of composition, listening and recording.

2.2. SOUND DIFFUSION DEVICES

A sound diffusion device is a set of equipment, more or less complex, and connected in various ways, which allows the sound projection of an electroacoustic music to function, whether the work is recorded or produced in real-time. This device should be able to reproduce as accurately as possible so that musical works, although the physical space is not neutral, exert a decisive influence on the perceived sound result. Plus, the device must be designed so as "[…] toujours essayer de tirer parti du lieu, de l'espace et du son acoustique […]" (Henry 1977), as Pierre Henry said in 1977. But, as different concert spaces generate different sound results for the same work, the diffusion devices, differently installed from one concert place to another, produce different levels of resonance and radiation of the sound waves.. In addition to these issues concerning the relationship between the device and the physical space, we need to be aware of a tendency to consider the devices and especially the speakers, as "[…] acoustiquement neutres, ce qui est évidemment faux: ils constituent des corps résonants avec des caractéristiques propres." (Vaggione 1977).

The sound device used should therefore be sufficient, and be well distributed in space, so that the dispersion of sound waves tries to reproduce as faithfully as possible the internal sound space inscribed in the musical work. Knowing the characteristics of the device and the sound diffusion in the physical space is essential for a good sound projection, i.e., for the proper interpretation of the work.

2.3. THE PERFORMANCE

The role of performance in the context of electroacoustic music, despite already abundantly discussed, points to a slightly controversial issue. Can a fixed electroacoustic music piece be effectively interpreted? What does performance mean in this context?

These questions are derived directly from the fact that, historically, we associate performance, or musical interpretation, to a particular activity that involves the act of reading symbols inscribed on a score and translating them into sounds through a set of instrumental gestures. This understanding of music performance, where performing means "translating", derives from cultural learning. Yet, and above all, it derives from the fact that instrumental music exists only through performance. In short, "[…] la musique instrumentale n'a pas d'espace interne au sens physique du terme: son support étant purement symbolique, l'espace interne est actualisé au moyen de l'interprétation, de la mise en sons." (Vaggione 1977)

However, electroacoustic music, made of sounds fixed on a support, seems to leave no room for an interpreter, for an instrumental gesture, for a performance, "[…] la mesure où il y a définition concrète de l'espace interne de l'œuvre. Le type de support utilisé véhicule non pas des symboles, mais des sons déjà «interprétés»". (idem.)

Thus, the sounds of electroacoustic music, with all their characteristics determined by the composer (and perpetuated in audio recordings) eliminate the translation of symbols into sound. This is comparable to recording an instrumental work: consider the recording of a Mahler symphony; is it appropriate to re-interpret a music piece that has been interpreted before? The obvious answer would be "no"; just put the CD into the player and enjoy the pleasure of listening.

As Tiffon explains, electroacoustic music: "[…] se trouve paradoxalement mieux «révélée» par l'entremise d'un spécialiste de la projection sonore, nouvel interprète aux responsabilités sans doute réduites, mais néanmoins essentielles pour une perception entière des jeux d'espace qu'elle contient." (Tiffon 2002)

So, what is the performative act within electroacoustic music? The act of projecting sounds in a concert hall, using a more or less complex device, that is often different from a concert hall to another, requires from the performer a set of skills and knowledge comparable to the "savoir faire" of any other instrumentalist. The scope for interpretation of a fixed work is thus reduced, sometimes leading to depreciating the work of the interpreter. However, as Vaggione explains:

> "Être aux commandes d'un instrument de diffusion – ou de projection – spatiale, nous donne quelque chose de plus que la possibilité d'agrandir une image sonore: c'est également celle de recréer son mouvement virtuel. C'est ainsi que le son se met à vivre, que les plans – les multiples degrés d'énergie contenus dans les morphologies composées –, se manifestent à la perception. La «lisibilité» des morphologies découle de leur mise en mouvement, d'une cinématique de la projection sonore."
> Vaggione 1977

Thus, as in an instrumental music concert, the interpretation is essential to the work, different in each concert, different for each performer or ensemble. A given work of electroacoustic music,

"[…] n'a pas qu'une seule vérité. On peut un jour souligner ceci, un autre souligner cela, à condition que le total reste le bon, c'est-à-dire que par l'articulation des contrastes, le contenu formel et symbolique ouvre chez l'auditeur une symbolique correspondante, par la grâce imprévisible d'une mise en relief des formes concrètes exactement ajustée aux conditions acoustiques et psychologiques d'un espace et d'un groupe d'auditeurs."
Bayle 1996

The interpretation of an electroacoustic work is therefore a necessary condition for the listener to understand the work. The instrumental gesture, often discreet, as previously stated, is in these works often replaced by the gesture of the sounds.

3. THE CONCERT: PERFORMANCE OF VIRTUAL INSTRUMENT

"Ce ne sont là que quelques aspects du métier d'interprète spatialisateur qui répond, comme toute autre discipline instrumentale, au couple compétence/performance: la connaissance technique de son instrument, la connaissance analytique et mémorisée de l'œuvre, et le désir de la transmettre en suivant le «feeling» du moment, l'émotion vécue au concert."
Vande Gorne 2002

In fact, what we have seen in these last 50 years of evolution of electroacoustic music, is that the work of the musician or composer / performer in a concert situation has changed substantially. Let's clarify a little better.

The first aspect to consider is that, actually, in the context of music assisted by technological means, such as electroacoustic music in a concert situation, a very specific role is designed to the interpreter. This role is not associated with the traditional symbolic burden involved in a situation of performance of a musical instrument. This situation involves also the spectator.

There is not a noticeable association between gesture and sound: those who watch the interpreter may not associate the visible gesture and the audible sound. But this lack of expressiveness and its symbolic dimension does not mean that the interpreter does not play an active role. On the contrary: the interpreter is much more than someone that is just there to press certain buttons in a neutral and passive way. I.e., the interpreter performs a specific function during the execution of the work, and his function has implications upon the auditory experience. This is why the interpreter has an interference (positive or negative) in the final result. Its function is not neutral, his skills can achieve great complexity, reaching a level of complexity that makes their function to behave like the one of virtuosity and excellence in interpretation. This then leads us to conclude that this type of interpretation-music, we would say, can also be made in a good or bad way.

The second aspect to consider is the idea that the composition also happens at the time of presentation. This means that the presentation, in a certain context of a particular piece, under specific conditions, will have a singular compositional result. Of course we can establish a comparison with the music presented in a more traditional way, using musical instruments, in which the perception of expressiveness associated gesture is much more evident. But this comparison should be based primarily on the assumption that electroacoustic music, as other more traditional music, also implies an interference of someone at the time of the performance. “L’interprétation d’une œuvre acousmatique tend à enchaîner diverses figures spatiales qui renforcent l’écriture de l’œuvre, mettent en relief les figures existantes ou en créent de nouvelles.” (Vande Gorne 2002)

This means that this kind of performance does not reserve a part of simple neutrality, but an active one. And what do we mean by activity here? Especially reinforcing the idea that whoever performs this type of music is a full interpreter as one who performs a more traditional instrument. Although in a different way, the interpreter of electroacoustic music is someone who has a level of interference in the proper piece of music as the one that is heard in a concert presentation. “L’œuvre est faite pour être à chaque fois remise en jeu (ou en valeur) pour de nouvelles oreilles.” (Bayle 1996) So, we should proceed with the idea that electroacoustic music, by their possibilities, takes the performative element at the stage of the composition itself. That is, the composers rely increasingly on this dimension of interpretation in the creation of its music. Not only because they can make use of increasingly versatile diffusion systems that allow to work the spatialization in diverse ways, generated a vivid, a dynamic sound. As well, as the composition itself, this dynamic sound is increasingly regarded as the most effective way to direct the composer to the space issues, not only at the time of diffusion, but also at conception itself, as we shall see in the next section.

> “Thus our laptop artist who played solitaire to fool the audience during a ‘live’ performance was not truthful, yet this did not necessarily deprive the audience of a genuine pleasure in perceiving choices taken, pathways avoided, intentions fulfilled or unfulfilled which were already in the (pre-recorded) sound.”
> Emmerson 2007

4. COMPOSITIONAL STRATEGIES: COMPOSING WITH SPACE

> […] cet espace qui porte le corps du son l’anime d’une lumière intérieure, va constituer le champ de l’image et renseigner aussi sur ce qui se passe hors champ, que l’on peut subodorer, reconstituer. Autour de l’image flotte une aura.
> Pires. Bayle 2008

In electroacoustic music, as indeed in instrumental music, musical sound consists of a set of manipulable elements of possible different time domains, and the presence of sound in the perceptual space operations. The process of musical composition includes *intra* and *extra* musical elements that allow the production of schemes or processes at various temporal levels, ranging from the purely intellectual conception of the project until the full completion of the work in concert.

Realisable operations during the process of electroacoustic composition are of various types. They embrace the production of algorithms for the generation and manipulation of physical sound variables, the construction of perceived sound forms, and any other intellectual mechanisms or materials contributing to the design of the sounds in music. In fact, these operations can be, for the most part, comparable to the act of composing music in the traditional sense, since the composer works the sounds, creating their instruments, developing musical ideas with the aim of obtaining a particular sound result they have set. And, if in electroacoustic music one "[…] ne peut pas composer directement avec ce que l'auditeur est supposé entendre, puisque ce que l'auditeur entend résulte aussi d'opérations" (Solomos 2003), it will be audibly that the composer evaluates the operations performed during the compositional process, as Vaggione says about the purpose of Jean-Claude Risset's work: "[…] faire un son par synthèse numérique, ensuite l'écouter, déceler les saillances perceptives, afin d'affiner l'opération subséquente. […] [et] valider perceptuellement les produits des opérations de synthèse" (Vaggione 2003), because "il est difficile, en musique, de séparer le formel du sensible. L'opération est du formel qui est aussi du sensible." (idem.)

In the field of musical composition, the smallest action which has the aim of transforming a compositional element – the creation of a gesture, a sound motion in space, a spectrum of a sound – whether a concrete action or solely intellectual – is already a compositional operation. The creation of spatial sound gestures by the composer during the musical work development replace, to some extent, the performance: spatial composed gestures replace the instrumental gestures, not in the sense of anticipation as the traditional hearing in a traditional concert, but in the sense that "L'espace intervient surtout dans le souci de clarifier le son." (Solomos, 1996).

Slightly detailing this situation, we must consider that, because of the technological apparatus development, the *space*, quickly elevated to the same level as any other musical elements, became a key compositional element in electroacoustic music. Particular care is given to the current sound space from the moment of the musical work conception: the composer works each sound element picturing their disposal in a room, and the movement that will ideally result within the concert. Thus, the determination of musical sound gestures according to a particular arrangement of the sound projection systems will generate new sensations in music based on fixed supports, in one way or another, depending on the diffusion technology to be perceived by the listener on concert.

This composition of the sound space seems to eliminate or decrease the possibilities of the electroacoustic music performer interference. However, the performance, carried out from a diffusion system, or by using a virtual instrument programmed into the computer, will always be comparable to the act of interpreting. It will be comparable to interpreting a traditional score, in which well-defined symbols must be translated into well-defined sounds, also limiting the player to interpret certain, strictly composed music represented in the score. “Mais restera, encore et toujours, à «l’interpréter» c’est-à-dire faire au public le don de la musique. Jamais un nouveau format ne réglera le problème du don de la “vie de l’écoute”. (Bayle 1996)

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EVALUATING A METHOD FOR THE ANALYSIS OF PERFORMANCE PRACTICES IN ELECTRONIC MUSIC

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ABSTRACT

This paper discusses the application of a method for the analysis of performance practices of electronic music that was developed by Ciciliani and originally presented in the paper “Towards an Aesthetic of Electronic Music Performance Practice” (Ciciliani 2014). This paper will provide a brief summary of this model in a form which was revised since its first presentation.

In the winter semester 2014/15 a group of approximately 60 students used this method for the analysis of five different performance situations. These examples included performances DJ QBert, Alexander Schubert/Frauke Aulbert, Nicolas Collins, Marco Donnarumma and Carl-Michael von Hausswolff. Altogether more than 180 analyses have been generated. The different results have been compared in detail in order to evaluate the functionality and usefulness of the analysis method. The outcome of this assessment is discussed in the paper.

KEYWORDS

Performance Practice, Interfaces, Electronic Music, Embodiment, Presence.

1. INTRODUCTION

This paper discusses the application of a method for the analysis of performance practices of electronic music that was developed by Ciciliani. A brief summary of the method will be presented, which mainly draws from the paper "Towards an Aesthetic of Electronic Music Performance Practice" (Ciciliani 2014), but which also introduces some revisions to this model.

In the winter semester 2014/15 a group of approximately 60 students used this method for the analysis of five different performance situations by the artists DJ QBert, Alexander Schubert/Frauke Aulbert, Nicolas Collins, Marco Donnarumma and Carl-Michael von Hausswolff. Altogether more than 180 analyses have been generated. The different results have subsequently been compared in detail in order to evaluate the functionality of the used method for analysis. The outcome of this assessment will be presented below.

2. A METHOD FOR THE ANALYSIS OF PERFORMANCE PRACTICES

The method which is presented in this paper attempts to identify performance practices of electronic music that have become established during the last decades. Thereby every performance is understood to be an audiovisual means of expression, which inevitably becomes part of the presented work in the moment it is performed in front of an audience. In the context of this discussion, performance is confined to settings in which one performer presents a work for an audience.

The method uses altogether 11 parameters that are graphically presented as a parametric space. It builds on previous publications by Birnbaum et al (2005) and Magnusson (2009). For a detailed description of the main parameters see Ciciliani (2014). The next chapter presents a short summary.

2.1. *CENTRIPETAL* AND *CENTRIFUGAL* FORCES IN PERFORMANCES

Eight parameters are arranged in two groups, while each group occupies one half of the parametric space. The two groups are referred to as the centripetal and the centrifugal parameters. The terms centripetal and centrifugal are describing models of performance that either guide the attention towards a central point in the space, which is usually the performer, or away from the center towards the boundaries of the space.

The *centripetal*-model is characterized by:

- a *centripetal* disposition, meaning that the performer is at the center of attention;
- visibility of performer;
- high transparency of bodily actions and sonic reactions;
- events that can be related to the physical actions of the performer;
- sound sources in the direction of the performer;
- correspondence of body and sound;

The *centrifugal*-model is characterized by:

- a *centrifugal* disposition; the performer functions as a controlling rather than enacting entity;
- the performer is in a rather hidden position;
- little or no correspondence between actions and sonic results;
- there are no obvious causal connections between the performer's actions and the occurring events;
- sound sources are decentralized and/or spread out;
- independence between the performer's body and sound; (Ciciliani 2014)

Examples of the centripetal model are the vast majority of traditional instruments. An example of the centrifugal model is the performance practice that is tightly associated with the Acousmonium.

2.2. THE PARAMETERS OF THE *CENTRIPETAL* GROUP

The four parameters belonging to the centripetal group are:

- body: is the performer's body clearly exposed and visible?
- *presence*: is the performer's presence prominent as part of the performance? In general, *presence* refers to a perception of the performer that is experienced as intense and auratic. While the perception of a performer's presence is tightly connected to the performer's body, the body does not necessarily have to be clearly visible. Therefore 'body' and 'presence' are treated as independent parameters.
- *embodiment*: is embodied knowledge evidently used as part of the performance? When playing traditional instruments embodied knowledge plays a significant role as it would be impossible to apply the necessary fine motor skills if all motions were consciously reflected (Kim 2010). In the given context embodiment takes place when there is a very intimate connection between the physical actions of the performer and the reaction of the technology.
- transparency: is there a strong readability between the performer's actions and the sonic result? Often, transparency is achieved by presenting a strong correlation between physical movements and their musical consequences. However, transparency can be heightened in many different ways, including the use of technology.

2.3. THE PARAMETERS OF THE *CENTRIFUGAL* GROUP

The following four parameters are part of the centrifugal group:

- space: this parameter indicates whether the sound sources are in the proximity of the performer, thus emphasizing his or her role in the performance, or are they are spread throughout the performance space, thereby directing the attention to the boundaries of the space, or even beyond.
- mediatization: are there sounds that occur independently of any actions on behalf of the performer, as for example in tape mu-

sic? This indicates that the sounds could have been produced at a different time and that the sound was played back during the performance.

- camouflage: this parameter is positioned at the opposite side of the aforementioned parameter ‘transparency’. It indicates when active efforts have been taken in order to hide performance elements from the audience. Again, this is to some extent the case with acousmatic music, when the mixing board and the performer are positioned in the middle of the auditorium and thereby behind the people sitting in the first rows of the auditorium. As such camouflaging decisions are characteristic of certain types of performance practices it has been considered insufficient to merely indicate such instances by putting the ‘transparency’ parameter to its minimum value. Instead it is introduced as a separate parameter.
- degrees of freedom: this parameter indicates whether the chosen performance setup offers control on a large number of expressive parameters, or whether only very global aspects of the performance can be manipulated. As it is typical of traditional instruments to offer very nuanced control on many parameters, a high degree of freedom is considered to be characteristic of the centripetal model. Controlling the mix of a performed piece, as it is typical in acousmatic concerts, only offers minimal control on the timbre and no control on the timing. Therefore it is deemed characteristic for the centrifugal group that there is a rather low amount of degree of freedom.

As this parameter is part of the centrifugal group it has (somewhat counter-intuitively) been decided that a low degree of freedom is indicated by marking the parameter at its maximum value, and a high degree of freedom at its minimum value. This assures that the resulting overall shape that is made visible on the parametric space adequately indicates whether a particular performance tends to the centripetal or the centrifugal model.

2.4. A FLOATING PARAMETER INDICATING VISUAL MEDIA

Many performances include visual media, as for example video projections, specific uses of lighting or theatrical elements. If such media are utilized they can be added to the parametric space as a separate parametric axis. In order to differentiate it from the others, it is colored differently than the other parameters. Depending on the function and usage of the visual element, the parametric axis can be positioned in proximity to one of the other parameters.

For example, video projection is usually used in performances of live-coding, by displaying the code as it is being typed. In this case the projection strongly supports the ‘transparency’ aspect of the performance, as it shows in the most direct possible way, how the music is created. Even though the code may be cryptic for many audience members, the process is still made transparent (audience members also do not need to be familiar with the fingerings of woodwind instruments in order to understand the performance of e.g. a bass-clarinetist). In this case it would therefore make sense to position the parameter for the visual medium close to the parameter 'transparency'.

On the other hand, performances by e.g. Ryoji Ikeda are usually accompanied by large video projections with entirely abstract material. In such an instance the projection is forming a new virtual space in addition to the performance area, thereby expanding it spatially. Therefore it might be argued that the parameter for visual media should be positioned in proximity to the parameter 'space'.

2.5. TWO SEPARATE PARAMETERS FOR *PREVIOUS KNOWLEDGE*

Two additional parameters have been introduced in order to indicate whether any sort of previous knowledge are required in order to be able to adequately apprehend the performance of a work. Hereby it is differentiated whether specific knowledge is required that is bound to a specific work or whether the acquaintance with a particular larger cultural practice is necessary.

These parameters are labeled "work specific knowledge required" and "cultural knowledge required". They are displayed on a separate axis apart from the aforementioned parametric space.

It is assumed that strongly embodied instruments do not require any previous knowledge as practically every person can emphatically co-experience and understand certain gestures or movements when they are performed by a musician. However, in order to comprehend the actions of e.g. a virtuosic DJ, a basic understanding of the workings of a record player and scratching techniques are necessary. This is a specific set of cultural knowledge which is presupposed.

An example for work specific knowledge is Alvin Lucier's *Music for a solo performer*, in which the performer is equipped with an EEG. When producing alpha waves in a state of relaxation various percussion instruments in the space are incited by transducers and motors (Lucier 1995:300). An audience member that is not familiar with the setup would only see a motionless performer sitting on a chair with some wires attached on the head. It is very likely that he or she would experience the piece very differently than somebody who is aware of the connection between the percussion instruments and the performer. Therefore this is an example for a work in which a relatively large amount of work specific knowledge is required.

Many works may require work specific as well as cultural knowledge. The two parameters therefore do not exclude each other.

Often it is difficult to decide where the threshold lies between general cultural knowledge and specific cultural knowledge. Is a basic familiarity with a violin general or already specific? And how about when smart phones or tablets are used for performances? What is general and specific cultural knowledge strongly depends on the demography of an audience (e.g. age and cultural background). In the context of the analysis of a specific performance practice it might therefore be necessary to indicate to what cultural group a concrete value of this parameter refers.

2.6. DISTRIBUTION IN SPACE

Figure 1 shows the spatial arrangement of the parameters in the parametric space. The centripetal and centrifugal parameters are positioned on opposite sides. By placing points on every axis for a particular analysis and connecting those, a specific shape will result which will show in an intuitive way whether a particular performance practice tends to either the centrifugal or the centripetal models, or whether it is compound of a more heterogeneous combination of parameters.

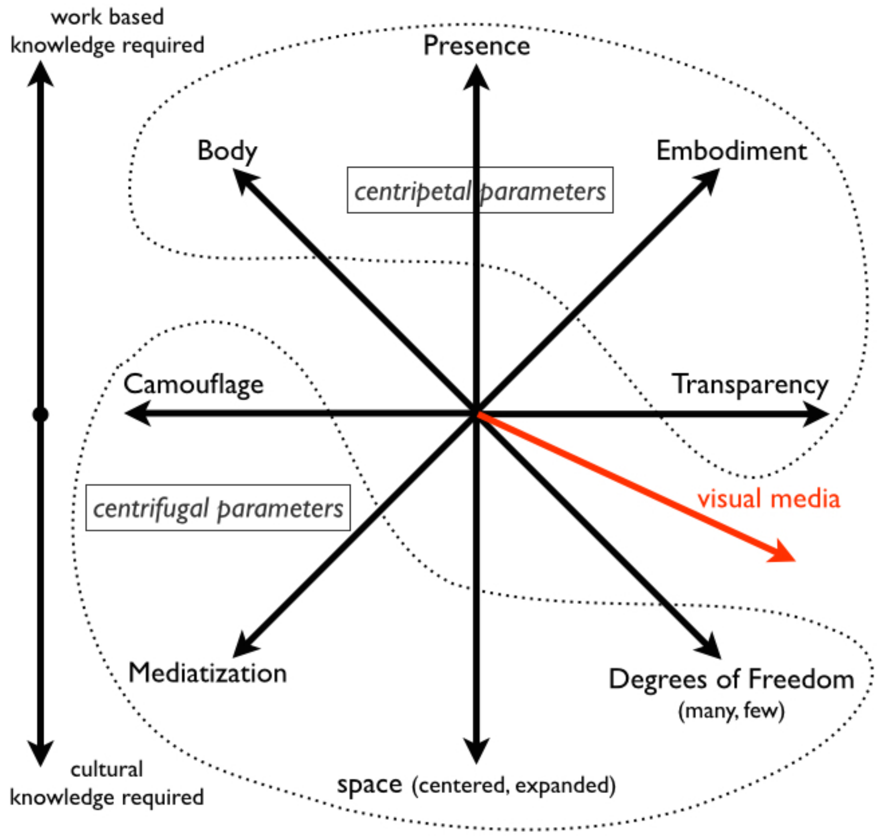

Figure 1 The spatial distribution of the parameters. Note that the visual media parameter can be pointed to any direction, depending on its function in a given context.

3. EVALUATION OF THE ANALYSIS METHOD

3.1. ASSIGNMENT FOR STUDENTS OF THE UNIVERSITY OF MUSIC AND PERFORMING ARTS GRAZ (KUG)

In the winter semester 2014/15 Marko Ciciliani offered a seminar on “Performance practice in electronic music” at the IEM – Institute of Electronic Music and Acoustics of the University of Music and Performing Arts Graz (KUG – Kunstuniversität Graz). A total of 61 students had to pick three from five examples of specific performance practices and analyze them according to the described method. Apart from two master students in computer music composition, all other students were bachelor and master students of the sound engineering degree program. Most of the sound engineering students are not very familiar with experimental or post-avantgarde forms of music.

Apart from handing in the filled in parametric spaces the students were required to submit short comments explaining why they assigned a specific value to a particular parameter.

The five examples were all taken from YouTube, so the students could get an impression of the sound and the visual appearance of a performance. The examples were:

1. DJ Qbert *https://www.youtube.com/watch?v=w80uZaBK718* 0:30 to ca. 5:00
2. Alexander Schubert *https://www.youtube.com/watch?v=tjzSX3D1ak0* "Your Fox's a Dirty Gold", performed by Frauke Aulbert
3. Nicolas Collins *https://www.youtube.com/watch?v=89jbl0ZuaH4*
4. Marco Donnarumma *https://www.youtube.com/watch?v=kDWkDy3tyXM* "Hypo Chrysos"
5. Carl-Michael von Hausswolff *https://www.youtube.com/watch?v=C-flW_g9skR8*

Additional information was given for the examples by Schubert, Collins and Hausswolff:

With Schubert a brief explanation was given on the technical setup. In this example the singer wears two Wii controllers with Nunchucks that have been integrated in sweatbands that she is wearing on her wrists. An explanation of the technical setup was also given with the Collins example. In that performance Collins uses a trombone where the mouthpiece has been replaced by a loudspeaker as the only sound source. In addition, a small computer keyboard is attached to the slide, giving the performer control of live processes. The additional information for the Hausswolff example consisted of the remark that Hausswolff uses a surround setup for the sound projection. In this context it was also mentioned that stereo sound projections can be assumed for all other examples except for Collins', where the loudspeaker on the trombone is the only sound source.

3.2. EVALUATION OF ANALYSIS

For this evaluation the results of the students' analysis (presented graphically as the points on the axes) have been translated into numbers. This was necessary in order to make the results comparable and to create a set of statistics. For every parameter in each analysis number "0" represents the starting point of the axis in the center of the parametric space and "10" describes the maximum distance from the center. The distance of each point from the center has been measured as precisely as possible. Afterwards the numeric results have been transferred into several MSExcel diagrams for further analysis.

The different values for the parameters are described as following:

0 – 1.5 minimum value
1.5 – 3.5 low value
4 – 6 medium value
6.5 – 8 high value
8.5 – 10 maximum value

Apart from the average value, what has been of special interest is the variance amongst all students that occurred in the selection of values for a particular parameter.

3.2.1. EXAMPLE DJ QBERT

56 of the 61 students have chosen to analyse this piece, more than any of the other works.

	Ø value	maximum area	high area	medium area	low area	minimum area
Centripetal parameters						
body	8,92	39/70%[1]	12/21%	4/7%	1/2%	0/0%
presence	9,15	46/82%	6/11%	3/5%	1/2%	0/0%
embodiment	7,53	25/45%	15/27%	11/20%	3/5%	2/4%
transparency	7,93	29/52%	13/23%	7/13%	7/13%	0/0%
Centrifugal parameters						
space	0,94	2/4%	1/2%	2/4%	4/7%	47/84%
mediatization	5,24	8/14%	11/20%	26/46%	3/5%	8/14%
camouflage	1,11	1/2%	0/0%	8/14%	5/9%	42/75%
degrees of freedom	5,23	10/18%	12/21%	13/23%	15/27%	6/11%
visual media	0,11	1/2%	0/0%	0/0%	0/0%	55/98%
work based knowledge	0,65	1/2%	1/2%	1/2%	4/7%	49/88%
cultural knowledge	3,20	8/14%	3/5%	6/11%	20/36%	19/34%

Two of the centripetal parameters – *body* and *presence* – and two of the centrifugal parameters – *space* and *camouflage* – were the most unambiguous. The students have set the values for *body* in the maximum and high area, for presence mostly in the maximum area. In contrast, the values for *space* and *camouflage* were predominantly minimal. The values for *embodiment* and *transparency* were spread out more evenly, although the maximum values were most frequently selected. This is similar to the parameter *mediatization*, but here most values were selected in the medium area. The values concerning *degrees of freedom* showed the strongest ambiguity. The students spread the placements almost equally between the five main areas with a slight preference for

1. Number of students setting the values in the particular area / percentage of students (rounded by MSExcel); the values of high significance (21% and more) are marked in red, lower values of significance (up to 20%) are set in bold type.

medium values. The parameter *visual media* was of no importance in this piece, as no additional visual media are used in this performance.

Almost all students assigned very low values for *work based knowledge* but higher ones for *cultural knowledge*. The latter also showed a lot of variance. This is interesting in so far as it indicates that many students take the understanding of the techniques of record scratching for granted (meaning that they do not interpret this as a specific cultural knowledge), while others interpreted this differently.

When these values are mapped to the parametric space, the following graph results:

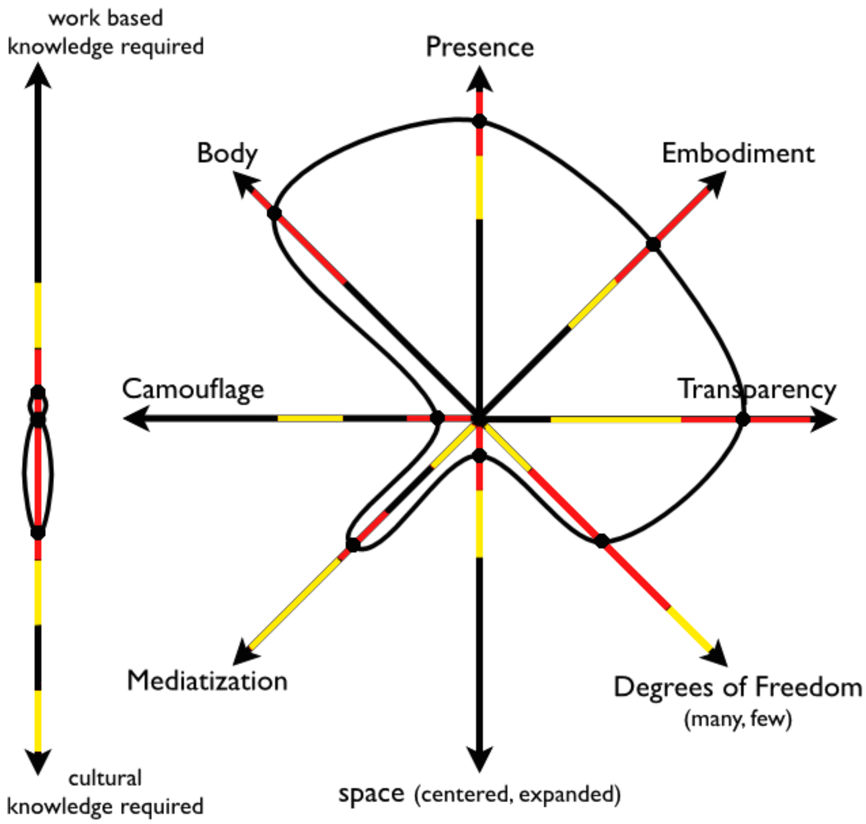

Figure 2 The average values for the DJ Qbert examples. The colors are indicating the variances: red – of main importance (21% and more), yellow – of notable significance (up to 20%)

3.2.2. ALEXANDER SCHUBERT

27 of the 61 students have chosen to analyse this piece.

	Ø value	maximum area	high area	medium area	low area	minimum area
Centripetal parameters						
body	9,57	23/85%	3/11%	1/4%	0/0%	0/0%
presence	9,67	25/93%	2/7%	0/0%	0/0%	0/0%
embodiment	7,35	14/52%	2/7%	9/33%	1/4%	1/4%
transparency	5,13	5/19%	5/19%	7/26%	7/26%	3/11%
Centrifugal parameters						
space	2,90	4/15%	1/4%	5/19%	3/11%	14/52%
mediatization	5,07	5/19%	5/19%	8/30%	3/11%	6/22%
camouflage	1,17	1/4%	1/4%	1/4%	3/11%	21/78%
degrees of freedom	3,78	1/4%	4/15%	8/30%	7/26%	7 /26%
visual media	3,92	5/19%	0/0%	11/41%	2/7%	9/33%
work based knowledge	4,22	2/7%	1/4%	13/48%	7/26%	4/15%
cultural knowledge	0,92	1/4%	1/4%	1/4%	1/4%	23/85%

Similar to the preceding example, the parameters *body*, *presence* and *camouflage* were the most unambiguous. The majority of the students set the values for the first two parameters in the maximum area, for *camouflage* at its minimum. In comparison, the values for *space* and *embodiment* were more evenly spread throughout different areas. However, the values for *embodiment* were once again in the medium area and higher. The highest variability was to be found in the interpretation of *transparency*, *mediatisation* and *degrees of freedom*. The placements of values for these parameters were set in all five main areas.

Most students indicated that no *cultural knowledge* was necessary but that to a certain degree *work based knowledge* would be useful. Although no specific visual media were used in this piece, some students interpreted the use of changing lighting as audiovisual design. However, it was impossible to include the axis for *visual media* in the following parametric space presentation, because its direction has greatly varied across the different results (mostly, though, in the *centripetal* half of the space).

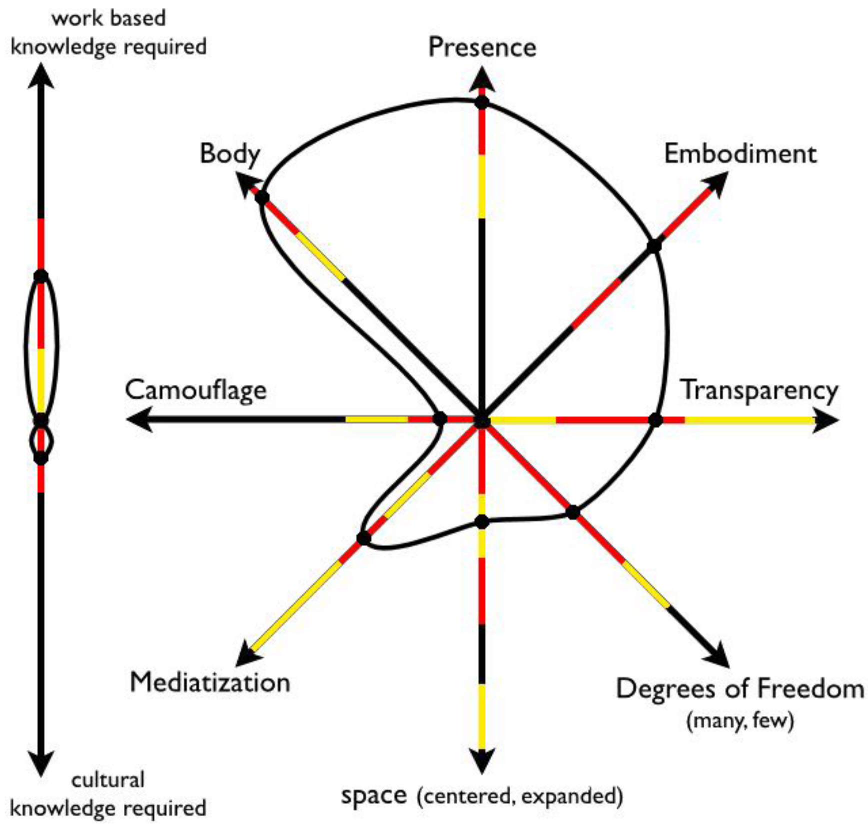

Figure 3 The average values for the example of Alexander Schubert

3.2.3. NICOLAS COLLINS

36 of the 61 students have chosen to analyse this piece.

	Ø value	maximum area	high area	medium area	low area	minimum area
Centripetal parameters						
body	9,64	34/94%	0/0%	2/6%	0/0 %	0/0%
presence	8,99	27/75%	6/17%	3/8%	0/0 %	0/0%
embodiment	6,11	8/22%	9/25%	12/33%	5/14 %	2/6%
transparency	5,86	8/22%	6/17%	15/42%	6/17%	1/3%
Centrifugal parameters						
space	2,80	6/17%	2/6%	3/8%	3/8%	22/61%
mediatization	3,97	4/11%	4/11%	8/22%	13/36%	7/19%
camouflage	0,82	0/0%	0/0%	4/11%	4/11%	28/78%
degrees of freedom	4,90	4/11%	9/25%	9/25%	7/19%	7/19%
visual media	0	36/100%	0/0%	0/0%	0/0%	0/0%
work based knowledge	3,69	4/11%	7/19%	4/11%	11/31%	10/28%
cultural knowledge	1,83	2/6%	1/3%	3/8%	9/25%	21/58%

As in the previous examples, the values for the parameters *body* and *presence*, *space* and *camouflage* showed once again the least variability. However, the values for *embodiment*, *transparency*, *mediatisation* and *degrees of freedom* showed a high degree of volatility. No visual media were used.

Most of the students indicated the necessity of some *work based knowledge* but only a minority the need for *cultural knowledge*.

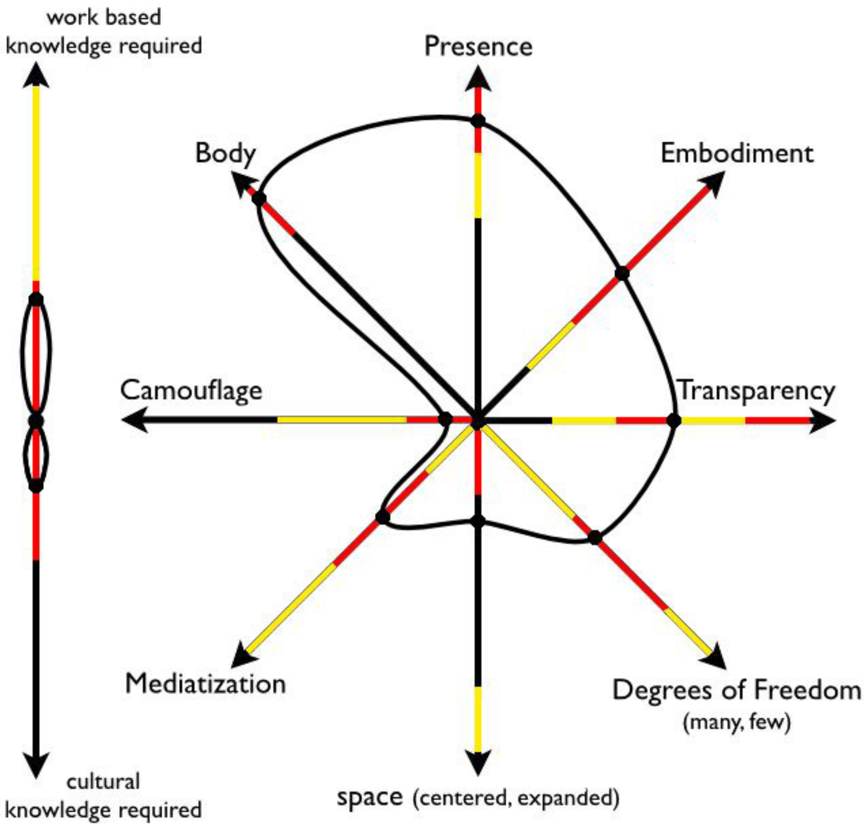

Figure 4 The average values for the example of Nic Collins

3.2.4. MARCO DONNARUMMA

32 of the 61 students have chosen to analyse this piece.

	Ø value	maximum area	high area	medium area	low area	minimum area
Centripetal parameters						
body	9,28	26/81%	3/9%	3/9%	0/0 %	0/0%
presence	9,26	28/88%	1/3%	3/9%	0/0 %	0/0%
embodiment	7,19	15/47%	7/22%	5/16%	1/3%	4/13%
transparency	4,25	4/13%	4/13%	10/31%	4/22%	7/22%
Centrifugal parameters						
space	3,06	5/16%	2/6%	4/13%	4/13%	17/53%
mediatization	4,10	5/16%	3/9%	10/31%	3/9%	11/34%
camouflage	2,06	1/3%	2/6%	6/19%	3/9%	20/63%
degrees of freedom	6,77	10/31%	12/38%	5/16%	2/6%	3/9%
visual media	7,81	16/50%	5/16%	11/34%	0/0%	0/0%
work based knowledge	6,24	12/38%	4/13%	8/25%	3/9%	5/16%
cultural knowledge	0,41	0/0%	0/0%	1/3%	1/3%	30/94%

The values for the various parameters are slightly different than in the preceding examples but the main tendencies regarding the volatilities are similar: *body*, *presence* and *camouflage* are the unambiguous parameters, while the distribution of values for *embodiment*, *transparency*, *mediatization* and *degrees of freedom* is widely spread across the value regions. As this is an explicit audiovisual work the parameter *visual media* is important. However, the direction into which this parameter was pointed varied again to such a large amount that it was impossible to display the result in the graph.

Practically all students agreed that no *cultural knowledge* was required, while the need for *work based knowledge* showed a large degree of variability.

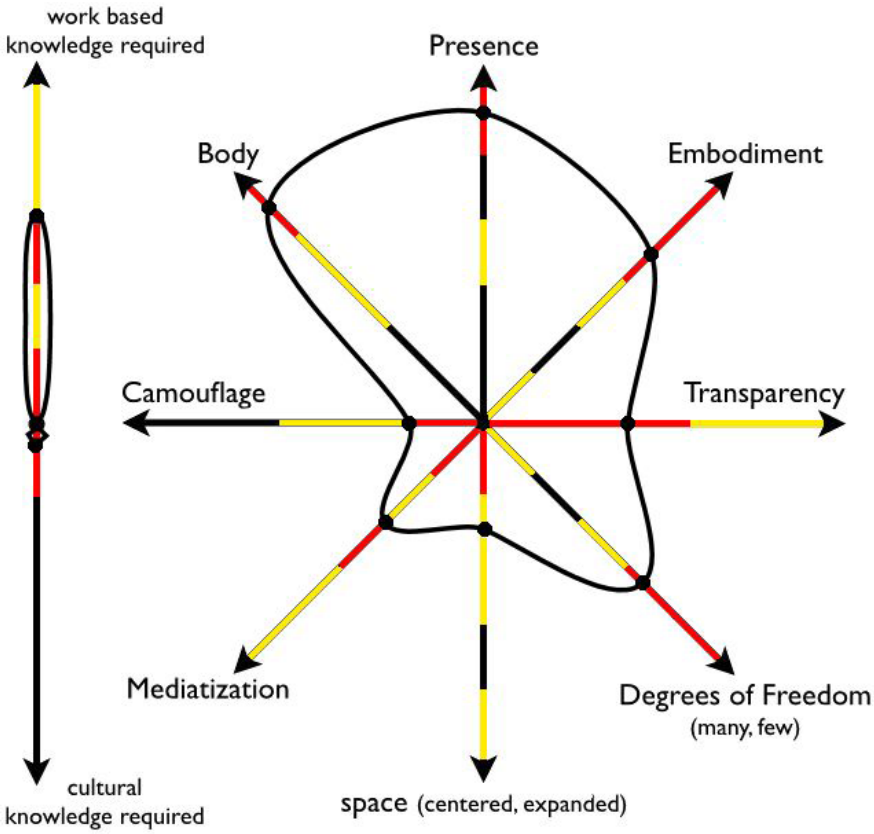

Figure 5 The average values for the example of Marco Donnarumma

3.2.5. CARL-MICHAEL VON HAUSSWOLFF

34 of 61 students have chosen to analyse this piece.

	Ø value	maximum area	high area	medium area	low area	minimum area
Centripetal parameters						
body	3,20	1/3%	2/6%	13/38%	5/15%	13/38%
presence	4,01	5/15%	4/12%	6/18%	11/32%	8/24%
embodiment	0,48	0/0%	0/0%	0/0%	5/15%	29/85%
transparency	0,81	1/3%	1/3%	1/3%	1/3%	30/88%
Centrifugal parameters						
space	7,84	24/71%	1/3%	3/9%	0/0%	6/18%
mediatization	7,66	22/65%	4/12%	4/12%	0/0%	4/12%
camouflage	7,97	20/59%	7/21%	5/15%	1/3%	1/3%
degrees of freedom	9,94	17/50%	3/9%	7/21%	4/12%	3/9%
visual media	6,70	11/33%	10/30%	7/21%	2/6%	3/9%
work based knowledge	1,51	1/3%	3/9%	3/9%	1/3%	25/76%
cultural knowledge	2,26	5/15%	1/3%	2/6%	2/6%	23/70%

In this example the centrifugal parameters are much more pronounced than the centripetal ones – all of their average values are in the high area. Interestingly, unlike in the other examples there is much ambiguity in the parameters *body*, *presence* and *camouflage*. In contrast, most of the students agreed on the values for *embodiment* and *transparency* in the same area (minimum). The values for *mediatization* and *degrees of freedom* are rather spread out evenly but with a clear preference for the maximum area.

Most of the students have indicated no or only very little need for *work based knowledge* and *cultural knowledge*. In this example *visual media* is an interesting example. Although Carl-Michael von Hausswolff uses only static red lighting that is pointed at the audience – thereby blinding it, the students have mostly been aware of its high importance for the perception of the work. However, their opinions in this matter have again differed strongly regarding the value and direction that they assigned to it.

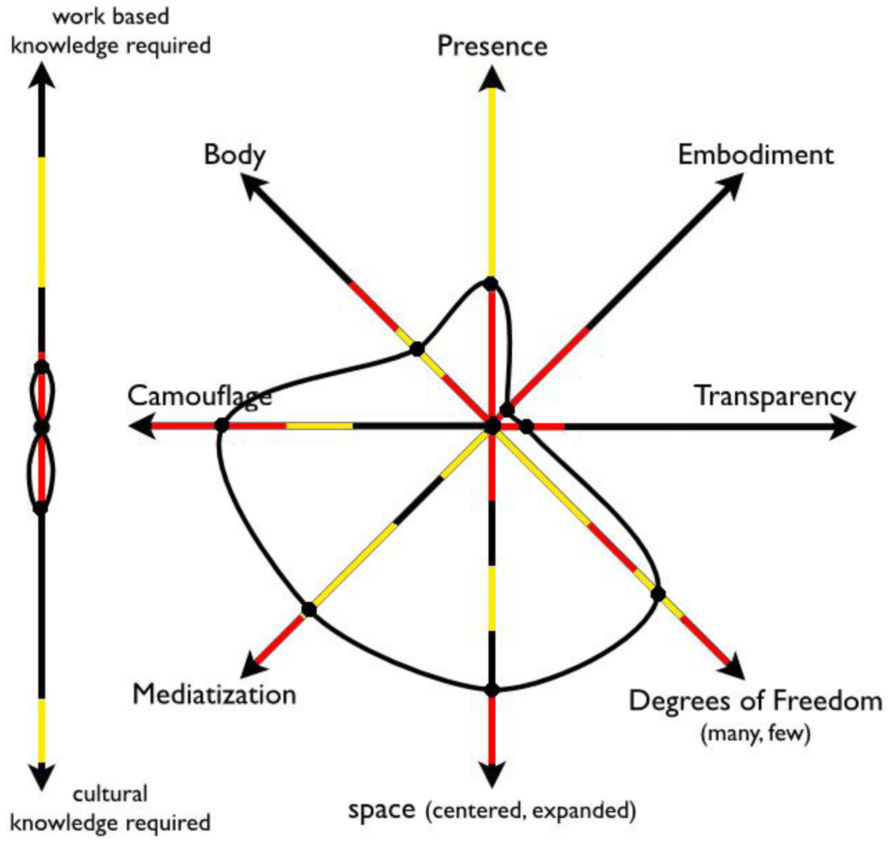

Figure 6 The average values for the example of Carl-Michael von Hausswolff

3.2.6. CONCLUSION

The set of parameters trying to identify performance practices of electronic music, together with the depiction of the final results in a shape in a parametric space, turns out to be a useful tool. Although the usefulness of some of the parameters might not be obvious when reading their description (for example the need for *transparency* and camouflage) they turn out to complement each other well when applied to a concrete performance situation. The parametric space makes it possible to see all the results at once, understand and compare them in an almost intuitive way.

The students' results show, though, a significant amount of volatility with some parameters. In four of the five examples the parameters *embodiment*, *transparency*, *mediatisation* and *degrees of freedom* have been interpreted in different ways. In contrast, in the same examples the parameters *body*, *presence*, *space* and *camouflage* were interpreted with very little variance. However, it is interesting to note that in the last example (von Hausswolff) these tendencies were almost reversed. This might have to be analyzed in much greater detail, but a possible explanation would be that depending on the chosen example, certain parameters are more obvious than others. Although the first four examples were quite different, they were all focussed on one performer who was clearly visible and highly active (centripetal tendencies) while the last one was the only one where the performer was hidden and the sound spread out (centrifugal tendencies). If this explanation is correct, this would mean that it is not because of the general nature of a particular parameter that it shows more volatility, but that the greater variance mirrors a particular character of the analysed example.

The additional parameters *work based knowledge* and *cultural knowledge* also showed a high degree of variance. The question, if a particular example required a certain sort of previous knowledge was apparently answered in a very subjective manner. The parameter of *visual media* can be very useful in a case of a single depiction of a parametric space. However, in a statistic evaluation as this one it proved impossible to include it in the final graphs.

4. FURTHER RESEARCH

The different shapes that result with the described method help to compare different performance practices with each other. However, when large amounts of models would be compared, it would be helpful to have a quantified value that could express a specific character of a performance practice. It will be investigated whether the results of all parameters of a single performance could be summarized in a single numeric vector, which could then more easily be compared with other performance practices. In this way a larger database of analyses could be collected over time, where groups of performance practices could be compared with each other based on their numeric 'tags'.

Related to a different field, it would be interesting to investigate in how far the selected values of the parameters differ with the cultural background of the person using the model. There is reason to believe that especially the parameters that indicate different degrees of required previous knowledge might strongly depend on the user's personal familiarity with a specific style of performance. Furthermore, already with the discussed analyses of the students it is noticeable that they estimated the values for e.g. *transparency* higher with performance practices that they are familiar with (in this case DJ Qbert) than others that were outside the style of music they usually consume (e.g. Nic Collins). Judging from the style of performance or the used technology it is not obvious why DJ Qbert's performance would be significantly more transparent than Nic Collins'.

5. SUMMARY

The results of the students' analysis show the usefulness of the proposed analysis method. The resulting shapes in the parametric field offer an intuitive way to compare the different performance practices with each other. Thereby it offers the possibility to better assess its aesthetic value and its effect in conjunction with a specific musical or audiovisual work.

The results of some of the parameters show a high degree of volatility, while other are more consistent. It will require the analysis of a larger number of works in order to find out whether certain parameters generally tend to be interpreted with much variance or whether this depends on the analyzed example of performance practice. But even if the former turns out to be the case this does not necessarily indicate a weakness of the particular parameter. It is also possible that certain parameters again require a larger expertise in order to evaluate them accurately, which – by itself – is no indication of the uselessness of a particular parameter.

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INTERFACING WITH THE NIGHT

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ABSTRACT

In this paper, the authors consider the interfaces between academia and dance music. Dance music and club culture are, we argue, important to computer music and the live performance of electronic music, but there are many different difficulties encountered when trying to present electronic dance music within academic contexts. The authors draw upon their experiences as promoters, performers, researchers and audience members to discuss these difficulties and how and why we might negotiate them.

KEYWORDS

Dance Music, Club Culture, New Interfaces for Musical Expression, Live Coding.

1. INTRODUCTION

The *club* is home to a range of musical practices, taking place after dark, in windowless spaces with large sound systems and intensive visual projections. The history of clubbing forms an important part of contemporary electronic music, in terms of how it is experienced, performed, and conceived. The club itself is a rich subject for research, in terms of the musical practices, interactions, modes of listening and the social environment we find there. However, the club, and dance music in general has an often difficult and uncomfortable relationship with academic research.

There are a number of challenges involved in bringing the environment of the club to an academic conference, which we will reflect upon through this paper, with reference to our own interventions. One challenge has been prejudice against repetitive and beat-driven music, classified under the straw man category of *popular* music, meaning that the club as a hotbed of intense experimentation and creativity has at times been marginalised within academic discussion. As these prejudices finally melt away, new ways of presenting music at conferences have become possible. In the following, we draw on our experiences as curators, practitioners and researchers in bringing elements of club culture into the academic realm, and sketch some of the possibilities that might emerge from the intersection of these two worlds.

2. CONNECTING WITH THE LOST FUTURE

Computer music has had a long-running problem with electronic dance music. Steady beats have been treated with suspicion, described in pejorative terms as "grid-based", where repetitions of discrete events have been seen to make music too easy to consume and therefore fatally undermined by commodified mass production. We might see this as sharing similar motivations to Adorno's earlier critiques of repetition and its role within a society of commodification (Adorno 1941). Following this logic, for repetitive music to maintain art music status, inaccessibility and unpopularity must somehow be maintained, for example through the use of noise (Zareei et al 2013).

This split between art and popular music has long been questioned as a kind of cultural schizophrenia, and its reintegration foretold (Born 1987). By the last turn of the century, in the world of commercially saleable music, divisions between highbrow and lowbrow had appeared to break down completely (Seabrook 2001). Following the shocking, generational waves of skiffle, rock, punk, it became clear that enriching, experimental and challenging music need not necessarily mean unpopular. These genres pushed the limits of sound, embracing exotic, industrial and alien rhythms and timbres; movements in sound that come intertwined with challenging shifts in culture. With the advent of rave and the hardcore continuum, another shocking generational shift, mass commercialisation momentarily seemed to fall behind decentralisation and democratisation, where anonymous DJs, white labels, and free parties were the norm.

Fast forward to 2014, and the picture has changed somewhat; the music of mass culture seems lost in the past, a phenomenon which Fisher (2014) describes in terms of *hauntology*, being a depressive state of lost futures trapped in a period of late capitalism. Art and music play with these images of lost futures, sometimes used to critique the world in which we live, often through reappropriating and recontextualising past aesthetics: musical styles are not just 'revived' in a never ending 80s themed school disco, rather, critical and musical work can be done by revisiting older musical styles. This leaves us with an unexpected opportunity; with the slowdown in mainstream progress, approaches to music composition in academic institutions have the opportunity to catch up, and look for new musical futures which have renewed meaning for people outside the academy. This is not about impacting people with research, but rather academics taking part in wider cultural movements.

In making new interfaces for musical expression, we often consider the performer's relationship with the instrument, but rarely that of a wider community. From the perspective of Anthropology, Tim Ingold has recognised the cultural processes of adapting to algorithmic automation as the "irreducibility of skills"; human processes are turned into algorithms, but we then create new human skills in response based on these algorithms (Ingold 2011, p.62). This can be seen in the very history of techno, going back to female factory workers in Lancashire creating clog dances which mimicked the sound and movements of the industrial machines which they operated – astonishing, repetitive noise music created out of otherwise inhumane working conditions (Radcliffe and Angliss 2012). By creating new kinds of events around technology we are not simply presenting new music, but rather creating space for people – performers to create new cultural meaning for technology. This turns the research impact agenda on its head – as researchers we are not impacting audiences, but rather contributing one thread in a woven tapestry of cultural change; making space for, and responding to, the musical activity around us. From this perspective, we can reflect upon what it means to curate a public dance music event that interfaces with an academic conference, finding resonance between cultures.

3. A SHORT HISTORY OF DANCING ACADEMICS

The International Computer Music Conference is the largest of its kind, and at the time of writing has celebrated its 40th year. The conference has included late night concerts every year since 2007, when the evening programme in Copenhagen ran until 1am. The following year in Belfast included dance music within late programmes in the club style Mandela Hall, and the 2009 evening programme in Perth included a nightclub venue, although concerts there were seated and multichannel. The 2010 conference in New York included a category for music for a club atmosphere, and the 2011 Huddersfield call included a "club electro" music, repeated in 2012 and 2014. In short, the nightclub is now accepted as a potential venue for academic computer music, although music submissions are still overwhelmingly electroacoustic in style and format, and our informal canvassing of delegates has not found stories of significant numbers of delegates dancing in these venues.

The present authors have attempted to push elements of dance music within more academic contexts. Although live coding of music has become well established in computer music over the past ten years, it has had little take up as a practice outside the academy. This changed since the coining of the portmanteau "algorave" by the present second author and Nick Collins in 2012, put into action in a London warehouse in an event organised by Dan Stowell, Matthew Yee-King and Ryan Jordan as a warm-up event for the Supercollider Festival (Collins and McLean 2014). The notion of the algorave immediately took on a life of its own, with events independently organised across the world, including Mexico, Australia, Japan, Canada, Slovenia, Spain, Belgium, Germany and the Netherlands. Many of these have been associated with academic or festival conferences. Again, people have not always danced, which underlines the risk inherent in interfacing with the nightclub; if the right atmosphere is not created, then there is no space for music to be enjoyed in. From a research perspective, failure of an algorave can be illuminating. For example, if we find ourselves standing in a room looking at each other, issues of gender disparity which gravely undermines computer music culture become difficult to ignore.

As artistic co-chair of the International Conference on New Interfaces for Musical Expression (NIME) in London 2014, the present first author organised *Algorave NIME*, a club night at the end of the NIME conference which took place in Corsica Studios, a London club that is at the heart of many dance music communities within London, hosting regular events by labels such as Hyperdub, NTS radio and others. The music featured live coding, homemade electronics and music controlled by plants, along with DJs. The styles of music presented were diverse, mostly with repetitive beats, and ranging from experimental techno to dancehall. A well-tuned Funktion one sound system ensured the sound was appropriately physical. In our view, the night went extremely well, the room filled near to capacity, all performances were well received including a schedule-busting encore, and many people danced into the early hours.

We made specific efforts to connect the academic community of the NIME conference to the wider, non-academic music scene in London. We promoted the event through channels such as NTS radio, had a poster and flyer campaign, created a 'public facing' side of the website (for non-delegates to find out about concerts and installations) and received coverage from BBC World Service. This resulted in over 100 ticket buying members of the public attending, alongside the conference delegates.

4. DANCE MUSIC AND NEW MODES OF MUSICAL EXPRESSION

Dance music informs the musical background of many working in computer music and related fields, and the club provides a space in which many of the changing technologies and possibilities for performing electronic music are explored. The growing hegemony of Ableton's "Live" software is testament to this: an environment which foregrounds the possibility of liveness, of electronic music emerging out of human interactions with a machine, including through add-on hardware controllers. Ableton Live is often used as a post-production and remixing tool, but its success is in presenting a way to perform live what would otherwise be music of the recording studio. It has contributed however to a particular view of liveness in electronic dance music culture; music is chopped up, tweaked and triggered but not fundamentally composed or improvised during performance. There are many exceptions to this rule, but this is the pervasive view; for example, live coding is often described by journalists as "Code DJing", even where no pre-composed pieces are involved, and the code is not always mixed as such, but created and rewritten live. The assumption is that music is brought to the club to be collectively experienced, perhaps selected live by DJs as curators, but not created as part of the flow of live experience. This popular understanding of the role of DJs illustrate the way in which conventional notions of liveness are challenged by the club, and there is a unique dynamic of musical creativity we find there.

Simon Reynolds uses the term *hardcore continuum* to describe the vein of creative dance music in Britain that emerged from hardcore in the early 1990s, which has been sustained by various pirate radio stations, club nights and DJs and has begotten such styles as Jungle, Grime and UK Garage. Reynolds perceives these as the most urgent and innovative new musics to emerge in recent times (Reynolds 2008). Whilst the relevance of this concept has been questioned, and Reynolds has been criticised for excluding some genres and styles from the continuum and implicitly questioning their legitimacy, the idea is valuable because it points to the club and surrounding cultures as a rich, dynamic environment, a hydrothermal vent of musical creativity occurring in a meshwork of dancing bodies, dubplates and new technologies. Within the hardcore continuum, musical styles evolve and mutate quickly, and there is an immediate engagement with emerging tools of musical performance, whether this is new software or hardware such as CDJs. Importantly, it is the functionality of the music and the laboratory-like environment of the club that creates an almost cybernetic feedback loop stimulating creativity. Club nights are in general multi-room, where people can freely circulate to catch a mood that suits them. This also supports risk-taking; noise, arhythmic breaks and long form improv might send some of your audience out, but they will happily find their way to another room, and the more readily curious will be left.

Whilst it might not be the primary intention of every artist performing electronic dance music to actually make people dance, the feedback loop between dancing crowd and performer intensifies the experience of performing and listening. The immediate feedback from a dancing crowd brings focus and structure to the machine-interactions of a performer, where the musical decisions they make have literally biological consequences in shaping the energy in the room. Through the dancing audience, a performer's key presses and mouse clicks end up directly connected to audience members' swinging elbows. While notions of "embodied cognition" continue to be fashionable in music psychology, the club offers excellent ground to connect research with large numbers of actual bodies.

From notions of embodied cognition and the extended mind (Clark and Chalmers 1998, Wilson 2002, Dourish 2004), we can understand listening itself to embodied and thus inseparable from how we move our bodies when listening. Cognitive processes occur not in some detached mind, but are bound up with a moving body and the environment that body is interacting in and with. Dancing is not some secondary physical activity done after a brain has heard and comprehended music, it is bound up with how we perceive that music in the first place.

Drawing on this, we can see that within the club, and within dance music in general, quite different ways of experiencing and presenting music can be found. A dancing audience is not focused on a stage, and some performance aspects that we might sometimes try and bring into electronic music through the construction of digital musical instruments lose some of their importance. Performing electronic music in a club can bring us to think of new ways of interfacing with electronic music that is not gestural and does not draw on traditions of instrumental performance. In "Against the Stage", Francisco Lopez (2004) argues that electronic music differs radically from the traditions surrounding the presentation of music in a concert hall, and must avoid imitating the performance practice and values that we find there in order to realise its potential.

5. THE CLUB AND THE CONCERT HALL – CROSSOVERS AND DEPARTURES

Club spaces may still be seen as somehow opposed to, or simply less important musically than the concert hall. On the other side, academic music might be seen by practitioners as out of touch and their performances inauthentic. A curator who stages club music at an academic conference runs the risk of falling through the cracks between two opposing cultures. The exchanges between Stockhausen, Aphex Twin and Squarepusher in new music magazine The Wire (Witts 1995), reveal a mutual misunderstanding between the artists echoing this greater cultural divide. Stockhausen criticises the use of repetitive rhythms in Aphex Twin and Richie Hawtin: a repetition, however distasteful to Stockhausen, that is to a large degree essential in club music. The functionality of the music, and its "special effect in dancing bars", is dismissed, perhaps half in jest, as somehow being complacent with a public who will eagerly move onto their next musical hit, rather than allow the music to be elevated to some eternal canon.

Nonetheless, the very existence of the article points to the parallels perceived between electroacoustic composition and contemporary electronic dance music, and the dialogue between these different yet related musical forces does suggest these alternative ways of approaching, staging and experiencing music can be blended into a cohesive programme.

An increasing number of promoters and record labels – such as *Non-classical*, the *London Contemporary Music Festival* or *Pan* – are nowadays blurring the lines between electro-acoustic composition, traditional 'computer music' and dance music, staging both within the same evening and drawing on the physicality and materiality of sound and other shared facets that these approaches explore. Digital music and digital arts festivals such as Sonar and Transmediale have showcased the wild experimentation in dance music that happens outside academia, with very large dancing crowds responding to new sounds and new ways of making music with enthusiasm.

There are clearly many crossovers between these scenes, though the question still remains how we as researchers could interface better with dance music and bring some of this energy into our own events. Hosting a successful club night as part of an academic conference takes more than just having dance music playing after 10pm. How do we blend beatless, electro acoustic music into programmes with dance music that should be danced to? What are the risks and curatorial responsibilities of bringing these together into a cohesive conference music programme?

Many of the difficulties we find in presenting club music within such a programme are down to the very context-specific nature of music and musical experiences: how a piece of music is experienced, is shaped strongly by the context within which it is presented. Two hours of pounding, repetitive synthesised kick drums experienced mid afternoon, seated, in a university concert hall is likely to have different affective potential than the same music played in a dark club at the witching hour. Drawing on the concept of 'Musicking' described by Christopher Small (1998), this context itself must be understood in the widest possible sense, incorporating the people (from the performers to the cleaners and the bar staff) the buildings and playback technologies involved, such that the way we experience music together plays out wider social constructs.

Club music particularly is very context dependent. The names of different genres often reflect very specific physical places and geographical regions: Detroit Techno, Chicago House (the name itself referencing the Warehouse club in Chicago), garage (named after New York's paradise garage), and more recently genres such as Niche Bassline, named after a Sheffield nightclub. "Gabba", a genre of hard, fast house music from the Netherlands, is Rotterdam slang for "mate". Through these names, even, one can see how certain locations play key roles within a wider community, culture and its own mythologies, of which the music plays a key role, and dance music is often routed in specific communities.

Central to many of the mythologies of dance is the idea that clubbing is framed as an 'outside' to regular life, or as a place with different rules and values, a mythology captured memorably on film by Tony Manero's character in *Saturday Night Fever*. Dead end jobs and oppressive social norms evaporate on the dance floor. Described in this way, the club might start to sound radically different to an academic conference. However, there are ways in which we might imagine a club night actually playing a similar role within an academic conference and the community surrounding it. Academic conferences act in some ways as community building events, bringing together specialists from around the world for what is often an intense experience of knowledge exchange along with a very important socialising aspect.

Of course, there are also differences. The demographic of an academic conference will be different to that of most club nights, and these people are not brought together by a specific rhythm or the culture of a certain venue or scene in the same way. However, if we are to see a successful presentation of dance music within an academic conference, it should draw upon this shared community, and we must understand dance music as not just a collection of sounds, but something with a social role that is very dependent upon place, atmosphere and values.

Reflecting again upon *Algorave NIME*, the evening felt very much like it was occurring within and, we hoped, serving a specific community. Some were old friends, some had known each other on-and-off over the years, meeting at the annual range of conferences such as NIME, ICMC, SMC and others. They had spent an intense few days together, with packed schedules of papers and concerts. They will have shared inspirations and annoyances. Repetitive rhythms, affordable cider and a Funktion one sound system provided an atmosphere to bond a community in collective acts of dancing, but hopefully also providing a space that was in some way 'outside' of the conference.

6. CONCLUSION

Electronic dance music and the unique listening and performing atmosphere of the club is, as we have argued, of great importance to anyone interested in electronic and computer music. Nonetheless, there are myriad difficulties with staging such music or creating a club-like space within academia and academic conferences. Simply having some music with repetitive rhythms within a conference programme does not properly represent dance music. We need to consider the whole context of dance music and club culture when exploring how we as academics interface with it. We could see this interfacing as an opportunity to explore the ways in which we can create new spaces for culture, fully exploring new musical practices, environments and the social interactions we find there.

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PAPERS
USER INTERACTION

ON PERFORMATIVITY: AUDIOVISUAL SYSTEMS AS AESTHETIC ARTIFACTS

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ABSTRACT

This paper explores three different understandings of performativity in order to provide a particular reading of the live production and manipulation of sound and images. It begins by addressing a performative analogy between the visual and auditory as developed through technological means. It then discusses the concept of interactive performativity, as tied to the creative engagement of the audience (as user) in exploring the operative and productive possibilities of a system. Finally, and emancipating from the notion of human-based operations toward machinic autonomy, performativity is seen as a aesthetic quality of the experience of digital computational systems as aesthetic artifacts.

KEYWORDS

Performance, Performativity, Audiovisuality, Interactivity.

1. INTRODUCTION

The notion of performativity can unfold in different understandings pertaining to distinct disciplinary approaches, artistic fields and cultural contexts. This apparent lack of conceptual clarity entails the potential for different readings of the live production and manipulation of visual and auditory events as a theme of creative exploration. Rather than aiming at a stable definition of the notion, this paper explores different conceptions of performativity, related to distinct audiovisual systems and roles of author, audience and system in defining the audiovisual outcomes.

We begin by addressing performativity according to the idea of an operative analogy concerning the live production of sounds and images, developing in time and extending into space. We discuss its expansion through technological means, which points towards the process-based and interactive nature of digital computational audiovisuality. We then approach the concept of interactive performativity, which shifts the view from the creator of the system towards the creative engagement of the audience (as user) in exploring the system's operative and productive possibilities. We thus propose a view of performativity that is gradually emancipated from the idea of human authorial control according to a gradual transfer of creative agency to the audience and, ultimately, to the system itself, without the need of human action. According to this, performativity becomes an aesthetic quality of digital computational systems as aesthetic artifacts, of their live (unique) performances as moments of experience.

2. PERFORMATIVE ANALOGY

The idea of a performative analogy is tied to an operative strategy for the live production and presentations of sounds and images that can be traced back to a specific strand of development concerned with the creation of experimental devices, such as color-organs and related apparatuses, for correlating the visual and auditory. This tradition owes reference to French Jesuit priest and mathematician Louis-Bertrand Castel, who around 1725 designed a *Clavecin Oculaire* that would perform color as a *musique muette*. Castel projected the implementation (aimed at validation) of a model of correspondences that was emancipated from previous holistic models of a global harmony, addressing specifically the visual and auditory realms (Daniels 2011, 11). These color-tone analogies were essentially subjective, as conceived in theory and put into practice with a visual music performance device. This fact did not prevent the subsequent exploration of sound-image correspondences as a form of technological invention and aesthetic experimentation. Numerous artists and inventors created devices that produced light in correspondence to music, or that explored the aesthetic qualities of color and light in a purely visual manner, as a free play of color and form.[1] These developments reveal a tendency towards a "musicalization of the visual" (Whitney 1976) while also entailing a gradual shift from strict correspondences towards free forms of association and, ultimately, an emancipation from music, as proclaimed by Thomas Wilfred with the art of *Lumia*.

Almost each artist or inventor developed his own model of correspondences, which eventually disproved each other in their diversity and lack of compatibility.[2] Similarly, these devices remained tied to their creators rather than being widely adopted as performance instruments. They can nevertheless be seen as the "real forerunners of performative visuals" (Naumann 2011, 87), which emphasize a performative analogy between the musical and the visual through their live production and manipulation.

2.1. STRUCTURING TIME, FILLING SPACE

We can see this history as a gradual expansion of the visual arts towards time, as well as an extension into space through projection, as something immaterial, existing in time, moving, and filling space. As artists embraced the medium of film conquering new possibilities for aesthetic creation, music provided the model for structuring time. Walter Ruttmann proclaimed, in 1919, a new form of "painting with time" emerging as a rhythm of optical events, as explored in *LightPlay Opus 1* (1921). This *absolute film* was followed by a long tradition of abstract animations devised in analogy to musical concepts, as developed by Viking Eggeling, Hans Richter and later Oskar Fischinger or Mary Ellen Bute.

In contrast with the immutable nature of film as completed artwork, the live manipulation of optical events was explored through film and light projections. The concept of *Raumlichtmusik* (space light music) and the multiple film projections devised by Fischinger in the 1920s, optimized as a "Form-Play" accompanied by live music as an "endless space without perspective", can be seen as a predecessor to the light-shows of the 1950s, such as Jordan Belson's *Vortex Concerts*. Sound, light, color were brought together in a space where "there is no separation of audience and stage or screen; the entire domed area becomes a living theater of sound

1. The former can be exemplified by Bainbridge Bishop's *Color Organ*, patented in 1893, Mary Hallock-Greenewalt's *Sarabet* (1919), Alexander László's *Sonchromatoscope* (1925) or even Lloyd G. Cross's *Sonovision* (1968). Artists such as Alexander Wallace Rimington, with his *Colour-Organ* (1893), or Bainbridge Bishop, with the concept of *painting music* (1877), explored free forms of association, while others explored a free play of color and light, as seen from Thomas Wilfred and his *Clavilux* (started in 1919), Vladimir Baranoff-Rossiné's *Piano Optophonique* (1920), Zdeněk Pešánek's *Spectrophone* (1926) to Charles Dockum's *MobilColor Projectors* (started in 1936) or Oskar Fischinger's *Lumigraph* performances (of the 1950s).

2. Castel's efforts to "make his natural-philosophical idea an empirical and technological reality" were "fruitless", according to Daniels (2011, 12) since "it was not possible to prove the correctness of his table of color/sound correspondences or indeed any of the experiments by other researchers" and "due to the lack of compatibility between physical reality, theoretical insight, aesthetic vision, and technological feasibility."

and light" (qtd. in Keefer 2009, 3). These endeavors involved the live (real-time) performance of both sound and image as well as their *spatialization*; as principles that would find continuity in expanded cinema and multimedia performances during the 1960s and 1970s (see James 2010).

2.2. INTERACTION AS PERFORMANCE

Media-technological operations become the basis for devising sound-image relations in the middle of the twentieth century, when the creative exploration of the film medium contrasts with that of analogue electronic technologies, emphasizing transformation and paving the way towards interaction (Lista 2004). In contrast to the discrete material nature of film, the "constant flux of electronic signals", in its "processual immediacy", allows for a real-time manipulation of the audiovisual (Spielmann 2010).

This is reflected in the way that Nam June Paik transfers the principles of John Cage's experimental music to electronic television, arguing that "INDETERMINISM and VARIABILITY is the very UNDERDEVELOPED parameter in the optical art [...] a new decade of electronic television should follow the past decade of electronic music" (qtd. in Daniels 2005).[3] Paik paves "the road to manipulable images" through sound (Kwastek 2010, 165). And while music provided a model for structuring time in abstract film, electronic sound would provide the operative model for video through interference and interaction.

A new stage in the machine-supported creation of sounds and images emerges where the direct manipulation of real-time processes is paramount. As Peter Weibel stresses, "...the signal itself is no longer a carrier for depicting the object world but rather the image itself; autonomous worlds of sound and image that can be manipulated by both the observer and the machine. An artificial world of sound and images is emerging, one which can be generated by machines alone" (1992, 17).

Artists soon engaged in an exploration of these aspects through the development of video synthesizers and image processing techniques,[4]

3. This is achieved in the exhibition *Exposition of Music – Electronic Television*, in 1963, through a repurposing of the broadcasting functions of TV, reproductive functions of record players and tape recorders. Due to the lack of recording technology these first experiments were with modified TV sets, directly manipulated by the audience through a number of acoustic-oriented interferences in the image process.

4. Video can be simply signal processing rather than recording, as Spielmann (2010) explains, it can be defined by its manipulation of electronic signals. Artists began building analog video synthesizers, as video equivalents of audio synthesizers that allowed one signal to be used to control another signal in real time. Examples include the *Paik/Abe Synthesizer* (1969) that could edit different sources simultaneously, in real time. Video synthesizers were used to alter live camera sources, as well as to generate abstract imagery. With Stephen Beck's *Direct video synthesizer* (1970) waveforms could be produced by oscillators and allowed the creation and influence on elements like color, form, movement, and even the illusion of depth. Similarly, video processors, such as the *Rutt/Etra Scan Processor* (1973) made the control and modulation of electronic signals possible through the analysis of the smallest units in video, its waveforms (Spielmann 2010, 316).

assuming them as instruments for real-time audiovisual manipulation (as a means to perform a work) and occasionally live performance. Even if video synthesizers where then unpractical as widely adoptable performance instruments, Stephen Beck used his *Direct video synthesizer* for *Illuminated Music* (1972-73), in order to create a visual flow with a compositional structure that allowed for variations in performance.

As Woody Vasulka stated, "there is an unprecedented affinity between electronic sound and image-making… this time the material, i.e. the frequencies, voltages and instruments which organized the material were identical" (1992, 12).[5] It is this technical continuity between sound and image, or the "unicity" of its raw material as "an unformed electronic signal" (Spielmann 2010, 318) that allows a conception of video as "interaction device" (Lista 2004, 74). However, in contrast to the forms of audience interaction promoted by Paik, in the work of Steina Vasulka, namely *Violin Power* (1970-78), interaction is applied to the creative process, while playing the video as an instrument, as a performative act.

As Spielmann argues, by exploring the "transformative characteristics" of electronics, its "process-oriented, multidimensional" and "open-ended" audiovisuality, the Vasulkas emphasize a contrast between video and previous audiovisual media, while also bridging the way to algorithmic audiovisuality (2004, 8). Their creative strategies find continuity, and are further expanded, with digital technologies. Taking on this idea, we can identify two conceptually distinct uses of the computer as an artistic medium, which seen under the perspective of audiovisuality, are tied to a concern with the creation of audio-visual forms (through computational means) and to a focus on the creation of interactive experiences (that are articulated through images and sounds). These ideas ultimately converge within the broad spectrum of digital computational audiovisuality and interactivity.

2.3. AUDIOVISUALITY AND INTERACTIVITY

Following an interest in the creation of a multidimensional art for eye and ear, John Whitney saw in the computer a means to define precise compositional relations, initially, as mathematically structured anima-

5. The author completes stating "the advent and use of the oscillator became the natural link. As in our case, many of our colleagues and friends used audio oscillators of audio synthesizers to generate their first video images. The first video instruments were inspired by the architecture of audio instruments, and the first organization of images was negotiated in similar ways. With feedback, which all these instruments possess generically, the preliminary nomenclature of generated images was established" (Vasulka 1992, 12-13).

tions devised in relation to pre-existing music.[6] As computer technology evolved, Whitney was able to fully develop his idea of a "digital harmony" linking visual and musical design in order to achieve "powerful appeal… within the natural interlace and active coordination of eye to ear" (Whitney 1991, 598), as explored in *Spirals* (1987) or *MoonDrum* (1989).

Other artists used computers to produce abstract films in relation to musical concepts, often mixing computer generated imagery with animation, namely Lillian Schwartz,[7] who soon transferred these experiments to a live performance context in *On-line* (1976), where computer-generated visual effects accompanied musical improvisations. By the same time, Laurie Spiegel develops the *VAMPIRE* (1974-1976). *This Video And Music Program for Interactive Realtime Exploration/Experimentation* included a number of controls to modulate image and sound parameters in real-time.[8] Even if it remained confined to the laboratory, Spiegel defines it as an "unrecordable room-sized live-performance visual instrument" (1998, 190). This live performance is dissociated from the live production and presentation of sounds and images to an audience, but rather stresses the act of creation of the work, while interacting with a system, leading us to a distinct conception of performativity.

3. PERFORMATIVITY AS AUDIENCE INTERACTION

We can discuss performativity invoking the notion of a live action connecting visual and auditory events, as well as the transfer from passive reception to an active participation or performance of the work. These are ideas that, according to Shaw-Miller (2010), can be traced back to aspects explored by *Fluxus* and Intermedia art, namely through the concepts (derived from music) of notation and performative actions or events that could ultimately be executed by the audience. This shift towards an active role of the audience is also invoked by Paik's work, in its openness to interference and indeterminacy through audience

6. Examples are *Permutations* (1966-1968) assisted by Jack Citron at IBM Labs, or *Arabesque* (1975), assisted by Larry Cuba. In the1960s the processing capability of computers did not yet allow for the generation of complex imagery in real-time. Whitney had to use the computer to create frames that were animated on film. Only in the 1980s, with the advent of personal computing and real-time graphics was he able to directly map these animations to music, devising an instrument to compose images and sounds simultaneously in real-time, where "musical design intertwined with color design tone-for-tone, played against action-for-action" (qtd. in Levin 2010, 279).

7. Assisted by Ken Knowlton at Bell Laboratories, Schwartz produced several animations in collaboration with computer musicians, namely F. Richard Moore, in P*ixillation, Enigma, Apotheosis, Affinities, Galaxies and Mathoms* (1970-77) or Max V. Mathews in *Mis-Takes* (1972).

8. The *VAMPIRE* was one of the first computer systems (then a room-sized computer) for synthesizing both animation and sound in real-time. It allowed for real-time algorithmically generated images, including animation routines by Ken Knowlton, and was built on the basis of the *GROOVE* computer music system, created by Max Mathews, Dick Moore and colleagues (Spiegel 1998).

interaction, in contrast with vicarious forms of interaction. Therefore, rather than mere instruments for performance (controlled by their creators), we are addressing systems that offer a set of operative and productive possibilities for the audience to explore as their user.

The notion *performativity* is used by Levin (2010) as one of the main "principles" or "aesthetic possibilities" of digital computational art forms that are particularly prospective in exploring the creative possibilities of software, namely interactivity (Levin 2003). This notion encompasses a diversity of artworks that explore how a "feedback loop can be established between the system and its user(s) – allowing a user or visitor to collaborate with the system's author in exploring the possibility-space of an open work, and thereby to discover their own potential as actors" (Levin 2010, 271). These works are "only experienced properly when used interactively to produce sound and/or imagery" (2010, 275). However, their creators are not primarily concerned with the production of sounds and images, but with their roles as responses to interaction. They use the computer as an artistic medium for the creation of "process oriented and participatory forms that involve the manipulation of acoustic and visual information by the audience" (Kwastek 2010, 163).

An example is David Rokeby's interactive installation *Very Nervous System* (1986-1990), motivated by the aim of developing intuitive physical forms of interaction with computers. The artist proposed that sound becomes both "an extension of the body" and a "physical reality which one encounters with the body" (Rokeby 1990). This kind of interactive audience-activated environment is reminiscent of Myron Krueger's "responsive environments", explored as a "new art medium based on a commitment to real-time interaction between men and machines" (Krueger 2003, 387). His *VideoPlace* installation was gradually perfected as a continuous experimentation in interactive art, giving form to the idea that "response is the medium". But while Rokeby aimed to intrigue the audience with the immediacy of sound responses to their movements, Krueger sought to define a precise cause-effect relationship: "It is the composition of these relationships between action and response that is important…. The beauty of the visual and aural response is secondary" (2003, 385). Interactivity becomes the subject matter and the core of the aesthetic experience, rather than a mere possibility or an attribute of the work.

3.1. PERFORMATIVE SYSTEMS AS AESTHETIC ARTIFACTS

We can consider the notion of interactive performativity from the viewpoint of the system and of the audience's experience. These systems are *performative* in that they depend on "participatory human action" or "human performances" as a "primary input stream for controlling or generating audiovisual experiences" (Levin 2010, 275). But rather than mere instruments for the production of audio and visual artifacts, these systems are aesthetic artifacts in themselves, performed by their audiences.

From the perspective of the system, *interactive performativity* addresses digital computational systems that map human input to images and sounds, being that the work varies its behavior, particularly, with human input.[9] Sound and image become the means through which the user interacts and the products of interaction, as the results of operations performed by the work with the participation of the user. Ultimately, each system devises a specific way of governing the behavior or of generating visual and auditory elements,[10] and in this process, include (or even depend) on the user (Ribas 2013, 24).

Accordingly, from the perspective of their experience, these systems can be comparable but are inherently different from instruments since, as Kwastek argues (2011), their "operative possibilities" and "functionality" as "production devices" are potentially "unique, unknown and novel" to the user.[11] This originality creates a form of operative and productive "resistance" that incites exploration of the system's workings through interaction. This exploration becomes "an activity in its own right,… as an aesthetic experience on the boundary between the aesthetics of production and the aesthetics of reception", whose focus lies "in the process of interaction itself, not its outcomes" (Kwastek 2011, 157). The creative dimension of this exploration, rather than residing in audiovisual results, is tied to the engagement of the audience in "participating in the work itself", as a "creative pursuit", as a way of "constructing a meaning through this interaction" (Bilda, *et al.* 2008, 525).

As the audience assumes an active and constructive role in the creation of their own experience, this view of performativity implies a transfer of agency (from the creator of the system) towards both the audience and the system, in its ability to act and change its state, while adapting to its environment.[12] We can think of the transfer of some degree of agency to the system as its ability to act, by incorporation information (namely user input) and perform accordingly; hence, to interact, as a reciprocal ability to act and influence each other. Therefore, agency can be seen both as a "machinic reactive agency" tied to its modes of liveness and immediacy (Kwastek 2009) and, on the part of the audience, as an "aesthetic pleasure" that arises from interaction

9. These are "computationally variable works in which "computation is required "during the time of reception by the audience". They vary their behavior either without input from "outside the work's material", with input from "external data or processes", or with human input as audience interactive work (Wardrip-Fruin 2006, 389-99).

10. That is, according to the rules inscribed into the system by its creator or author.

11. This aspect "renders their creative exploration an aesthetic experience during interaction" since the image-sound relationships are defined by the system's creator, as conventions and not natural or physical "causal reactions" (Kwastek 2011, 158).

12. Agency can be seen as the ability "to act in or upon the world (…) having made a decision, to carry out (or execute) that decision"; and while "interaction implies reciprocal actions or influences of two (or more) entities upon each other, where an entity is some kind of organized object of multiple components that has some degree of autonomy and agency", autonomy implies that "an entity can stand alone in some sense, making decisions based on its own knowledge of its situation" (Jones 2011).

when it enables "meaningful action" leading to "observable results" (Murray 1997, 153).

As argued by Boden and Edmonds, the notion of performance replaces that of artwork, since each of its occurrences "can vary considerably from one occasion to another" and "even if the form of each particular human-computer interaction can be completely determined by the artist… the sequence of such events cannot" (2009, 41).[13] This emphasizes the double status of these works as artifacts and as processes or activities developing in time; thus not objects, but instances or occasions for experience. It also puts to the fore what Broeckmann (2005) or Jaschko (2010) define as the "processual" and "performative" aesthetic qualities of the experience of machinic creations.

4. PERFORMATIVITY AS AESTHETIC QUALITY

As suggested by Broeckmann (2005) the concept of the *machinic* is understood as "any kind of productive assemblages of forces, be they technical, biological,… or other", which evoke "something like 'working' or functioning'" as a "quality of such formations". The author then proposes aesthetic categories for considering the experience "effected by such machinic structures" as aesthetic artifacts, whose experience depends on "non-visual aspects" such as "generativity, interactivity, processuality, performativity", manifested as movements, processes, dynamics and change (Broeckmann 2005).

This understanding of process refers to a "time-based evolution" of "sequences of events" as results of ongoing computations; as non-visual (or non-sensorial) processes that give form to images and sounds as the results of an execution. The notion of *performance* designates both the "quality of a technological artifact in operation" and its *live* dimension – "making present (and perceivable) the results of an execution" as the momentum of aesthetic experience (Broeckmann 2005).

Process and performance are then two essential qualities of the machinic, as both generative and interactive artworks since "live processes take place that generate unique configurations and dynamics" performed either by the system or by system and user (Jaschko 2010, 130). This view goes beyond the notion of audience interactive performativity, considering the processual and performative qualities of generative and interactive systems. It implies a shift from human-based operations (and control) towards those of machinic creations as aesthetic artifacts.

In order to understand this, we can return to the "principles" of digital computational artifacts proposed by Levin, namely "processuality", as "the character of algorithmic processes" (2003), later addressed as "generativity" or the potential autonomy of a system to "produce an-

13. Similarly the authors assume that we may "speak not of the 'artwork' but of the 'art system' – where this comprises the artist, the program, the technological installation (and its observable results) and the behaviour of the human audience" (Boden and Edmonds 2009, 41).

imations and/or sound from its own intrinsic rule-sets" (2010, 277).[14] The term generative is often used to address the system's ability to produce variable outcomes regardless of the direct intervention of its creator, who "chooses to cede some degree of control to an external system" (Galanter 2006). In this sense, it is linked to the creative act of "making something make something… by setting a procedural system in motion and observing its outcomes", as a form of metacreation (Whitelaw 2005, 158).

Generative autonomy puts to the fore what rule-based processes may generate as forms and behaviors, drawing attention to the "rules of creation" of the work as "artistic constraints" (Bootz 2005); as "recipes for autonomous processes" that develop in time, in a self-organizing manner (Galanter 2006) potentially leading to unforeseeable results, which are not completely predictable neither by they creator nor by the audience as user (Boden and Edmonds 2009, 24).[15]

4.1. CREATIVE POSSIBILITIES AND AESTHETIC QUALITIES

These views emphasize processes or operations as observable activities performed by the work, defining its surface and supporting interaction.[16] In this sense, what they stress is not only a "unique aspect of software as a medium", the fact that "it enables response", but also other "fundamental expressions of software" that may include "dynamic form, gesture, behavior, simulation, self-organization, and adaptation" (Reas 2003, 175).

Processuality and performativity are seen as *aesthetic qualities* of the experience of these artifacts, however, the principles mentioned earlier address *creative possibilities*. They emphasize the possibility to devise dynamic audiovisual behaviors, whether autonomous or interactive. As Wardrip-Fruin (2006) states, the authoring of processes is an important element of media creation and a significant means of expression for authors, as the creative opportunity of defining new computational behaviors.

Echoing the idea that "one unique possibility" of the use of the computer as an artistic medium "is the ability to create behavior", Levin goes further to affirm "the aesthetic possibility of… building feedback systems around participant action" and "not transforming sound into image (or vice versa)" (Levin 2009). This his reflected in work such as

14. Generativity emphasizes that processes are internally defined in a manner that varies the work's behavior randomly or otherwise; the work does not depend on external data or processes (but may include them) in order to produce variable outcomes.

15. The work occurs while running, and we can think of each occurrence as a "unique performance" whose rules of creation can only be grasped through careful observation (Bootz 2005).

16. The surface is "what the work turns to its outside", including what it "makes available for interpretations and interaction" (Wardrip-Fruin 2006, 381), such as outputs and interfaces that the audience experiences, namely, its audiovisual modes of expression and communication.

AVES: Audiovisual Environment Suite (2000) or the *Manual Input Workstation* (Levin & Liebermann, 2004). In contrast, Antoine Schmitt explores the creation of autonomous behaviors. Namely, in *The World Ensemble* (2006), sound and image are intentionally reduced to the tangible expression of programmed entities; they only acquire meaning through action (Schmitt 2008).

In this sense, these works also entail different forms of user engagement through interaction, as a means of exploring the system's variable behavior or its productive possibilities – or as a form of influencing, or of defining, its audiovisual outcomes. By extension, and in contrast to interactive performativity, the notion of generativity implies the transfer of some degree of creative autonomy to the system, as detached from the direct control of its creator (or even other external factors). An alternative way of putting this is considering that agency, rather than pertaining to the user, is attributed to the system, when understood as the "property of an autonomous entity that is its capacity to act in or upon the world" (Jones 2011). And just human beings are capable of sensing their environment, making decisions and operate on it, a system can be imbued with these properties; again, in the very sense that Murray ascribes to it – taking action leading to meaningful results, while "exerting power over enticing and plastic materials" (1997, 153).

A distinctive feature of these systems is therefore the dynamics of their behavior (in its variable nature) of which sound and image are a consequence and expression (Ribas 2013, 22). The implied idea is that beyond the "retinal beauty" of sensory results, the "iconographic level" (Broeckmann 2005) or the "rhetoric of the surface" (Bootz 2005), these works entail a conceptual level of appreciation that is tied to the cognitive recognition of the processes they carry out. That is, an aesthetic level tied to their "procedural rhetoric" or "the practice of using processes expressively" (Bogost 2008, 125).

Sound and image become a surface expression of "expressive processes", as those that more evidently contribute to (or define) the works' meaning and expression (Wardrip-Fruin 2006). As aesthetic materials, they subsume to the performative quality of works that occur as "live processes" or activities taking place in the "here and now", as "unique moments and situations in progress", resulting for the user "in a strong sensation of immediacy an presence" (Jaschko 2010, 130). In other words, the expression and experience of these artifacts is shaped by their modes of *liveness* as temporal simultaneity, and *presence* as spatial co-attendance, together with their visual and auditory realization (Kwastek 2009, 93).

5. CONCLUSION

These different conceptions of performativity, tied to distinct audiovisual systems, highlight the roles of user and systems as agents defining their audiovisual outcomes. While the notion of a performative analogy emphasizes human authorial control in the live production of sounds and images, the focus shifts towards audience and system agency, as expressed through the notion of interactive performativity when applied to audience interactive systems. Their interactive exploration, through the manipulation of sounds and images, becomes paramount as aesthetic event and as a form of creative engagement. Ultimately, agency can be transferred to the system itself, as an aesthetic artifact and as an (autonomous) machinic performance.

In this context, what is highlighted as an *aesthetic quality* of these systems is their performative nature, pertaining to their generative and interactive potential. So what is underlined, as an authorial and *creative possibility*, is the opportunity of devising *dynamic behaviors*, whether autonomous or interactive. Hence, the subject matter (or content) of these works is not merely tied to their audio-visual surface representations, but rather their procedurally enacted dynamic behavior, as audiovisually expressed. In Simon Penny's words, we are experiencing artifacts "that exhibit dynamic real time behavior, or responsiveness to their environment" for which "a wholly new branch of aesthetics is demanded: the aesthetics of behavior" (Penny 2008).

Consequently, from the idea of an audiovisual aesthetics we move toward an aesthetics of process and performance, and from systems for performance towards performativity as an aesthetic quality of these systems, in their different degrees of autonomy and interactivity. The focus then shifts from their audiovisual modes of expression towards their procedural ones, or the dynamic (and often indeterminable) behavior that defines their meaning and experience.

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USER-CENTERED DESIGN OF A TOOL FOR INTERACTIVE COMPUTER-GENERATED AUDIOVISUALS

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ABSTRACT

The present study aims to design a tool for interactive computer-generated audiovisuals. In this paper, we investigate if the tools for audiovisual performance and composition have caught up with the growing interest and the practices in the field. We have adopted a user-centered design approach for our study, based on interviews and a workshop with practitioners. The interviews identified key themes – expressivity, ease of use and connection with the audience – that were explored in the workshop. During the workshop, a novel methodology was adopted – *reboot* – which expands upon the *bootlegging* technique. Key ideas regarding audiovisual performance gathered from the interviews; sketches for novel audiovisual tools resulting from the workshop; and the reboot technique, are the main contributions of this study.

KEYWORDS

User-Centered Design, Interaction Design, Human-Computer Interaction, Audiovisual Performance, VJing, Computer-Generated Graphics, Computer-Generated Sound.

1. INTRODUCTION

The field of audiovisual (AV) performance and composition has been particularly active in recent years. New festivals (for example: LPM,[1] LEV,[2] Mapping[3]), publications (such as: *See This Sound* series and web archive,[4] *LEA Live Visuals* special issue[5]) and conferences/seminars (for example: Seeing Sound,[6] Real-Time Visuals[7]), have focused in this field in the last years. From our own experience as performers, we have realized that audiovisual performances often rely on custom software made by the artists, and not on ready-made tools available to other performers. We would like to understand if the tools for AV performance and composition have caught up with the growing interest and practices in the field. The practical aim of this study is to design a tool for computer-generated audiovisuals, taking into account expressiveness, ease of use, and audience involvement. In this context, we consider that expressiveness is "not a distinct action or task that can be isolated for study, but rather a phenomenon that arises as a consequence of how an action is completed" (Hook et al. 2011). In this paper, we present early results from research examining user interfaces for procedural audiovisual performance systems.

We adopted a User-Centered Design (UCD) approach consisting of two steps. We first interviewed 12 audiovisual performers, to better understand their practice, in particular: the strengths and weaknesses of the tools that they use; and the role of the audience in their performances. We then conducted a 1-day workshop to brainstorm, create imaginary scenarios, and sketch possible future tools for audiovisual performance, taking into account themes identified in the previous interview stage. 19 participants attended the workshop. During the workshop, we implemented the *bootlegging* brainstorming methodology (Holmquist 2008) and introduced a novel twist on it, which we named *reboot*. This study gave rise to: key ideas on tools for audiovisual performance gathered in the interviews; the sketches for a novel tool for AV performance produced in the workshop (which used the key ideas as an input); and the reboot method (which was devised as a means to rapidly generate sketches based on an initial input).

1. LPM: *http://liveperformersmeeting.net*
2. LEV: *http://www.levfestival.com*
3. Mapping: *http://www.mappingfestival.com*
4. See This Sound: *http://see-this-sound.at*
5. LEA Live Visuals special issue: *http://www.leoalmanac.org/vol19-no3-live-visuals/*
6. Seeing Sound: *http://www.seeingsound.co.uk*
7. Real-Time Visuals: *http://www.realtimevisuals.org*

2. TOOLS FOR INTERACTIVE AUDIOVISUALS

Audiovisual performance has a long history, from color organs and the visual music cinema performances of early 20th century pioneers – artists such as Walther Ruttmann and Oskar Fischinger, who used "tinted animation to live musical accompaniment" (Moritz 1997) – to contemporary digital works. From the 1990s, there has been a strong interest in "screen-based performance", adopting "a long litany of names such as audiovisual performance, real-time video, live cinema, performance cinema, and VJ culture" (Salter 2010, 171). Chris Salter attributes this interest to two branches of techno-cultural development: on the one hand, "breakthroughs in digital computation, particularly the development of hardware and software components for the capture, processing, and manipulation of image and sound" and on the other hand, "the international rise of the techno/club scene, which rapidly exploited such technologies". From the terminology mentioned by Salter, we preferentially use *audiovisual* or *AV performance*, as it best encapsulates the two modalities of sound and graphics.

Two notable examples of contemporary audiovisual artists using computer-generated graphics and sound are Golan Levin and Toshio Iwai. They are relevant to this study because they are concerned with creating interfaces and instruments for audiovisual expression. Levin developed a suite of works under the name *Audiovisual Environment Suite* (*AVES*) and described his approach to audiovisual performance as being based on painterly interfaces (Levin 2000). Iwai creates playful pieces, crossing genres between game, installation, performance (with works such as *Elektroplankton*, *Composition on the Table*) and audiovisual instrument (with *Tenori-On*)(Nagle 2008).

There is a large choice of software tools for audiovisual performance. In this context, we use the term "tool" to define generic software systems that can be used by different artists to create their own performances (and not software created by an artist for a specific piece). These tools deal with audio, visuals or both. They can be ready-made commercial software such as Modul8,[8] Resolume,[9] VDMX[10] (with an emphasis on graphics) or Ableton Live[11] (with an emphasis on sound). There are also open-ended programming frameworks or environments – usually following either data-flow programming or textual programming paradigms. They usually carry with them steeper learning curves than turnkey software products. Examples of data-flow programming software used for audiovisual performance: VVVV,[12] Quartz Compos-

8. Modul8: *http://www.modul8.ch*

9. Resolume: *http://resolume.com*

10. VDMX: *http://vidvox.net*

11. Ableton Live: *https://www.ableton.com*

12. VVVV: *http://vvvv.org*

er[13] (with an emphasis on graphics), PureData[14] (emphasis on sound) and Max/MSP/Jitter.[15] Examples of textual programming frameworks or environments used for audiovisual performances: SuperCollider[16] (mainly for sound), openFrameworks[17] and Processing.[18]

Most ready-made commercial software tools for live visuals (such as Modul8, Resolume and VDMX) focus on video playback and manipulation. Therefore, artists interested in using video for their performances have a choice of using either ready-made (and easier to use) software, or programming languages / environments (with a steeper learning curve, but offering more flexibility). For artists dealing with computer-generated graphics, however, there is a scarcity of ready-made, easy to use software.

The design of tools for AV and VJ (Video Jockey) performances has been analyzed before from these perspectives: taking into account expressive interaction (Hook et al. 2011); ease of use (Correia and Kleimola 2014); and audience, specifically considering participation (Taylor et al. 2009) and awareness of performer's actions (Lew 2004). Our work is distinct because it takes into account all three aspects; it focuses on computer-generated audio and visuals; and because of the novel methodological approach regarding user-centered design.

3. METHODOLOGY

This study follows a UCD approach. UCD is "a broad term to describe design processes in which end-users influence how a design takes shape" (Abras, Maloney-Krichmar, and Preece 2004). In this case, the end-users are audiovisual performers. We adopted a UCD approach to better understand current practices of audiovisual performers and to design a tool that addresses their needs. The interviews aimed to obtain insights into the practices of audiovisual performers, and the tools they use. The questions were grouped in six sections:

- Characterization of performer;
- Tools;
- User Interface (UI);
- Audience involvement;
- Artistic goals and technology; and
- Specific performance recollection.

The interviews were conducted prior to the workshop, so that the insights gathered during the interview stage could inform the scenarios for the workshop. Workshops are defined as "collaborative design

13. Quartz Composer: *http://quartzcomposer.com*
14. PureData: *http://puredata.info*
15. Max/MSP/Jitter: *http://cycling74.com*
16. SuperCollider: *http://supercollider.sourceforge.net*
17. openFrameworks: *http://www.openframeworks.cc*
18. Processing: *https://processing.org*

events providing a participatory and equal arena for sharing perspectives, forming visions and creating new solutions" (Soini and Pirinen 2005). Due to the collaborative and participatory nature of workshops, they were chosen as a key element of the adopted methodology. A one-day, 6-hour workshop was conducted, aiming to produce sketches of novel tools for audiovisual performance.

For the first part of the workshop, we conducted a *bootlegging* session. Bootlegging is a "structured brainstorming technique particularly suited to multidisciplinary settings" (Holmquist 2008, 158). Bootlegging applies the notion of cut-up – a form of literary collage popularized by William Burroughs – to brainstorming sessions, mixing familiar concepts in a way that stimulates creativity. A bootlegging session requires a theme. It also requires the definition of four categories for idea generation, two relative to the user side and two related to the theme and technology. A presentation format should also be chosen. The participants, divided into groups, should then generate several ideas (as post-its) for each category, mix those ideas and create 4-5 random combinations of each category per group. Those combinations then become the trigger of a brainstorming session, attempting to imagine different potential applications for each combination. Afterwards, the groups are asked to pick one of the ideas and prepare a presentation in the chosen format (Holmquist 2008, 159).

For the second half of the workshop, we devised and ran a variation of the bootlegging technique, which we entitled *reboot*. Reboot is a brainstorming technique that builds upon bootlegging, and is intended as a follow-up to a bootlegging session. Similarly to bootlegging, it also requires a theme and four categories (the same ones as in the preceding bootlegging session) for idea generation. For more focused results, additional requirements are introduced to the initial theme, taking into account the results of the bootlegging session. Instead of relying on generating multiple variables for each category and random mixing, the variables for the four categories are deliberately chosen by the participants (one variable per category). Some or all of these variables may also be defined by the session facilitators. The same steps as in bootlegging are taken, with the exception of the mixing and combining steps. The aim of reboot is to give direction and focus after the open-ended and aleatoric nature of the first exercise. After having stimulated the creation of new application ideas with the bootlegging session, reboot allows the participants to concentrate on more specific solutions.

4. INTERVIEWS

4.1. PARTICIPANTS

We conducted 12 face-to-face interviews lasting between 25 and 56 minutes. 11 of the interviewees were male, 1 was female. The interviewees had between 4 and 18 years of performance experience.

When asked what is the most important feature of the tools they use, two interviewees mentioned modularity and flexibility of the software ("easily adaptable to different performance situations and its flexibility"; "the fact that it can be configured in so many different ways"). Two artists mentioned ease of integration with hardware and other software ("the way that Modul8 is built, with the options that you have, basically controlling those options with knobs and faders" and "Resolume was always working well alongside Ableton"). Two others mentioned expressivity and fluidity ("it creates images a bit more like you were creating music"; "you want to be like a musician, you want to play an instrument, you want to respond in real-time"). Other interviewees mentioned integration of environmental elements ("construction with the elements that are around"), generative capabilities and diversity ("the fact that it's generative (…) each performance becomes different"), communication of live creative process to the audience ("projecting agency to the audience"), reliability ("software can be glitchy, slow, crash") and speed ("I want to be able to do multiple processes very quickly").

When asked what features they would like to add to their performance tools, interviewees repeated qualities mentioned earlier, such as stability, modularity and diversity. Additionally, two artists mentioned that they would like to have a flexible timeline view in their software (because "the time of the performance is of a different time from the reality" and "for running more generative kind of installation type stuff"). Ease of mapping audio reactivity to graphics was also mentioned ("the ability to make a video file or a layer audio reactive with a single button").

Regarding ease of use, the interviewees who use commercial software agreed that these tools are easy to use. The others consider that the custom systems they have built are personal and not designed for others to use ("we always get it quite personal"; "I don't care about ease of use I care about expressiveness"; "I don't think that the system itself is complicated but the way it's controlled might be complicated"; "it's more the realization that it is your own tool and that you're showing your composition through that tool where the value lies"). Two of the artists make a distinction between systems created for their own performances, focusing on expressiveness and individuality, and systems that they have created for others, which are easier to use.

Regarding preference for type of UI, nine of the 12 interviewees use hardware controllers (with two expressing a preference for motorized controllers), and five of these complement the hardware controller with an Apple iPad running a controller software application (app). Hardware controllers and iPad (running Touch OSC or Lemur apps) are used to control the audio and/or visual software running on the laptop. Hardware controllers are favored because of the eyes-off tactile feedback they provide. The following quote reflects a general view for a majority of the interviewees: “the physical feeling for me is essential for performance: buttons, rotaries whatever; because I’m more precise – they never let me down and I feel the performance better”. For some, motorized controllers are preferred: “a motorized physical controller with real sliders makes it easier to be able to look at the screen without the need of looking at the controller”. iPads are used because of the identification and visual information they provide: “it’s really an easy way of labeling up all your effects and be able to see all that stuff without having to stick all bits of plastic to MIDI controllers or to keys in your keyboard”, although that comes with a cost: “but of course the problem is that you need to be looking at the iPad because you don’t feel with the finger”.

One of the artists uses live coding as a performance technique, because in his opinion “graphical interfaces are frustrating” and slow. He considers live coding natural for him, as he uses SuperCollider. He has some doubts regarding the impact of live coding on the audience: “I have a bit of a problem with live coding and people showing the screen, you know – I always just stand there and wonder how it’s like for most people”. The solution he has found is to integrate the code with the visuals: “I’m trying to find creative ways to display the code and also make it part of the graphics”. Another interviewee explores showing the Graphical User Interface (GUI) as a means of projecting the performance process to the audience: “there’s two visuals going on, there’s the visual object that is showing, which is somehow the thing to be manipulated, and then there’s the act of manipulation itself, which is some kind of GUI that sits on top of that”. He tries to find a balance between having more GUI and more ease of use for him, or less GUI and therefore less visual interference for the audience: “I could put loads of GUI and make things maybe clearer for the audience and they could see more of my actions, but then it starts to crowd over the graphics that are underneath”. The remaining controls are executed with key presses. Two other artists use only the computer keyboard and keyboard shortcuts as their interface.

4.3. AUDIENCE REACTION AND PERCEPTION OF LIVENESS

Audience reaction to the performance, as perceived during the performance or communicated afterwards, is important for eight of the 12 interviewees. When questioned if their audiences understand the interactive and real-time element of the performances, five replied that it depends on the audience and the setting. According to these artists, some audiences might be more knowledgeable in computer-based performance than others, whereas in some venues the visual element might not be as valued as in others. Four of the artists state that it is indifferent for them if the audience understands that the visuals are interactive or not. For these artists, the importance of the performance lies in the quality of the experience, not in the perception that it is live. For two of the interviewees, audience perception of liveness derives from the assumption that it is live if there is someone on stage ("if you see … another people doing other things") or to post-performance feedback ("they'll actively tell me why they've enjoyed it … I'm pretty confident that it's communicating what it's trying to"). One interviewee considers that the audience generally does not understand that the performance is being done live – "people can't see much what we're doing" and "people think once you have a laptop on stage that laptop is doing everything for you", therefore: "we are considering: should we actually make that clearer".

Interviewees were asked to suggest ways to improve audience understanding of liveness. Two of the interviewees did not have interest in improving communication with the audience, with an additional one stating that it would make sense only in specific performances. Live coding, or further displaying aspects of the code, is a possible path for four of the artists. The live coding interviewee suggests further integration between displaying code and additional visuals ("make the codes animated somehow" and "add some comedy to it"). Two artists who are not currently using live coding contemplate using that performance technique in future work. Another interviewee mentioned the notion of "debug interface" to showcase parameters to the audience, in the same way that a programer uses debug windows to check for values ("almost like another layer of visual information that's purely only really for the developer but that is displayed for the audience"). Two of the artists suggest adding live camera feeds to convey a sense of liveness, either pointed to the audience ("more cameras where the space of the audience is") or to their stage setup ("a camera over my head on my set up showing what I'm doing"). Additional suggestions are: using custom apps that the audience could download and interact using their mobile devices during a performance ("custom apps or information that's being kind of gathered or created by the audience"); and tracking audience movement as an interaction mechanism ("body positioning, and somehow one of the persons in the audience can affect the music somehow, or the visuals").

5. WORKSHOP

5.1. PARTICIPANT CHARACTERIZATION

The one-day workshop took place in October 2014, at Goldsmiths, University of London. The call for participation was circulated among mailing lists within the Goldsmiths and London Video Hackspace[19] communities. 19 participants (12 male and 7 female) took part in the workshop. Ten described themselves as VJs and/or AV performers, three as programmers, one as video artist, and four as musicians – all practitioners in the field of audiovisual performance or related fields (music, video, media arts). One anthropologist studying audiovisual performance also participated in the workshop. Four of the partici-

19. London Video Hackspace: *http://www.videohackspace.com*

pants develop work with video footage, another four with computer-generated graphics and six with both. Nine of the participants stated that they build their own tools for performance, with Max/MSP (five), openFrameworks (three) and with Processing (one). Three of the workshop participants had been interviewed in the previous stage of the study.

5.2. BOOTLEGGING

In our bootlegging session, the theme was: "Software for interactive computer-generated audiovisuals, using a single screen". The constraint of the single screen aimed to stimulate creativity in terms of user interface, avoiding a performer-specific screen populated with GUI, common in commercial software. The participants were divided into five groups. During the generation stage, each group produced post-its with dozens of variables for each of the chosen categories – user, situation, interface and device. In the mixing stage, these were randomly mixed within each group, and each group was asked to produce four random combinations with one item per category. Each of these combinations was pasted to an A3 paper. The groups were then asked to think of different applications per combination. Finally, they were asked to pick one of the applications and develop it conceptually, preparing a presentation based on a storyboard and wireframes (figure 1).

The bootlegging session achieved the aim of stimulating creativity in participants and opening up the range of possibilities for audiovisual performance outside of the usual scenarios. Many of the concepts were humorous, ironic and playful. The five concepts were:

- *Botanical garden motion sensors*, a garden transformed into a performance space, augmented with surround sound and visuals projection-mapped on trees;
- *Fish food – an audio-fishual dance ensemble*, a reactive aquatic audiovisual environment for public spaces;
- *Interactive surgery blanket*, a special fabric for health purposes, incorporating a flexible screen, which reveals physiologic aspects of the patient it is covering, with bodily functions being sonified and visualized;
- *EAVI sleeper*, a system incorporating a blanket with different biological sensors, which generates an audiovisual performance based on the biological data of a sleeping "performer"; and
- *Blind date sensory experience*, a system for two artists who meet on an online "blind date" for a networked audiovisual performance.

Figure 1 Bootlegging presentation

5.3. REBOOT

After the serendipity, humor and technological speculation generated by the bootlegging stage, the reboot stage aimed to bring more focused results. The participants were regrouped into different combinations. The groups were asked to brainstorm on the same theme as the bootlegging session, but adding a few more constraints:

- to focus on a performance scenario, and
- to take into account key qualities in tools for audiovisual performance detected during the interviews – expressivity; ease of use; and connection with the audience.

After the brainstorming session, the groups were asked to prepare a presentation, also based on a storyboard and wireframes.[20] Two of the concepts (*Gestural Touchscreen* and *Meta/Vis*) aimed to reach a balance between expressivity and ease of use. The additional three concepts focused on audience participation. Two of these (*Sensor Disco* and *Fields of Interference*) consist of performance spaces without a single main performer – the audience becomes the performer:

- *Gestural Touchscreen* is a touch-screen based application, controlled entirely by gestures. There is no GUI. Users can only load SVG files as visual content and there is a built-in physics engine (figure 2).
- *Meta/Vis* also relies on multitouch, but adds a “pre-performance” configuration stage. This stage adopts a data-flow paradigm, although substantially simplified. Objects such as sound, visuals, control, generative and physics can be linked with arrows in different configurations, and contain drop-down menus for additional options. The group described it as “a simplified Jitter-style patching system”.

20. The five sketches can be downloaded from: *http://nunocorreia.com/files/IG-AV-sketches.zip*

- *Sensor Disco* consists of an environment containing multiple sensors. By moving in the space, audience members trigger and modulate sounds, which are visualized on the walls and on the floor.
- In *Fields of Interference* users creates sound and visuals by moving with their mobile devices in a room. The system is composed of an array of sensors, which sonifies and visualizes Wi-Fi interference from mobile devices – using surround sound and an immersive dome-like projection screen.
- In *Beat the DJ*, there is a main performer role (in this case, a DJ/VJ), and the club environment becomes a game where audience activity "unlocks" audiovisual content. In the beginning, the audio and visuals are simple (for example, a drum loop and a few melody lines) but audience reaction can give the DJ/VJ more elements to play with. These elements can potentially trigger further reactions from the audience.

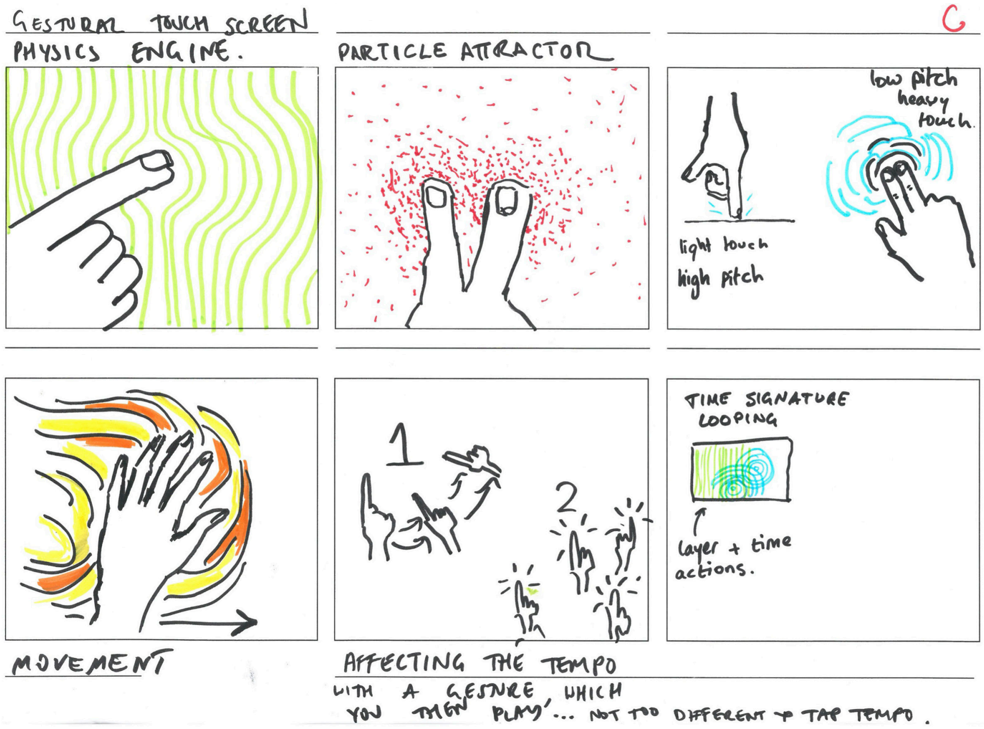

Figure 2 Storyboard from reboot session (*Gestural Touchscreen*)

6. DISCUSSION

The adoption of a UCD approach generated surprising results, which would not have been achieved from a top-down design process. In the beginning of the reboot session, we asked participants to reflect upon themes identified in the interview stage – expressivity, ease of use and connection with the audience. The resulting sketches successfully incorporated those reflections. The unconventional approaches of several of the sketches would not have been possible without the earlier bootlegging session, which stimulated out of the box thinking amongst the participants, enabling them to envision possibilities that go beyond traditional solutions. We were thus satisfied with the methods adopted, from interview and identification of themes to bootlegging and reboot. We believe that reboot is an important methodological contribution of the study.

6.1. EXPRESSIVITY, FLEXIBILITY AND EASE OF USE

One of the key themes detected in the interviews was expressivity, to be able to make visuals "like a musician" and the desire to play an audio-visual tool with the same expressivity and fluency as a traditional musical instrument. Another was flexibility and the possibility of reconfiguring the software in many ways. Yet another was ease of use – existing ready-made tools are easy to use, but they focus mostly on video manipulation, and there are few targeting computer-generated graphics. Combining these elements can be challenging, and often there are trade-offs between expressivity, flexibility and ease of use. Two of the sketches that came out of the workshop, *Meta/Vis* and *Gestural Touchscreen*, address these issues. Both rely on multitouch interaction so as to convey a sense of immediate control of sound and visuals. In *Gestural Touchscreen*, the expressivity comes from the rich variety of gestures that can be used to control sound and visuals and from the pressure sensitivity capabilities. The flexibility arises from the possibility of loading SVG (Scalable Vector Graphics) files as visual patterns to be animated and manipulated, making the graphical possibilities virtually endless. *Meta/Vis* also relies on multitouch gestures for expressivity (although less than *Gestural Touchscreen*). The focus of *Meta/Vis* is on flexibility and reconfiguration. To solve this, while maintaining ease of use, it incorporates a simplified data-flow programming component – basic blocs such as sound, visuals and control that can be re-routed and that contain simple drop-down menus with options. Both *Meta/Vis* and *Gestural Touchscreen* address ease of use by: implementing multitouch gestures that are easy to understand, while allowing for a great variety of control (particularly in *Gestural Touchscreen*); and adopting ingenuously easy solutions for reconfiguration (with the SVG approach in *Gestural Touchscreen*, and the simple data-flow modules of *Meta/Vis*).

6.2. AUDIENCE INVOLVEMENT

Another key theme detected in the interviews was audience involvement: the importance for some artists of conveying the liveness of the performance to audiences; and how to have audiences participate in the performance. Three of the sketches from the workshop address the issue of audience participation. In *Sensor Disco*, audience positioning in the space affects sound and visuals; in *Beat the DJ* the amount of physical activity of audience participation enriches the sound and visuals with a game-like "levels" logic; and in *Fields of Interference* the Wi-Fi signal from mobile phones of audience members is sonified and visualized.

7. CONCLUSIONS

Although the field of audiovisual performance has a long history, it has not been thoroughly documented, and it has not been the subject of design research. Technological developments present numerous opportunities – in interaction with the tools; creation of sound and graphics; visual and auditory diffusion; use of networks; ubiquitous computing; and audience participation. This study focused on one aspect of content generation – computer-generated audiovisuals – and arrives to concepts that explore some of these opportunities for performance, using a UCD approach. The study is an early stage part of our research. With this study, we were able to identify key ideas on audiovisual performance in the interviews; participants produced sketches for novel tools in the workshop; and we conceived and tested the reboot brainstorming technique. The sketches produced in the workshop show great promise in addressing key themes and concerns identified during interviews to practitioners – such as expressivity, flexibility, ease of use and audience involvement. These concepts can be useful for audiovisual performers, or designers of tools for audiovisual performance. The study also proposes an extension to the bootlegging methodology, which we entitled reboot. Reboot extends open-ended brainstorming, bringing additional focus through fine-tuned iteration. In this case, the focus was defined based on key themes identified during the earlier interviews stage. The interviews set themes. Bootlegging facilitates serendipity and out of the box thinking. Reboot brings themes from interviews into an iteration of bootlegging to provide focus and structure to the brainstorming process without constraining it to a task-based exercise.

In a future stage of the research, we will conduct another workshop with performers and programmers, in order to develop these sketches into functioning prototypes. Some features from the different concepts might be merged into one or more prototypes. Afterwards, we will conduct tests with these prototypes in a performance setting. The prototypes will be made available as open-source code. With this study, we hope to contribute to the audiovisual performance community, and the expansion of the range of creative possibilities at their disposal.

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INTERACTIVE MUSICAL CHAIR: SEATED PERCUSSION WITH REAL-TIME VISUALISATIONS

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ABSTRACT

This project, *Musical Chair*, explores the visualisation of percussive sounds, and rhythmic and temporal interplay through an interactive, multimodal installation. Building on the software developed through an earlier project, the *Colour of Music*, the visualisations explore graphical representations of percussive timbre and rhythm. Multiple sound sources, in this instance cajons, have been used in order to allow group playing with multi-user visualisations and a machine 'playing companion'. The challenge is to visualise communal music making in such a way that individuals can identify their own sounds and recognise how they fit together into a whole improvised performance. This paper discusses the design of the *Musical Chair* system, alongside an overview of the software developed for its installation at the Centre for Life, Newcastle, UK, concluding with a data capture and evaluation plan for the installation.

KEYWORDS

Interactive, Installation, Colour, Visualisation, Sensor, Synaesthesia.

1. INTRODUCTION

We experience an inherent and intentional multimodality during many of our multimedia experiences, often incorporating combinations of visual and auditory stimulation. Combining different media forms is a common method of creating more engaging experiences by stimulating audiences through different sensory channels. This is particularly effective in places, such as museums, that have a wide array of optional activities and a large footfall, by facilitating highly interactive and explorative environments that could be considered key to heightening audience engagement.

As part of the *Colour of Music* (CoM) project (Ng *et al.* 2013, 2014) , we have been working on the concept of sound-colour mappings as a means of exploring *visual hearing*; this has primarily been through the application of reactive graphics that are generated from documented synesthetic phenomena. The concept has been prototyped and successfully premiered in a concert at the Sage Gateshead, in collaboration with the Royal Northern Sinfonia at the International Colour Science Convention, AIC 2013 (Association Internationale de la Couleur).

Building upon this existing project, *Musical Chair* seeks to further extend the core concepts behind CoM and transport it to a wider, more varied audience as an installation. Focussing on the development of a creative application for sound-colour synaesthetic mappings, this work is realised as an interactive multimedia installation for generative visualisations, hosted at the International Centre for Life (*http://www.life.org.uk/*), Newcastle, UK. This paper gives an overview of the project.

2. BACKGROUND

2.1. SYNAESTHESIA

Although our senses are inherently interdependent and multimodal (Daurer 2010), synaesthesia exists as a neurological phenomenon where the stimulation of one sensory modality results in an *extra* sensory perceptual response in another (Calvert *et al*. 2004, Ward & Mattingley 2006). Common manifestations of this sensation include the perception of colour for music, phonemes, numerals and letters, and 'tactile shapes' for taste. In the context of this project, the music-colour synaesthetic relationship is explored. There has been a range of research to study and quantify both the neurological and perceptual response of synaesthetes. When measuring a subject's response to musical tones, Neufeld *et al.* (2012), measured increased activity in a region of the brain involved in multimodal integration for music-colour synaesthetes. Paulesu *et al.* (1995) derive similar results when analysing brain activity in music-colour synaesthetes.

Music-colour association has a rich history within both the sciences and arts. An early scientific association of the two domains is detailed by Newton (1704). Historically, visual and auditory artists have mutually served as each other's inspiration. A direct transposition of this is characterised in the impressionist movement, particularly the work of Debussy. Additionally, musical timbre is frequently described as the 'colour' of music. Research into the music-colour synaesthetes perception of stimulatory audio has produced varied responses, reflecting the subjectivity of the phenomenon. Colour synaesthesia is generally individual. Despite this, there are several features that exhibit more common trends (Hubbard 1996; Marks 1974). These include: (i) pitch and brightness; (ii) loudness to size; (iii) colour and frequency. Many composers and artists, including Messiaen, Ligeti and Sibelius report synaesthetic responses that influence their work. This body of research, alongside other pre-existing literature, provides the basic principles behind the mapping strategies developed in this project.

Our mapping is based on the "common trends" as described above. Actual frequency-to-colour is not our focus, nor is trying to directly reconstruct synaesthesia. However, we have compiled a collection of mappings based on documented synaesthetic records of composers such as Scriabin, and we can select one of these mappings for the visualisation engine. We view these synaesthesia-influenced mappings as a means of enhancing multisensory integration, primarily for an audience that do not experience such perceptual phenomena (Hertz 1999).

2.2. TECHNOLOGY-ENHANCED LEARNING AND VISUALISATION

Through effective mappings, visualisation can enhance aspects of the data that are not apparent in its raw form. MacRitchie, Buck and Bailey (2009), visualised musical structure through motion capture of a pianist's performance gestures. This visualisation confirmed a relationship between upper body movements of a pianist and composition structure. The techniques have been applied in a wide range of contexts including multimedia performance and technology-enhanced learning. Oliver and Aczel (2002) and Ng (2011) reported accelerated learning using visualisation. Ng *et al.* (2007) and Ng (2011) discussed the i-Maestro 3D Augmented Mirror system, which increase awareness of bowing gesture and body posture using real-time visualisation and sonification.

3. DESIGN AND DEVELOPMENT

We have adapted existing visualisations and mappings (Ng *et al*. 2013), transforming them into an interactive installation. The installation features up to three sensor seats integrated with a cajon (a box-shaped percussion instrument, played by hitting/drumming the front or rear surfaces with the hands or fingers). It can be played either as an ensemble or solo. Through the sound-colour synaesthetic mapping, visitors are able to *see* the musical sounds that they are creating in real-time.

Participants are to sit and play the instrument, improvising rhythmical patterns and musical sounds, which affect and interact with the visualisation.

3.1. SYSTEM DESIGN

The cajon provides an accessible instrument interface, available in a range of sizes. It is easy to start playing, even by younger children and non-musicians, and it is able to produce a wide range of sounds.

Each cajon is augmented with a contact microphone (we use a piezo for this installation) and load bar cell sensors. The piezo signal is amplified and connected to a Raspberry Pi via a USB audio interface and the audio signal is used for hit detection and spectral analysis. The sensors consist of four strain gauges connected to an mbed microcontroller (*http://mbed.org/*). The set of load bar cell sensors measure a seated person's weight distribution. These are enclosed under the top surface and are used to determine the seated balance of the player. The audio data and position information are then packaged and transmitted over a local network to a central PC for visual mapping, rendering, and audio prompt (or a machine playing companion) (see Fig. 1).

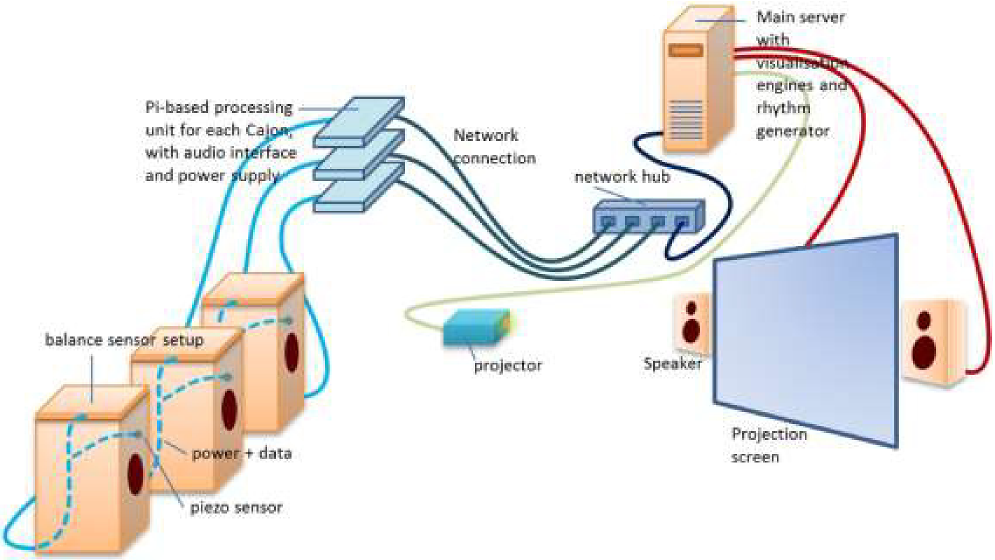

Figure 1 System setup.

3.2. DETAILED DESCRIPTION

3.2.1. SEAT MOVEMENT

An existing cajon build-kit design by Meinl (*http://meinlpercussion.com/*) was adapted for the purposes of this project. This included the addition of a wooden top that houses four load cells (or strain gauges) on each side. This arrangement means the movement of someone seated on the device will cause resistance changes in one or more of the load cells, which are converted into voltage changes and individually amplified and then digitised before being transmitted to an MBED microcontroller.

3.2.2. MICROPHONE

A single contact microphone (consisting of a Piezo electric element) is secured to the front panel inside the cajon, to pick up vibrations when the panel is struck; this signal is then amplified before being transmitted to the Raspberry Pi, via a miniature USB interface for audio analysis (see Section 3.3).

3.2.3. AUDIO ANALYSIS

Audio is streamed from the contact microphone at 44.1kHz/16bit using a USB audio interface. Advanced Linux sound architecture (ALSA) is used to digitise the audio signal. Hit detection is performed using a dynamic threshold at 3 times standard deviation with the background (non-hit) signal mean updated on the last 30 seconds of data. The threshold can be configured to reflect upon the acoustic characteristic of the environment.

Once a hit is detected, a buffer of 2048 samples is passed to a fast Fourier transform (FFT) engine to detect the fundamental frequencies and their related amplitudes that are used for the sound-colour mapping. To perform the FFTs, Andrew Holme's GPU_FFT library has been integrated (see *http://www.aholme.co.uk/GPU_FFT/Main.htm*). Due to the Pi being headless, the GPU can be utilised for processing. According to Holme (2014), the approach is up to 10 times faster than running the FFTs on the main processor. The magnitudes of the FFT array are estimated as square sum of the real and imaginary parts, and the frequency domain data is analysed.

We select up to 5 FFT bins with the largest magnitudes. These frequencies, their corresponding magnitudes, along with the RMS of the detected hit and time-stamped onset, are added to the socket send with the unique identifier of the cajon. Additionally, the package also consists of a flag bit to identify whether someone is sat on the instrument and data from the load balance sensors and sent to the machine handling visualisations. The data sent to the main PC can be mapped to visual and sonic parameters for rendering.

3.3. INSTALLATION

Two augmented cajon instruments have been used at our latest installation at the Maker Faire UK, Centre for Life, Newcastle, UK on 25-26 April 2015. Software including a visualisation engine and a machine playing "companion" package are installed on a machine that receives data from the cajon instruments.

The visual projections include an instructional video that plays when the system is dormant. When a member of the public sits on the cajon, it brings the installation to life, guiding them through a percussive exploration of tempo and simple rhythmical patterns with visual and auditory instructions. The software has been designed to provide a 'tempo challenge' to the museum visitors.

The tempo of an accompanying drum machine decreases and increases over time. The challenge for the visitor is to stay in time with the machine drum tempo, supported by the visualisation. The machine tempo information is sent to the visualisation engine for comparison with detected onsets. Using a bank of pre-set patterns, the companion's rhythmic content changes over time. It allows for musical structure variation, whilst encouraging a progression of complexity, through increased syncopation and polyrhythm.

The visualisations build on work from the aforementioned Colour of Music project; transforming the sound and gestural input from the players into real-time visual interactions. In this installation, we explored visualisation to convey the feeling of tempo and rhythms. A visually represented interplay between the abstract animations from the visitors and the machine-companion is used to communicate the correlations and synchronicities of individual tempi, while highlighting differences in their rhythmical patterns. By cycling through different programs, the system keeps the visualisations fresh and engaging for the users. Each program features different textural qualities and frequency-to-colour mappings.

The visualisation system is driven by multimodal user input to provide an intuitive system of visual feedback. The underlying design of the system consists of centrally positioned, user-controlled objects and peripheral machine-controlled objects (see Fig. 2). The peripheral objects respond to the auto accompaniment, and act as visual cues – conveying rhythmic information to the user. The central objects respond directly to the users' interactions.

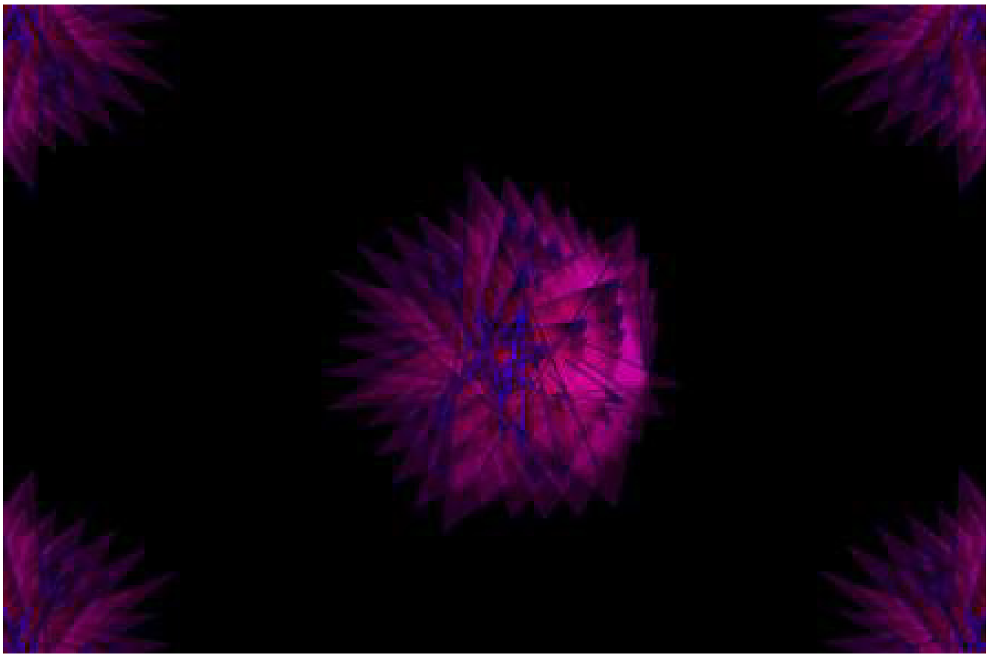

Figure 2 Example visual feedback.

User-controlled objects respond to user input via three parameters: position, colour and size. The position of the object is controlled by the position of the user on the cajon (via information received from the strain gauge sensors). The colour and size of the object are controlled by information from the audio analysis, where the colour fluctuates according to the frequency content of the hit, and the size changes according to the loudness of the audio stream. If two visitors are interacting with the cajons, the screen is split in half so as to display two central objects. This visualisation strategy is also applied to the machine companion player, which is located around the edges of the display, growing towards the centre in accordance with loudness.

4. CONCLUSION AND NEXT STEPS

Based on the concepts outlined in this paper, the approach of ICSRiM's visual mapping strategies has transitioned from real-time concert performance to live interactive interface for installation. At the Centre for Life, the system has logged every beats of users' time difference verses the machine drum to measure how long individuals take to match tempo and rhythmical pattern changes and variations. The next step is to analyse the data recorded from the installation to understand how people interact with the system to study the impact of visualisations as a tool to guide percussion tempo interpretation in an edutainment scenario.

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HUG ME – A TANGIBLE INTERACTIVE MULTIMEDIA INSTALLATION THAT EXPLORES HUMAN SENTIENCE

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ABSTRACT

Sentience is one of the singularities that distinguish us as humans, and hugging is one of the gestures that may have several feelings behind it. A hug may be associated with feelings of love, happiness, joy or just be a social behavior, among others. This paper describes the concept, validation and implementation of *Hug Me*, a tangible interactive multimedia installation that explores human emotions and participants' feelings, based on how they hug. The installation consists of a mannequin with sensors that detects when a participant hugs it. According to the characteristics of the hug, it perceives what the participant may be feeling and creates an audiovisual ambience in consonance with that feeling. The paper describes also the scientific investigations and validation of the installation.

KEYWORDS

Hug, Sentience, Human, Feelings, Interaction, Tangible, Installation.

1. INTRODUCTION

Sentience is one of the singularities that distinguish us as humans, and hugging is one of the gestures that may have several feelings behind it. A hug may be associated with feelings of love, happiness, joy or just be a social behavior, among others. Hugging is also an intimate form of touch. In fact, several studies suggest that ever since we are born, the human touch and human hug is essential for our personal development (Stack 2009). Nevertheless, our society now faces a challenge of human touch scarcity, in much due to the social isolation that came along with the widespread adoption of technological communication (Turkle 2011). This social isolation makes us less prone to accept others and ourselves as physical beings, makes us believe that the sense of friendship and belonging is achieved by likes, followers and virtual friends. As an antithetical approach to this new inhibition of touching and hugging, we sought to create an artwork that explores human sentience based on a return to the human hugging, highlighting this tangible act as an initiator of collective memories and social culture.

This paper describes *Hug Me*, a tangible interactive multimedia installation that further explores human sentience, by inviting participants to hug an anthropomorphized interface that creates a digital ambience representing their sentiments during that hug.

2. CONTEXTUALIZING

Several realms of digital media and interactive art are significant to trace the area of focus and groundings of *Hug Me*, namely:

1. Projects that explore the act of hugging as a way of reconnecting people to one another (throughout remote communication). The concept of digital systems recognizing hugs or producing the sensation of being hugged is explored in several works, mainly aiming at improving the communication experience between people over long distance. Under these, we should refer *Hugvie* (Nakanishi et al. 2013), a cushion with a minimalistic human form, meant to be hugged while people are communicating with each other. A microcontroller receiving data from a mobile phone will make the doll vibrate to recreate the heartbeat, creating a richer communication experience between them. Also, the *Like-A-Hug* (Wills 2012) project, which is a "wearable social media vest", designed to inflate like a lifejacket when friends "like" a photo, video, or status update on the wearer's Facebook wall. Besides these projects regarding remote connections between people, there are also projects that intend to foster interpersonal social touch. In *Hugginess* (Angelini et al. 2014), a wearable system based on smart t-shirts with conductive fabric, the hugs are recognized and used to reciprocally exchange digital information during the touch, encouraging people to have physical contact.
2. Projects that explore the act of hugging as a metaphor (a conceptual reflection of connecting people to the artwork). In fact, several ap-

proaches have applied the physical act of hugging to create proximity between the participant and the artwork, namely as a metaphor of the symbiotic relationship between humans and the concept that grounds that artwork. We find it on projects such as *oneHug* (Praschak 2010) and *hug@ree* (Mendes, Ângelo and Correia 2011), which seek to amplify the bond between participants and the environment, specifically through the act of hugging.

3. Projects that explore human sentience and sentiments through digital interactive systems. On this field, *We Feel Fine* is “an emotional search engine and web-based artwork whose mission is to collect the world’s emotions to help people better understand themselves and others” (Kamvar and Harris 2011, 117). It searches throughout user-generated content (specifically from blogs, micro-blogs, and social networking sites) for sentences that express user’s sentiments and presents them in an interface that allow users to search or browse about these sentiments. It should be noticed that we do not directly address the academic field of sentiment analysis as research in this area has its main focus on algorithms for opinion extraction and categorization (Kamvar and Harris 2011), which is not the focus of our work.
4. Also worth to call to the context is the field of surrogate human interaction, with affective humanoid social robots that “extend the realm of communication to the machine world by playing the role of humans” and of which some “are designed to trigger human emotions” (Zhao 2006). Although this is not the central focus of *Hug Me*, it might be an area for future developments, as the act of hugging itself substantially increases oxytocin levels, even when using surrogates, and the oxytocin hormone has an important role in social bonding (Lee et al. 2009).

The research areas exemplified by these works express the wide representation of hugs and sentiments within digital and interactive media. Maybe the extensive exploration of these topics is due to the high significance they have for us as both individuals and social beings. But those technologies are the same setting us apart from the human touch, as supported by Turkle (2014). So, following the statement of Steffen and Bluestone, “the way artists use and misuse emerging technologies in their work can prompt deeper reflection about our society than a two hundred page report written by eminent sociologists can” (2011, 96), *Hug Me* seeks to engage participants in a deeper reflection about the human sentience that resides in the real interpersonal human relationships.

3. HUG ME

3.1. CONCEPT, PITCH AND PROJECT OVERVIEW

Hug Me further explores the fusion between the participants and the act of human touch, by creating a virtual representation of participants’ feelings based on their hugs. Using sensors on a mannequin, the system understands different hugs and the feelings associated with each of them, based on participants' arms position, the hugging strength and duration. When it senses that a hug is given, audiovisuals with memories associated with the feeling detected are projected around the place where the person and the mannequin are (Fig.1).

Figure 1 General view of the installation

3.2. SCIENTIFIC VALIDATION OF THE CONCEPT AND CONTENTS

The first thing necessary for the project was the scientific validation of the concept, the contents, and user interaction, specifically in four topics, each guiding a research stage (RS):

- RS.01: Understanding which feelings may be implied in a hug;
- RS.02: Understanding how does the human body express each of those feelings.
- RS.03: Understanding how should those feelings be represented (this RS is divided by several others, one for each feeling, following results of RS.01).
- RS.04: Understanding how can a digital system recognize those feelings.

RS.01 – UNDERSTAND WHICH FEELINGS MAY BE IMPLIED IN A HUG.

During this RS, we sought to understand some basic concepts about the act of hugging, specifically why do people hug, what can a hug mean and which feelings may be implied on a hug.

It might not seem difficult to define a hug. On a basic description, a hug is a form of physical contact between two (or more) living beings, where one puts their arms around another and holds them closely. This physical contact is usually executed when a person has feelings towards another, or done as a social behavior. The act itself will trigger feelings on both (or all) the persons involved in the act.

Despite the importance of the act of hugging (*e.g.* Bloom 1995, 239), we realized that the correlation between this gesture and human sentiments is sparsely scientifically studied. In fact, an extensive search in all major scientific databases[1] returned very few results related with the act of human hugging and its relation with emotions and feelings, and none that would provide us valuable insights for a comprehensive understanding of the human sentiments implied in a hug. Accordingly, we needed an approach that would allow us to validate a concept of the act of hugging and, more specifically, what may this gesture mean in terms of human feelings. To do that, we conducted a semi-structured interview to a medical PhD in psychiatry, specialized in human relations.[2] To structure this interview, we previously performed a broad search about the act of hugging in user generated content. Two trained students searched for questions, opinions, sentences and reflections about the act of hugging that people usually make in generalist online platforms, such as blogs and social networks. Our purpose with this search was to assess how the act of "hugging" is expressed and understood in popular culture, and then use the results of that assessment as a base for the interview. As stressed by Hannula, Suoranta and Vadén, *"the value of studying (popular culture) lies in the fact that (it is) perceived as representing and presenting that reality in which people live and which they produce through their own actions"* (2005, 72.)

The analysis of the interview resulted on a list of broad settings for people to hug:

- *Setting 1.* People hug because they feel in love for each other;
- *Setting 2.* People hug when they share some reason to feel joy or happiness;
- *Setting 3.* People hug when one (or more) of them is leaving or arriving back;
- *Setting 4.* People hug for protection or comforting someone;
- *Setting 5.* People hug in social situations;

Each of these settings has one or more feelings implied. Settings 1 and 2 are directly connected with the feelings implied, namely love for setting 1 and happiness for setting 2. In setting 3, the feeling implied is a deep emotional state of nostalgia or profound melancholic longing. It should be noted that this feeling occurs when people are departing, not when they get back together. When people are getting back together, the feeling is of joy and happiness (setting 2). In fact, people do not say "I miss you so much" to someone that is arriving, people rather say "I have missed you so much", which means that the feeling of longing is actually gone by then. Setting 4 (hugging for protection or comforting someone) cannot be considered a feeling. The act is usually done between two persons who have feelings towards each other, but is not a

1. *e.g.* Scopus, EBSCO, Web of Science, Science Direct, Google Scholar, Microsoft Academic.

2. We would like to thank Professor Júlio Machado Vaz for his participation on this project.

feeling *per se*. For instance, when a mother hugs a child for protection, the feeling implied is (usually) love. Setting 5 may happen for several reasons, but generally implies one of three situations: a) people don't have any feeling, and the hug is only a social behavior; b) people are happy for some reason (for instance, a great notice at the workplace), in which case we have feelings of joy or happiness (setting 2); or c) the hug is not expected or "not welcome" – which creates a situation where one or both parts feel uncomfortable.

Accordingly, with results from the interview, we defined four major feelings that might be implied on a hug: love, happiness, longing and discomfort. Thus, these were the feelings we selected to include in the project.

RS.02 – UNDERSTANDING HOW DOES THE HUMAN BODY EXPRESS EACH OF THOSE FEELINGS.

To understand how the human body reacts when giving (and receiving) each kind of hugging, we made a semi-structured interview to a theatre choreographer and teacher in a theatre school. Along with this, two of the participants on the project attended to lessons on a workshop of body language and emotions expression, specifically organized by the same theatre school. The entire interview and the classes were recorded in video for subsequent analysis. From the analysis of the interview and the workshop classes, we reached some outcomes about how the body expresses each of the feelings defined during RS.01. Next, we briefly expound some of the more relevant.

Hugs that are related with feelings of love have a lot of body contact, are strong and durable hugs and the touching area is on the lower back, near the waist. In a hug of happiness or joy, the most important factor is the starting velocity. The bodies embrace and attach to each other very strongly, almost like they are seeking to merge. This is a very intense and strong hug, where the stronger contact is made by the arms and not by the body. Longing hugs are long and with gradually decreasing strength. The areas commonly touched are the shoulders. Uncomfortable hugs are slow, without rhythm, without strength, with the minimum possible contact. Only the upper parts of the torso are slightly in contact, as people try to keep as much distance from each other as they can.

RS.03 – UNDERSTANDING HOW SHOULD THOSE FEELINGS BE REPRESENTED.

To comprehend how should those feelings be represented, we pursued to assess the popular understanding and imaginary for each feeling, again valuing the inclusion of popular culture. Accordingly, an online questionnaire asking about which memories the respondents associate to each feeling was sent to about 8230 people, of which we received 282 answers. The questionnaire comprised 4 open questions, one for each of the aforementioned feelings, each of them asking "Which memory or situation first comes to your mind if you think about [*the feeling*]".

We chose to make only open questions as the objective was for each person to share their personal experience, memories or imaginary. The analysis of responses focused on memories more connected to specific images, possible and real situations, and that were not redundant on feelings. For example, we would not consider an answer like "being in love is to feel the happiest person ever for being with someone" for the love feeling, as it expressed the feeling of love with another sentiment. Also, we excluded images directly connected to hugs, as it would not convey any distinctive view about that feeling (for example, for the love memories, if someone answered "two people hugging"). From this analysis, a total of 111 memories or images were selected: 34 for happiness, 24 for love, 29 for longing and 24 for discomfort.

RS.04 – UNDERSTANDING HOW CAN A DIGITAL SYSTEM RECOGNIZE THOSE FEELINGS.

From the results of the research made during RS.01 and RS.02, we realized that the main characteristics of the different kinds of hugs are the strength, time and body position (arms and torso). Accordingly, a digital system is able to understand humans' feelings based on these parameters of each hug. Hence, the basic system to recognize participants' feelings based on their hugs includes pressure sensors attached to a mannequin (as it will be more natural to participants to embrace an anthropomorphized form) that delivers data to a computational system that decodes the feeling and plays audiovisual contents in the surroundings.

3.3. DESCRIBING THE INSTALLATION AND THE PARTICIPANTS' EXPERIENCE

Hug Me is an interactive multimedia installation that creates virtual environments according to how people hug. The installation consists of a mannequin, placed on an empty dark room, with a low glowing light and an inscription with the sentence "hug me" written on it, on the top of the mannequin. In the room, there is ambiance music playing all the time, along with voices that call the participant to hug the mannequin.

When the participant reaches the mannequin and hugs it (Fig.2), the system immediately triggers a blinking red LED in the mannequin's chest (the place of the heart) along with the sound of a heartbeat. This feature has a dual purpose:

- it seeks to simulate a heartbeat to create a more realistic experience;
- it provides real-time feedback to the participant. As time (duration) is one of the metrics the system uses to understand the feeling behind each hug, it could not trigger the audiovisual feedback immediately. According to Krueger (1977), "Response is the medium", meaning that interactive systems need to give immediate feedback to users' interactions, otherwise it may become either uncomfortable or confusing to the participant if he/she performs some action without any feedback from the system.

Figure 2 User hugging.

When the system recognizes a given feeling, it triggers the audiovisual contents related with that specific feeling (Fig.3). Also, the system records data from that hug on a database.

Figure 3 Room with visuals.

The data from all the hugs will then feed an application that shows the prevailing sentiments of all participants through data visualization. This application, called "The Room's Mood" (Fig.4) got inspiration from "We feel fine" (Kamvar and Harris 2011). It consists in glowing patterns of different color, created and modified in real time, according to data from the hugs given so far. For each of the feelings, a color has been attributed, according to the colors usually related with it in color psychology literature: pink for love, yellow for happiness, blue for longing, as it has been associated with tenderness and sadness, and grey for discomfort, as it is associated with negative emotions. These options were grounded on findings and recommendations of (Cherry n.d.), (Brave and Nass 2002) and (Hemphill 1996). The patterns are blurry and change slowly in random directions. However, the degree of each color on the canvas is always directly proportional to the data received from the hugs given by participants. This application is used to change the color of the walls outside the installation location, according to the predominant feelings at each moment. This way, the installation explores the feeling of each participant as an individual (whenever it is hugged and triggers the audiovisuals related with the feeling it senses) but also the feelings of the participants as social humans, whose feelings are interdependent of people around them.

Figure 4 ”The room's” mood projection.

3.4. AUDIOVISUAL CONTENTS CREATION

The audiovisual content to be played by the installation was created based on the analysis of the responses to the questionnaires done during RS.03. We filmed 122 scenes for the 111 memories chosen from that research. We also used some clips from YouTube and Vimeo because we wanted to enrich participants' experience with content derived from spontaneous and free online sharing from anonymous users to the (virtual online) world. The few selected clips were under a Creative Commons license and therefore with permission for non-commercial use.

For the editing of the video, we searched in specific web-forums for guidelines for the use of effects on video adequate for each feeling. The final concept for the editing was:

- *Love:* Black and White images, slow movements;
- *Happiness:* use of a yellow glare, with a slightly blurring filter;
- *Longing:* Sepia toned colors, with ‘8mm camera’ effect;
- *Discomfort:* cold toned colors, sharp images, and high contrast;

All the videos were edited according to these visual effects (Fig.5). A fact about this editing is that some footage was used for more than one feeling (as the same memory was referred to more than one feeling on the questionnaire answers) and it did actually provided a different sensation (feeling) depending on the effect used (as reported by participants – see point *4. Results on participants' experience*).

Figure 5 Examples of visual aspect of footage after edition for each sentiment.

The audio for each film sequence was selected from the Mobigratis.com website, a website that provides free music from the catalog of the musician Moby for independent, non-profit videos, films or shorts, via a simple online application system. Two trained students selected music tracks that would fit the video sequences for the representation of each feeling, which were edited (cut) to fit the time of each sequence.

When a sentiment is detected by the installation, it randomly triggers one of these audiovisual sequences, according to the detected feeling (per example, if the sentiment of love was detected for the given hug, it would trigger a random audiovisual sequence about love).

3.5. IMPLEMENTATION AND TECHNICAL OVERVIEW

The technological requisites for the system summarized in Fig. 6 were defined during RS.04.

Participant's hugs are translated into digital data using Force Sensing Resistors (FSR) connected to an Arduino board microcontroller. The data is forwarded to a computer where an algorithm detects the type of hug based on the pressed areas, the strength and the duration of the pressure. Then, the system plays related audiovisuals and saves the result sentiment in a database that might be used for future analyses and developments. The 12 sensors were placed according to data gathered during RS.02, as seen on Fig.7. According to data acquired during that research, this would be the number and places we needed to measure the three aforementioned characteristics for each hug. During the interaction, the microcontroller also triggers a "heartbeat" on the mannequin (high intensity red LEDs blinking along with sound) with the dual purpose of creating a more realistic experience and delivering immediate feedback to participants.

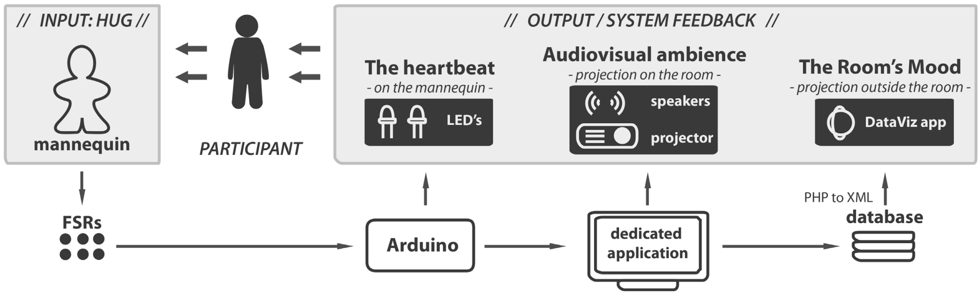

Figure 6 System technical overview.

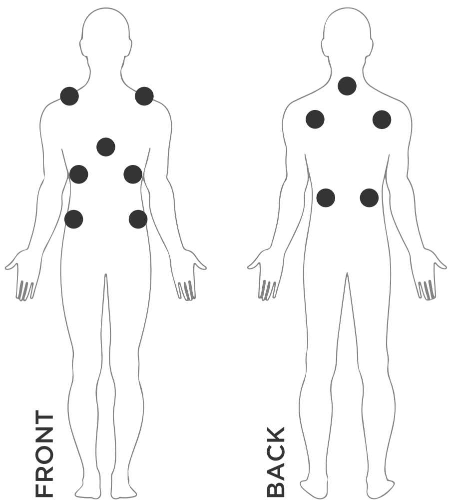

Figure 7 FSR's positions on the mannequin.

Using previously saved database data, "The Room's Mood" application generates data visualization with the percentage of hugs for each feeling that is projected outside the room. This application (developed in Actionscript 3) queries the database through a PHP bridge that processes and delivers data in the form of an XML file.

4. RESULTS ON PARTICIPANTS' EXPERIENCE

The analysis of participants' reactions during exhibitions was made through observation and open questionnaires, and focused mainly on three points: the overall experience (in terms of individual appreciation); the personal perception of the system accuracy; and perceived suitability of contents to represent each feeling.

Results suggest that most of the times the system accurately recognizes the feelings when a hug is given. We say "most of the times", as it should be noted that some participants could not specify the feeling they were having. Many of them answered with sentences that began with "I don't know, maybe it was (...)". Also, these results are prone to bias: if participants were asked after the experience what each of them was feeling whilst hugging the mannequin, chances are that at the time they would be influenced by the experience they just had. On the other hand, if the participants were asked before the experience, it would influence their behavior during the experience and therefore, the way they hug. One future development would be to develop a more reliable measurement instrument to assess with the system's accuracy.

Results concerning participants' perceived suitability of contents to represent each feeling are more reliable and suggest that most participants and viewers recognized each digitally created ambience (according to the chosen memories for each feeling) as a correct representation of that sentiment. These results are suggested by both the answers to questionnaires and observation of general bystanders. In fact, participants had many people around them, usually people waiting for their time to hug the mannequin or after that, with curiosity to see others' participation. These viewers would often express or comment with sentences such as "wow, it's happiness" (or any other sentiment) when the audiovisuals were triggered. During our observation time, all these sentences correctly told the emotion the system was recreating. Thus, we may affirm that people's imagery of sentiments (gathered by self-administered questionnaires – see RS.03) may be considered a reliable source of information for a commonly recognized representation of those specific sentiments.

Last, but not least, one commonly observed behavior of participants after the experience was to go and hug bystanders they were with (Fig. 8). It might be that, in fact, the act of hugging did increased participants' oxytocin levels, developing their pursuing for social bonding, as we have postulated earlier. Or maybe seeing those images of sentiments projected reminded them of what really matters: the importance of physical connection with people they love. Either way, this suggests that the installation did influenced people to go from interact with a digital system to personal human-to-human interaction.

Figure 8 Participant embracing and kissing his partner after hugging the mannequin (hug recognized as "love").

5. CONCLUDING THOUGHTS

Hug Me further explores a connection between participants and what makes us humans: our ability to develop feelings, along with the need for physical contact with the dual purpose of nourish and express them. The anthropomorphized interface of Hug Me, along with the act of embracing it in order to experience the artwork, becomes a metaphor of human sentience. In fact, the way to interact with the installation also becomes part of the piece: when each participant embraces the mannequin, he bonds and merges with the artwork itself. The audiovisual feedback is an expression of the participants' feelings, actively interpreted by the system. The artwork is that feedback: the representation of the participant's feelings (not the physical installation itself). Van Dam said: "I think, therefore the computer gives me what I thought about" (1997, 64). Hug me expands this concept towards the realm of human feelings: I feel, therefore the computer gives me back what I am feeling about. But we agree with Turkle when she says, *"robots can't empathize. They don't face death or know life"* (2014). Digital systems might be able to understand, represent or even mimic sentiments, but we are the ones who really feels them, and that is what makes us humans.

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NOW AND THEN: THE POSSIBILITIES FOR CONTEXTUAL CONTENT IN DIGITAL ART

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ABSTRACT

The paper begins by considering the relative lack of emphasis on context (other than that of the technical means of production) in much contemporary Digital Art. For many works, there is no context other than that provided by the computational infrastructure required for to be experienced. Other than this, the work remains identical regardless of physical location, the time elapsed since its creation or who is using it. As an artist interested in social process, this placing of artefacts and experiences outside of some of the usual means for developing cultural meaning and reference is troubling and unsatisfactory (although the point is made that successful works do not necessarily require contextual content to produce a satisfying user experience).

The author then explores what 'context' might constitute for digital art works and how context might be generated and validated in a post-physical age (referencing Walter Benjamin's ideas about reproduction and authenticity and also considering Philip Auslander's taxonomy of live performance).

After this theoretical discussion, the paper then uses the provisional conclusions about the possible nature(s) of digital context to examine ways that increasing access to semantically tagged networked data might allow artists to produce works which embody social (and other contexts) in ways that other, physically based, genres take for granted. Semantic tagging as a context-producing mechanism is examined and ideas about future web and knowledge developments by Tim Berners-Lee and Pierre Levy are explored as potential avenues for generating resources for digital artists.

KEYWORDS

Interactive Digital Art, Context, Liveness, Semantic Web.

1. INTRODUCTION

This paper arose out of the author's experience of making and experiencing interactive digital art, specifically, a growing realisation that in much contemporary digital art there is no context other than that provided by the technical means of its presentation – the type of device or computer that it requires to be presented. Other than this, the work is essentially the same in any part of the world, at any time, and for any viewer. As Tony Sampson puts it,

> "We look at an artwork, we move around it, we study it from different angles and distances. But within the virtual world, this is all utterly removed. And perhaps there is a dangerous process at work here, in which the virtual eats up the real."
> Sampson 2014

In a 'real' artwork (a piece of furniture, a painting or a book), as the physical artefact ages, perhaps being passed from one owner to another, undergoing subtle chemical changes due to oxidation, sunlight or humidity, perhaps sustaining marks or damage through (mis)use, it builds up an accretion of signifiers that are not part of the original work, but which nevertheless are an essential part of the object's authority; a record of its passage, place and significance. So for a book, we might find some pages with corners folded down signalling the location of passages deemed worthy of repeated consultation or, for certain older bindings, uncut pages providing evidence that the pages concerned had never been read. We might find a name written inside the front cover recording the book's original ownership or even perhaps annotations or defacings of the text itself, evidence (feedback) of previous readings that evoked such strong reactions that a reader felt compelled to attack the artefact. Less dramatically, there might be accompanying documentation of previous commercial activity (a bill of sale or a price label) or maybe a musky odour or signs of infestation, testifying to age or conditions of storage.[1] Walter Benjamin identified those parts of a work relating to its history as a work's "aura', details that are part of the received work's materials, but constituents whose referents are partly or wholly exterior to the work; links of association which anchor and locate the work within a wider narrative of culture and consumption, for example its patina and provenance. They are thus not part of the original artefact, but rather extra-textual addenda, aspects of its overall meaning which are concerned with the work's context and which, in turn, inform the reception and significance of the artefact.

These bundled (variable) sets of associations which inform the 'reading' of physical artefacts such as; links to other texts, cues locating the work in a specific time, place or social situation, and distinguishing features upon which perceptions of uniqueness can be founded are often

1. See Gershenfeld 1999:26 for an extended discussion of the affordances of physical versus digital library interfaces.

entirely absent from works whose domain is the digital.[2] As an artist interested in social process, this placing of artefacts and experiences outside of some of the usual means for developing cultural meaning and reference is troubling and unsatisfactory.

Of course, this is not to say that interactive digital art is necessarily flawed, or that there are no digital artists creating works that are situated in a highly specified context; I would argue that neither assertion is the case. Rather, this paper will argue that the nature of the digital artefact, with its innate capacity for exact duplication, necessarily weakens some of the usual mechanisms whereby artefacts acquire relevance and authority although, I will also suggest that technology, particularly ubiquitous networked technology, does provide at least some means for artists to create works which engage with context.

2. CONTEXT AND CURRENT PRACTICE

The recent *Digital Revolutions* exhibition at the Barbican Gallery, London provided an opportunity to experience a wide range of interactive digital media. Some artefacts were avowedly artistic, some presented themselves more modestly as games or demonstrations of technique. Chris Milk's *Treachery of Sanctuary* was a particularly striking and popular work (amongst many others) and perhaps exemplifies some of the ways that contemporary interactive art operates.

On walking into the work's exhibition space, the audience member is confronted by a triptych of large, bright screens set 3 or 4 metres back, separated from users by a shallow reflective 'pool'. The enabling technology, the means of production is completely hidden, but what is immediately evident (since the space was arranged so that the work could be watched as well as directly experienced) was the spectacle produced by other users' interactions; arresting and engaging images which because of their scale and dynamism drew and captured the viewer's attention even without actually engaging with the work themselves. The visual imagery of generated silhouetted birds and angels composited with the dynamically processed image of the user is deliberately intended to reference religious imagery, a key theme of western art:

> "…it is also my intention to reflect the parallel experience of the artist as he journeys through the creative process. This parallel journey hinges on a religious concept."
> Milk 2012b

However, these allusions are general rather than specific, they do not refer to any specific birds or angelic figures; They locate the work as drawing on traditions of expression rather than acting as nodes of

2. Of course the equipment required to experience a digital artifact, where this is presented to users (for example works presented on a games console), may well show signs of its passage through time and its prior usage. Here again though, digital technology's loosening of the link between content and delivery mechanism (for example the importance of open standards and platform independence) means that the capacity for these kinds of contextualisation is diminished.

intertextual relationships.[3] They are also perhaps more appreciable to those watching rather than active participants.

A major part of the work's appeal is ludic and physical, one could observe users playfully experimenting, absorbed in trying to understand the 'rules' behind the piece's operation as they gradually progressed from screen to screen:

> "As the player proceeds through the game, she gradually discovers the rules which operate in the universe constructed by this game. She learns its hidden logic, in short its algorithm."
> Manovitch 1999, 83

The attractions and significance of the piece for the user (and, to some extent for the watcher) is wrapped up in the essential 'liveness' of this process, the playing out of the process of specific discovery associated with this space and artefact with its imposition of 'special' rules that have to be discovered and then the demonstration to an audience that the medium had been successfully mastered. While the work was conceived as a journey for the user,[4] it is significant that the work itself is unaltered by the user's experience, no trace, either physical or digital, is left of the individual's 'performance' other than the photographs many users encouraged their friends to take.

3. CONTEXT AND THEORY

We are familiar with context being part of the overall 'text' in non-digital work; part of the rich mixture of signs and materials which inform the viewer or user's experience of the work and their construction of its meaning. However, as Benjamin observed, any reproduction endangers this aspect of a work of art,

> "In the case of the art object, a most sensitive nucleus – namely, its authenticity – is interfered with… The authenticity of a thing is the essence of all that is transmissible from its beginning, ranging from its substantive duration to its testimony to the history which it has experienced. Since the historical testimony rests on the authenticity, the former, too, is jeopardized by reproduction."
> Benjamin 1936, 215

If mechanic reproduction, with its essentially material nature operating on physical originals imperils authenticity, it is not unreasonable to suggest that digital works, without a physical original and employing a medium in which copies are necessarily indistinguishable from the original, are necessarily challenged in this aspect.

3. I wouldn't want to suggest that references to other digital texts are entirely absent; for example one could suggest echoes of Text Rain (Utterback & Achituv 1999) in the projected interaction between the user's image and the diving birds in the first screen.

4. The Artist actually suggests the work represents two, overlaid journeys,
Each panel in the piece represents a step on a journey. The panoptic narrative interpretation is of the universal human experience: birth, death, and regeneration. But it is also my intention to reflect the parallel experience of the artist as he journeys through the creative process.
Milk 2012b

For interactive digital work, to include contextual materials (particularly over a sufficiently long time span that memory cannot help) requires the incorporation of dynamic generative processes; the work needs to respond not only to the user, but also to some aspects of its context, the time, location, environmental conditions or preoccupations of those surrounding it. Given this, there are clear and close connections to concepts of liveness and immediacy since the contextualising elements must necessarily be dynamic and, as we have seen, many interactive installations already operate, to some extent, as vehicles for performance by users to audiences.

Philip Auslander has argued that, particularly for recorded performances, Benjamin's assertions about the relationship between reproduction and aura need re-examination,

> "…aura is not a characteristic of the object but an effect of the beholder's historically conditioned perception of the object."
> Auslander 2009

He goes on to suggest that the auras of recorded performances contain both elements related to the historical present and transformed traces of the point at which the work was produced. I would suggest that interactive digital art can usefully be considered as a performative form and that such art may indeed generate contexts which reflect both the point at which the work was encountered but also, in some cases, the moment and means through which the work was originally realised.

4. DIGITAL CONTEXTS

It is now necessary to consider what a specifically digital context might be, whether potential dangers and opportunities might emerge and further, how any such digital contexts might be generated and validated in a post-physical age.

Digital technology and the specific means of production can easily, perhaps inevitably, provide another contexts for the activity of digital artists. Most, perhaps all, practitioners would to some extent follow Marshall McLuhan in conceiving technology as an essentially enabling, even liberating, extension of the human body.

> "Today, after more than a century of electric technology, we have extended our central nervous system itself in a global embrace, …we approach the final phase of the extensions of man – the technological simulation of consciousness, when the creative process will be collectively and corporately extended to the whole of human society."
> McLuhan 1994, 19

However, there is another view that cannot be ignored when exploring the contexts of a body of work which has technology at its core. For Foucault, technology was not a neutral tool providing opportunities for artists, but a system for exercising power and control; a set of constraints which necessarily encoded ways of thinking and acting congruent with the controlling power.[5]

> "…technology is the essence of power in its most insidious forms – discipline as that which not only regiments and normalizes the body, pervading it so deeply that it creates, as an instrument of its power, the very facet of ourselves that we are inclined to consider most our own and the least tainted by domination – our self."
> Behrent 2013:87

This aspect of the relationship between power and technology has been identified as a specific weakness of much digital art, an unconscious paradigm of approval, a contextualising assumption through which artists expect their work to be experienced:

> "The inherent technological utopianism of Digital Art is irresponsible, naive and dangerous."
> Fuller and Morrison 2004

However, it can be argued that technology is both threat *and* opportunity for those making digital art. Indeed artists working in all media both physical and digital have often used the symbols and objects of power in ways that subvert and critique the ways power is exercised.[6] If digital artists are excited and stimulated by the possibilities they are given by digital tools, they also have the artist's habits of dissent and creative invention which may help them evade the constraining effects of technology.

5. DIGITAL CONTEXTUALISATION RESOURCES

If digital utopianism and techno-conformity are the concomitant potential negatives of making art using digital technology, part of the opportunity offered to digital artists is the potential for accessing data, particularly semantically relevant data. The importance of managing information in ways that permit the following of human-significant referential links has been recognised since Vannevar Bush's seminal 1945 paper describing the (imaginary) *Memex* machine,

> "The human mind does not work that way. It operates by association. With one item in its grasp, it snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain."
> Bush 1945

The associative links identified as crucial by Bush are implemented in digital systems through the use of *metadata*, additional information that is added to pieces of digital data that specifies its significance and associative relationships. This tagging (adding of metadata) commonly goes far beyond indexical affordances supporting the simple association of items by order or date, indeed metadata can often be significantly

5. For a detailed and thorough examination of this view of technology that concentrates on digital technology, see Schiller, 1981.

6. In the field of digital art, one could mention the organisation Furtherfield (*http://www.furtherfield.org/*) and the artist Stanza (*http://www.stanza.co.uk/*)

larger than the data item it relates to.[7] Tagged data becomes information that is 'understandable' (or at least readable in terms of significance) by machines and allows computers to support the links of association and emotional meanings between objects that humans enjoy and follow. They are of course some of the same types of associations that in a physical object, produce and validate the object's aura.

The World Wide Web is widely seen as the closest implementation of Bush's imagined information-system, although the database and metadata extensions which might support the more advanced (and significant) chains of reference he describes are only comparatively recent. The development of the Semantic Web, "a web of data that can be processed directly and indirectly by machines" (Berners Lee et al 2001) provides the technical and information infrastructure for large collections of information already accessible on the Internet to be manipulated using human-significant criteria. While it is not universal, the amount of tagged information accessible via the Internet is now very substantial and increasing.

This availability of networked data sources employing semantic tagging, combined with increasingly pervasive network access, together provide digital artists with the potential for a dynamic context-producing mechanism which, following Auslander's idea of the point of contact being part of the basis for the digital work's aura, can infuse the instant of user-experience with some of the contextual content that static, physical artefacts carry (i.e. elements whose associations and significances lie outside the work, and which locate it in a social and cultural context). In the case of the digital work, these external references are generated dynamically using the affordances of semantically enhanced data.

6. DIGITAL CONTEXTUALISATION PRACTICE

While the suggestion that the combination of the Internet and metadata could provide digital artists with the facility to reinvest objects with an aura may be accepted in principle, to understand some of the potential, it is necessary to look at some specific implementations of digital work that addresses ideas of context. One example is the *Remember Me* project (De Jode et al 2012). In this project, those donating articles to second-hand shops were asked to provide details of the object's history and significance. This information was then placed in a database and before being placed on sale, the article was tagged with a code allowing a buyer to go online and discover an item's history. The digital system is providing a context-supporting infrastructure, preventing physical objects with a discontinuous pattern of ownership from losing their histories of use. Through a fairly simple application of data tagging and networked storage, objects are allowed to become 'special' again due to their previous significances; their auras are digitally reattached.

7. For example, a single tweet message (limited to 140 characters) has an associated metadata accompaniment of several thousand characters, see Krikorian, 2010 for details.

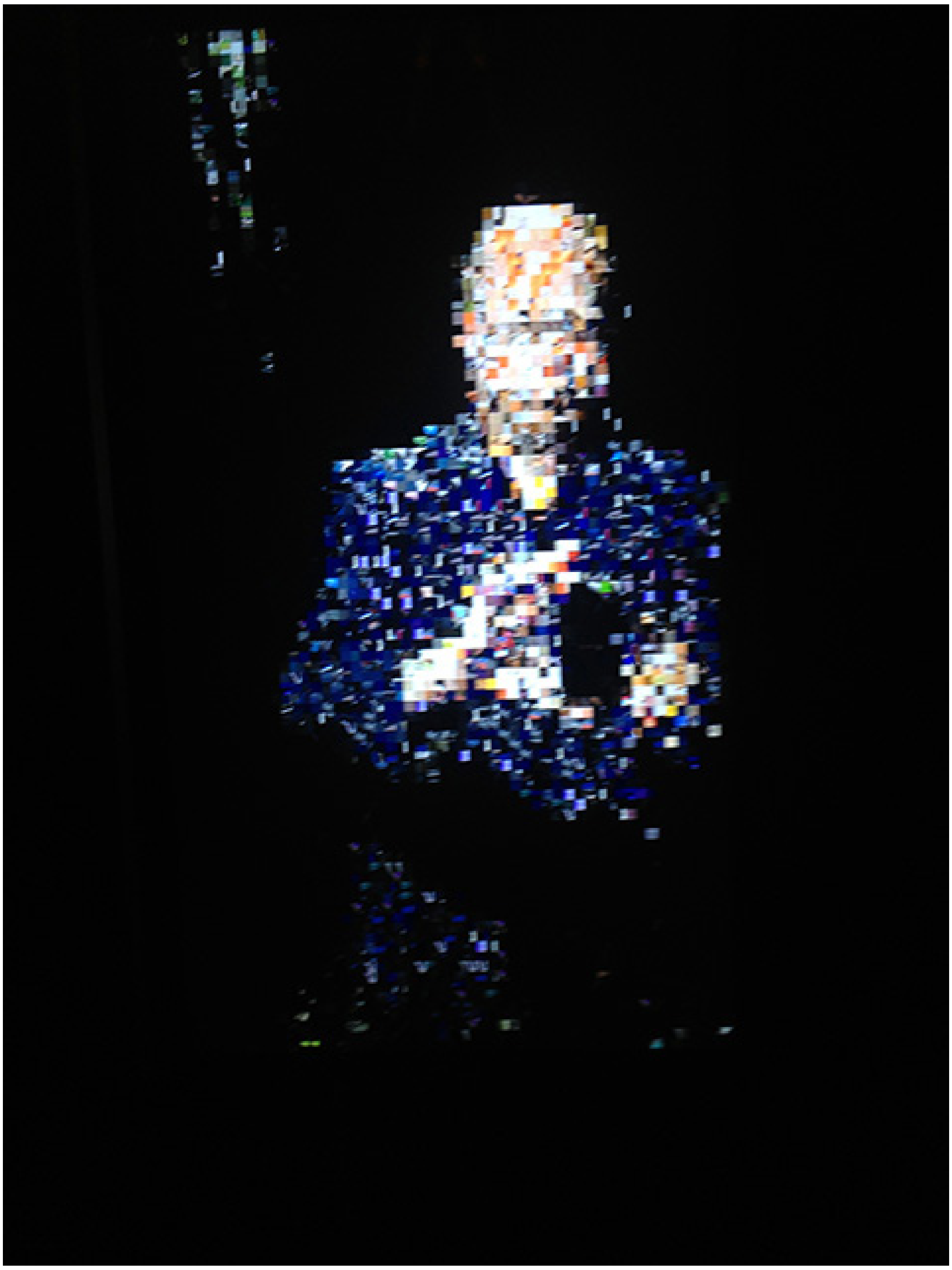

Figure 1 *You. Here. Now.* sample display

The author's *You Here Now* (2013) employs a different approach. In this work, the websites of selected local news organisations are continually trawled for images which are then downloaded and cut up into small fragments. Each of these reflects the preoccupations and priorities of the news gathering organisation it originated from, but because of its size, it is prevented from functioning iconically; it is a part-image, which will usually suggest a larger context, but which will almost never present its references fully formed (i.e. it is unlikely to be a wholly 'readable' image). Each image-fragment is stored with its average colour value in a large dynamic database. The installation appears to the viewer as a screen showing a flickering field made up of thousands of small square elements. When a user stands in front of the installation, their image is registered by a camera and their portrait gradually emerges 'painted' in images drawn from that day's news as camera pixels are replaced by image fragments from the database. The preoccupations of the host society form the context for an image which necessarily reflects the moment of experience.

7. CONCLUSION

You. Here. Now. is part of a long-term project to explore the use of software which uses networked information and semantic metadata to inform a series of interactive and performative digital artworks which explore notions of dynamic context. Thanks to the increasing density of metadata within the overall networked information system, developing tools that use this developing facility for machine 'understanding' to produce contextually significant digital artefacts is becoming increasingly feasible. The contexts available for reference might include real-time data about social media concerns, word associations within searches and other social activity. It is hoped that these projects will result in the progressive, incremental implementation of a Context Library, a software package released under an open source licence, which supports the easy addition of a wide variety of dynamic contextual content to creative digital artefacts.

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PLAYFUL INTERACTION: DESIGNING AND EVALUATING A TANGIBLE RHYTHMIC MUSICAL INTERFACE

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ABSTRACT

In this paper we introduce the Drum Duino, a type of tangible robotic musical instrument. The Drum Duino allows fun, playful interaction for children to compose and explore rhythms played on different objects, inspired by traditional methods of play, while emphasizing collaborative participation. The device combines digital sequencing and programming with physical hitting on objects in order to create a new form of rhythmic music. We present an iterative research through design approach and evaluation with 10 preadolescents using the co-discovery method. Our results highlight the benefits of tangible interfaces such as collaboration and low thresholds of interaction and exploration.

KEYWORDS

Tangible User Interfaces, Sound Creation, Drum Patterns, Arduino.

1. INTRODUCTION

Non-traditional musical interfaces have gained much attention as a way to allow fun and playful musical interaction. Such interfaces expand beyond the metaphor of desktop computing. It allows its users rich experiences such those described by Hornecker and Buur (2006), including externalization, multiple access points, configurable materials and direct haptic manipulation.

Additionally, advances in DIY hardware prototyping (e.g. laser-cutting, 3D printing and electronics platforms such as Arduino) are simplifying the design and development of such physical interfaces. Furthermore, these physical interfaces are enabling new creative forms of education and interaction. Combined, these tangible interfaces may create new opportunities for teaching abstract concepts due to the benefits they offer in sensory engagement, increased accessibility, and group use (Zuckerman, Arida, and Resnick 2005). Another benefit of tangible interfaces, according to Xie et al. (2008), is their ability to facilitate increased interaction and concurrent use, whereas in a traditional desktop interface context, active use is often restricted to one person.

The benefits of tangible interaction are also noted by Antle et al. (2009), concluding that a tangible based approach is more successful and faster than the mouse based variant when solving puzzles. These results argue for increased use and exploration of tangible tools for fun, play and learning.

With this paper we explore a musical instrument that is related to what Overholt, Berdahl and Hamilton (2011) have termed *actuated musical instruments*: physical instruments that have been endowed with virtual qualities controlled by a computer in real-time but which are nevertheless tangible.

While Overholt et al. (2011) emphasizes equipping traditional instruments (i.e.: a violin, or piano) with additional abilities, we emphasize the use of everyday surfaces or objects as musical instruments. This principle is recalled by composer Tod Machover (2007) as looking for household objects that make interesting sounds, that could in turn be combined to create new textures, emotions and narratives.

The rest of this paper is structured as follows: in section 2 we describe the Drum Duino. Following this, we present similar work. Section 4 focuses on the method used to test the system. Finally, we report on the results, discussion and outlook.

2. RELATED WORK

The Drum Duino is based on the premise of physical sound generation, rather than sound control or synthesis, and builds on the principle of equipping instruments with computerized components to allow alternative ways of sound generation that is not synthesized.

This is a departure from novel tangible devices such as Block Jam (Newton-dunn and Gib 2003), that produce digital sound by combining, or manipulating physical artefacts to generate or manipulate digital sound. Similarly the Radio Baton (Mathews 1991) uses two batons containing radio transmitters, allowing x, y and z coordinates to be synthesized into music notes to generate music, when tapping or moving the batons across a square. Commercially, the FirstAct electronic drumstick (Small and Izen 2011) is an instrument that simulates drumming sounds when tapping the drumstick against any surface, while Sounds Pegs (Brennan 2013) also turns everyday objects into sources of synthesized music. O'Modhrain and Essl (2004) translate the properties of sand and grain into sound, by combining bags with sand, cereal or Styrofoam with a microphone.

These examples can be contrasted with actuated instruments (Overholt, Berdahl, and Hamilton 2011) such as the Overtone (Overholt 2005), an augmented violin, or the Haptic Drum (Holland et al. 2010), where the frequency of hitting the drum can be increased. In these projects, the emphasis is physical sound generation with traditional instruments.

However, the Drum Duino remains different from both tangible musical interfaces and actuated instruments in two respects. Firstly, it does not digitally synthesize sound and secondly, it allows everyday surfaces and objects to be transformed into sources of music, thus departing from traditional instruments such as drums. In this, it is most similar to DrumTop (Troyer 2012). This device allows the player to put down objects on a table-like surface. Pushing down objects in certain rhythm allows patterns to be recorded. Objects are tapped physically to generate sound. The DrumTop is limited to the size of the objects that can be placed on its surface.

These examples show the possibility of (digital) sound generation with everyday objects, but also the possibilities of augmenting existing instruments to change interaction with music.

3. SYSTEM DESCRIPTION AND DEVELOPMENT

A distinguishing attribute of the Drum Duino is that it does not generate sound through digital sound synthesis, but through physical impact of a push rod, actuated by a solenoid, with another surface or object. The speed and rhythm of the solenoid's pulse can be changed via a circular control panel that mimics the visual language of a Djembe drum. A potentiometer in the centre of the control panel will allow changes in speed, while rhythm can be changed by adjusting the flaps situated around the control panel. Adjusting the flaps (up or down) changes the pattern that controls the rhythm of the pushrod against the surface.

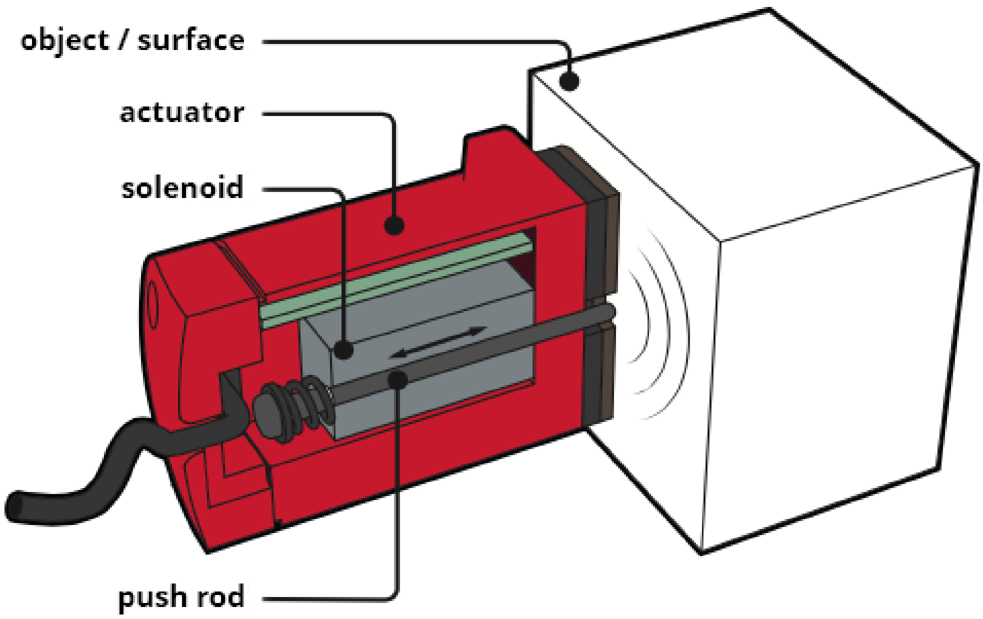

Figure 1 Overview of the actuator, pushrod and solenoid

Actuators are colour coded (red, green and blue), and the control panel also allows storing a flap-pattern to a particular actuator via an associated button. For example, if all flaps are down, and the red button is pressed, the red actuator will play no pattern. Respectively, if only flap 4 is down, and the blue button is pressed, the blue actuator will skip the 4th tap. The control panel remembers the pattern for each actuator; changing the red pattern does not impact the blue or green sequence. As such, combining different actuators with different materials allows different rhythms to be played. The rhythms are repeated indefinitely as long as the Drum Duino is turned on. The interaction with the Drum Duino is very similar with methods of sound creation that many people will recall from their childhood: the banging of fingers, rods or batons against hard surfaces to generate rhythmic sound.

The current design of the Drum Duino was inspired by two earlier iterations that followed the same basic premise, as described by Saldien and De Ville (2013). The design was an improvement, based on the feedback and results of informal tests at the TEI 2013 Works in Progress conference track. The result of these changes is a simplified and more robust device, which was used in an evaluation with preadolescents presented in this paper. As the design of the Drum Duino progressed, our manufacturing techniques evolved from relying solely on manual tools to incorporating digital fabrication to a large extent. The reason for this evolution is twofold. Firstly, manual tools offer a great deal of flexibility in the front end of the design process: they allow quick modifications based on input from early, informal user tests. As the design of the Drum Duino matured, we gradually moved toward digital fabrication techniques such as laser-cutting and 3D printing. These techniques can create more robust, better functioning, and better-looking parts, but require that more time be spent on CAD design. Though, the biggest advantage of digital fabrication techniques in our situation is the speed at which complex components, such as the actuator housing, can be reproduced. We intend to continue this trend in future Drum Duino prototypes by moving toward a modular kit where users are not limited in number of channels or in the length of the beat patterns.

Figure 2 Moving the flaps on the Drum Duino control panel with all three actuators in view

The current version of the DrumDuino this aims to leverage various attributes associated with tangible interfaces. It encourages physical interaction collaboratively in a shared space. Additionally, the system allows direct haptic manipulation of controls, with instant feedback during use, while allowing multiple access points (Hornecker and Buur 2006).

4. METHOD

As stated, the goal of the Drum Duino was to allow fun and playful interaction for children to compose and explore rhythms together, inspired by traditional methods of play, with a low threshold of use, while emphasizing collaborative participation.

In order to evaluate this, we used the co-discovery method, also known as constructive interaction (Kemp and van Gelderen 1996; Als, Jensen, and Skov 2005). According to Kemp and van Gelderen (1996), it is specifically useful to understand experiences and impressions of new products, noting its usefulness in exploring novel artefacts. Using this method, children interact together with the product. Researchers evaluate with questions about use and experience, while observations during co-discovery are also a valuable source of insights. Although Van Kesteren et al. (2003) note that co-discovery results in less verbal comments, when compared with related methods such as think aloud protocols or peer tutoring, Als et al. (2005) found no significant difference between think aloud protocols and co-discovery. However, they stress the benefit of co-discovery since children may have trouble following instructions for a think aloud test. Furthermore, co-discovery has been used in similar projects where the usability of non-desktop based interfaces were evaluated, including a tangible interface for child story telling (Cassell and Ryokai 2001), and tools for children to program physical interactive environments (Montemayor et al. 2002). Given this, we chose to use co-discovery as our evaluation method.

Figure 3 Setting up the Drum Duino together with two participants

Preadolescents were recruited through a technology hobby club for children. Following the recommendations of Van Kesteren et al. (2003), we formed 5 pairs of two children. Participants were socially acquainted through regular attendance of the hobby club and were aged between 8 and 11. Five males and five females took part.

Initially, we demonstrated how the actuators and flaps can be used to trigger sounds and rhythm. Following this, children were handed the actuator and allowed to interact freely with the Drum Duino. The only instruction given was “To create a rhythm”. The children’s interactions were recorded using a camera for later analysis. After being given 10 minutes of free exploration, we started posing some general questions about their experience with the Drum Duino. While we aimed to evaluate the Drum Duino as a device for fun exploration of music, rhythms and materials, our focus for this paper is also to explore the benefits of tangible interfaces (accessible, conducive to group learning and sensory engagement) as described by Zuckerman et al. (2005).

After our demonstration of the Drum Duino, children started a 10-minute free exploration session. This involved turning up the speed, moving the flaps up and down or putting the actuators to the ear as a way to understand the source of the sounds. Additionally, they were asked to associate certain rhythms with familiar sounds (jackhammer), or creating a ticking clock.

5. RESULTS

The actuators captivated the attention more than the control panel. The groups all spontaneously explored the various sounds that could be made with the Drum Duino, through variation of objects, ranging between metal tubes, glass bottles, the table surface or other household objects such as tin cans. A preference was given to loud surfaces. Combinations were also tried: placing the actuator against a block of wood attached to a piece of metal as opposed to a block of wood alone.

While we anticipated children strapping the actuators to various surfaces and then adapting the rhythm by moving the flaps, children preferred much more to hold the actuators against particular materials as a way of exploring sounds and rhythms. This further enforces the exploratory nature of the actuators: they can be quickly attached to any surface to generate sound. Only after many surfaces and objects were inspected did participants turn to changing the rhythm and playing more complex patterns.

Notable enthusiasm for the Drum Duino was due its ability to *turn everything into music* as a participant in the second group remarked. When asked whether they would classify the sounds as music all the groups agreed, although with differing levels of confidence: *it would be hard to make music, but with enough practice, it should be possible*.

6. DISCUSSION

Following the remarks of Zuckerman et al. (2005), we can conclude that tangible interfaces present certain advantages when compared with desktop interface. These include increased accessibility, sensory engagement and group learning. With the Drum Duino, we created a device that has a specific focus on these factors.

6.1. GROUP USE

Especially notable during our evaluation of the system was how the separate actuators facilitated concurrent use. Children freely experimented with the actuators and sounds and there was no disagreement between partners about rhythm creation. Arguably, this might be contributed to the fact that each actuator can be programmed individually, but that the rhythm will always stay in sync during play. Children can thus adapt their own rhythm and sound, using their own actuator, rapidly changing sound by alternating surfaces and objects, without impacting their playing partners' fun.

6.2. ACCESSIBILITY

In contrast with actuated musical instruments discussed by Overholt et al. (2011), the actuators presented new types of instruments. Striking was the ease with which children interacted with the actuators: while the device itself is completely novel, children had no trouble playing and generating sounds. This low threshold of use makes it possible for children to explore patterns and rhythms of ever increasing complexity, with a flat learning curve. For example, even before changing speed or rhythm, it is possible to explore sound and materials, while manipulating the rhythm using the flaps. This allows infinite possibilities in music creation. Rhythm and music discovery is thus presented in a very playful way, with no prior experience of use needed.

6.3. SENSORY ENGAGEMENT

Lastly, from the point of sensory engagement, the Drum Duino presents clear advantages over drum computers that are controlled via GUIs, knobs and keyboards. A central tenet in the design of the Drum Duino is its auditory engagement, achieved through physical contact of the pushrod to various surfaces. As mentioned, for the participants, the easy control of the sound generated by the pushrods combined with assorted objects was the most important aspect of the system. There was an agreement by all participants groups that the device was fun to play with, while simultaneously conceding that the noise generated might become annoying for parents.

From the perspective of physical interactive play, the Drum Duino presents a compelling example of a physical musical interface that allows fun exploration of rhythms and music, while simultaneously understanding the material properties of every day objects. Central to its design is the idea that tangible interfaces have the opportunity to be accessible, be conducive to group use and engage the senses.

7. FUTURE WORK

Given the focus on the actuators during our tests, we think there is merit in further exploring this type of interaction in future versions of the Drum Duino. This also confirms more to the metaphor introduced earlier by Machover (2007) of simple tapping to produce music. As such one concept is to create stand-alone solenoids that can detect and repeat knock patterns, while focussing more on the actuators as main tool for interaction.

Currently, one of the biggest drawbacks of the Drum Duino is that it has a tendency to produce annoying noises, as opposed to enjoyable music. The participants echo this sentiment: in general, they found the device engaging, but noted that it would be difficult to make music with it.

This problem can be addressed in two ways. Firstly, the instrument should be able to produce more varied sounds. This can be done by adding more actuators or by influencing the physical parameters of the solenoids (e.g. by varying the impact force, by adding different nibs to the ends of the push rods, by allowing flexible mounting of the solenoids to the objects). Secondly, future versions should also allow the user to program more complex sound patterns. Presently, the Drum Duino is limited to 8 step patterns, which tend to sound monotonous. Future versions could work by incorporating a more flexible pattern interface or by allowing the Drum Duino to be controlled through standardized protocols such as MIDI.

Following the next design iteration, we also plan to perform a more detailed user study involving professional musicians with the device. The objective of such a study would be to investigate different control paradigms, such as interfaces integrated in the solenoid actuators versus control through existing devices, such as computers or sequencers. Additionally, the Drum Duino could also be evaluated in a longitudinal study, where its value can be assessed over a longer period of time to account for novelty effects.

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PLAYING IN 7D: CONSIDERATIONS FOR A STUDY OF A MUSICAL INSTRUMENTALITY IN THE GAMEPLAY OF VIDEO GAMES

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ABSTRACT

We believe that it is not at random that the term *play* is used in diverse contexts and across various media. *Playing* a musical or sonic instrument and *playing* a video game are, in principle, different activities. Yet, *play* is somehow involved.

The intersection between music and video games has been of increased interest in academic and in commercial grounds, with many video games classified as 'musical' having been released over the past years. The focus of this paper is not, however, on 'musical' video games themselves, but on exploring some fundamental concerns regarding the instrumentality of video games in the sense that the player plays the game as a musical or sonic instrument, an act in which she becomes a musical performer. And this something that is not necessarily exclusive to those considered to be 'musical' video games.

We define the relationship between the player and the game system to be action-based. We establish a parallel rationale regarding the musician and the musical instrument, focusing on intersections between these two activities. Afterwards, we propose that the seven dimensions we found to govern that action-based relationship to be a source of instrumentality in video games.

With this study we not only aim at raising a deeper understanding of music and sound in video games but also of how the actions of the player are actually embedded in the generation and performance of music and sound. In this paper we aim at setting up the grounds for discussing and further developing our studies of action in video games intersecting those with that of musical performance, an effort that asks for multidisciplinary research in musicology, sound studies and game design.

KEYWORDS

Action, Gameplay, Instrumentality, Music, Sound, Video Games.

INTRODUCTION

Music and games are not exceptions when it comes to the ubiquity of computational systems in contemporary societies. Studies focused on intersections between the field of video games and that of musical performance seem to be an emerging field of interest. Ours was initially captured by the thoughts of Aaron Olderburg on *Sonic Mechanics: Audio as gameplay* (2013); Julio D'Escriván's thoughts and works regarding performing digital media in opposition to perform with digital media (2011, 2014); Julian Oliver's works relating audio, music and video games; Chris Novello's *Illucia: a patchable videogame system*;[1] and by *The Adventures of General Midi* (2014) by Will Bedford, a video game that generates parts of the game world based on the content of MIDI files.

In *Sonic Mechanics: Audio as gameplay* (2013) Aaron Olderburg proposes that "[u]sing game mechanics to expressively proceduralize experiences such as sound and using sound to break apart the visual-centric space of games opens up the potential to create new expressive forms of gameplay." We agree that most mainstream contemporary video games are primarily visual-centric. Nevertheless, our intent is not to follow Olderburg's recommendations in a strict manner, but to complement them proposing that to rethink the visual-centricity that is currently found in video games one needs to first pay close attention to the relationship established between the player and the game system, in order to only then be able to see and be aware of how it affects the entanglement between music/sound and play itself.

Our premise is to explore fundamental concerns regarding the video game player as a musical performer, in the sense that they play a video game as a musical or sonic instrument. This notion of instrumentality not only advocates the need to understand the computational attributes of the system and the ludological traits of the game but mainly the specificities of the relationship that is established between the player and the game system during gameplay.

This relationship has been the core focus of our studies, which we identified as being *action-based*. We studied action as the quintessential component governing the relationship between the player and the game system, having discerned seven dimensions through which it may be deeply analysed: *Traversal, Chronology, Depth, Responsiveness, Transcoding, Thinking & Actuating,* and *Focus*. Each of these dimensions frames very specific perspectives on the relationship player-system, taking into account the process-intensive (Crawford 1987, 2003, Carvalhais 2013) nature of computational systems.

1. Illucia is a patchable video game system developed by Chris Novello, that consists of a patchbay controller that allows the interconnection between video games, music software, text editors, and so.

"Process intensity is the degree to which a program emphasizes processes instead of data. All programs use a mix of process and data. Process is reflected in algorithms equations, and branches. Data is reflected in data tables, images, sounds, and text. A process-intensive program spends a lot of time crunching numbers; a data-intensive program spends a lot of time moving bytes around."
Crawford 1987

And although we have no intention of claiming the non-existence of other dimensions – avoiding the presumptuous and colossal mistake of thinking that we have uncovered them all – we acknowledge that these already grant us a large amount of variables to work with. With this into consideration, we believe that the exploration of these dimensions is of the utmost importance in the analysis of the player-system relationship; a relationship that bears a central role within the poietic and aesthetic dimensions of the musical or sonic compositions that are dynamically performed during gameplay.

1. INSTRUMENTALITY IN PLAY

From games, music, sports, film and theater to other artistic, recreational, and entertainment activities, and so forth, *play* is a term that we see used across diverse contexts and across various media. In principle, *playing* is a term that, in all of those contexts, consists of different activities. Yet, if we disregard the differences that emerge from semantics and context, the relationship between the player and the game system and between the musician and the musical instrument are similar, being both governed by a communicational feedback loop seeded in a sort of cybernetic entanglement. In order to play, both the player and the musician act on an artefact – e.g. a video game console controller or the strings on a guitar – obtaining a response. The relationship between the player/musician and the game system/instrument is, from this perspective, grounded on the cycle established by the actions they express towards each other, resulting in a kind of performance: *play*. Play is thus inexistent without *action*, otherwise the cybernetic relationship falls apart. Here, to play is to operate, and whether that is done in a more or less ludic fashion is, to a certain level, a matter of semantics.

This may seem a somewhat simplistic perspective on the subject. A cybernetic feedback loop is present in various contemporary activities, which are different from playing games or musical instruments, such as driving a motor vehicle, for instance. Nevertheless, it is important to notice that we are not saying that games and musical instruments are equivalent because of that cybernetic feedback loop. We are stating that, from a strictly operational point of view, the relationship player-system and the one musician-instrument are quite similar: *operator-artefact*.

The question now is: Why would we want to reduce everything to an operational standpoint? The fact is that this is the ground in which video games stand, as seen through the perspective of an action-based computational medium. The game progresses as the player operates its system.[2] It is this operation that is the focus here. And, as previously said, this is a point of convergence between playing video games and playing musical instruments in which we are interested. We are not claiming that this is a great discovery or some grand fact because it is not. We are simply noting that through the perspective of a framework that is action-based – such as the one we propose[3] – this is their common ground. Can this be a common ground for video games and other artefacts? It certainly can. But that kind of study is beyond the scope of this paper, as the contexts and purposes of those other artefacts direct us to other fields of knowledge. In other words, they may have a common ground but that does not imply that they are equivalent, only that that common ground is a good place to start, it is a proper place to ignite our research.

Our goal is thus not to repurpose, reconfigure or even to appropriate particular components of video games in order to create musical instruments; an operation where the original video game would stop being a game to become an instrument or where the newly created instrument would not be a game but a mere sum of game components. In contrast, our study is much more focused on how video games themselves can be used to perform music and sound; to serve as musical or sonic instruments and still continue to be games. In short, how can video games simultaneously be musical instruments and games?

This marks the start of our pursuance of what we are calling *instrumentality* in video games.[4] Instrumentality may be briefly defined as the quality of something to serve as a means to an end. But, from our perspective, an instrument is not just a tool; it consists of an artefact that is used – in this case, that is 'played' – to produce or to perform something, or even that produces and/or performs by itself. With this in mind, we propose that this notion of instrumentality – applied to video games – is rooted in three characteristics: *dialectical ability*, *freedom of expression*, and *actors*.[5]

1.1. DIALECTICAL ABILITY

Video games are a very specific kind of computational artefact: one that is meant to be *played*. In this context, we use the term *dialectical* to illustrate the ability that allows the game system to act in opposition to the player, consequently challenging them, and vice-versa. The first situation is very evident in older video games where the player is constantly challenged by the presence of enemies that populate the game world and

2. We have identified various ways in which the player operates the game system, from moments where this feedback is continuous to those where it is not.

3. A summary of that framework is described in chapter 2 of this article. However, for a deeper knowledge into these subjects we recommend reading our various publications mentioned in each section.

4. Studies on instrumentality in video games are actually something that we believe to be applicable beyond the scope of music and sound. But that is outside the scope of this paper.

5. With further studies we are expecting to uncover more of these characteristics.

that contribute to a game world topography that could already be challenging to traverse. The win and loose conditions ever present in those games (and in many contemporary ones) acutely illustrate this point.

Notwithstanding, in some contemporary video games this is not so clear. In many there is no win or lose conditions. The focus is on experience, narrative, exploration, and so on. In any way, by providing the player with a plethora of choices, often questioning her moral standpoints or her judgmental capabilities, we may still consider the system as an opposing force to that of the player – even when this kind of situations is pretty implicit. The choices the player makes can dramatically change the unfolding of events and, consequently, the game's narrative. This is a kind of conflict the game system constantly presents to the player, through various means and nuances.

On the other side, the player also challenges the game system by not only exploring its capabilities but also its limitations, testing it by forcing or even bending the rules, extracting as much as she can from it in order to understand it – sometimes – to the fullest.

> "Conflict can only be avoided by eliminating the active response to the player's actions. Without active response, there can be no interaction. Thus, expunging conflict from a game inevitably destroys the game. (…) Conflict is an intrinsic element to all games. It can be direct or indirect, violent or nonviolent, but it is always present in every game."
> Crawford 2011, loc. 285-301

Musical instruments with computational capabilities have the potential to establish this dialectical relationship with their operators. We are not saying that musical instruments with no computation capabilities don't pose a challenge to their operators, because they do – especially when learning or mastering them (understanding them to the fullest). But that is not the only point. The question is not just on challenge itself, but on the ability to compute those challenges' and their outcomes, in response to the operator's actions, in order to mould the narrative that constitutes her experience. And that requires, as insinuated, computation capabilities.

The relationship that the operator establishes with this type of musical instruments is, such as with video games, action-based. They are seeded on interaction, as the operator's actions are transcoded into the machine that acts based on the algorithms it is governed by and the data it collects. Computational artefacts, as used in *algoraves*, for example, explore and harness the process-intensive nature of computational systems (Crawford 1987, 2012, Carvalhais 2013, Kwastek 2013) into the poiesis and aesthetics of musical and sonic compositions. In this context, often during a live-coding session, the operator programs the machine, a performance that cannot be considered analogous to that of playing a musical instrument because it actually is the performance of playing that musical instrument.

Dependent on the traits of the software and the capabilities of the hardware, the computer, consequently and without a doubt, performs in a very different fashion than a traditional acoustic instrument. Usually, the audience is unable to perceive what is going on, to understand how the operator (musician) is playing, and how sound/music are generated. There is no direct correlation between the sonic output and the gesture of the musician. "Regardless of whether any sensors can capture the resilient nuances of physical gesture, software is necessarily symbolic, and physical action will always be mediated through code." (Sa 2014) In fact, in many occasions the performance doesn't even contribute to the music itself, but solely to a visual spectacle that keeps the audience entertained.

> "[A]re we in presence of a phenomenon of conformity in which audience tends to replicate what is the average tendency of preferring a certain degree of visual entertainment (served mostly by the gestural information) in detriment to the *absolute* value of the aural performance?"
> Joaquim and Barbosa 2013

In essence, computational artefacts are *played* differently from traditional instruments because their very natures diverge. The foundational difference – which is of most interest to us – is that traditional acoustic instruments are not capable of establishing this dialectical relationship with their operator. Conversely, computational musical instruments can, as this capability is intrinsic to computational artefacts.

And video games, due to their computational traits stand closer to the latter than to the former. Video games are bound to their intrinsic computational genesis, with *action* at their core. And by being computational artefacts, they express a wide range of variance within this dialectical relationship; a relationship that sometimes is not clearly perceived in the ways the player and the game system challenge each other.

1.2. FREEDOM OF EXPRESSION

In *Levels of Sound: On the Principles of Interactivity in Music Video Games*, Pichlmair and Fares Kayali (2007) discern between two major types of audio games: *rhythm games* and *electronic instrument games*. In the first category, the player tries to follow very specific instructions, such as following a given musical score, a particular rhythm or aiming at the correct pitch when singing to the microphone; a performance that is monitored, measured and evaluated by comparison to one considered the standard of excellence. Here, we can find video games that became famous and that have mainstreamed musical game genres, such as *PaRappa the Rapper* (1996), *Guitar Hero* (2005), *Rock Band* (2007), *Singstar* (2007), or even *Rocksmith* (2011) – that uses a real guitar as a controller instead of a toy guitar –, or even yet *Patapon* (2007) – as a somewhat less known title.

Regarding the other category, the authors call *electronic instrument games* to those where the player "plays the game as an instrument. The game provides – or at least pretends to provide – all the freedom of expression that a musical instrument calls for." (Pichlmair and Kayali 2007) *Sim Tunes* (1996), *Small Fish* (1998), *Electroplankton* (2005), and *Fijuu2* (2006) are identified as examples.

Although the authors present seminal concepts to this ongoing study, we are not in full agreement with the terminology employed in their taxonomy – *rhythm* and *instrument* –, as at a first glance we may feel tempted to state that games in the first category don't possess instrumentality, opposing to the games included in the second. But a deeper inspection will show that that is not such a clearly defined issue.

We may then briefly state that a game that acts as a musical instrument is a game that is played in order to produce and/or to perform sound and/or music. So, we may say that, according to this concise definition, games in the first category also possess instrumentality, as they produce sound that derives and/or is moulded by gameplay, and which result may be seen as musical and/or sonic compositions. From this perspective, the difference between both categories doesn't seem to rely now on whether they possess instrumentality or not. We believe that that potential is already there. In our view, and as the authors insinuate, that difference depends on *freedom of expression*:

> "Rhythm games offer little freedom of expression apart from the prerogative to perform while playing. They strictly force rules on the player on how she has to react to a specific stimulus displayed on screen or communicated by sound. (...) [P]layers are not building their own environment of sound."
> Pichlmair and Kayali 2007

It is thus this freedom of expression that marks the difference, setting games like *Guitar Hero* and *Electroplankton* apart. Games in their first category – rhythm – force the player to perform in a every specific and contained way, while in their second category – instrument – the player is granted more freedom, aiming for more diverse types or arrangements of formal expression and performance. With this in mind, we conclude that the difference between these two categories is not a matter of having or not having *instrumentality* (or the potential for it), but a question of *expressiveness* within their own instrumentality. This is a perspective that entails that both these categories already possess instrumentality, or at least instrumentality in potential. This freedom of expression is what distinguishes games where the player is obligated to follow a very strict path in which any diversion results in failure from those where the player is liberated and able to choose from multiple to an indefinite number of paths – whether by manipulating general game elements or going all the way inducing deep reconfigurations within the game world and its inhabitants.

1.3. ACTORS

As previously stated, the player-system relationship is nurtured by *action*. With this in mind, we propose a framework grounded on the existence of elements that we define as *actors*. Actors are entities that have the ability to act in, on or within the game world. They are entities with the ability to influence the course of events and to alter game states, making it progress. In sum, everything able to act in the game is considered an actor, whether it is a playable character, an enemy, a power-up, the cursor pointer, an item, the camera, etc... As long as they act, producing an effect on the game world and on each other, they are actors. In fact, through this perspective the game system and the player are also actors – albeit high level and complex.

But actors are different between themselves. Although from this perspective, a power-up and the player are both actors, they don't have much in common. The difference resides in their composition, which is based on an encapsulated and recursive formative structure. Meaning that a network of actors is able to constitute a more complex actor, and that a network of those more complex actors is also able to constitute an even more complex actor, and so on. With this in mind, an actor's composition may incorporate more or less complex networking and still be able to act as a single actor.[6]

The game system is an actor because its diverse components act in a network that contributes to the enactment of the game. A human player may also be seen as a collection of simpler actors that act articulately, allowing the player to receive and process information and to actuate based on that – e.g. just think of human sensory organs such as eyes, ears, the skin, as input devices; think of the brain as a processing unit; and all the sets of muscles, tendons and bones that allow the player to physically express herself as output actuators – not to mention all those that keep her alive, having the ability to influence her affective state.

So, this encapsulated and recursive formative structure allows the existence of actors with various degrees of complexity. The deeper we go into that structure the more specialised the actors are, focused on performing very specific actions. On the other hand, the higher we go into that structure, the more dynamic the actors' behaviours are, making them more versatile. A common power-up as the flower in *Super Mario Bros.* (1985) can be considered an actor that is set at a lower level than the player in this structure. While the flower has a very limited set of behaviours and actions at its disposal,[7] the player is much more versatile.

The actors' diversity is thus expressed by variations in the complexity of their formative structure, and depending on that several kinds of actors may emerge. Eventually, actors in higher levels may even be able to experience agency, as defined by Murray (1997), thus being able acknowledge the effects of their actions and those of other actors in the game.

2. PLAYING IN 7D

Considering what was previously enunciated, we propose a framework centred on the action-based relationship between the player and the

6. This is actually something similar to what can be seen in actor-network theory (Latour 2005), in object-oriented programming, and even more similarly in Ian Bogost's unit operations and tiny ontology (2012).

7. The flower power-up in *Super Mario Bros.* (1985), once touched by the playable character, allows it to shoot fireballs. The playable character looses that ability if touched by an enemy.

game system. We propose seven dimensions that emerge from the behaviour of these actors:

1. *Traversal* is related to the journey of player in the game through the hardcoded narrative – the narrative that is fixed and scripted directly into the game – and the emergent narrative – the narrative that is expressed through occurrences derived by the behaviours of the player, of the game system and of other actors;
2. *Chronology* is a dimension focused on the ability of the player and of the game system to manipulate the relationship between objective time – the time the player takes to play – and event time – and the time that flows in the diegesis of the game world –, which consequently affects the sequences of events in the game;
3. *Depth* is a dimension concerned with the influence of the player's actions in given layers of the game system's structure, from its surface to its core, from its aesthetics to its mechanics, thus proposing diverse player functions that occur during gameplay;
4. *Responsiveness* is a dimension that looks at the fundamental input and output structure of the actors (sensors, processing core, and actuators) to discern its diverse basic states drawing the possible combinations of communication in the relationship player-game system;
5. *Transcoding* is a dimension that studies the relationship between the performance of the player and its proxy in the game word considering the player space – the space where the player is actually situated – and the game space – the space where the game actually occurs, where the game world resides;
6. *Thinking & Actuating* is a dimension focused on the player as a collective actor of biological origins in order to discern between diverse types of actions that are expressed by means of varying intensities in the processes of conceptualisation (thinking) and of enaction (actuating) of an action;
7. And *Focus* is concerned with the player's attention span – input of information, the actor's sensors –, and how the game system challenges her, sometimes by overload and other times by deprival.

For a deeper discussion on the matters described in the following sections we suggest reading the works where we explore to a greater extent each of these phenomena.

2.1. TRAVERSAL

Traversal (Cardoso and Carvalhais 2013d, b, 2014b, Carvalhais 2013) can be defined as a journey, featured within the dialectical relationship between the player and the game system. Traversal regards the experience of the player when crossing the ergodic[8] landscape of the video game, focused on the diverse expressions that emerge from the relationship between the hardcoded and the emergent narratives.

8. See Aarseth (1997).

The *hardcoded narrative* is static, fixed. It is a narrative "framed" (Bissel 2011) in the script of what usually is the story of the game. The *emergent narrative* (Salen and Zimmerman 2004, Carvalhais 2011a, b) is dynamic, fluid. It emanates from the relationship between the player and the game system. It transpires from the rules of the game that are put into motion, and it is solely experienced during play. And therefore it is difficult to be re-enacted with exactness, as a given event only occurs due to a very specific alignment of other previous events, many of which may be the result of chance.

The different types of traversal we propose are summarily described as follows:

1. *Branching* is a type of traversal that occurs when the player is asked to choose between mutually exclusive paths or events;
2. *Bending* occurs when the player is able to access optional non-mutually exclusive paths or events;
3. *Modulating* happens when the player is able to make adjustments to the social network of the actor's within the game, regulating the disposition or affinity of those actors towards her and each other, in a system in which events emerge from these relationships;
4. *Profiling* is a kind of traversal that is focused on the analysis of the player's behaviour, on understanding how she plays and acts within the game, in order to determine how events will unfold, either by proposing challenges of increasing or decreasing difficulty, or simply to personalise the narrative and the overall experience;
5. Contrarily to the types of traversal previously enunciated, *exploiting* is a kind of traversal that does not operate in a designed part of the algorithm. Exploiting happens when the player explores errors and malfunctions within the game.

2.2. CHRONOLOGY

Chronology (Cardoso and Carvalhais 2012c) focuses on the exploration of the sequences of events as the game is played. It is about inspecting the actions that are used to manipulate or influence those sequences. The relationship between the hardcoded and the emergent narratives in video games provides an experience that emerges from the relationship between predetermined and non-predetermined sequences of events, respectively. While the hardcoded narrative on its own can be navigated out of the intended order, the emergent narrative cannot. This renders video games dependent on the experience of the player, and on the chronology of that same experience. When the player manipulates the relationship between these two kinds of narrative, she is also manipulating the relationship between two distinct types of time: event time – the time that flows in the diegesis of the game world – and objective time – the time the player actually takes to play.

In this dimension, the player's actions are thus constrained to the following: 1) By altering already experienced events the player propels the due consequences to the future – what would otherwise mean that her actions wouldn't have consequences, and thus that play wouldn't be meaningful; 2) The player cannot alter events that haven't happened, simply because she cannot access them; 3) The player only acts in the present time. Even if she is able to travel to the past and change it, that moment (past) is then her present time. And if she travels back to the future, that will become her present time as well. With these considerations in mind, we propose three main groups of actions focused on chronology.

Preterite actions are focused on accessing past events. We have discerned two disparate sub-groups here: 1) *Replay actions* allow the player to return and resume play from a particular moment in the past, usually in order to change its outcome; 2) *Review actions* also allow the player to return to a given moment in the chronology, but they do not permit her to change its outcome, only allowing the player to re-experience them, to inspect the past – sometimes from other perspectives – or to evaluate what happened.

Despite all actions being enacted in the present time, *present actions* are the actions that are solely focused on the really short time span that is the immediate present time. As a result they are usually fast actions, or even reactions.

And lastly, *preemptive actions* work towards forestallment. They are taken to prevent an anticipated event, or at least in preparation for it. This is an ability that not only depends on the experience and perspicacity or astuteness of the player, but also on the predictability and determinability of the game system and other relevant actors in play.

2.3. DEPTH

Depth (Cardoso and Carvalhais 2012a) is a dimension that is focused on discerning how the player's actions influence the game depending on where in its structure they are enacted. There are actions aimed at the surface of that structure, influencing the game only at its aesthetics level. And there are actions that are enact all the way into its more mechanical depths, influencing its rules and behaviours, reconfiguring them and even being able to generating new ones, in some cases. We explore these actions relating our work with that of Marie-Laure Ryan's "layers of interactivity" (Ryan 2011b, a), the MDA framework (Hunicke, LeBlanc, and Zubek 2004, LeBlanc 2005), and cybertext (Aarseth 1997), uncovering several player functions.

1. *Function 1* occurs when the player is focused on interpreting rules, on observing or perceiving the expressed behaviours within the game world.
2. *Function 2* is enacted when the player is concerned with following rules, on exploring and testing the behaviours of the actors found in the game world.
3. *Function 3* takes place when the player is involved in moulding rules, configuring and reconfiguring the behaviours of the actors present in the game world.

4. *Function 4* is developed when the player is embroiled in changing rules, adding new actors and behaviours to the game world.

2.4. RESPONSIVENESS

Responsiveness (Cardoso and Carvalhais 2012b, 2014a) is a dimension that probes the dialectical balance of action and inaction between the player and the game system, revealing a dynamic array of methods that have their foundations in functionality and dysfunctionality.

Functional methods are those where at least one of the actors is receptive to the other's output, when their behaviours are intertwined, featuring interactive, semi-interactive, and unidirectional methods.

Dysfunctional methods are unable to establish a direct pathway of communication between both actors, that are consequently unable to be directly responsive to each other's actions.

2.5. TRANSCODING

Transcoding (Cardoso and Carvalhais 2013c, 2014c) aims at an understanding of the translation between the player's and the game system's actions that occur during gameplay, taking into account the relationship between game space and player space.

In some games, the player acts within the game world by means of a surrogate: the player's *proxy*. The player's proxy is an actor that is directly controlled by the player. It may be her playable character, but it may also consist of other elements such the cursor she manipulates by pointing and clicking, for example.

Player space is the physical space where the player is situated, enveloping the necessary hardware to play the game. It is a space that the player's physical body can never leave, as it is intrinsic to its very own existence.

Game space is the space where the game actually happens, it is where the player plays the game, it is the space she inspects while playing. The game space is usually seen as the space where the game world resides.

INTANGIBLE	TANGIBLE
Arbitrary articulation	Game space < Player space
Symbolic articulation	Game space = Player space
Mimetic articulation	Game space > Player space

Table 1 Variations in Transcoding.

Intangible transcoding occurs when the game space and the player space are apart. In this case the player needs a proxy in the game space in order to be able to act within the game world. It is under this context that the transcoding between the player's actions and those of her proxy becomes relevant.

1. An *arbitrary articulation* occurs when there is no direct correlation between the actions of the player and her proxy. It is an articulation that the player usually apprehends by instruction or by trial-and-error, even for trivial routines such as pressing a button to make a given character jump in the game;
2. A *symbolic articulation* occurs when there is a partial correlation between the actions of the player and those of her proxy. In this articulation, their actions bear some similarity, they bear some resemblance, but they are not the same. An example of this can be found when pressing a combination of keys on the gamepad or joystick that resembles the movement of the player's character, such as when executing the *hadouken* combo in *Super Street Fighter 2* (1992);[9]
3. A *mimetic articulation* happens when the actions of the player and those of her proxy are homologous. Here the proxy imitates the player's actuations to the best of the system's capabilities, where more concrete examples are present in motion-based or partially motion-based video games, such as *Kinect Star Wars* (2012) or *The Legend of Zelda: Skyward Sword* (2011) – where the player swings her arm holding the game controller in order for the game character to swing its sword.

Tangible transcoding happens when the player's body is embedded in the space of the game, meaning that game space and player space are the same, or at least in the same dimension, which in turn implies that the player's proxy is dismissed. A tangible transcoding allows players to actually touch each other as a significant component of gameplay.

1. *Game space is smaller than player space* when the actuations related with the actions of the player only involve a part of her body, something that usually happens when playing *Fingle* (2012) on a phone or tablet;
2. *Game space is equivalent to player space* when the totality of the player's body is involved in game space, and consequently the immediate space that surrounds her becomes a space of play, of the game. This occurs when playing *Dance Dance Revolution* (1998), for example;
3. *Game space is bigger than player space* when the player is forced to travel in order to play, meaning that the game space now incorporates a scale of actual geographic proportions, something very evident in location-based games such as *Ingress* (2013).

2.6. THINKING & ACTUATING

Thinking & Actuating (Cardoso and Carvalhais 2013a) explores the interdependencies in player action that can be found between the player's

9. The *hadouken* (a surge of energy that is shot towards the direction the game character is facing) is a combo that can only be executed when playing with *Ryu* or *Ken* and by pressing the following combination of keys in one swift move: move the joystick or the d-pad a quarter of a circle, starting from down and then hit the 'punch' key (↓, ↘, →, punch).

stage of thinking and conceptualisation and the stage of actual actuation or enactment. We have identified three types of action in this context.

Premeditated actions are those in which the player is required to invest conscious mental effort in their planning. The player takes the time to deliberate how to put things in motion. These are actions that require the player to deal with heavy loads of information.

Trained actions are those that the player executes rather unconsciously, that are learned and mastered by rote, becoming automated and choreographed. These actions are voluntarily initiated and terminated by the player, but their performance is not under her conscious control, as they are conditioned and dependent on the training the player has undergone.

Finally, *autonomic actions* consist of automatic, mechanic, organic responses of the player's body. They are actions that, although may be influenced, are not directly controlled, initiated or terminated by her, as they depend on the physiologic operations of her body.

2.7. FOCUS

Focus (Cardoso and Carvalhais 2014d) is concerned with how the system challenges the attention span of the player. We identified four dimensions: time span, sensorial scope, frame, and actuation automation. In all of these the player is able to express three alternative states: focused, defocused, and unfocused.

DIMENSIONS / STATES OF FOCUS	TIME SPAN	SENSORIAL SCOPE	FRAME	ACTUATION AUTOMATION
Focused	Short	Narrow	Single	Automated
Defocused	Long	Wide	Non-simultaneous	Mixed
Unfocused	None	Total	Simultaneous	Non-automated

Table 2 Variations in Focus.

Time span is focused on the exploration of the temporal durations that the player is granted to act on the game, limits that stress the player enforcing gameplay pace and speed:

1. A *short time span* (focused) promotes fast-paced action and quick decision-making;
2. A *long time span* (defocused) grants the player time to plan her actions, to ponder, to act with care, but it is nevertheless a limited time;
3. *No time span* (unfocused) allows the player to relaxedly act and explore the game world.

Sensorial scope is related to how much of the game world the player is able to simultaneously perceive:

1. A *narrow sensorial scope* (focused) forces the player to be attentive to the immediate, to her surroundings, or to the vicinity of her proxy in the game world, coercing her to act quickly, on impulsion;

2. A *wide sensorial scope* (defocused) permits the player to perceive beyond those immediate surroundings, granting her time to anticipate behaviours that unfold all around the game world;
3. A *total sensorial scope* (unfocused) allows the player to perceive the entirety of the game world, straining her attention span with the simultaneous occurrences of various, and sometimes, unrelated events and actions.

Frame refers to the 'windows' through which the player witnesses the game world and its events:

1. A *single frame* (focused) promotes the player's undivided attention to it;
2. A game with *non-simultaneous frames* (defocused) permits the player to explore the game world through multiple frames sequentially;
3. A game with *simultaneous frames* (unfocused) allows the player to witness diverse parts of the game world or from diverse perspectives, at the same time.

Actuation automation relates to the variations found between automated and non-automated actuations, when the player simultaneously realises two or more actions:

1. An *automated actuation* (focused) involves the player in actions that are repeated in short-term cycles, capable of being patterned through training and thus incorporated into somewhat self-executing processes;
2. A *mixed actuation* (defocused) involves the player into actions that require her to execute both automated and non-automated actuations. This is something that divides the focus of the player, and which success is attained due to the her capability of keeping automated actions ongoing without monitoring;
3. A *non-automated actuation* (unfocused) involves the player in improvisation, forcing her to be attentive in order to adapt to the events that are in development. Managing two different actions that use this type of actuation may become a daunting task, as the player's focus is seriously divided, constantly alternating between them.

SUMMARY AND FUTURE WORK

> "Games are less of something created than something explored, manipulated, or inhabited. They are less musical composition and more musical instrument – to be played, by players."
> Zimmerman 2014

We have suggested that playing a video game and playing a computational musical instrument are activities that, from an operational point of view, may be considered similar. But even so, the instrumentality of video games is still different and, up to a point, rather unique. We have demonstrated that *freedom of expression* has a wide variance across the spectrum of contemporary musical video games, from lower – in *Guitar Hero* – to higher – in *Electroplankton* or in *Fijuu2*. And that instrumentality in video games is a phenomenon that requires *dialectical ability*, a relationship of frequent opposing forces, something that is at the core of the cybernetic relationship established between the player and the game system. Finally, we proposed that video games are dynamic systems in which *action* is at their core, and defined *actors* as the elements that act within the game, changing its state and evolving its narrative.

Ultimately, we presented a framework that explores seven dimensions of action. One of our goals is to use it as a methodological tool to analyse the instrumentality of video games. For example and at the moment, we are considering if the demonstration of *Super Mario Spacetime Organ* (2012)[10] performed by Chris Novello to promote the *Illucia* can be considered a demonstration of the potential of instrumentality of video games within the dimension of *chronology*. We are also pondering if *The Adventures of General Midi* (2014) is a game (or a prototype of a game) focused on a particular manifestion of instrumentality within the dimension of *depth*. With this in mind, our most immediate goal is to collect sufficient case studies aimed at each of the seven dimensions and their respective sub-dimensions. In parallel, we are also working towards the development of prototypes in order to test the boundaries of each dimension.

We aim at an understanding of how instrumentality related to sound and music in video games can be achieved and moulded by these dimensions; a task that asks for multidisciplinary studies in game design, sound studies and musicology, working towards the production of experimental artefacts with potential for concerts, performances and installations, and with great prospects for applied research in the development of both innovative video games and musical instruments.

Beyond this context, this study on instrumentality in video games is actually something that we believe that may be applicable beyond the scope of music and sound. We are confident that they may also play a role in serious games and similar pedagogic activities.

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10. At the time of writing, a video and more information about this subject could be consulted at *http://vimeo.com/49142543*.

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ENABLING CREATIVITY: INCLUSIVE MUSIC INTERFACES AND PRACTICES

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ABSTRACT

Inclusive music practices involve the use of music interfaces, aiming to overcome disabling barriers to music making faced by people with disabilities. In this paper, design approaches, and the question of 'openness' are discussed, as are practices with interfaces for sound and music creation in sonic arts and electronic music broadly. In addition, I examine ethnographic examples from my research with The Drake Music Northern Ireland, a music charity that aims to enable people with disabilities to compose and perform their own music through music technology, to argue that in inclusive music, it is through the social interactions and practices using a DMI or musical tool that design limitations can be exposed and challenged, and new adapted uses or affordances emerge.

KEYWORDS

Inclusive Music, Assistive Music Technology, Critical Making,
Enabling Technology.

1. INTRODUCTION

The barriers to music making that people with disabilities face can be viewed through two predominant theoretical models: the medical model and the social model (Lubet 2011). The former sees disability as arising from the physical or mental limitations of the musician, whereas the latter sees the exclusionary design of the musical instrument or interface as the disabling factor. The social model perspective naturally shifts the focus to enabling: techniques and technologies for transcending or transforming disabling barriers. In the following, I discuss musical control interfaces and digital musical instruments (DMIs) used in electronic music and inclusive music practices.

Digital disability is a phrase coined to provoke the recognition that ICT and digital technologies, commonly hailed as a panacea for people with disabilities, in practice often act to further exclude users (Goggin and Newell 2003). The Helen Hamlyn Centre for Design (Royal College of Art) and Scope Disability Charity report 'Enabling Technology' argues that whether mainstream, hacked or adapted, many devices can be made to empower people with disabilities to live and act more independently (Jewell and Atkin 2013).

I will first discuss musical interface design broadly from the perspective of the different motivations, ethos and goals that DMI designs can aspire towards. Second, I will introduce the field of inclusive music and the tools and practices that it encompasses. Third, I move into a discussion of my own ethnographic research conducted with the Drake Music Project Northern Ireland (DMNI), a music charity that facilitates workshops to enable people with disabilities and learning difficulties to compose and perform their own music, sharing examples of accessible music interfaces and situations as I have experienced them in the field. In conclusion I suggest that music interfaces and their usage in practice at DMNI reveal important parallels to other forms of music that are also inextricably linked to digital music technologies; the different meanings in their making, and the importance of the social interactions surrounding these technologies as they are actually used in practice.

2. THE MEANINGS IN MAKING

The availability of assistive music technology (AMT), accessible DMIs and mainstream adapted devices for people with disabilities continues to grow and diversify, largely because of two factors: the nature of the materiality of digital technology, and intertwined with this, the availability of cheap and powerful tools for hacking and coding unique, personal and bespoke hardware and software for music and sound creation. Recent studies into DIY, hacking, and maker culture, analyse the growing interest in individualized and personally manufactured designs and devices, emphasizing the democratization of knowledge, technology and material culture (Blikstein 2013; Tanenbaum 2013; Lindtner 2012; Lindtner et al. 2014) alternative values and ideologies, and a return to an interest in physical materials (Ratto 2011; Lindtner 2014). This is attributed to readily available technology and knowledge at low or no cost, and the "openness" of many software based technologies (Hamidi et al. 2014; Tseng 2014).

The practices of composers, hackers, and makers creating or modifying tools and instruments for various musical and sonic ends can arguably also be seen as growing, diversifying and transforming. Some seek to improve the screen-mouse-keyboard paradigm of interaction (Jordà 2001; Miranda and Wanderly 2006), or introduce a new one; to find innovative ways to free oneself from the restraints of laptop performance (Cook 2003); to propose a more embodied, intelligible way of performing computer music or to subvert contemporary standardized trends in electronic music performance (Kim and Seifert 2006; McGlynn et al. 2012). Whilst others aim to create tools of intentionally restrictive interactive potential for performances incorporating techniques of constraint (Bowers and Archer 2005; Magnusson 2010); and others still pursue experimental research aims (Gurevich et al. 2010; Marquez- Borbon et al. 2010; Donarumma 2011).

New modes of interaction and making, from the embodied and extended, to the virtual or augmented (Tanaka and Bongers 2001; Duckworth 2003), the intra-infra-contra-hyper (Bowers and Archer 2005), to the hacked and bent offer new imaginings of musical tools and instruments and novel approaches to music performance (Miranda and Wanderly 2006; Goldman 2011; Green 2011).

Matt Ratto (2011) builds upon the possibilities offered by open source software and hardware, as well as developing technologies such as 3D printing, and explores how making can supplement and extend critical reflection on the relations between digital technology and society. He defines his experiments as 'critical making': a mode of materially productive engagement that is intended to bridge the gap between physical and conceptual exploration (Ratto 2011). His research can be likened to the way in which practices surrounding DMI design, creation and performance challenge traditional musical ontological questions such as: what counts as a musical instrument (or even a musician)?; what constitutes a musical performance; and what is musical communication?

Turning now to look at interfaces in inclusive music, I hope to show how the idea of 'critical making' and challenging the traditional definitions of what counts as a musical instrument, a performance, a musician is of vital importance in inclusive music.

3. INCLUSIVE MUSICAL CONTROL INTERFACES

The hardware and software practices discussed above are examples of the ways in which electronic musicians and composers can potentially create new tools, patches or instruments for individual works, or configure software or adapt mainstream hardware in unique ways specific to each instance of performance. This is possible due to the advent of electronic instruments, particularly controllers and digital musical instruments (DMIs), which have made instrument design itself available to composers and technologists as a form of musical communication (Miranda and Wanderly 2006; Goldman 2011). In a similar vain, bespoke AMT can be created, aiming to overcome specific barriers for individual musicians or user groups, or to be widely accessible tools for music and sound creation.

Inclusive DMI designer Brendan McCloskey (2014) identifies four terms used to describe design ethos in accessible design: 'accessible'; 'assistive'; 'universal' and 'inclusive'. Noting that the distinctions between these terms often overlap and blur, a device is deemed: *assistive* or *accessible* if it addresses a specific physical and/or cognitive impairment, and *universal* or *inclusive* if it enhances usability through an appreciation of a wide spectrum of capabilities amongst the population (McCloskey 2014: 46).

In a report entitled *Engagement with Technology and Special Educational and Disabled Music Settings*, Farrimond et al. (2011) give a comprehensive summation of music technologies used in these settings. The report refers to pioneer of electronic music Robert Moog's (1988: 214–220) definition of contemporary music technology, identifying "three diverse determinants of musical instrument design and musical instrument structure. The first is the sound generator; the second is the interface between the musician and the sound generator; the third is the... visual reality of the instrument". Farrimond et al. (ibid: 13) argue that this modular system allows each element to be modified, adapted or replaced depending on the individual needs of a musician.

For musicians who face barriers to participation a modular system can offer significant benefits over traditional, un-modifiable instruments (ibid). They identify five major musical interface types: distance and motion tracking technology; touch screen technology; tangible interfaces; wind controllers and biometrics (ibid: 26-29). Farrimond et al. (2011) also discuss the variety of barriers, additional to the subjective barriers faced by musicians that exist between the potential of music technology to meet the needs of musicians with disabilities or special education needs such as the training of facilitators; and obtaining consistent resources and funding (ibid: 29).

As Farrimond et al. (2011: 13) illustrate, contemporary music technology that follows Moog's (1988) definition of a modular system is more suited to musicians with disabilities because different interface types can be appropriately utilized in response to an individual musician's specific barriers to access and participation. In addition, the more 'open' a DMI or digital device is (as opposed to 'closed' or un-modifiable) the more it can be adapted for a specific user's needs or purpose. In other words, open (adaptable or open source) technologies can be hacked or modified to overcome disabling barriers to music making for people with disabilities.

A recent study into accessible design titled *Enabling Technology* (Jewell and Atkin 2013), identifies that open source hardware, such as Arduino and Raspberry Pi, and 'curated ecosystems', such as iOS and

Android, also afford enormous versatility and customization needed by people with disabilities.

I turn next to discuss my own research with DMNI through which I have found that no matter how open or accessible a technology is said to be, whether it actually has an enabling effect and the ways in which it can be creatively used to enable participation is understood through observing and participating in practice. In the following, the focus is turned to practices with inclusive musical control interfaces.

4. INCLUSIVE MUSICKING WITH DIGITAL TOOLS

I am currently engaged in a year-long ethnographic study of DMNI, which I am undertaking through participating in DMNI activities and workshops; self-learning the functionalities and affordances of each piece of equipment used in the workshops; and semi-structured interviews and focus group discussions aimed at forming an understanding of the experiences and views of the workshops and the use of digital technology from the different people involved in DMNI.

My research methodology is participant observation, so the study began formally in February 2014 when I joined a sixteen-week training course to become a DMNI access music tutor. Around ten other Belfast based musicians were also inducted at the same time. As the training progressed, I began to shadow and assist workshops, eventually co-facilitating inclusive music workshops in different contexts, gaining first-hand experience of inclusive musicking with DMNI's plethora of equipment. On many levels I felt like an inexperienced trainee, which enabled me to fully immerse myself in the experience of learning to be a DMNI access music tutor. Throughout the duration of my research I have often been challenged to improvise and spontaneously find different ways of communication, musical collaboration and adapting technology for non-conventional usages.

I have chosen two instances of creative use of accessible DMIs and mainstream technology in inclusive music workshop settings, introducing some of the techniques and technologies utilised in inclusive music.

4.1. ENABLING CREATIVITY

From the first session of the training course onwards, DMNI CEO Dr. Michelle McCormack always emphasised that the important point in inclusive music is not the technology being used, but rather how you bring out creativity in another. Defending simple technological solutions, such as MIDI switches and pad based controllers, Michelle stressed to the group of trainees that although now there is an abundance of new technologies and devices for music and (accessible music), especially those created in universities, in practice they often do not last and do not achieve sustained use. The various reasons she gave are well documented in academic research, such as: issues surrounding lack of intelligibility (Jordà 2001; Wessel and Wright 2002; Cook

2004) and lack of time and resources for users to gain a level of mastery (Farrimond et al. 2011; Gehlhaar 2014).

My own experiences in the field, through participation and close observance of workshops, have corroborated what Michelle has continually emphasised to the trainee access music tutors. Furthermore, I have seen that through the social interaction between musician and facilitator and the creative, improvised solutions with musical control interfaces that arise as a result, musicians with disabilities are enabled to participate and engage in the musical process.

4.2. WORKSHOPS

Workshops are delivered once a week in social care facilities, schools and at the DMNI studios (based in Belfast and Newry). The groups are comprised of adults or children (sometimes mixed groups) with a range of both physical disabilities and learning difficulties, depending on the client or care provider DMNI is working with. The format of the workshops discussed here followed the structure of most DMNI short-term workshops. This generally consists of five phases:

1. Rapport and relationships are formed between access music tutors and the participants.
2. A song or soundscape is composed through discussion and experimenting with ideas.
3. The song is structured and mixed through discussion and critical listening.
4. The composition is then arranged for performance.
5. Once the composition and performance arrangements are complete, a performance may be organised to present the work to a public audience, including the participant's parents and carers.

4.3. ULTRASONIC TIMPANI

For musicians with quadriplegic cerebral palsy who experience sensory-motor challenges, the major barrier to participation is limb motor control (McCloskey 2014: 44). Movements take time, and keeping a motion or action steady and consistent, two essential requirements for playing a tradition musical instrument, is not easily possible. McCloskey (ibid: 11) argues that some MIDI instruments may be inclusive or accessible in nature, but most are not optimised for musicians with quadriplegic cerebral palsy who have a limited degree of upper limb motor capability.

In one afternoon workshop with an ensemble comprised of three just such musicians and two supporting facilitators (including myself), after a period of drawing out some ideas from the participants, it was decided by the group that a timpani part would suit the piece that was currently being composed. As a large marching band drum set has its home in the DMNI Belfast studio, the group decided that we could make recording playing rhythms on the drum with a regular drumstick. I had to hold the drum in the air, bringing it to arm level for the musicians. A condenser microphone was set up for recording into DAW software. However, after a few attempts it was clear that one of the musicians was not happy with his recording efforts.

The following solution came from He (my cohort). Facilitator A took an iPad to the musician; they together recorded one drum hit into *Garageband*'s (*https://www.apple.com/uk/mac/garageband/*) sampler so he could then play a rhythm with a sample, rather than on the actual drum. The musician's hand motion was not controlled enough to discretely use the iPad touch screen interface. Facilitator A improvised a solution, adapting the iPad with a *Soundbeam* (*http://www.soundbeam.co.uk/*) sensor via an *iRig* (http://www.ikmultimedia.com/products/irig/) Audio-MIDI interface adapter. *Soundbeam* is an ultrasonic sensor that transforms sonar responses into data that can control MIDI events. Through echolocation, a hand or object breaking the beam of the sensor at different points sends different values of data. There is no physical interface, no knobs, sliders or pads, so for a musician who finds working with physical objects a difficulty, the *Soundbeam* enables control of discrete note events. The musician was now able to play the timpani sample with concentrated effort. He recorded a track that he was satisfied with.

This is one example chosen from many to illustrate a trained access music tutor's improvisatory problem solving efforts towards overcoming an individual's specific barrier to participation in the composition process. In this instance a musician was enabled to play his own timpani line and participate as the other musicians had. After witnessing this the other two musicians decided to abandon their initial acoustic recordings and play the sampled timpani through the iPad sampler too.

An acoustic instrument can be made more accessible for musicians with different abilities by sampling and playing it through an iPad touchscreen interface. In turn, the iPad can be adapted with the *iRig* and *Soundbeam* to include an even broader spectrum of users. This example of a facilitator adapting tools to overcome a disabling barrier illustrates how inclusivity and accessibility is not solely determined in the design and making. Most importantly, it is the social interactions and creative practices through which technologies are utilised and assemblages of devices are spontaneously adapted to overcome disabling barriers.

4.4. OPENING THE DOOR TO PARTICIPATION

The *Skoog* (*http://www.skoogmusic.com/*) is another accessible DMI, which comprises a 'soft, squeezable object', variably sensitive to touch, responding to a light touch or the total compression of its malleable interface. The object is multi-touch sensitive with five colour-coded responsive zones. Each zone can have a particular note or sampled sound allocated to it and multiple parameters are variable from within accompanying software. Using physical modelling developed within *Max/MSP* (*www.cycling74.com*), it is possible to dynamically manipulate the various instrument sounds though 'pressing, squeezing, rubbing, stroking, tilting or manipulating the Skoog' (Farrimond et al., 2011: 28).

Psychologist and musician Dr. Ben Schögler, co-inventor of the *Skoog* delivered a training session for the DMNI trainee access music tutors, part of a daylong session focussing on different interfaces used in the DMNI context. He recounted one experience to us, which I summarise here.

Ben told us the story of a boy with Asperger's syndrome who was working with a community musician and Skoog practitioner, Lewis. They had met through a group music making session with the *Skoog*. This particular boy was the only one from the group who would not engage in the workshop. He was consumed in playing with a door handle away from the group. The care workers there said that he always did that, explaining it as 'just repetitive behaviour'. Lewis had refused to accept this; he felt that it was this boy's way of having some control over his environment. Lewis took the *Skoog* to the boy at the door and recorded the door handle's rattling sound and subsequently mapped the sample onto the *Skoog*'s physical interface. The sound of the boy playing with the door handle was transformed into a musical instrument. When Lewis started playing with the sound of the door handle on the Skoog, it caught the boy's attention. Through the process of interacting with Lewis, the Skoog and the sampled sound of the door handle, slowly group participation too was enabled. This example echoes the 'Ultrasonic timpani' and was chosen as emblematic of the potential of DMIs for inclusion. It also exemplifies the way in which the affordances of the technologies can only be utilised through the creative and spontaneous interactions between facilitators and musicians working together.

5. CONCLUSIONS

The music interfaces and their usage in practice as I have experienced in my very specific research with DMNI reveal important general parallels to other forms of music also inextricably linked to digital music technologies.

Electronic musicians use DMIs and musical control interfaces in subversions of the mainstream (Sicko 2010; Danielsen 2010; Demers 2010; Butler 2006, 2014). Sonic arts challenges the boundaries of what constitutes music, sound and research through the utilization of music and audio processing technology and attempts a turn away from traditional composition conventions and music theory (Emmerson 1986; Smalley 1997; Bowers 2002; Wessel and Wright 2002; Prior 2008). Through inclusive music practices using mainstream and inclusive musical control interfaces, exclusionary designs are exposed and solutions to removing disabling barriers are explored. At the same time, common assumptions of what musicians with disabilities can actually achieve are challenged and traditional notions of disability are deconstructed (Lyons 2006; Cappelen and Andersson 2012; Jewell and Atkin 2013; McCloskey 2014). These technically closely related but stylistically and ideologically divergent examples show how neutral and heterogeneous digital music technologies are, exemplifying some of the broad and variegated applications that are possible.

These attempts at subversion, resistance and deconstruction are enacted in practices of design and making, and of composition and performance. Ratto (2011) defines critical making as a mode of materially productive engagement intended to bridge the gap between physical and conceptual exploration. In the context of inclusive music, the questions of who this productive engagement is open to, who is excluded and why, must be asked.

In a similar vein, in response 'open' technology, I add to this that even 'closed' designs can be modified, so rather than defining a technology as open or closed, analysing a device's level of 'openness' may be more useful. Through my fieldwork at Drake Music Northern Ireland (DMNI), I have seen that although a hardware interface can be hacked to suit a specific individual, a more immediate and spontaneous solution emerges through linking tools together in arrays, attempting to create for a musician the opportunity to discover the most appropriate control interface for their own specific capabilities. Sound generators that have inaccessible interfaces can be adapted with controllers or sensors to overcome a specific barrier to its utilisation. In all cases it is the trained facilitator implementing the hack, or adapting a tool for the musicians, so an important question to ask when considering openness is: open to whom? A precondition for the person hacking or adapting a tool is a certain level expertise; thus, a universally open technology is hard to conceive.

Often very simple technologies, such as switch-based interfaces, are best suited for certain DMNI participants with very limited physical mobility. On the other hand, comparatively complex iPad apps work for other participants. Thus, it is important for facilitators to refrain from discounting solutions based on an imposed distinction (e.g. level of openness; acoustic or digital; synthesiser or sample based (Dalgleish 2014)). Sometimes a partnership between user and instrument can be unexpected and even when a device does not match with a participant's abilities, the process of finding out can bare valuable musical results. Ultimately, it is through the social interactions and practices using a DMI or musical tool that design goals and ethos are actually tested. It is in practice that design limitations can be exposed and challenged, and new adapted uses or affordances emerge.

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PAPERS

AUTHOR INTERACTION

NONLINEAR DYNAMICAL SYSTEMS AS ENABLERS OF EXPLORATORY ENGAGEMENT WITH MUSICAL INSTRUMENTS

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ABSTRACT

This paper presents a small-scale study that examined links between the inclusion of nonlinear dynamical processes in musical tools and particular kinds of engagement. Communication-oriented attitudes to engagement that view the tool as a medium for transmission of ideas are contrasted with material-oriented attitudes that focus on the specific sonic properties and behaviours of a given tool, and the latter are linked to the inclusion of nonlinear dynamical elements. Methodological issues are raised and discussed, particularly with regard to the holistic nature of musical instruments, the difficulties of independently testing isolated design elements, and potential methods for addressing these difficulties.

KEYWORDS

Nonlinear Dynamical Systems, Engagement, Exploration, Mapping, Free Improvisation.

1. INTRODUCTION

This paper examines the use of nonlinear dynamical systems as elements within the design of digital musical tools, and the effects they can have on how musicians approach using such tools. A short study is presented alongside the preliminary results. This study is considered a precursor to a proposed larger study that will take place in 2015.

Worth (2011) distinguishes between two contrasting approaches to engaging with musical tools. The first – referred to as *idealist* – views the tool as an ideally transparent medium through which the musician's ideas pass from thought to sound. The second perspective – referred to as *literalist* – is more material-oriented, and views the tool as something to be engaged with and experimented with, and as a source of ideas. Worth traces this latter attitude in the work of artists associated with the Mego label, but similar attitudes can be found in other fields, notably free improvisation where the instrument is variously referred to as an "ally" (Bailey 1992), something to have a "relationship" with (Unami 2005), something with its own "intentions" (Hopkins 2012), and where the performer may be "played by" the instrument (Borgo 2007, p. 57). Keep (2009) discusses similar attitudes in experimental music, where the exploration of inherent sonic properties plays a significant role. Gurevich and Treviño (2007) discuss the tendency towards the former idealist approach in the New Instruments for Musical Expression (NIME) community, noting that the term *expression* seems to include a tacit assumption that the performer's role is to communicate something "extramusical", and that this assumption risks excluding alternative modes of engagement such as those found in experimental musical practices. Musicians concerned with a more literalist approach often seem to value instabilities and unpredictable elements in their engagement with a given tool (Keep 2009, Unami 2005, Prévost 2007, Warburton 2001).

This paper links these elements to the properties of nonlinear dynamical systems, and examines potential links between the inclusion of such processes in musical tools, and particular approaches to engaging with these tools. A study was conducted in which participants engaged with a range of different digital musical interfaces, some of which included nonlinear dynamical elements and some of which did not. Although concrete conclusions are difficult to draw from this initial small-scale study, the findings suggest links between specific design decisions taken in creating musical tools and the approaches taken by musicians to engaging with these tools, particularly a link between the nonlinear dynamical elements and more open exploratory engagement as opposed to communicating pre-established ideas. This research has relevance for considerations of musical instrument design, and for considering the relationships between contemporary musical practices and contemporary musical tools. It may also be relevant to HCI more broadly, particularly in situations where designers wish to foster creative engagement and exploration, for example in interactive drawing tools or in computer games (physics based games already provide interesting examples of exploratory engagement with dynamical systems).

Nonlinear dynamical systems and their relation to musical practice are considered in more detail below in Section 2 and an overview of past work is given in Section 3. This is followed by description of the methodology used in the study, initial findings, and discussion contextualising these results and highlighting interesting aspects of the methodology.

2. NONLINEAR DYNAMICAL SYSTEMS AND MUSIC

Chaos, instability, unpredictability, and complex behaviours are all closely associated with nonlinear dynamical systems (Strogatz 1994). Links between such systems and musical behaviours have been noted and explored in a variety of contexts. Pressing (1988) describes the links between their properties and approaches to composition. Many composers have worked explicitly with such systems: e.g. David Tudor, Insook Choi, David Dunn, Ryo Ikeshiro, Dan Slater, and countless others. Microphone-loudspeaker feedback provides a simple example of a nonlinear dynamical system affording a complex range of musical behaviours: the system may change over time with fixed input (e.g. swelling or fading away), there are abrupt transition points where the system will jump from one relatively stable state to another (e.g. abrupt changes in register to different harmonics), it is chaotic in that it is highly sensitive to initial conditions, and it exhibits hysteresis, such that the state of the system depends not only on the present input, but on the history of the input, enabling properties such as mode locking (e.g. placing the microphone in exactly the same place may not produce the same pitch every time).

Nonlinear dynamical systems can be found in the workings of many acoustic instruments: governing airflow in wind instruments, in the relationship between reed movement and airflow in the bore of reed instruments, bowing interactions in string and percussion instruments, and in more subtle aspects of many other instruments (Smith 2010). Free improvising and experimental musicians often seem drawn to these elements: bowing objects, using feedback (acoustic or electronic), working directly with piano strings rather than the keys, exploring multiphonics and unstable areas in reed instruments, etc.

3. RELATED WORK

Hunt and Kirk (2000) studied the effect that complex mappings could have on engagement with musical systems and observed that interfaces incorporating complex mappings were often seen as more fun, and helped to facilitate complex musical gestures. A similar result may be expected from nonlinear dynamical systems as they interrelate inputs and outputs in a similar manner, but add further complexities in the form of time dependence and nonlinearity. Extending the complexities of the interaction in this way may therefore yield a similar alteration in engagement and affordances. The language used by many researchers working with nonlinear dynamical systems in music seems to support this claim. Burns and Burtner (2004) describe interaction with their feedback networks as "engaging" with a system rather than "commanding" a system. Kiefer (2014) talks of the "compelling, unpredictable, and strangely lifelike behaviours" encountered in perturbing musical systems based on echo state networks. Bowers and Hellström (2000) describe how the inclusion of nonlinear dynamical aspects in their instruments goes beyond merely supporting exploration, and actively "incites" it.

Precedent for attempting to investigate the effect of nonlinear dynamical instruments on creative and exploratory engagement can be found in the longitudinal study conducted by Gelineck and Serafin (2012). Modular devices that incorporated physical modelling elements were given to three experimental composers for a period of several weeks. A common response from the participants was that the instruments were unpredictable and too difficult to control, and that they would be impractical in a live environment. The definition of the term experimental in this context appears to be much broader than the specific meaning used by Nyman (1974) and Saunders (2009) and referred to in Section 1 in relation to a literalist model of engagement; almost all the participants appeared to be attempting to pass their ideas transparently through the tools, as opposed to engaging with and exploring their specific sonic properties. An important distinction between the present study and the study conducted by Gelineck and Serafin is that free improvisation plays a significant role in the practice of several participants of the present study, allowing for a comparison between the attitudes of musicians working with a more material-oriented approach with those engaged in communication-oriented practices.

4. METHODOLOGY

Four interfaces were created for the purposes of this study: two based around nonlinear dynamical processes, and two that did not include such processes. The four systems are described in more depth later in this section, and an overview is provided in Table 1. Each system took the same input: two dials and a slider from a MIDI controller. Four participants were asked to engage with each of the four interfaces for 5-10 minutes, to create a short 1-4 minute recording, and to complete a questionnaire for each interface. Short interviews were then conducted at the end of the session. The order in which the interfaces were presented was randomised for each participant.

4.1. COMPARABLE INTERFACES

A wide range of factors may affect a musician's experience and engagement with a particular musical system, making it difficult to establish the significance of a specific element. The inputs, mappings, and available sound world may all contribute to the nature of a musician's (or non-musician's) engagement. The specific designs of the four interfaces attempt to address some of these considerations (leaving aside the influence of the input controller for the purposes of this study). In particular, these four interfaces attempt to distinguish the influence on participant engagement of the nonlinear dynamical elements as distinct from both nonlinearities in static mappings, and from the particular sound world afforded by each interface. Audio excerpts from the four interfaces can be heard at *http://tommudd.co.uk/icli-examples.*

Interface	Nonlinear Dynamical	Mapping	Audio Engine
1	Yes	Continuous	Resonated Duffing oscillator
2	Yes	Discontinuous	Resonated Duffing oscillator
3	No	Discontinuous	Resonated oscillator
4	No	Continuous	Granulated sample player

Table 1 The four interfaces used in the study

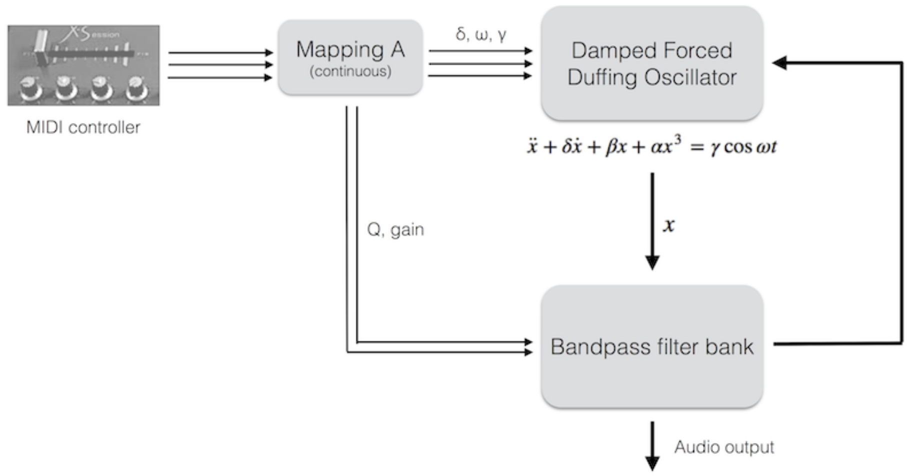

Figure 1 Interface 1. A damped forced Duffing oscillator coupled with a bank of linear resonators. The user interacts with the system via three MIDI controls.

INTERFACE 1 – NONLINEAR DYNAMICAL SYSTEM WITH MAPPING A

Both interfaces 1 and 2 are based on a damped forced Duffing oscillator (Guckenheimer and Holmes 1983), shown below as a discrete map. This is a nonlinear dynamical system that models the forced vibrations of a beam that is fixed at one end.

$$x_{n+1} = y_n$$
$$y_{n+1} = -\delta y_n - \beta x_n - \alpha x_n^3 - \gamma sin(\omega t)$$

This equation is implemented at sample rate (44.1kHz in this instance) and coupled with a set of resonators such that the xn term is passed through the filter bank, and the output of the filter bank is used in its place in the above equation. This combination of a nonlinear function coupled with a linear resonator bears a close resemblance to the structure of many acoustic instruments (McIntyre et al. 1983) and hence to many physical models (Smith 2010). The specific structure of interface 1 is shown in Figure 1.

INTERFACE 2 – NONLINEAR DYNAMICAL SYSTEM WITH MAPPING B

Interface 2 differs from interface 1 only in terms of the mapping from the MIDI controls to the system parameters: interface 1 uses continuous linear changes (mapping A), whilst interface 2 uses discontinuous mappings that cause jumps in the parameters at particular points (mapping B). This distinction was included to assess how significant the nonlinear dynamical component was in comparison with the static discontinuities in the mapping. In other respects this interface is the same as interface 1.

INTERFACE 3 – STATIC SYSTEM WITH MAPPING B

Interface 3 is very similar to interface 2, but with the Duffing system removed as shown in Figure 2, rendering the interface non-dynamical and linear. The discontinuous mapping is retained however. Although the system is similar to interface 2 and to a lesser extent interface 1 in terms of the processes involved, the range of possible sounds is very different.

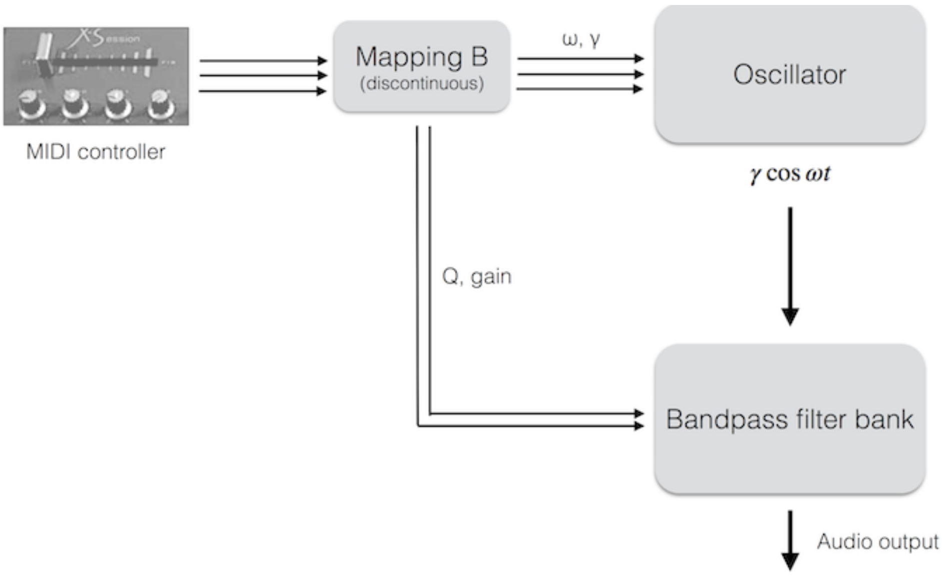

Figure 2 Interface 3. Duffing system and the feedback are removed, leaving an oscillator and resonant filter bank. Discontinuous mapping B is otherwise preserved from interface 2.

INTERFACE 4 – STATIC SYSTEM BASED ON AUDIO RECORDING OF INTERFACE 1

Interface 4 attempts to preserve the sound world of the Duffing systems by basing the interface around a two minute audio file recorded from interface 1. The system is therefore not a nonlinear dynamical system, but retains a very similar sound world to interfaces 1 and 2. The inputs are mapped to position in the sample, granular pitch and overall volume.

4.2. PARTICIPANTS AND DATA COLLECTION

All recruited participants had a significant background in music, but varied considerably according to how significant they felt that free improvisation was in their own practice. The questionnaires asked participants to use Likert scales to measure their agreement with statements relating to: how unpredictable they found each interface, to what extent they could repeat an action, how much they felt they understood each interface, to what extent they felt that there was more to discover, and whether they felt that the interface fitted in with their own practice. In addition, participants were asked to rank the interfaces according to how satisfying they found their experience. Data was logged from the systems themselves, allowing concrete differences in engagement to be examined in the participants' recordings and practice sessions.

5. PRELIMINARY RESULTS

As mentioned above, this is a preliminary study where refinements to the methodology are as relevant as findings from the data. As the sample size is small, the numerical data is not strong enough to produce concrete evidence of any particular hypothesis, but helps to provide broader pictures of user engagement when combined with questionnaire and interview responses. The results shown below therefore highlight potential areas for more detailed study.

5.1. DIFFERENCES IN ATTITUDE BETWEEN SELF-PROFESSED IMPROVISERS AND NON-IMPROVISERS

The four participants – A, B, C and D – varied in terms of their engagement with free improvisation, rating themselves respectively as 1, 5, 7 and 8 on a scale from 0 (no engagement) to 10 (entire practice). The three participants that professed an interest in improvisation all felt most 'satisfied' by interface 1. The interviews highlighted a range of justifications for this, such as:

- "[interface 1] was really fun [...] much more enjoyable" [compared to interface 2] – participant C
- "I felt I could explore, the unpredictability was nice" – participant D
- "I felt like it changed more, it was more variable" – participant B

Participant D linked interfaces 1 and 2 closely however and referred to both as being open to exploration. Participants B and C differed in how unpredictable they found interface 1?, with some rating interface 4 and interface 2 as equally or more difficult to predict. Participants B and D both felt that the interface fitted in best with their existing practice compared with the other interfaces.

By contrast, participant A, who did not identify as an improviser (1/10) ranked interface 1 as the least satisfying of the set. Interfaces 1 and 2 were grouped together as being more unpredictable than interfaces 3 and 4, and despite describing the unpredictable elements as fun, preferred interface 3:

> "[…] it was easier to […] get somewhere I had in my mind. The other ones were more noisy […] so I couldn't control [them] that much. (participant A)"

5.2. INFLUENCE OF THE SPECIFIC SOUNDS AFFORDED BY EACH INTERFACE

The available sound worlds in the various interfaces appeared to play a key role in the participants' preferences and their approach to engaging with the interfaces. Participant A's preference for interface 3 over interface 1 was due at least in part to the scope for "Stockhausen-like" staccato sounds in interface 3 that the participant preferred to the "droney" sounds of interface 1.

Participant B was similarly influenced by the sound world and felt as though preference for a particular interface's sound combined with the potential for variety were the chief factors in determining their preference.

5.3. SIGNIFICANCE OF THE MAPPING

Given the similarities at the core of interfaces 1 and 2, there were some surprising differences in the participant's attitudes towards them. Participant C saw interface 2 as significantly more unpredictable, and "a bit of a wilderness", worrying that it would be a problem in live performance, and as noted above, was consequently less enjoyable. The participant ranked it as the least satisfying despite ranking interface 1 as the most satisfying. Participant B preferred the continuous nature of interfaces 1 and 4 as they allowed for small, incremental adjustments, as opposed to interface 2 where "the margin seemed to be quite fine".

5.4. EXPLORATORY ENGAGEMENT

As mentioned in several of the quotes above, interfaces 1 and 2 were generally linked to an exploratory approach, whether participants saw this as something that suited their own practice or not. Participants' Likert scale responses tended to agree with the statement "I feel that there are many areas that I could still explore and discover" in relation to interfaces 1 and 2. Participant A and participant C both seemed less inclined to explore freely and both expressed some frustration with trying to achieve ideas that they had in their head through the interfaces that they perceived as more unpredictable. This is illustrated in the quote from participant A given in Section 5.1. Participant C sees the unpredictability as a problem under particular circumstances (notably in interface 2):

> when something has happened that might have been a bit unpredictable [...] there's a certain couple of things that you can do that will get you to where you want to go [...] an overall idea that you have in mind, but obviously if it's too unpredictable then you can't even do that. (participant C)

Participant D felt that unpredictability was a problem in certain situations but not others: "in the ones that I felt that I could still explore, then the unpredictability was a good thing". Interfaces 3 and 4 were seen as frustrating to engage with in an exploratory manner and instead, were considered as something that might be more appropriate for them to use in a song based context. Participant C also made a distinction in the kinds of interaction they felt would be relevant for different areas of their practice, aspects that were too unpredictable were not seen as appropriate for song-based contexts.

6. DISCUSSION

The results point at potential links between the nonlinear dynamical elements and a tendency for exploratory engagement, albeit with certain caveats relating to the methodology (discussed further below). A common thread across the four interviews was the appropriateness of different kinds of interaction for different musical contexts, which is consistent with the distinctions in how people with differing musical practices and backgrounds responded to the different elements. Examining participant's responses in terms of the communication and material oriented approaches outlined in Section 1 appears to be a useful approach, and provides a framework for considering differences in attitude across the different participants. These results can be compared with Hunt and Kirk (2000) who also concluded that whilst some saw complex interactions as being more fun, some users preferred interfaces that provided more simple controls for individual sonic parameters. The present study suggests however that participants may actually alter their attitude towards complexity – and particularly unpredictability – given the specific nature of the interface, and the musical style that is suggested by a particular interface.

The methodological insights encountered through conducting this study are also of interest. The instruments could be stripped back to just the elements under consideration and simplified in all other respects, but as Stowell and McLean (2013) point out, this may reduce the instrument to the point of being unmusical. This study takes the opposite approach in order to attempt to encourage rich musical interactions between participants and the tools. The interfaces are therefore complex and contain many aspects beyond those directly under consideration, making it more difficult to isolate the influence of the nonlinear dynamical systems. The differences in attitude that some participants had towards interfaces 1 and 2 seems to highlight this, as they use the same underlying system, and differ only in the nature of the mapping to the system. This study has attempted to get around such problems by including multiple mappings so these distinctions can at least be noted, and so that it may be possible to separate changes in engagement that relate to this mapping decision as opposed to the nonlinear dynamical system. The use of a system which generates sounds similar to the nonlinear dynamical interfaces (interface 4), and a system which is technically similar (interface 3) is likewise an attempt to separate the effect of the nonlinear dynamical elements from the influence of both the specific sounds available and from the other aspects of the sound engine beyond the nonlinear dynamical component. Using this approach, results that present distinctions between interfaces 1 and 2, compared with interfaces 3 and 4 are therefore more likely to relate to the influence of the nonlinear dynamical elements, and less likely to relate to the other elements.

7. SUMMARY

The small-scale study presented in this paper suggests links between the inclusion of nonlinear dynamical processes in musical tools and particular kinds of engagement. Distinctions are made between approaches that focus on communicating ideas that are formed independently of the tool and approaches that focus on exploring the specific sonic properties of the tool. Links are made between the latter mode of engagement and the use of nonlinear dynamical processes. Methodological issues are raised and discussed, particularly with regard to the holistic nature of musical instruments, the difficulties of independently testing isolated design elements, and potential methods for addressing these difficulties. The results at this stage are tentative, and further studies are proposed with greater participant numbers.

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GRUNTCOUNT: BLURRING THE PIECE/SYSTEM/INSTRUMENT DISTINCTION

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ABSTRACT

Martin Parker's *gruntCount* is a multi-version, configurable composition for improvising musician (or musicians) and computer. Performers embark on a journey through sound processing modules that are specifically customised to individual playing styles. It exists in no fixed state, yet allows for a growing set of rehearsable, replicable and configurable pieces, in which all musical material, timing, overall duration and levels of effort are managed by the live musician. In order to optimise elements of *flow* and of *liveness* in each performance, *gruntCount* challenges traditional definitions of 'piece', 'system' and 'instrument', instead establishing an environment for human-machine improvisation that serves the musical result and not the system itself. This paper refers to a selection of sound examples from the bass clarinet version (2012-14) and examines formal time-shaping possibilities within a structured performance, while exploring the environment's qualities of coaction and configurability in an era of new score types.

KEYWORDS

Live Electronics, Computer Music Systems, Improvisation, Performance Practice, Liveness.

1. INTRODUCTION

The work described here represents an attempt to address fundamental concerns of contingency and spontaneity within a structured framework that offers maximal performer agency, but also allows both composer and performer to be heard through the music. Martin Parker's *gruntCount* is a multi-version, configurable composition for improvising musician (or musicians) and computer. The digital signal processing (DSP) parameters employed are created and formalised in an improvisatory environment with the performer and subsequently plotted onto a series of graph-like curves on the visual interface. These pieces are enacted from the performer's interaction with the on-screen notation. The live musician's sound stimulates the onset of the computer's responses, which evolve (and occasionally provoke) as a path is negotiated through the piece. Players are also at liberty to create and store their own plots within the software, thereby providing the potential to use *gruntCount* as a tool in other musical contexts. We will examine how *gruntCount* inhabits aspects of piece, system and instrument, and how, through its use by performer and composer, it blurs the distinctions between.

We would like to note that this work also contributes to debates around the computerised landscape of live electronic musicking (Small 1998). Feenberg describes computerisation as a missed opportunity to inform and empower labour (Feenberg 1991). Citing Zuboff (1991, 94), he proposes that it has instead tended to further entrench divisions between management and labour. We see *gruntCount*'s approach as a step towards a more even distribution of authorial agency and view the 'computerisation of the musicplace' (to paraphrase Feenberg and Zuboff) as an opportunity to explore liveness, flow and nowness, rather than to impose even tighter restraints on the performer, such as those implied by pitch-trackers, tapes, click tracks and score-following softwares. This is not an ideological stance, however. Working in the ways we describe below, we like the sound that comes out – while the player is definitely improvising, what is delivered has the potential be a formally coherent concert item.

1.1. GRUNTCOUNT

Each edition of *gruntCount* is personalised from the outset, with composer and performer working together to produce the elements of a system for creating well-defined and structured musical pieces that invite liberal performer input, spontaneity and intuition. In the bass clarinet version (2012-14), this preparatory stage involved a period of system 'training', in which the composer engaged in real-time free improvisations between himself and the player, creating at speed a unique set of interrelated DSP parameter presets – these constitute the version settings. The electronics are all derived from the way in which these version settings respond to live input (there is no sample library).

A trace of this *interactive*, improvisatory exchange is present in every subsequent rehearsal, performance and adaptation of the version.

Having designed these settings, *gruntCount*'s compositional agenda proceeds with the plotting of various journeys or curves through the DSP settings. These curves may resemble a graph or automation curve, but in fact represent specific trajectories through a *parameter space*, which itself has nested settings within it. There is a formal design here, a quality and style, and yet the manner in which the piece is individuated is entirely defined by the live performer, whose physical efforts (or 'grunts') move the assemblage forward.

The vertical playhead in the *gruntCount* interface, passing from left to right through the performance, will only move when excited by sound. This affords the performer absolute control over the initiation of the piece, and a considerable degree of influence over its pacing and flow. Notably, the ability to create moments of suspension within the reactive electronics is possible when the player is silent or plays under the activation threshold.[1] By setting the number of grunts to be detected, the approximate duration or *timespace* of the piece may be estimated. This timespace, in conjunction with adjustment of the input threshold volume, determines the level of effort that will be required to bring the piece to its conclusion. In this way the immediate concerns of the performer on stage are not system-based but sonic and musical. The player can openly respond within an ongoing feedback loop, "managing unfolding states of attention." (McCaleb 2011)

Figure 1 The latest version of *gruntCount* (v4.2). Setup procedure is ordered down the left hand column, including version and curve selection, an array of audio in/out settings, sample rate, vector size and microphone input(s).

1. Listen to *gruntCount-Example-PlayingUnderTheRader2-ObjectsOfSound2.wav* and *gruntCount-Example-PlayingUnderTheRader-laptop.wav*, *http://dx.doi.org/10.7488/ds/170*.

The first incarnation of *gruntCount* was created with flautist Anne La Berge in 2011, and the environment was soon adapted for other improvisers. The initial stand-alone application, made in Max/MSP 5, incorporated *gruntCount*'s distinctive graph-like interface. This version was used for the bass clarinet premiere in Edinburgh in March 2012, as well as for the CD recording session (Parker, 2013).[2] The latest version was created anew from a second studio session.[3] It has a refined interface, branded for the publisher sumtone.com (Fig. 1), and features an ordered setup procedure designed to be learnable by non-specialists in digital audio technology (for which reason it is also a stand-alone app). A short video tutorial by the composer is included to facilitate this learning process, which here allowed for practising to begin within 30 minutes of downloading the software package.[4] Finally, full-screen display functionality is added for any laptop size, so that visual elements are optimally viewed and attention can be managed without irrelevant distractions.

In April 2014, a remote application was added to allow for hands-free, on-stage operation of the main settings by the performer and for expression pedal control of overall output from the electronics. This small addition had the unintentional yet profound consequence of affording absolute control – a power of veto in effect – to the live performer, now able to suppress the electronics, fade in or out, or conclude the entire piece before the end of the curve.[5]

2. PIECE, SYSTEM OR INSTRUMENT?

In order to optimise elements of *flow* and of *liveness* in performance, *gruntCount* challenges traditional definitions of 'piece', 'system' and 'instrument'. The following section will examine how *gruntCount* inhabits aspects of each and how, through its use by performer and composer, it blurs the distinctions between them.

2.1. THE PIECE MODEL

A piece of music may be described as a discrete unit that has some replicable features for future performances. It has a structure and a quality of style or aesthetic that is imagined in advance of a performance. A piece is more or less predictable, and has a relatively consistent duration. Pieces are (for our purposes) inherently hierarchical – pitches and their order, note lengths, tempi, dynamics and other elements are prescribed to a degree and require a score or other form of instruction.

2. *http://sumtone.bandcamp.com/track/many-boffins-died-to-give-us-this-information*

3. Version 4.2. The session took place on March 26, 2014 at University of Edinburgh, Edinburgh College of Art, Reid School of Music.

4. *https://vimeo.com/111283604*.

5. Listen to *140527_LivePerformance_Edinburgh_objectsofsound_02.ogg* and *140723_LivePerformance_Edinburgh_jazzfestival_02.ogg*, *http://dx.doi.org/10.7488/ds/170*.

The composer's role is to imagine, to create, shape and notate, whereas a performer will learn, practise, interpret, reanimate (Emmerson 2007) and reveal.

Representations of imagined music for interpretation by another person inevitably involve a measure of indeterminacy. Elements of timing and space, fine-grained dynamic shading and phrase shaping, as well as adapting the piece to different venues and concert scenarios mean that all live music is in flux. Pieces are always subject to contingency and intuition in performance. The *gruntCount* software is, at least in some sense, a score. The curve produces a structure that reflects compositional choices and projections, constituting a framework around which the improviser *negotiates* a path through the piece.

A *gruntCount* curve represents an act of formal composition. Whilst this is a replicable form, to be re-enacted anew, a high value is attached to considerations of liveness in performance and to the improvisatory skill of the experienced performer. Like a piece, *gruntCount* requires practice – it must be learnt and understood. It requires the finding of techniques and the building up of a bank of experience and familiarity. Getting to know and recognise the character of an electronic part is analogous to learning the other instrumental parts to a piece of chamber music or concerto (Winkler 1998; Pestova 2008). Familiarity with the behaviour and character of the composer's DSP settings (the *orchestration* of the electronics), their particular ordering and nuancing within the composed curve, and discovering the potential for drama or space in the whole, requires rehearsal.

However, the intention from the outset in *gruntCount* was to bring performer agency and autonomy to a level approaching that of the non-hierarchical structures accessible to improvisation ensembles (Lewis 2000). By inviting a co-created and improvisational quality to each performance of the same curve, some aspects of *gruntCount*'s pieceness begin to blur. The more it relinquishes hierarchical interrelations between creator and enacter in favour of a model of coaction, the more systematic it becomes.

2.2. SYSTEMS

As a configurable composition, *gruntCount* could be seen as a contribution to contemporary obsessions with choice and individuation. However, we were more interested in the idea that configurability, choice and individuality are innate dimensions of music. Performers discover what it feels like to play within a constantly adapting environment, choose how to play, what to play and when, but with the confidence that a plan for the improvisation is already in place. In this respect, *gruntCount* is presented to the player as a system first, then a piece.

Computer music systems tend to be designed to anticipate a wide range of input – they don't just do one job. They are not limited to producing music of a specific duration and most systems are built robustly with the expectation of being used by others. They are also highly configurable, so that parameters may be adjusted to allow for the independent musical style and aesthetic of various users. *gruntCount* was developed as a composition system with flexibility, adaptability and scalability built into many aspects of its design. Its systematic nature evolved iteratively as different problems and solutions to them became apparent.

Systems theorists well know that a system imposes itself upon its users in stealthy ways: “when a system is set up to accomplish some goal, a new entity has come into being – the system itself.” (Gall 1975) When using music systems for piece creation, they also bring a voice to the composition. In the case of *gruntCount*, as work with more performers developed, composerly considerations of sound and form shifted towards designerly issues of interface and ease of use. At a point in the system’s development, it reached a stage where it became impossible to change the behaviour of some of the sound processing modules without rendering obsolete all of the previous versions for multiple instruments that by then were travelling with various performers. In this way, the system had imposed a block on its further development. New versions can of course be made, but changes to the components can no longer be implemented.

One unexpected outcome of working on the bass clarinet edition was a warping of the system’s purpose by the player to create a kind of simple, bespoke digital effects rack. By creating fluid curves within isolated bands of just a few selected settings, distinct units of sound processing became available as the basis for the bass clarinet’s character in a recording session of improvisations with a guitarist. This act of appropriation (or *patch-hacking*) by the performer reflects a confidence in its operation and configurability, and demonstrates a form of instrumentality in the combined assemblage of acoustic instrument and computer music system.

2.3. INSTRUMENTALITY

Before it sounds, an instrument must be played, requiring a more or less ongoing input of energy to maintain its sound production. It is spontaneous but limited to a definite character. Its timespace is only set out in the number of simultaneous sounds that can be made and their duration (the resonance of a string or drum skin, for example), but remains otherwise open. Acoustic instruments are resistant (Waters 2013; Parker 2007) and experiencing these resistances requires the player to either overcome them or explore their qualities and limits.

Schroeder and Rebelo frame the performer-instrument relationship as “a multimodal participatory space” (Schroeder & Rebelo 2007) – one in which all elements have an affective influence. They argue against the objectification of instruments as extensions of the body, where the relationship with the performer is seen as “a transfer from the body to the world”, preferring a back-and-forth interdependence that is revealed by an exploration of physicality and resistances. “This means that the performer only becomes acquainted with the ‘thing’ at hand by being able to test boundaries, negotiate subtleties and uncover threshold conditions." (*ibid.*)

Because of the the constant slippage of certainty away from the player in *gruntCount*, and the not-quite-knowableness of the parameters (nested dynamism), situations arise which require practice, familiarity and the development of a contingent and nuanced control. It then becomes possible to 'play' the whole, making subjective decisions about sounds and their qualities prior to and during a performance. Choosing the number and types of microphone and loudspeaker to use and their positioning, for example, and the balancing and spatialisation of the software output alongside the amplified live sound, can be determined in advance, very much as part of the setting up of an instrument for performance and integral to the idea of an individual player's 'sound'.

Riva and Mantovani suggest that in *first-order* mediated action (acquiring fluency in the use of a tool) our perception of our bodily selves moves outward (Riva & Mantovani 2012, 206). They explain that our sense of space and what we can do in it operates by integrating two "reference frames" – the *peripersonal* (immediately reachable with the body) and the more subtle *extrapersonal* (how we remember and learn to relate to the space beyond our reach, and to objects in it) – and conclude that "our peripersonal space is extended by the proximal tool: we are present in it." (*ibid.*, 207) Developing the operation of a secondary (distal) tool constitutes *second-order* mediated action – in our case performing with *gruntCount* – and "shifts the extrapersonal space to the one surrounding the distal tool: we are present in the distal tool and in the space surrounding it." (*ibid.*, 208)

Green also remarks that we tend to focus on the "material boundaries of whatever particular device is taken to be the locus of sound production", whereas from a wider viewpoint, "objects form a part of a network of relationships with other objects and with people." (Green 2013). These relationships are in constant flux, so there must be an ongoing reassessment of the nature of the environment. We can therefore view an instrument as a "coalition of resources being used *at a particular moment*." (*Ibid.*) One *interacts* with an instrument to form a broader one, blurring the distinctions between elements in the performance ecosystem (di Scipio 2003; Waters 2007). A new human-instrument identity is established as an aggregate, and it behaves as an assemblage of intimately tied agents.

3. BLURRING: WHAT'S IN IT FOR ME?

3.1. PERFORMER INTERVIEW

MP: As a player, what do you gain by the blurring of these edges?
PF: For me now it's not a piece, not a series of pieces, anymore – it's an *environment* in which I can quickly access either a way to put together an existing piece, a way to create a new one, or even a way to provide the basis for a hacked software instrument. I also learned as I used it

– it taught me things: how to set up a live electronics system, about configuring DSP settings and soundcards, how to manage the input coming into the system with the threshold and number of 'grunts' – at which point I realised these adjustments are to do with the level of physical effort in a performance. It helped me to feel like an active and invaluable agent in the creative musicking process.

In performance it's a bit like going into a wrestling bout, or a tricky negotiation. It's that same feeling you have when you're about to do a free improv with another person that you know well: you know the sorts of things that might happen, you're in a space you've been in before, but you don't know exactly what's going to happen. It provokes you but you can poke it back, and stoke it up with chaos knowing that it feeds on all that high energy. It can also be surprising and playful, amusing even. I remain open in the way that improvising actors are open to receiving offers – *gruntCount* makes a lot of offers, but I have the choice between control and influence and can also choose deference to it. I can just let it be.

On a more prosaic level, as a system it allows me to manage the *physicality* of my performance, which is important for a wind player. I pace myself by manipulating the settings for each performance, and define the level of effort required to get through a piece, up to a point – of course, you never know where it's going to take you exactly. And when it came to finding a solution for playing a solo set with electronics at short notice, I only had to learn a few small things to get *gruntCount* to do what I needed it to do. It already sounded great, and responded to me in a way I was familiar and happy with. Sometimes you need to just go with what you know.

3.2. COMPOSER INTERVIEW

PF: What do you get from musicians across different countries carrying this around in their backpacks?
MP: As an experimental musician, it's frustratingly difficult to run actual experiments on the same idea that many times. More often than not, similar experiments tend to run across multiple projects when the fortuitous opportunity to get some music out there comes along. However, in the case of *gruntCount*, I've been able to repeatedly explore this work with multiple players in many different contexts and it's so far had an exciting life. I've learned a lot about the range and scope of collaboration between player and composer.

I discovered that if you try to rush the initial stages where settings are designed, you just don't get very coherent sound worlds that work with the instrument and the player longterm. However, if you're careful in the training stage and if the performer practises the curves, much like they would a score, the piece takes shape very quickly. I have also discovered that if a performer understands how the software works, what's going on under the hood, even a little bit, their performances are very strong.

It's important for me that this work sounds live. I want to hear the performer thinking through what's going on, playing with their own sense of anticipation, tension and release. For me, this is where music really starts to happen. I've often thought that a player on stage who is free enough to think about what's going on in the room, they're perhaps not feeling oppressed, tense, or subject to demands that are beyond their control. A player who is thinking is a player who understands, is well informed and practised and for me when *gruntCount* works, it's got the sound of spontaneity, a here and nowness that's considered, not just bursts of energy.

4. NESTED DYNAMISM

The signal processing in *gruntCount* is made up of four 'voices' and three live 'effect' processors.[6] Voices are content creators/co-players, in that they respond to and develop material provided by the player. The effects are used as colours that help to smooth between live sound and processing. Live player or computer voice can be mixed into any of the live effects processors (Fig. 2). Every sound a player makes pushes the playhead through a slippery set of parameter changes that are linked to audio processing modules mixed in parallel. Live sounds provoke movement through the dynamically evolving DSP settings, which is highly engaging for the player, as the ground shifts beneath them with every sonic gesture.

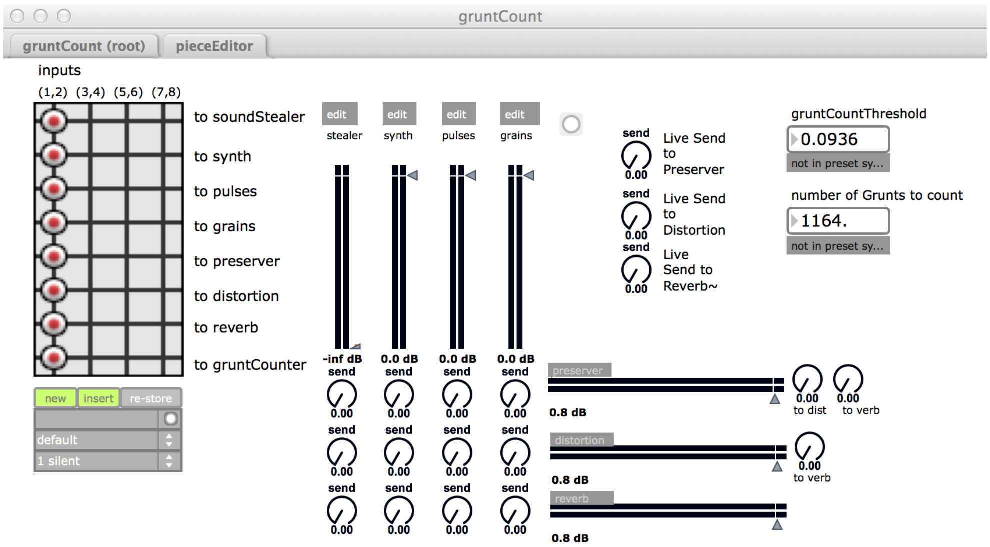

Figure 2 Versions are made and edited in the piece editor window. The four 'voices' (middle) are content generators and co-creators, while live 'effects' (right) help to colour both these voices and the performer's sound.

The state of each moment is also modulated by sound. For example, in the 'soundStealer' voice, different amplitudes of input trigger differ-

6. The four voices comprise a 'soundStealer' (a multiple sampling engine), synthesiser presets, a pulse generator and a granulator. The three effects are reverb, distortion and the 'preserver' (a dynamic sustainer of material).

ent live sampling processors that can also listen to – and sample – each other's output. One sampler might take only very loud sounds, while another may be ultra-sensitive and pitch-shifted deeply. The processing employs a method that we describe as *nested dynamism*. This idea is key to sustaining a sense of movement and flow in the computer part and maintaining a distinctive, meaningful and dynamic relationship between player and electronics.

5. LIVENESS AND FLOW

The flow of these improvisations – their pacing, coherence and sense of space – is directly influenced by the way that an inner *thread of attention* is maintained by the musician throughout the performance. This may also be understood as the managing an evolving flux of liveness. Several authors have proposed a deeper understanding of liveness as incorporating various *qualities* (Stroppa 1999; Emmerson 2007; Croft 2007; Sanden 2013) and it is to Sanden's terms for a nascent taxonomy that we will refer here:[7]

- liveness of spontaneity
- interactive liveness
- temporal liveness
- liveness of virtuosity
- spatial liveness
- causal, or corporeal, liveness
- trace corporeal, or vestigial, liveness
- liveness of authenticity
- virtual liveness

The *gruntCount* performer directs and influences some of these qualities, such as the *spontaneous* liveness of improvisation, the *interactive* liveness perceived in moments of wrestling or negotiating with the electronics, particularly since the system is designed to produce occasional unexpected elements (a kind of benign provocation). While *gruntCount* is purely reactive, any perceived sense of interaction should not be dismissed. Emmerson has proposed that "what we perceive when we perceive 'interactivity' becomes a measure (but not *the* measure) of liveness" (Emmerson 2012, his emphasis) and Sanden goes further, claiming that "the value of liveness is not located in what is *actually* happening but in what we *perceive* as happening." (Sanden 2013, 109)

There is also a *temporal* play of liveness during a performance: the electronics refer back to the initial studio session, reactivity happens in the moment and the sampler is fed with material for future regurgitation, which we then recognise from the recent past. There may also be a liveness that resides in the performer's *virtuosity*. There are qualities of *spatial* and *causal* liveness, since both musician and loudspeakers are physically present in the room – the resultant sounds can be heard and the player's effort witnessed. Spatial frames may be played with

7. although rather out of expedience than any suggestion of ideological supremacy.

(Smalley 1996) in both the electronics and the setting up of any amplification on the instrument. These can be manipulated in settings (panning or spatialisation) or by using physical movement; for example, by withdrawing from the microphone to starve the system, or conversely by moving in close to it in order to play very quietly, combining low input with high gain, rather like an electric guitar.

Certain elements remain outside the sphere of control of the performer, such as the *trace corporeal* presence of the composer, some *vestigial* traces of will, and other spectral elements from the wider culture which affect live performances but remain mostly unnoticed. Notions of *authenticity* contribute to liveness – in *gruntCount* we are true to ideas of what the piece/system should and should not be and do, to the way the live instrument and electronics should sound (artistic voice), and to how the whole reflects the relationship captured in the initial studio interaction.

Finally, there is what Sanden terms *virtual* liveness in digital technologies, addressing the significance of identities not actually present, but formed in the minds of performer and audience. Humans exhibit a tendency towards animism with regard to objects and to a "systematic anthropomorphism" (Guthrie 2012), which by extension may lead to the projection of virtual personae in an interactive computer music environment. In a performance of *gruntCount*, player and listeners each experience this subjectively and may perceive it (as this performer does) as a form of *personality* within the electronics. This seems to be helpful, perhaps even necessary – after all, to wrestle, to negotiate, to play, to make music together, requires a partner, a companion, an adversary.

The balancing of these various elements forms part of the musician's embodied knowledge and skill as acquired over a considerable period of time. This shifting assemblage of liveness qualities can produce a sense of abstract narrative, a more or less taut thread of attention drawn between musician-instrument and audience. When successful, this thread may contribute to another sense of flow: that of 'optimal experience' (Csikszentmihaly 1975),[8] where the perception of time is altered or even suspended and levels of concentration, motivation and enjoyment are significantly raised.[9]

6. CONCLUSIONS

The main compositional aim for *gruntCount* was for it to behave credibly as music on stage, while meaningfully addressing challenges of liveness and spontaneity. The identities of visible performer and instrument on stage, as well as perceived virtual identities within the

8. which is here connected to an idea of optimum user experience (UX)

9. This is not the place for diving into a detailed discussion of flow as optimal experience. Which is not to say that studies of flow in musical performance are still relatively thin on the ground (Wrigley & Emmerson, 2013) and that research in this area would be both welcome and potentially influential.

purely acousmatic electronics, become part of a *gestalt* in which each element is augmented. While existing as both a set of discrete, replicable pieces and a configurable system with which to make these pieces, we have discovered that *gruntCount*'s ease of use and emphasis on performer agency also afford it qualities of instrumentality. This level of user experience is to be welcomed in live electronic music practice and appears to engender flow in the performer, although more tailored research would be required to assert this.

By making a piece with a system that plays like an instrument, we further blur the definition of each. Importantly, our individual roles are also smeared. The performer does much more composing and top-level piece design, taking greater overall responsibility for what is heard. Meanwhile, the composer is required to become a more expert systems designer, making fewer concrete decisions about what should happen on stage, instead defining a range of possibilities that afford what *might* happen. Given the numerous considerations involved in mixing and blending acoustic sound with electronics, both composer and performer also become instrument builders. The blurring of these roles, and the shifting of their emphasis in appropriate directions, leads to an environment where composer and performer are more able to focus on bringing liveness and spontaneity to musical ideas.

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PUSHPULL: REFLECTIONS ON BUILDING A MUSICAL INSTRUMENT PROTOTYPE

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ABSTRACT

The ‘liberation of sound’ by means of electronics, as anticipated by Edgard Varèse (1966), amongst many others, released musical instruments and musical instrument making from the physical constraints of sound production. While this may sound naïve in light of two decades of musical games and NIME, we consider it a valid and important starting point for design and research in the NIME field. This new freedom of choice required instrument makers to explicitly reflect on questions such as: what general expectations do we have of a contemporary instrument? What do we want it to sound like? And, detached from its sonic gestalt, how should the instrument look, feel and be played? What is it supposed to do, or not to do? Based on these questions, this paper is an interdisciplinary approach to describing requirements for and expectations and promises of expressive contemporary musical instruments. The basis for the presented considerations is an instrument designed and played by the authors. Over the course of the design process, the research team touched on topics such as interaction and mapping strategies in relation to what we call artificially induced complexity. This complexity, the authors believe, may serve as an alternative common ground, substituting originally prevalent physical constraints in instrument building.

KEYWORDS

Instrumentality, Electronic Musical Instruments, Live Performance and Physical Interaction, Instrument Building, Interdisciplinary Research.

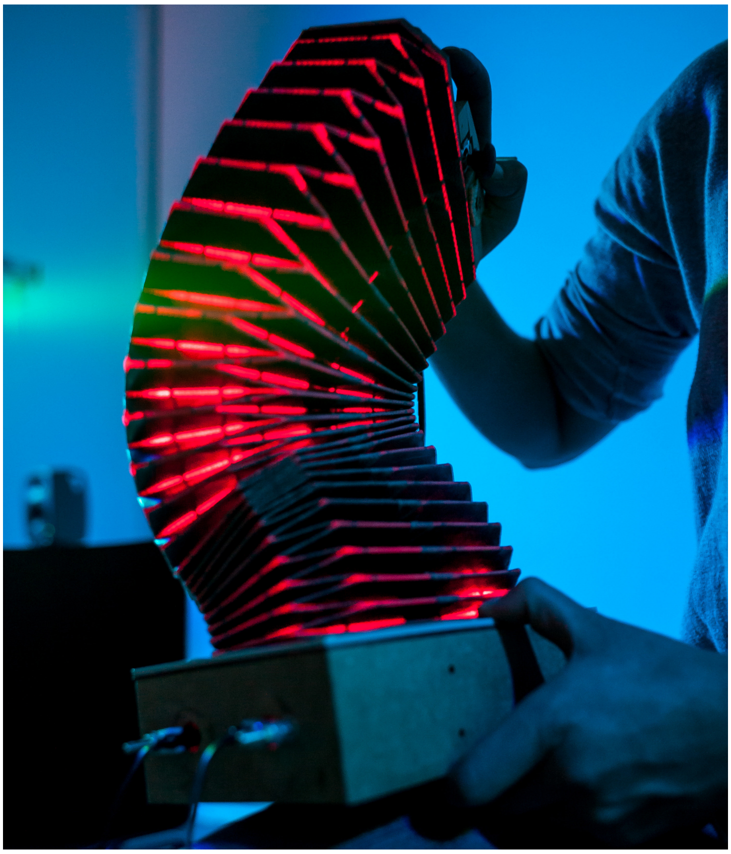

Figure 1 PushPull during live performance.

Figure 2 PushPull prototype.

1. INTRODUCTION

Today, more than ever before, the process of designing and developing a musical instrument prototype requires a large number of decisions regarding almost every aspect of the intended device. While many of such decisions were formerly dictated by physical necessities, most prominently the causal relationships between factors like size, form, material and energy coupling and their influence on an instrument's sonic gestalt, these relations are now simplified by means of electronics and digitization. To the contemporary instrument maker, this means not only an increase in artistic freedom, it also enforces explicit, *seemingly independent* decisions regarding aspects like the instrument's sonic and visual gestalt, its playing technique, and the choice of raw materials (cf. Magnusson 2009). Since the physical constraints are now much reduced, each of these decisions needs to be justified aesthetically: why is the instrument supposed to look and sound as it does? Why does it allow a particular sonic latitude, why does it feel a certain way?

In this paper, we argue that the dissolution of former causalities induces the establishment of new ones. Complexity can inform the design of an instrument in such a way that the resulting artefact bears the necessary qualities for expressive and dynamic playing. Using the example of the musical instrument prototype *PushPull*, we illustrate how, over the course of instrument development, such continuous decision-making demands the integration of considerations concerning appearance, interaction, and sound production. Combining approaches from design theory and traditions of instrument building with the above-mentioned demands could possibly yield instrument-specific causalities.

Section 2 introduces the notion of complexity after Hunt *et al.* We then illustrate how these thoughts shaped our decisions on exterior appearance (Section 3), interaction (Section 4), and sound production (Section 5). Finally, we get back to the idea of instrument-specific causalities and discuss how they have been established in the case of PushPull (Section 6).

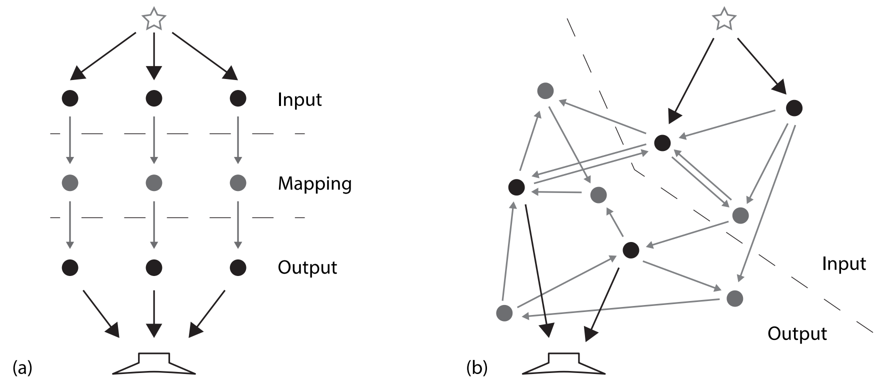

Figure 3 Instrument structure according to (a) Wessel vs. (b) a more open structure with non-hierarchical constraints. Note that the explicit mapping shown in (a) is blurred in (b) due to system-inherent feedback.

We understand complexity as a measure of interrelations between the elements of an instrument. If there are few interrelations, the complexity is low, whereas a high degree of complexity applies when a clear separation between the modules of an instrument cannot be made, as is the case with traditional instruments. As stated by Hunt *et al.* (2000, 1),[1] traditional instruments are highly complex as they do not have a clear separation between input and output. Rather, borders between elements are heavily blurred; modulating one parameter has a (non-linear, more or less audible) effect on others.

Complexity is closely related to constraints of instrument elements and their horizontal and vertical interrelations. A *horizontal interrelation* of two constraints refers to related limitations, e.g. the length of a violin bow and the different bowing techniques possible at specific bow locations. By comparison, *vertical interrelations* between constraints are those limitations which simultaneously affect elements of different types, e.g. the size of an acoustic instrument and its spectral characteristics.

The 'liberation of sound' by means of electronics released musical instruments from those physical constraints of sound production: it became possible to construct instruments from independent modules with defined communication interfaces. Vertical interrelations between constraints did not appear due to physical limitations; rather, they had to be explicitly introduced.

A trend towards modularity can be observed among today's commercially available instrument modules : horizontal interrelations between constraints are minimized as far as possible in favour of generic interfaces (e.g. fader boxes which allow parameter changes to be made by moving one fader without influencing the others).

1. "In acoustic musical instruments the sound generation device is inseparable from the human control device, and this yields complex control relationships between human performers and their instruments." (Hunt et. al. 2000, 1)

Since complexity not only contributes to the character of an instrument but also motivates the player to search for means of expression, we propose that the level of complexity may serve as a measure of an instrument's artistic potential. We therefore argue that introducing constraints and interrelations between the different elements of an instrument makes the interface less arbitrary, hence enabling the unification of its identity.

Why, then, work with electronic instruments at all? Our answer to this is that, unlike traditional instruments, digitization and electronics allow for explicit, precise shaping of the interrelations between instrument elements, thus producing broad variation in instrument and sound designs. In the following sections, we describe how these thoughts on complexity informed the design of PushPull.

3. EXTERIOR APPEARANCE

For centuries, bellows have been used for sound production in organs, squeezeboxes, and bagpipes, their permanent and regular airflow inevitably visually reminiscent of breathing in and out – the literal embodiment of corporeality, of life itself, as Michel Serres puts it:

> "It [the body] breathes. Breathing, both voluntary and involuntary, can take different forms, transforming itself by working like the bellows of a forge. After the piercing cry of a baby's first breath, its first sigh, the body begins to enjoy breathing, its first pleasure."
> Serres 2008, 314

Here, the movement of the bellow serves not only as a metaphor for corporeality and liveliness, but also for the labour and effort of a blacksmith.

Furthermore, bellow-like elements can be found in more recent electronic instruments, such as the accordiatron (M. Gurevich & S. von Muehlen) and the squeezevox [sic] (P. Cook & C. Leder, both 2000). The developers of the accordiatron state in their documentation paper that they found the 'squeeze box [to be a] compelling starting point because of the expressive physical engagement of the performer and the subsequent value for live interaction.' (Gurevich & von Muehlen 2000, 25) Similarly, the squeezevox has been designed with the purpose of controlling vocal sounds; in this case, the bellows are used to control breathing in a more literal sense.[2]

Speaking of the 'visual intrigue' of an instrument, they stress the importance of its exterior appearance: 'A performance instrument should be interesting to watch as well as to hear, otherwise part of the purpose of live performance is lost.' (Gurevich & von Muehlen 2000, 25)

In the case of PushPull, the bellow, as an archetype with a long tradition both as a part of musical instruments and as a reference to the blacksmith's tool, served as the central element of the setup. It met our requirements regarding modes of interaction, while at the same time triggering enough imagination to allow for 'mystic associations', not only for the audience but also for the musician herself.

2. C.f. http://soundlab.cs.princeton.edu/research/controllers/SqueezeVox/, 27 Oct 14

To create this mysticism, a PushPull performance begins in complete darkness with only some red light emerging out of the bellows, thus attracting all attention to their movement.[3] This strong visual characteristic complements the archaic look of the black latex bellow with its fine, grid-like texture. Reminiscent of snakeskin, this leather-like material, in combination with the wooden hand grip, turns the interface for digital sound synthesis into an object with a strong mechanical but, at the same time, organic appearance.

Underpinning PushPull's exterior appearance is a close relationship of cultural connotations, technical requirements, materiality and playability. These aspects, influencing each other during the decision-making process, realize the complexity inherent in the instrument's gestalt.

4. INTERACTION

The way of interacting with the instrument plays a significant role in matters of linking parameters. Out of a multitude of possibilities, we picked three coherent elements that we found to be in accordance to our complexity hypothesis described in Section 2.

According to J.J. Gibson' s theory of affordances (Gibson 1979), every object is equipped with certain action possibilities – affordances – that aid humans in their interaction with their environment. Following this thought, musical instruments exhibit affordances that suggest particular modes of interaction – for example, a keyboard affords playing by pressing keys, a guitar affords strumming, etc. Creating an instrument, therefore, includes reflecting on and creating its affordances.

As mentioned in Bovermann et. al., "creating an instrument […] is not only about the interface itself but the routines and patterns merging the object with the subject" (2014, 1638). Playing an instrument requires input from both mental and physical processes. Practising on the instrument is said to result in a certain kind of tactile knowledge or 'body schemata' (Godøy and Leman 2010, 8). These memorized motor patterns, in our opinion, are essential for intuitive and expressive playing. Therefore, we wanted PushPull to allow the development of such body schemata. This can be achieved by introducing physical constraints and therefore a direct (passive) force feedback, which in turn enables the musician to develop a subliminal association between movement, force, and sound.

The aspect of physicality is often brought up as a motive for attempting to create an individual set-up. During an interview, electronic musician Jeff Carey described his desire for "a physical grip on the sound":

> "Performing on stage with musicians and feeling like a piece of office furniture was unrewarding enough to push me to have a physical grip on my sounds […]."
> Carey 2014

3. In fact this quite dominant element (LED light in combination with light sensors and reflective foil on the inside of the bellow) originates from a technical requirement, which will be further described in Section 4.

In the context of electronic live music, this physical grip has been neglected for a long time. Even though there have been several attempts to bring the body back into the performance of electronic music since the early 1980s,[4] the main set-up of electronic music performance in most cases still oscillates between keyboards and an office-like environment of laptops.

We therefore decided to implement complexity on the level of interaction by creating affordances, which, just as in traditional instruments, would force the performer to see her interaction not only as being in direct connection with the instrument but also with the sound itself.

In the case of PushPull, the instrument is strapped to the upper leg and played either left- or right-handed. There are four buttons,[5] one for each finger, and a thumb stick, which offer further options for sound generation. Pressing one of the black buttons starts a sound process, which can be manipulated with the other control elements (thumb stick, moving the bellow). In order to switch between three sound engines, the musician has to press the red button together with one of the black buttons. The intended close physical contact was created by placing the hand flat onto the handle and securing it with the strap. Thus, the movement of the bellow becomes a transformation of the hand's movement. An inertial measurement unit inside the top part senses the acceleration of the hand. Light sensors within the bellow measure the distance between its top and base, providing a rough estimation of its contraction. Furthermore, hidden inside are two microphones on the base that pick up the airflow into and out of the valves along with an Arduino for serial communication. The specific positioning of the sensors creates control signals that are intentionally not independent but instead entangled in a variety of ways by the interface. The result is a high number of interrelations, which create mapping options that are very specific to this instrument.

Taking materiality and object behaviour into account, we established an organic link between movement and generated sound via the mapping. For instance, the seemingly ubiquitous demand for physical effort that has been called a prerequisite for expressivity (c.f. Croft 2007, 63f) is here fulfilled by the natural resistance of the airflow in and out of the valves. But what is much more important is that many of the interactions are not clear gestures with obvious purposes and con-

4. The 1980s and 1990s saw a huge variety of somewhat experimental wearable interfaces being developed, many of them glove-shaped (e.g. The Hands by STEIM's Michel Waisvisz (1984), Laetitia Sonami's famous Lady's Glove (1991) and their commercially sold counterparts, such as VPL's DataGlove, Mattel's PowerGlove and the Exos Dexterous Hand Master, the latter three being compared in a 1990's article tellingly entitled 'Reach out and Touch Your Data' (Eglowstein 1990)). Some innovations from this time resembled futuristic jumpsuits, like Yamaha's Miburi (1996), with others further exploring the musical potential of the entire wardrobe, such as the diverse developments of MIT's Media Lab, most prominently the Dance Sneakers and the Musical Jacket (both 1997).

5. One red and three black buttons.

sequences; instead, the setup encourages the development of implicit knowledge on how to shape the sound.

5. SOUND PRODUCTION

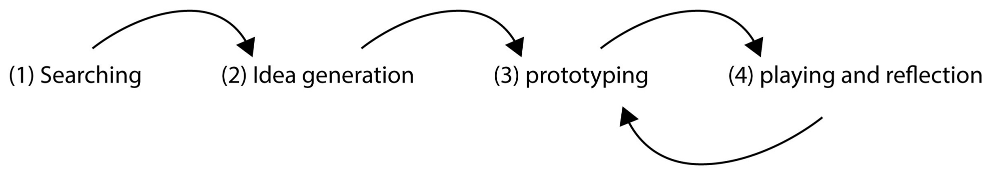

Figure 4 Structure of the design process.

As described in Section 2, computation enables the separation of energy coupling. However, it can also help to form networks in which sound generation and control fuse into each other, creating complex functionality.[6] This does not necessarily result in behaviour comparable to that of traditional instruments; rather, it may form a gestalt with no counterpart in the physical realm. Without this counterpart, there is no existing model of interaction with the same constitutive elements of sound creation. In order to be able to form such models that emphasize inner and outer relations between object behaviour, interaction, and sound generation, we did not start programming until we first had the working hardware artefact at hand. Sound patches were developed within cycles of creating code, playing the instrument, observing, reflecting, and adjusting the existing constraints and interrelations (see Fig. 4). Using two microphone input signals as the control input for the digital sound processes meant that, by means of the close link between digital sound process and acoustic properties, even simple sound patches produced a unique and complex musical outcome.

In the following, one of the sound patches used is described in greater detail, in order to give an example of instrument-specific design options. The sound of breathing is created by routing the two microphone inputs, which capture the noisy airflow turbulences, into band-pass filters. The filter frequencies are controlled by hand movements (e.g. pitch and roll). These movements are sensed by an inertial measurement unit (see Section 4) that provides information about acceleration and orientation of the hand in three dimensions. The resulting sounds can range from small and short rhythmical structures to slow-moving wind-like soundscapes with high dynamics. After some practice, the player is able to handle the latency and damping of energy transfer, mainly introduced by the bellow’s force feedback, quite well. Accurate playing in time and with a defined intensity is thus a matter of human capabilities.

In terms of the sound characteristic of the instrument, we differentiate between interrelations that include physical elements (e.g. sensors,

6. In accordance with Hunt *et al.* (2000, 2), we understand complex mappings as a condition of musical expression: ‘[t]he resulting instrument‘s expressivity is much dependent on the specific mapping strategies employed. [...] [S]killed musicians take advantage of complex mappings.’

speakers or materiality) and interrelations that consist solely of digital parts. While, for example, the actual positioning of sensors in the physical artefact constitutes a fixed correlation and therefore establishes an (object-) specific sonic character, in the case of the purely digital, it is possible to inject dynamic structures that allow the adjustment of inter-element relations at will. When aiming for a complex instrument with many elements in the digital realm, it can be decided individually for each element whether it should remain static or be changeable on the fly, e.g. during performance. We found that the number of controllable elements of a sound patch made available to the performer could easily exceed the number of available interface elements. A further fact is the finite amount of elements that can be physically and consciously controlled in parallel by a human. Deciding that an element (e.g. an oscillator input frequency) should be changeable requires the definition of value ranges and mapping functions. In multidimensional parameter space, a playful exploration may be a promising alternative to a systematic approach. As described by de Campo (2014), these heuristics may lead to the discovery of unapparent but appealing mappings.

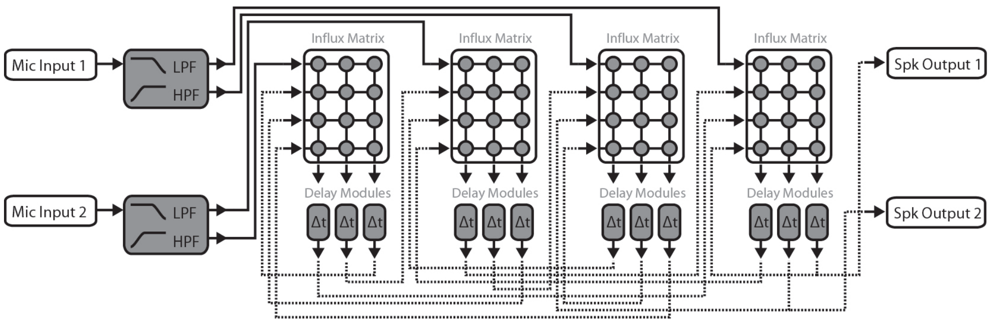

Figure 5 Influx Patch used in PushPull

Reconfiguring inner functionality in order to explore possibilities of mapping can become an engaging musical live practice in its own right. Fig. 5, for instance, shows a patch where there are no digital sound generators to be found. Instead, the input parts (the two microphones and three sensors) are randomly (re-)connected and (re-)scaled on demand by pressing a button. The central element of influx provides highly flexible mix matrices that form linear combinations of inputs and outputs (dcf. ibd.). The matrices and some filter and delay modules comprise the fundamental software parts. Delayed outputs feed back into matrix inputs, introducing complexity in the form of memory. Using the bellow to provoke the system from the outside can result in dramatic soundscapes, ranging from thunder-like noises to tonal sounds with complex harmonic spectra that can be evolved over time. The system tends to either explode, reach timbral stability, or fall into silence. Global parameters that influence all delays, for example, can be controlled by hand movements. This control changes with each new set of connections. The instrument provokes a form of music making that is not comparable to playing traditional instruments; it is instead an artistic practice in the field of second-order musical cybernetics:[7] the instrument creates ever new sets that form nontrivial behaviour evolving over time. This behaviour is a result of the inner and outer complexity of the artefact. It can be observed and triggered by interaction in terms of movement. This serves to literally irritate the system as it becomes confronted with mechanical turbulence. According to the theory of second-order cybernetics (Foerster 2003), an observation process is not objective: artefact and observer, instrument and player are connected in a circular manner. The observer is a constitutive factor in the system. Taking this into account, she has to observe her process of observation or interaction. While this circularity may be seen as common in a design process, when applied to live performance, it may result in interesting shifts in common performance ecology (Bowers 2006): the performer cannot plan far into the future because she does not know how the instrument will behave. She can only anticipate future occurrences by actively listening to the instrument. In this sense, music making comes to be more about finding interesting correlations of movement and sound, instead of implementing such correlations beforehand.

6. CONCLUSION

In this paper, we presented the process of designing and building Push-Pull, a hybrid musical instrument prototype that uses the bellow as a physical interface. We described how complexity was implemented on all relevant levels in order to create a particular instrumental identity or gestalt. This required continuous decision-making, which we showed to be based on a set of considerations, associations, and convictions.

As outlined at the beginning, we argued that, in the case of electronic musical instruments, the dissolution of former causalities might bring about the establishment of new ones. Now that the once necessary union of sound generation and control in one device has become as optional as the correlations between material and sound and between playing action and resulting sound, it falls to the instrument maker to define instrument-specific causalities every step of the way. Once an instrument does not sound the way it does because it has a particular shape or is made from a particular material, the instrument maker has to decide why her instrument will sound like it does. Her justification will most probably not relate to physical aspects, but rather be underpinned by conceptual motivations. Rather than fixating on the length of strings or air columns when justifying the choice of a particular playing technique, the electronic instrument maker is most likely to simply be inspired by a specific gesture or a promising interface model, or could alternatively be a player already experienced in an existing technique. Similarly, the choice of a particular material only rarely re-

7. A good overview of second-order cybernetics by Ranulph Glanville can be found at *http://www.facstaff.bucknell.edu/jvt002/BrainMind/Readings/SecondOrderCybernetics.pdf*, 29 Oct 2014.

lates to its resonance quality; durability and aesthetic value are now more common concerns.

What can be observed here is a shift from physical necessities to aesthetic decisions. Instrument making is no longer a playful illustration of physical laws. Its process now resembles a decision tree. In this sense, we used the concept of complexity as a guiding principle through this tree, taking the idea of a coherent instrumental identity as our root.

While some new justifications develop out of the evolving instrument, others are grounded in individual choices. In both cases, they are a central part of instrument design and deserve much consideration.

Yet, there is one universal, recurring rationale that we became acquainted with during the process of designing and building PushPull. Sometimes, the best reason for a particular decision is simply: 'Because... I like it that way.'

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DESIGN AND USE OF A HACKABLE DIGITAL INSTRUMENT

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ABSTRACT

This paper introduces the *D-Box*, a new digital musical instrument specifically designed to elicit unexpected creative uses and to support modification by the performer. Rather than taking a modular approach, the D-Box is a *hackable instrument* which allows for the discovery of novel working configurations through circuit bending techniques. Starting from the concept of *appropriation*, this paper describes the design, development and evaluation process lasting more than one year and made in collaboration with musicians and hackers.

KEYWORDS

Hacking, Appropriation, DMI, Constraints, Embedded Hardware.

1. INTRODUCTION

The relationship between instrument designer and instrumental performer is more complex than these roles might suggest. Performers commonly develop playing techniques that were not part of the designer's original intentions. It is also common for performers to modify their instruments; regardless of the number of musical features and interaction techniques an instrument provides, its design will never fully satisfy the needs of every artist. Historical examples are plentiful, from Dizzy Gillespie's modified trumpet in the 1950s to the personalised electric guitars played by B. B. King and Eric Clapton to Keith Emerson's custom Moog modular synth (recently recreated by Moog Music).

Circuit bending (Ghazala 2005) is a practice by which musicians modify, repurpose and otherwise hack electronic devices. The origins of circuit bending date back decades (Collins 2008), but the practice is currently the focus of a vibrant online community which partly overlaps with open-source "maker" communities developing new musical interfaces. Curiously, however, it is rare to see a musician playing a hacked latest-generation DMI (other than those created by that musician). Many circuit benders prefer working on cheap electronics, including toys and other objects which are not designed for music-making, rather than more complex products of the DMI community.

The design of DMIs and software-based instruments can discourage hacking, especially by musicians without engineering training. Many DMIs are "black boxes" whose inner workings are difficult to understand, if they are accessible at all. High-speed digital circuits are more easily damaged by arbitrary rewiring than analog circuits of previous eras, and software is likewise fragile, where exploratory modifications are as likely to create a crash as to produce interesting sonic results. Therefore, while many new DMIs are created, future performers have limited scope to move beyond the original designer's specifications. Where conventional instrument designs pass from one musician to another, acquiring new creative meanings along the way, many DMIs exist only for a few performances and disappear to be replaced with completely new designs (Jordà 2004).

To investigate the relationship between instrument design and *hackability*, we created the *D-Box*, a self-contained digital instrument intended to be repurposed and rewired by the performer in unusual ways. Section 2 presents the initial investigations informing its design, including a study of unexpected use of a highly constrained instrument (Section 2.1) and interviews with instrument builders and circuit benders (Section 2.2). Section 3 presents the D-Box hardware and software, with a focus on features aimed at encouraging hacking. Sections 4 and 5 describe uses of the instrument in workshop and performance settings. Overall, the goal of the project is to create a DMI whose capabilities can be extended and modified in directions that we as the designers did not anticipate.

2. INSTRUMENT APPROPRIATION

The process of developing a personal working relationship with an object is known as *appropriation*. It can be useful to consider appropriation in the design of human-computer interfaces: as Dix (2007) writes, "you may not be able to design for the unexpected, but you can design to allow the unexpected." Appropriation is common in musical performance, where the musician develops a personal approach to the instrument which might not fit the designer's original intentions.

These violations of the instrument's metaphor have been described by Bertelsen et al. (2007) as *metonymic deviations* and have been observed in the domains of both music software and physical musical instruments. While software appropriation is generally limited to creative (mis-)interpretations of the metaphor, when dealing with physical instruments this process may be pushed to its extremes and include the modification of the instrument itself. For electronic hardware devices, hacking and circuit bending can be seen as the most common forms of extreme appropriation. Before considering these types of modifications, however, our first step toward designing a hackable instrument consisted of studying usage patterns of a simple DMI, aiming to understand how design features influence exploration and appropriation.

Performer appropriation of a musical instrument relates to the instrument's *affordances* (possibilities for action) but appears to be even more strongly guided by the exploration of *constraints* (Magnusson 2010). On traditional acoustic instruments, constraints can be a powerful motivator for creativity and the development of personal style, but curiously, when playing DMIs, musicians often perceive constraints to be restrictive and frustrating (Magnusson et al. 2007). Sometimes constraints can also elicit diversity of style in the digital domain, as Gurevich et al. (2010) showed with a simple one-button instrument; however, many DMIs are highly complex and tailored to the specific needs of only a few musicians, typically the ones involved in its design.

2.1. THE CUBE INSTRUMENT STUDY

To better understand how affordances and constraints affect musicians approaching and exploring a DMI, we ran a user study with a deliberately limited instrument. Building on the investigation in (Gurevich et al. 2010), we explored the relationship between *dimensionality* (number of independent controls) and appropriation. Full details can be found in Zappi and McPherson (2014); highlights are summarised below.

We created a novel DMI, simply called the *Cube Instrument*, which consisted of a wooden box containing a touch+force sensor, speaker and a BeagleBone Black[1] (BBB) embedded computer. It resembled no other familiar instrument to avoid suggesting any playing conventions. When the touch sensor was activated, a tone was produced, presenting a clear

1. *http://beagleboard.org/black*

and simple metaphor. A user study was conducted wherein 10 musicians received an instrument. Although all were externally identical, 5 out of the 10 replicas were configured to support 2 Degree-of-Freedom (DoF) control, namely timbre and pitch, while the remaining 5 had only timbre control (1DoF). Participants were randomly assigned a 1DoF or a 2DoF instrument with no modification allowed; they were then asked to prepare two original solo performances over the following month.

Quantitative and qualitative analyses were run on audio/video recordings, sensor usage data logs (saved on the instrument), interviews and written questionnaires. As in (Gurevich et al. 2010), performers showed a remarkable variety of styles and techniques, linked to the exploration of both main and hidden affordances (i.e. those not explicitly designed into the instrument, such as scraping the sides of the box or filtering the speaker with the hand). Some performers said they turned to unconventional playing techniques after feeling overly limited by the constraints of the instrument; others found the constraints themselves to be conducive to exploring subtle musical variations.

Participants who were assigned a 2DoF instrument showed a tendency to rely less on hidden affordances than those with a 1DoF instrument. It might be expected that 2DoF participants, having a richer instrument, would have explored a wider variety of main affordances, but this was not the case. Counterintuitively, higher dimensionality appeared to simply hinder the appropriation of the instrument, reducing the exploration of *both* main and hidden affordances. This was a striking result. While the 1DoF group tended to seek more unconventional ways of playing, which is one of the rationales behind musical hacking, the 2DoF group fixated more on perceived limitations, and they spontaneously described modifications they would have liked to have seen in the instrument design to overcome the constraints they perceived as most limiting.

2.2. HACKING CONSTRAINTS

The findings of the Cube Instrument study informed our approach to designing a hackable DMI. To maintain the incentive to appropriate the instrument, the initial configuration of the D-Box needed to remain simple and clear to the performer. On the other hand, following the performers' requests for additional capabilities, we sought to give performers a way to overcome the initial constraints by modifying the instrument.

Modular approaches to electronic instrument design are common, including classic analogue synthesisers, interconnectable hardware blocks such as littleBits and Patchblocks,[2] and software environments such as Max/MSP and PureData. However, modularity did not fit the purposes of our project. Modularity implies customisability within fixed boundaries: no matter how many blocks can be interconnected or how many parameters can be tweaked, the possible modifica-

2. *http://littlebits.cc* and *http://patchblocks.com*

tions are defined *a priori* by the designer. There is a risk of creating an over-determined design (Redström 2006) which neither includes all the features required by the musicians nor leaves them with enough space for creative "misuses." Very large or general modular environments (particularly software environments) may not present such limitations, but generality comes at the cost of either a complex initial instrument which is hard to understand, or that the performer builds the instrument themselves from simpler blocks, which was not our goal.

Instead, we aimed to allow musicians to modify the instrument by *hacking* its constraints: extending and subverting the limits of the device by rewiring it and bending its circuitry to change its behaviour. Exposing the inner workings of the instrument allows the exploration of unplanned and unpredictable configurations, enabling new modes of creative expression. Hackable DMIs are differentiated from modular designs not necessarily in the total number of possibilities, but where those possibilities lie. A limited but hackable system may push the musician to find unprecedented and idiosyncratic effects which would be unlikely to be discovered or imagined, even given a limitless set of interconnectable blocks.

Hackability is uncommon in novel DMIs, whose designs are generally resistant to arbitrary hardware modification by an end user without technical training and access to the design plans. To understand more about hacking techniques, we individually interviewed three London-based music hackers. Two individuals were *instrument builders* who develop instruments from scratch and one was a *circuit bender* who modified existing devices. We also attended performances by two other circuit benders.

Though the artists came from different backgrounds and worked independently, each expressed a consistent set of opinions. Among this group, programming was described as "alienating" and "confusing" as opposed to hardware hacking, which was seen as more "rewarding" and conducive to "immediate" physical results. The search for compelling ways of obtaining unusual sounds was the main motivation for hacking. To achieve their goals, all the artists used similar techniques, shorting or cutting connections or assembling electronic components and sensors. Interestingly, none of the artists had an engineering background, but based their approach on experience and trial-and-error techniques. The fragility of a working device and its tendency to go silent when things went wrong were seen as deterrents to hacking. One artist described opaque, hard-coded software processes as the "biggest enemy" of hacking. Finally, all artists targeted open-endedness in their works; each hack was described as an ever-evolving instrument, stemming from a precise plan but in continuous development. Making music with the instrument inspired further modifications and hacks in an ongoing loop. This approach, based on the personal artistic usage of the device, was seen to account for the main difference between hackers and conventional instrument designers, as memorably summed up by one participant: "You know Bob Moog? He never made an album."

3. D-BOX DESIGN

Guided by the results of the Cube Instrument study and interviews with circuit benders and instrument builders, we created the *D-Box*, a digital musical instrument specifically designed to elicit unexpected creative uses and to support modification and customisation by the performer.

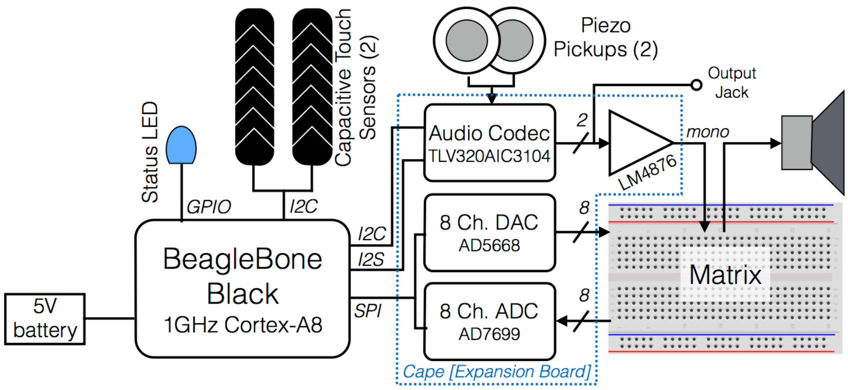

Figure 1 Hardware for the D-Box. Hacking is focused on changing the matrix, a breadboard accessible through the side of the box, though other elements of the instrument can also be altered.

3.1. HARDWARE

Figure 1 shows a diagram of the D-Box. The core of the instrument is a BeagleBone Black single-board computer with a custom *cape* (hardware expansion board). The cape contains stereo audio input and output, a 1.1W monophonic power amplifier, an 8-channel 16-bit ADC and an 8-channel 16-bit DAC. The ADC and DAC are collectively termed the *matrix*, and these signals are brought out to a breadboard for the performer to modify as described in Section 3.3.

The D-Box is enclosed in a 15cm laser-cut wooden cube (Figure 2), identical in size to the original Cube Instrument (Section 2.1). Sound is generated by a 10cm full-range speaker. In contrast to the Cube Instrument, the top of the box contains two touch sensors, derived from (McPherson 2012); each is 10cm long and measures the location and contact area of up to 5 touches along a single axis. One touch sensor is stacked on top of a pressure sensor made out of resistive velostat material. Two piezo disc pickups amplify the acoustic vibrations of the box. The D-Box is powered by a 5V, 1000mAh rechargeable battery pack. A blinking status LED indicates when the box has booted and is ready to play (roughly 10 seconds after power-up).

3.2. SOFTWARE ENVIRONMENT

For the D-Box, we developed a new ultra-low-latency audio environment (*BeagleRT*) which improves on the latency and reliability of the standard ALSA Linux audio environment on embedded devices (McPherson and Zappi, 2015a). The D-Box runs a Debian Linux OS with Xenomai real-time kernel extensions. Communication with the audio and matrix hardware is handled by the BBB PRU (Programmable Realtime Unit), which passes the data to the D-Box program running at a higher priority than the Linux kernel. Audio is sampled at 44.1kHz, and each of the 8 ADC and DAC matrix channels are sampled at 22.05kHz, synchronous with the audio clock. Where standard embedded Linux audio needs a hardware buffer of at least 128 samples for reliable performance (Topliss et al. 2014), the D-Box can run with hardware buffer sizes as small as 2 audio samples (1 matrix sample). For deployment, we chose a buffer size of 4 audio samples (2 matrix samples) as the optimal tradeoff between latency and processing overhead; in this state, the latency on the matrix is 182µs round-trip (ADC to DAC; 2 samples in and 2 samples out).

The D-Box program is written in C++ using the Xenomai real-time task API. The software uses an oscillator bank to reconstruct and transform sampled sounds. By using the NEON vector floating-point unit, up to 700 oscillators could be used at a time without underruns. This limit was not strongly dependent on the hardware buffer size. Analysis of sampled sounds is performed on a computer by SPEAR (Klingbeil 2006) and the resulting partial-based representation is stored on the D-Box via an SD card. 7 short sounds were loaded by default, and the user can also add their own.

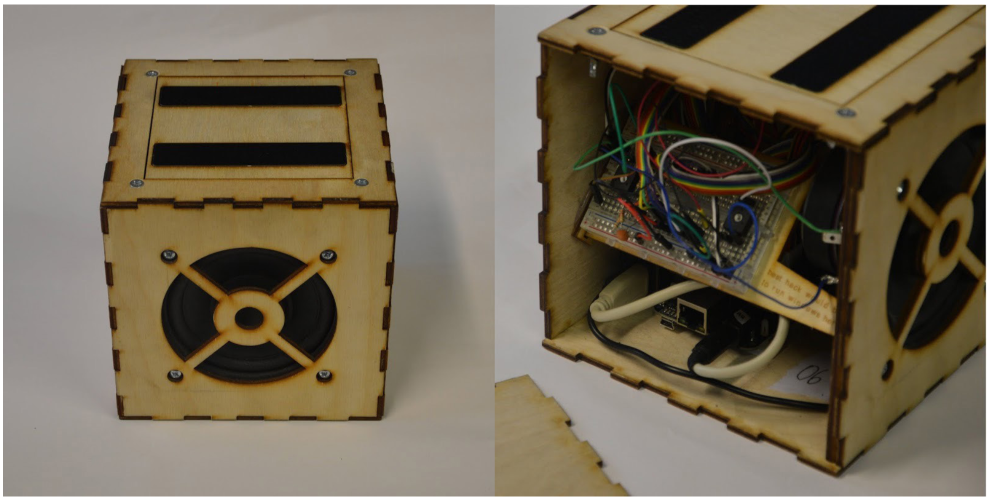

Figure 2 On the left: shot of the of the D-Box, showing the 2 sensors and the speaker. On the right: a detail of the matrix.

Oscillator bank synthesis enables interesting transformations of the stored sounds, including pitch shift and time stretching independent from one another, change of amplitude/envelope, altering the waveform of each oscillator for timbre effects and detuning the oscillators to create inharmonic sounds. These effects are collectively controlled by the circuits attached to the matrix (Figure 3). Additionally, the piezo pickup inputs are amplified to accentuate the mechanical sounds of the box.

The D-Box software and other examples of the underlying BeagleRT platform are available online.[3]

3. *http://code.soundsoftware.ac.uk/projects/beaglert*

3.3. HACKABLE HARDWARE FEATURES: CONTROL ON THE MATRIX

In this study, we focused on hardware hacking rather than software modification, inspired by the practices of circuit benders. The side panels of the D-Box open to reveal a breadboard to which all matrix inputs and outputs have been connected. In its standard configuration, the breadboard is pre-populated with simple circuits which define the instrument's basic metaphor. If left unmodified, the D-Box plays back the first of the default files every time the sensor opposite the speaker is touched, with pressure controlling volume. The original playback speed of the file is preserved, while the pitch can be altered with a range of 1.5 octaves by moving the finger along the touch sensor. A bandpass filter can be controlled using the second sensor, using up to 5 fingers to introduce 5 bands.

The basic principle of the matrix (8 ADCs and 8 DACs) is to create feedback loops between software and analog electronics. Analog signals are sent via the DACs, transformed through simple circuits on the breadboards, and read back into the ADCs. Each matrix channel has a separate function, as described in Figure 3. Though some of the matrix inputs function as simple control voltages (CVs), many of them have a dynamic behaviour which depends on the nature of the feedback from output to input. For example, the speed of playback is controlled by a hysteresis oscillator comprising a software-based comparator and a hardware-based RC network between output 1 and input 1 (red circuit in Figure 3). Changing the resistor and capacitor values affects the speed of playback and unusual effects can be obtained by removing these components or connecting wires to unrelated parts of the matrix. Additional details on matrix feedback loops can be found in McPherson and Zappi (2015b).

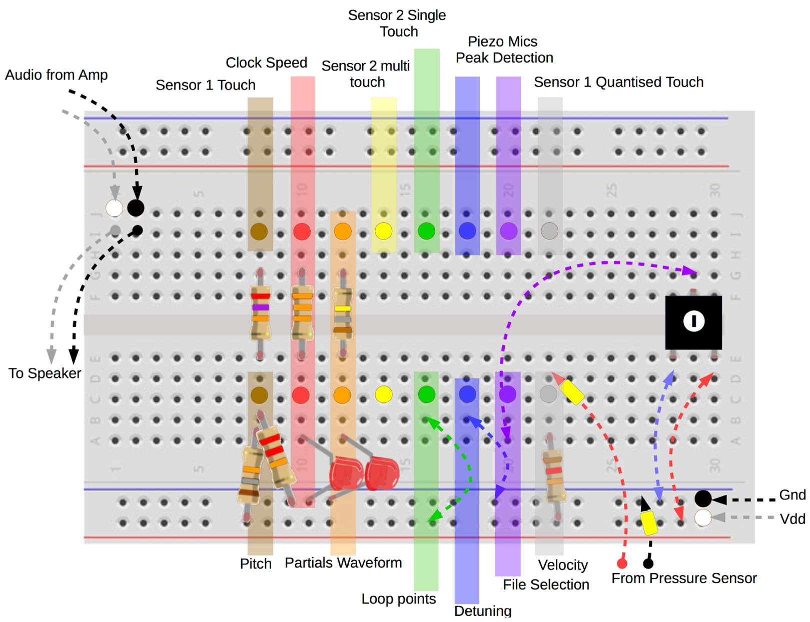

Figure 3 Matrix channels: the 8 analog outputs from the cape reach the breadboard on the top row of coloured dots. From the lower row, voltages are sent back to the 8 inputs of the cape.

To ensure that no matrix wiring decision would damage the instrument, a 220 ohm resistor is placed in series with every input and output on the cape, before it arrives at the matrix. Likewise, the 5V (Vdd) supply rail, also present on the breadboard, has 100 ohms in series with it. The speaker output is also routed through the breadboard, and this signal is restricted to 0-5V range. No breadboard wires attach directly to the I/O pins of the relatively fragile BeagleBone. Any two breadboard signals, including 5V and ground, can thus be shorted to one another without risk of damage. Since silence is perhaps the least interesting result of hacking an audio circuit, and the D-Box is designed so that no choice of wiring produces silence. In software, limits are placed on certain parameters, including playback speed and amplitude of oscillators, such that even extreme matrix settings produce some audible output.

The introduction of these design features makes the space of possibilities wider and subtler than what could be achieved through a simple patch-cord approach. Any electronic components can be used, weakly coupling or mixing signals between different parts of the circuit with resistors, introducing time-dependent behaviour with capacitors, or adding sensors; wires can be left floating or recklessly shorted together. Moreover, in contrast to modular approaches, the signals exposed on the breadboard are not straightforward inputs or outputs of familiar units (e.g., oscillators, filters or envelopes). Rather, most of them are intermediate stages of hardware-software feedback loops that, in turn, oscillate or produce time-dependent envelopes. Modifying and cross-coupling these signals tends to produce nonlinear and often unusual behaviours which are more akin to circuit bending effects than to modular synth patches.

Other hackable features are present in the physical design of the D-Box: the top sensor panel can be removed or rotated in any direction; the pickups can be removed and repositioned; and the box can be played equally well with side panels open (wiring as a performance technique) or closed (wiring as preparation prior to performance).

4. PRE-STUDY: SÓNAR WORKSHOP

As preparation for the main D-Box user study, we ran two workshops at the Sónar electronic music festival in Barcelona, in June 2014. The workshops used a preliminary version of the D-Box; compared to Section 3, the main differences were fewer (3) preloaded sounds, no piezo pickups, and fewer matrix options. Each workshop had 15 participants drawn from the general public. During the 90-minute workshop, each participant received a D-Box to play and modify. Participants sat at a long table covered with various electronic parts to use. The session consisted of initial familiarisation with the instrument, explanation of a few specific modifications, then a short period of free hacking.

Informal feedback from workshop participants was positive; it was seen as an engaging activity and demand exceeded available space. Following the workshop, we examined the wiring of each box and found a wide variety of configurations. Often the behaviour of the modified box would be surprising to us and would only be understandable on close evaluation of the wiring, supporting our goal of enabling performers to produce results we did not explicitly design for. Floating or "useless" wires going to unused columns on the breadboard were common, suggesting that participants tended to explore the wiring through arbitrary or empirical processes rather than strictly through a theoretical understanding of its function. This empirical approach would be seen again in our main study of experienced performers, though the performers tended to make more elaborate changes to the wiring (most likely due to longer timeframe and greater experience).

5. THE D-BOX USER STUDY

The unpredictable hacks we saw at the Sónar workshop provided hints of the design's effectiveness, but further study was needed to assess how the D-Box features would affect musicians working on a piece over an extended time. We thus organized an extended user study observing how musicians appropriate and modify the box, and whether they perceive any of these activities as "hacks."

14 identical D-Boxes were built and given to musicians of varying background, including instrumentalists, electronic composers and circuit benders. Participants were asked to prepare 2 solo performances over the period of roughly a month (range 20-62 days on account of performer scheduling constraints). As a reward for their time and effort, participants could keep the instrument at the end of the study. In contrast to the Cube Instrument study, participants were allowed (but not required) to open the D-Box and modify the circuits inside; they were told that the matrix (breadboard) could be freely rewired while connections on the BBB itself were more fragile, but any sort of wiring and physical reconfiguration was permitted. Each participant was given an identical small bag of electronic components. Data gathering included written questionnaires, interviews, audio, video and sensor usage data directly saved on the instrument.

5.1. STYLE, MODIFICATIONS AND "META-HACKING"

At the time of writing, 10 of the 14 participants have completed the study. Most numerical data remains to be analysed, but a first qualitative analysis highlights some interesting results. As expected, performers exhibited an extremely wide variety of styles and playing techniques. Much of this variety was attributable to functional modifications of the instrument, but we were also able to observe extensive exploration of its original features. As in the Cube Instrument study, the touch sensors were used in many different and sometimes unusual ways; techniques included multi-finger tapping to play melodies, rhythmically rubbing the wood panels and wetting the sensors to obtain infinite sustain. These similarities with the previous user study suggest that, as targeted, the unmodified design of the D-Box was broadly perceived as simple and clear, but still very constrained.

8 of the 10 musicians chose to modify their instruments. Comments and interviews suggested two primary motivations for hacking. Some participants modified the matrix to overcome limitations they perceived as encumbering during the composition phase. For example, some of them had to dynamically modify the pitch range of the instrument to play their piece; others felt constrained by the fixed playback speed, which did not allow proper syncing with other sound sources, and decided to modify the circuit to make it adjustable. Other participants, mainly skilled circuit benders and instrument builders, took an attitude to hacking related mainly to their musical background. They explored their D-Box focusing mostly on the matrix. Most of their hacks discarded the original capabilities of the instrument and, so far, it is still unclear to us exactly how many of them work. Two participants suggested that the matrix could be connected to external musical devices, including modular synths, but time constraints prevented them from exploring these possibilities. A different participant connected an Arduino to the matrix to manipulate the choice of samples based on level detection of the piezo pickups.

In a group discussion, participants were asked whether modifying the D-Box constituted "hacking". Musicians with circuit bending background pointed out that the design of the matrix allowed them to directly apply their usual hacking techniques. In general, the fact that the circuits were not soldered but arranged on a modifiable breadboard helped speed up the bending process; however, some participants felt that the absence of a fixed circuit to "poke" diminished that sense of subversion that characterises hacking. All participants agreed that hacking includes the misuse of a device, enabling features that go beyond the original purpose of the instrument ("something you are not supposed to do"). From this perspective, some participants didn't consider changing the matrix to be "hacking", since the matrix design was meant to be subverted. Still, these participants identified modifications which they considered to be beyond even the hackable features of the D-Box. One participant referred to this process of modifying a hackable instrument in ways you are not supposed to as "meta-hacking." Identified examples included feeding the speaker output back into the matrix and creating feedback by touching the piezo microphones to the speaker.

6. CONCLUSION

The D-Box is a self-contained musical instrument whose design is intended to be modified by the performer. Rather than take a modular approach to building and modifying the instrument, a simple and apparently limited interface is presented to the performer in the beginning, but the internal mechanics of the instrument are exposed inside the box for rewiring in arbitrary ways.

The user study revealed a wide variety of style and two general motivations for modification: as a means of overcoming limitations of the device, and as an expression of personal performance technique. The approach based on overcoming limitations extends the original Cube Instrument study in showing the role of constraints in encouraging creative (mis)uses of technology, where the second approach shows that the design is flexible enough to accommodate the needs of experienced circuit benders. Finally, the fact that many of the novel behaviours were unknown even to the original designers suggests that the space of possibilities is ultimately determined by the creativity of the performer rather than strict limitations imposed by the designer.

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A WIRELESS FUTURE: PERFORMANCE ART, INTERACTION AND THE BRAIN-COMPUTER INTERFACES

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ABSTRACT

Although the use of Brain-Computer Interfaces (BCIs) in the arts originates in the 1960s, there is a limited number of known applications in the context of real-time audio-visual and mixed-media performances and accordingly the knowledge base of this area has not been developed sufficiently. Among the reasons are the difficulties and the unknown parameters involved in the design and implementation of the BCIs. However today, with the dissemination of the new wireless devices, the field is rapidly growing and changing. In this frame, we examine a selection of representative works and artists, in comparison to the current scientific evidence. We identify important performative and neuroscientific aspects, issues and challenges. A model of possible interactions between the performers and the audience is discussed and future trends regarding liveness and interconnectivity are suggested.

KEYWORDS

Brain-Computer Interface (BCI), Electroencephalography (EEG), Human-Computer Interaction (HCI), Wireless, Performance Art, Real-Time, Liveness, Mixed-Media, Audience.

1. INTRODUCTION

The use of Brain-Computer Interfaces (BCIs) in the arts originates in the 1960s with the pioneering work of composers like Alvin Lucier, David Rosenboom, and others. Today there is an increasing number of musical works in the field, but there are still limited known applications in the context of real-time audio-visual and mixed-media performances[1] and accordingly the knowledge base of this area has not been developed sufficiently. The reasons are merely two. On the one hand, the low-cost commercial devices have only recently been available in the market, making the technology approachable to artists. On the other hand, the design and implementation of BCIs presents several difficulties and is dependent on unknown parameters. However, today the field is rapidly growing and new approaches and definitions are requested. In this frame we shall refer to the use of BCIs in the context of real-time audio-visual and mixed-media performances as *live brain-computer mixed-media performances*. After a brief introduction in section 2 to BCIs and the particular difficulties they present, we examine in section 3 a selection of representative works and artists, in order to identify important performative and neuroscientific aspects, issues and challenges and show how the development of the field is changing with the dissemination of the new wireless devices. In section 4 we outline possible directions for the future research and practices and we suggest a model of possible interactions between the performers and the audience.

2. BRAIN-COMPUTER INTERFACES: LIMITATIONS, DIFFICULTIES AND UNKNOWN PARAMETERS

Wolpaw and Wolpaw (2012, 3-12) defined a BCI as:

> "[…] a system that measures CNS [Central Nervous System] activity and converts it into artificial output that replaces, restores, enhances, supplements, or improves natural CNS output and thereby changes the ongoing interactions between the CNS and its external or internal environment."

Among the non-invasive techniques used for signal acquisition in BCIs, the most common is Electroencephalography (EEG). EEG, a technique that can be applied to humans repeatedly with no risk or limitation, is the recording of the electrical activity along the scalp, by measuring the voltage fluctuations resulting from the current flows (Teplan 2002, Niedermeyer and da Silva 2004). The recorded electrical activity is then categorized in rhythmic activity frequency bands,[2] which are associated to different brain- and cognitive- states. EEG is a very effective technique for measuring changes in the brain-activity with accura-

1. We use the term "mixed-media performances" as introduced by Auslander (1999, 36): "[…] events combining live and mediatized representations: live actors with film, video, or digital projections […]."

2. The EEG rhythmic activity frequency bands are delta (<4Hz), theta (4-7Hz), alpha (8-13Hz), beta (14-30Hz), and gamma (30-100Hz).

cy of milliseconds. However, one of its technical limitations is the low spatial resolution, as compared to other brain imaging techniques, like fMRI (functional Magnetic Resonance Imaging), meaning that it has low accuracy in identifying the region of the brain being activated.

At the same time the design and implementation of the BCIs presents additional difficulties and is dependent on many factors and unknown parameters, such as the unique brain anatomy of the person wearing each time the device, the task/s being executed, the type of sensors used, the location of the sensors which might be differentiated even slightly during each session, and the ratio of noise and non-brain artifacts to the actual brain signal being recorded. More specifically among the non-brain artifacts are included the "internally generated", such as the EMG (electromyographic) deriving from the neck and face muscles, the eye movements, but also the heart activity, and the "externally generated" like spikes from equipment, cable sway and thermal noise (Swartz Center of Computational Neuroscience, University of California San Diego 2012).

In recent years, with the accelerating advances in neuroscience and biomedical engineering research, new low-cost devices which use wet or dry sensors have been developed. Neurosky introduced in 2007, the first, to our present knowledge, wireless device for consumer use, which was also the first device with a dry sensor that did not require the application of a conductive gel, nor skin preparation (bnetTV.com 2007). In 2009, Emotiv launched two wireless devices, the EPOC and the EEG neuroheadset, with 14 wet sensors plus 2 references. At the same time, alongside with the companies building new wireless interfaces, a community of developers and engineers working on DIY (do it yourself) devices has also emerged, such as the OpenEEG project (OpenEEG project 2014), which is a relatively well-known community amongst artists and creative practitioners. This way and within only a few years, the EEG technology has been made more approachable and easy-to use and therefore the applications in the arts have radically increased and the practices have changed. As we will discuss further on, the new wireless devices help the artists to overcome important constraints, but at the same time they also present new challenges.

3. THE USE OF BCIS IN REAL-TIME AUDIO-VISUAL AND MIXED-MEDIA PERFORMANCES: NEUROSCIENTIFIC AND PERFORMATIVE CHALLENGES

3.1. KINESIOLOGY, FACIAL EXPRESSION AND NOISE

Since the first works with the use of BCIs, performers have encountered considerable limitations to their kinesiology and even their facial expression; either in cases they use wired devices and electrodes, and/or because of the contamination of the EEG-data with noise and non-brain artifacts from the cranial and body muscles. A well-known example is *Music For Solo Performer* (1965) by Alvin Lucier, which is considered the first real-time performance using EEG. In this work, the performer has two electrodes attached to his forehead, while he sits almost without moving on a chair, opening and closing slowly his eyes, thus controlling the effect of the visual stimuli on his brain-activity and consequently the alpha rhythmic activity frequency band, which is associated with a brain-state of relaxation. The electrodes are connected via an amplifier to a set of speakers, who transmit the electrical signal and vibrate percussion instruments placed around the performance space (Ashley 1975).

Another example is *INsideOUT* (2009) by Claudia Robles Angel, in which she uses an open source EEG interface from Olimex, consisting of one analogue and one digital board, connected to a computer. Two electrodes, one on her forehead and one on the back of her head, are connecting respectively the frontal lobe's activity with the sound output from the computer and the occipital lobe's activity with the video output. The sounds and images are projected on a screen and onto the performer. They are controlled by the values of the signals acquired via the electrodes and processed via the MAX/MSP software (Angel 2011). In one of her interviews, Angel mentions that with the EEG interface she could not move because it "is so sensitive that if you move you get values [noise] from other sources" (Lopes and Chippewa 2012). Today, the new wireless devices have provided the performers with greater kinetic and expressive freedom, while in some cases they also include filters and algorithmic interpretations which can be used to some extent for the real-time processing of the acquired data. However there are certain issues, which will be discussed more in detail in section 3.4.

3.2. RHYTHMIC ACTIVITY FREQUENCY BANDS AND COGNITIVE STATES

The limitations imposed in the performers' kinesiology and facial expression, like in the previously presented examples of works, have further implications and result in additional performative constraints, such as the inevitable focus in the control of only the relaxation state and the associated alpha rhythmic activity frequency band. For performers that are interested in using BCIs while engaging in more active situations and states of tension, like for example in works that involve intense kinesiology and speech, the use of wireless devices is indispensable. Consequently they are also enabled to consider all the different frequency bands, associated with a greater range of brain- and cognitive-states. The EEG-data can be further processed and differentiated according to the tasks executed and in consistency with the dramaturgical conditions of the performance. In this way the use of the BCIs as a medium in live performances is enriched. Examples of such works are presented in the following sections.

3.3. SPATIAL RESOLUTION AND THE HEAD VOLUME CONDUCTION EFFECT

As we discussed in section 2, one of EEG's technical limitations is its low spatial resolution, which is also further influenced by the "head volume conduction effect" (He and Ding 2013), meaning that the recorded electrical signal is further blurred, as it passes through the different anatomical tissues of the head, before it reaches the scalp. The result of this phenomenon is that positioning the electrodes or sensors on different locations on the head cannot be easily associated with the activity of specific regions of the brain. In neuroscience research, in order to bypass this limitation, apart from the clinical grade systems that can use up to 256 electrodes, there are methods and tools, such as invasive BCIs, the complementary use of fMRI scans, as well as complex linear algebra mathematical modelling. However, these techniques are currently not applicable to artistic performances and especially in cases where low-cost interfaces are used with limited number of electrodes/sensors, either wireless or not. For this reason, either the artists should not rely the concept of their *live brain-computer mixed-media performances* on the localisation of the electrodes/sensors or they should consider applying a combination of pre-performance study and on-performance use of computational processing, which however is complex and therefore challenging.

3.4. RAW EEG DATA VERSUS "DETECTION SUITES"

The new low-cost wireless devices have not only given greater kinetic and expressive freedom to the performers, but with their accompanying user-friendly software, SDK (software development kit) licences and a variety of connectivity solutions, they have enabled artists to establish communication with different hardware and boards like Arduino, and software like Pure Data, MAX/MSP, Processing, Ableton Live and others, creating prototypes and playful applications. This easiness is largely achieved because these devices enable the real-time raw EEG data extraction, but at the same time they also include ready-made algorithmic interpretations and filters for feature extraction. For example the user can view and process/map data under categorisations such as "frustration" or "excitement", "meditation" or "relaxation", "engagement" or "concentration", which are differentiated amongst the different devices and manufactures.

For example, Adam John Williams with Alex Wakeman and Robert Wollner presented in 2013 a project, which uses an Emotiv EPOC headset in order to connect with and sent to a computer the participants' EEG data, converting them to:

> "[…] OpenSound Control messages, which were sent to a Mac where Max MSP used the data to adjust the rules of a generative music engine. Tempo and sync information were then packed along with the original EEG messages and transmitted to the Raspberry Pi upon which the visuals were generated."
> Williams 2013

As it is shown in the video documentation, the software processes different inputs titled as "Bored/Engaged", "Excited", "Excited LT", "Meditation" and "Frustration", which are associated with the Emotiv's "detection suites" (Emotiv 2014).

Lisa Park in her work *Eunoia* (2013), a Greek word meaning goodwill and beautiful thinking, reinterprets in a way Alvin Lucier's *Music for Solo Performer* (1965) by using Neurosky's Mindwave wireless device, monitoring her brain-wave activity and processing the EEG-data categorised in different rhythmic activity frequency bands, but also states, such as "Attention" and "Meditation". These data and the corresponding values are amplified and transmitted through five speakers, positioned underneath equal number of round metal plates, filled with water, and associated according to the artist with the emotions of "happiness", "anger", "sadness", "hatred", and "desire". The speakers vibrate the metal plates and "varieties of water forms" are created (Park 2013).

Although the use of the aforementioned "detection suites" serves in the artists' hands as ready-made tools for the creation of inspiring and imaginative works, there are two facts that we should bear in mind. On the one hand the algorithms and methodology upon which the interpretation and feature extraction of the brain's activity is made are not published by the manufactures. On the other hand the published neuro-science research in the field of emotion recognition via the use of EEG data is fairly new. Thus, the use of these "detections" of emotional states should not necessarily be regarded as accurate and therefore the creative results may not be consistent to the artists' original intentions.

Two examples in the direction of scientifically established use of emotion interpretation via EEG in the arts, come from the field of computer music research. The Embodied AudioVisual Interaction Group (EAVI) at Goldsmiths, University of London, has developed a BCI toolkit, that can be used with both clinical grade and consumer level devices, and has the ability of detecting Event Related Potentials (ERPs) used for "making high-level musical decisions", like for example in Finn Peters' *Music of the Mind* (2010) album and tour (Grierson, Kiefer, and Yee-King 2011). For their under development performance piece *The Space Between Us*, Eaton, Jin, and Miranda (2014) describe the measurement and mapping of valence and arousal levels within EEG, for which there are different known methods with well documented results. Similar approaches can contribute to a new system of validation and evaluation, enabling further advancements in the field.

3.5. COHERENCE, SYNCHRONICITY AND INTERACTION WITH MULTIPLE PARTICIPANTS

One of the most cited works, Mariko Mori's *Wave UFO* (2003) is an immersive video installation, where computer-generated graphics are combined with the "real-time interpretation of three participants' alpha, beta, and theta brain-waves" (Mori, Kunsthaus Bregenz, and Schneider 2003). The participants are wearing EEG devices with three electrodes/sensors attached to their foreheads, recording the frequencies of their brains' right and left hemispheres. According to which frequency is showing higher activity, projected animated spheres on the ceiling (one for each participant's hemisphere) take a different/associated colour (red for beta band, blue for alpha and yellow for theta). At the same time is also animated each participant's brain coherence with a second pair of smaller spheres, the "Coherence Spheres". By coherence the artist refers to the phenomenon of synchronicity of the alpha-wave activity between the two brain's hemispheres (Mori, Kunsthaus Bregenz, and Schneider 2003). When this is achieved, the "Coherence Spheres" are joining together. If all the participants reach this state, then a circle is created, as a scientific and visualisation approach to the artist's idea of connectivity. Coherence in Mariko Mori's work also serves as an example of a real-time interaction between the brain activity of multiple participants and the visualisation of the brain-data as a form of physicalisation, which is the process of rendering physical the abstract information through either graphical representation and visual interpretation or sonification (Tanaka 2012).

More recently, the Marina Abramovic Institute Science Chamber and neuroscientist Dr. Suzanne Dikker have been collaborating in a series of projects, like *Measuring the Magic of Mutual Gaze* (2011), *The Compatibility Racer* (2012) and *The Mutual Wave Machine* (2013), which explore "moments of synchrony" of the brain-activity between two participants, when they interact by gazing at each other (Dikker 2014). As Dikker explains by "moments of synchrony" are meant points in time when the two participants present the same predominant brain-activity (Marina Abramovic Institute 2014). Could we expect to see in the future *live brain-computer mixed-media performances* where an interaction between the performer/s' and the audience's brain activity, jointly contribute to the final creative output/result? In this case what kind of new connections and cognitive issues might emerge?

4. TOWARDS THE FUTURE

4.1. LIVENESS AND INTERACTION WITH THE AUDIENCE

In real-time audio-visual and mixed-media performances, from experimental underground acts to multi dollar music concerts touring around the world in big arenas, liveness is a key element. In the case of performers using laptops and operating software, the demonstration of liveness to the audience is a challenge approached in various ways. The Erasers (2013) for example, transform the stage into a kind of audio-visual laboratory, where the creative process and the different techniques they use to produce moving images and sound, as well as the final outcome are immediately visible to the audience. Other performers use two projections, with one of them showing their computers' desktops and the other one showing the visual output/result. A similar approach is also live coding, a programming practice disseminated in contemporary music improvisational performances.

In the field of *live brain-computer mixed-media performances*, the members of PULSE4ART group, awarded in *Errors Allowed Mediterranea 16 Young Artists Biennial* (2013), have mentioned that in their 2014 new project they will engage the audience by having them wear the headsets and contributing their EEG data to the performance, much like the way it was realised in their 2013 project *ALPHA* (Pulse 4 Arts and Oullier 2014). The project is an improvisation-based performance with live music, live visuals and the brain-activity of two dancers wearing two EPOC headsets extracted and mapped real-time to projected moving images (Association Bjcem 2013). Also Lisa Park, in her demo video for her upcoming performance *Eudaimonia*, a Greek word meaning bliss, presents the idea of an installation with the collaboration of eight to ten participants wearing portable BCI devices. As in her 2013 performance, discussed in section 3.4, the brain-activity of the participants will be physicalised as sound-waves, played by speakers placed underneath a shallow pool of water, vibrating and creating "corresponding ripples and droplets" on the surface (Park 2014).

From these and other examples a question deriving is: what might be a model for interaction between the performer/s' and the audience's brain-activity in the context of a *live brain-computer mixed-media performance* and how could liveness be presented to the audience? In Figure 1, we present a proposal for such a model, which demonstrates the collective participation and co-creation of the mediatized elements of the performance. According to the model, the audience is made aware of the liveness of the performance by realising the interaction taking place among its EEG activity, the audio and visual outputs and finally the performer/s themselves.

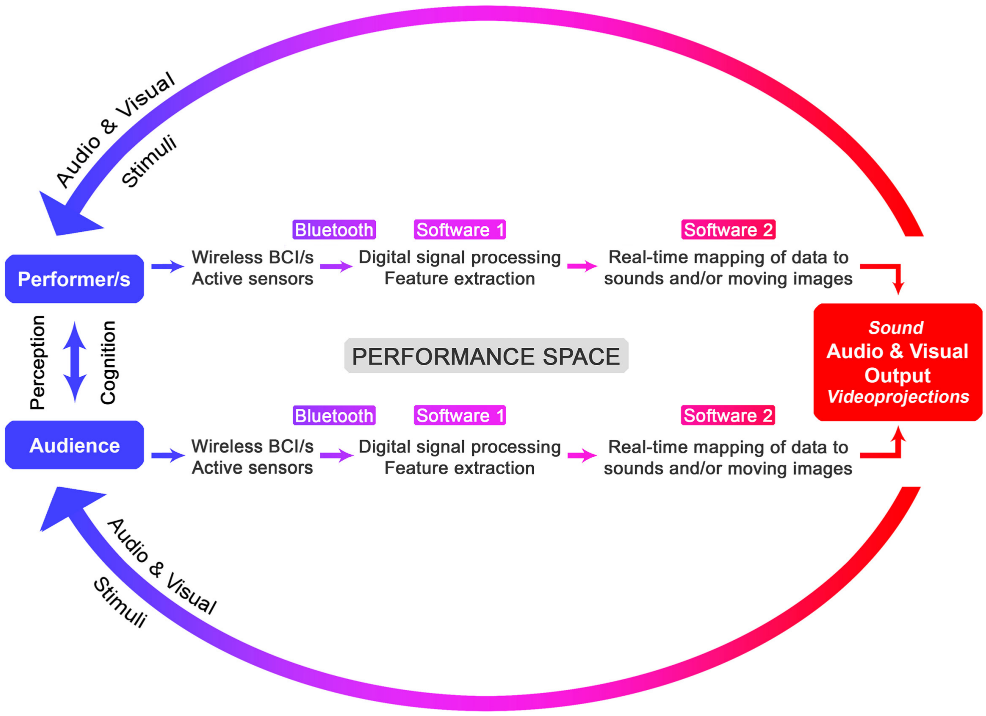

Figure 1 A model of interactions between the performer/s and the audience in *live brain-computer mixed-media performances.*

The model currently serves as the basis for the development by the authors of a new multi-brain EEG-based BCI system, which will be used in the context of a new live brain-computer mixed-media performance, due to be presented in the coming months.

4.2. INTERCONNECTIVITY

As the research and development of applications are advancing, new possibilities are emerging for the BCIs to connect with other devices, and ultimately the World Wide Web. The idea of using technology, sensors and computers to connect the human body to the Internet is not new in the arts. Stelarc, a performance artist using biotechnology, robotics, virtual reality systems and the Internet, probes and acoustically amplifies his own body (Stelarc 2014). During the *Telepolis* event that took place in November 1995, a series of sensors were attached to different parts of his body, connected to a computer with a "touch screen interface & muscle stimulation circuitry", and via the computer to the World Wide Web (Smith 2005). Through a "performance website" the audience remotely viewed, accessed, and actuated the body by clicking/sending commands to the computer interface located together with Stelarc at the performance site. The result was causing the body to move involuntary (Stelarc 1995).

In August 2013 Rao and Stocco conducted in the University of Washington the pilot study *Direct Brain-to-Brain Interface in Humans*. In the published research report is described the first brain-to-brain interface between two humans, which transmits EEG signals recorded from the first participant to the second over the internet (Rao et al. 2014). In August 2014 Grau et al. published the results of a series of experiments with established "internet-mediated B2B [Brain to Brain] communication by combining a BCI […] with a CBI [Computer-Brain Interface]". Of course the Brain to Brain research is a newly-born scientific breakthrough and therefore currently far from being applicable in the arts. However, the use of EEG data transferred via the internet is a reality and it is only a matter of time to witness similar applications in the context of *live brain-computer mixed-media performances*, the practices and theories of interconnectivity.

5. CONCLUSIONS

There is no doubt that the new wireless devices are not only the future, but already the present in the field of *live brain-computer mixed-media performances*. Artists are not only enabled with the new EEG technologies to use their own brain in their creative practices in the most direct way made so far possible, but they are also given a new freedom of access, interpretation, communication, interaction, and the ability to investigate new performative patterns.

The presented and discussed artists and their work is only a sample of the continuously increasing number of imaginative applications, creative and playful ideas that have emerged within only a few years. The new wireless devices help performers to overcome the so far dominant constraints, providing them with greater kinetic and expressive freedom, but at the same time they also present new challenges. By taking into account both the advantages and disadvantages, the opportunities and limitations of the technology, in comparison with the current scientific research and methodologies, artists can enrich their practices in a meaningful and consistent to the medium way. They will be able to contribute to the advancement of the field and the creation of a greater and more validated area of investigation in discourse with other relevant practices. We expect in the near future much progress and new aesthetic experiences intersecting and transcending the boundaries of performance and new media art, experimental psychology, computational neuroscience, and modern brain-computer interface design.

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BRAIN: THE ULTIMATE ENACTIVE INTERFACE?[1]

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ABSTRACT

*Eshofuni@TheAbyss*is a multidisciplinary project and performance, proposing real-time representations of brain phenomena using a brain-computer interface. It implements novel representational approaches to action/perception/reaction processes, specifically, to the contextual balance ratio between reason and emotion. It is an *ecological* approach based on a theoretical framework that implies that behavior and evolution depend on environmental synergies and are a consequence of enactive dynamics, be they physically or symbolically based. This paper discusses the project within the context of live interfaces while also introducing a transdisciplinary approach to brain phenomena, addressing a multiplicity of aspects that are fundamental to its understanding and, consequently, to the project. We discuss the definition of interface, then introduce the brain complex neuro-physical electrical system with pre- and experience-independent, built-in *possibilities*, but which is also *moldable* by interaction, and propose that it is a candidate for the ultimate dynamic interface; we then *correlate* this system with the performative art event(s) and respective environmental synergies; next we explain the representational, conceptual approach and strategy of *Eshofuni@TheAbyss* and finally, we discuss the implications of this approach and propose some insights on the matter.

1. The use of certain expressions within specific contexts tends to be interpreted as signs belonging to those contexts. In this case, the *enactive interface* has a potential relationship with the theory of interfaces. But the choice of those two words in this paper has a (simultaneous) purpose that goes beyond the former framework. The aim is to explore embedded implicit meanings in the text related to the two words – enaction + interface – qua indexical and/or symbolic signs, *per se* and/or as a full expression.

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KEYWORDS

Brain, Interface, Environment, Enaction, Brain-Computer Interface, Art.

1. INTRODUCTION

On writing about the seminal book *Endophysics: The World As An Interface* by Otto Rössler, Ichiro Tsuda (2002, 213-214) proposes in his conclusions that "Endophysics tells us that reality only exists at interfaces. By perturbing the interface slightly, we can have different senses of reality". Interestingly, Peter Weibel (1996, 343) raises questions about the same theme saying "The world changes as our interfaces do. The boundaries of the world are the boundaries of our interface. We do not interact with the world – only with the interface to the world." Finally, Manovich (n/a) in his essay *The Interface as a New Aeshetic Category* postulates that "Content and interface merge into one entity, and no longer can be taken apart".

2. THE INTERFACE DILEMMA

Is there a proper definition for interface? Definitions may reference functionalities and/or characteristics, they may be considered iconic, symbolic or ecological. In *Computers as Theatre*, Laurel writes (1991, p.4) "interface is not simply the means whereby a person and a computer represent themselves to one another; rather it is a shared context for action in which both are agents". An interface based on the perception-action loop paradigm – integrating multiple modalities (e.g., vision, sense of touch, sound) – can be considered as enactive (Fukuda, 2011, p.77).

Reference dictionaries define interface with variations of a common denominator which can be taken as the definition itself – (Interface is): "the place or area at which different things meet and communicate with or affect each other" (*www.merriam-webster.com*); "A point where two systems, subjects, organizations, etc. meet and interact:" (*www.oxforddictionaries.com*).

We propose that: *Interface is whatever, whenever or wherever entities of different systems establish contact that opens and promotes the possibility of data transduction and transfer between them.*[3]

3. BRAIN BASICS

The human brain is a complex multi-system whose architecture is based on multiple layers and systems (e.g., groups of neurons devoted to certain routines or functions, such the auditory system) that are networked and permanently communicating with each other (e.g., through electrical phenomena) (Sporns, 2011).

3. Data here should be understood in a broad sense, i.e., from physical to conceptual, e.g., electric energy, a virus, words in the mind, a graphic form.

It is a system of sets of circuits that is able to detect and evaluate the relevance of myriads of physical energies in the environment and, plans and executes appropriate reactions to them. It provides us with numerous functional schemas such as basic senses[4] and basic integrated postural and locomotor movement sequences (Buzsáki, 2006). Through sensing, perception and cognition, it allows us to be aware of the environment and of ourselves (Buzsáki, 2006; Wilson and Foglia, 2011).

3.1. A PRIORI VERSUS A POSTERIORI

As a system, the brain is by itself a universe with a priori characteristics, i.e., congenital *possibilities* (not only structural, but also functional) with ongoing intrinsic spontaneous activity (Raichle, 2010) capable of wandering in the absence of external demands (Malia et al, 2008).

According to scientific evidence, a brain can live in isolation (Llinás and Paré, 1991) – and be kept alive as an isolated system as long as proper energy (e.g., glucose) feeds its basic functions (Bohlen and Halbach, 1999). However, many of the same empirical findings also postulate that although a brain may "live" in isolation, it does not produce useful constituents (e.g., data) for itself without environmental interactivity (Buzsáki, 2006). Most interestingly, it does not produce them for itself nor for the entity(ies) that could have a relationship whit it (e.g., the human-body that hosts it or other entities that interact with it, e.g., other humans). Or, more accurately, it may not fully develop if isolated from a dynamic context (Buzsáki, 2006; Wilson and Foglia, 2011). Tsakiris et al. postulate that: "coherent experience (…) depends on the integration of efferent information with afferent information in action contexts."(2006).

3.2. REMARKS ON QUANTITATIVE BRAIN PHENOMENA

Brains generate electromagnetic oscillations – i.e., rhythmic activity –, which have been being recorded in the form of waves (Electroencephalography). A scientific consensus divided this rhythmic activity into bands by frequency (delta, 0.5–4 Hz; theta, 4–8 Hz; alpha, 8–13 Hz; beta, 13–30 Hz; gamma, >30 Hz[5]). Beyond mere taxonomy, this nomenclature arose because specific bands could denote specific biological significance. Certain characteristics of the brain's electric phenomena[6] may denote emotional processes (Trochidis and Bigand, 2012), while others[7] may denote a voluntary self-initiation of movement, or a kind of preparatory processing that precedes the actual action (Jo et al., 2014).

4. I.e., sensing, detecting features of the external and internal environments – olfaction, sight, touch, hearing, taste, etc. – supported by and interacting with the multiple body sensors.

5. The precision of the segmentation of the EEG frequency bands is not absolutely consensual among science communities.

6. E.g., inter-hemispheric asymmetry of certain bands such as alpha – 8-13 Hz – within the frontal lobes.

7. E.g., progression of spectral power before onset of a movement.

Brain electric phenomena could, as such, be seen as a kind of global mirror of its functions, namely in temporal frameworks, that could denote aspects such as environmental interaction.

3.3. AM I SPEAKING TO MYSELF?

Damásio (2010) proposes that the brain has the ability to create the self, which emerges from sensing our own physiology, but also the consciousness, which is based on a self-referential layer – where autobiographical phenomena are one of the most important aspects – that allows us to build a complex sense of ourselves in relation to ourselves, in relation to others and in relation to the environment. It could have arisen as a consequence of a layered evolution according to its necessities and strategies, and has a very peculiar characteristic: conceptualizing the future, besides reasoning about the present and retrieving the past.

Consciousness is, however, a puzzling concept and is not consensual among either philosophers or scientists, or indeed among themselves. There are approaches that reduce it to mechanistic ontological models (Zeman, 2001) but others (one of which is Cartesian *dualism*) "regard at least some aspects of consciousness as falling outside the realm of the physical". (Gulick, 2014)

4. INTERFACING

From this framework of theories, we can propose that the brain is, in a broad sense, a point of contact – an interface – between the I as a matter-less entity that is aware of its bodiless existence (at least conceptually), and the Am as a physical object empowered with mechanisms that can impact reality (by means of efferent data sent to the host mechanic system). Or between *I* and *Do*,[8] whereby I, through my will, will behave based on afferent information conveyed by body sensors – e.g., the skin, – and the central nervous system (CNS) to the brain, where it is processed.

5. SYNERGY OF INTERACTION DYNAMICS

An artistic performative live act, with performer(s) and audience (as the entities that share the act), is a participatory event, where both parts share and construct a simultaneous set of interlinked circumstances. It is an event where modal constituents – e.g., visual, sonic, olfactive – trigger interactive processes of analysis, perception, appreciation, feedback and co-processing between the entities involved, creating a dynamic and complex process of aesthetic experience, reasoning and emotion. Interestingly, art forms such as music are so powerful that they can activate nearly every known area of the brain and the deepest systems

8. To avoid going into a deep Aristotelian or Kantian discussion, we can formulate the *I* and *Am* qua being – i.e., as a consciousness conundrum – and the *I* and *Do* qua agent – i.e., as a physical behaviorism conundrum.

generators of emotions (Levitin, 2007), as well as elicit involuntary behaviors perhaps even by coercion (Sacks, 2006). However most of us can only guess what is going on inside the performer's mind, i.e., in the dynamics of this complex relationship, we are not able to *see* possible inner constituents of a *reality* not *visible* by immediate mechanisms.

6. TRANSCODING AND TRANSLATING THE BRAIN PHENOMENA

Both sciences and arts have been using technological apparatus and procedures which can record the brain's continuous electric activity and transcode it into discrete objects (Vidal, 1973) and representational models to denote and characterize the constituents of brain phenomena. For example, EEG topographic visualization uses (pseudo)colors coding schemas to represent specific occurrences within specific regions of the brain's geography[9] (Shankar and Ramakrishnan, 1998; Teplan, 2002).

There are many electroencephalography approaches – both representational and technological – but many are restricted by auto-regulation paradigms, i.e., although they may allow reconceptualization and evolution, they replicate the conventions and theoretical frameworks on which they depend. They also embrace laboratory presettings and aseptic paradigms in detriment of ecological contexts.

7. ESHOFUNI

Eshofuni[10] (Tomé-Marques et al., 2014) is a multidisciplinary project embracing art, communication design and programming, that proposes an approach to the real-time representation of brain data using a virtual physics engine – built fundamentally in the Max programming environment – and real-time Emotiv EEG BCI signal on performative contexts. *Eshofuni* invokes a conceptual parallelism inspired by Newton's laws of motion and equilibrium – a body continues in its state of rest, or in uniform motion, unless external forces compel it to change that state – and the theory that the brain has a default mode where it develops as a self-organized or spontaneous state without an external input, but for which external perturbations are crucial nevertheless to perform useful computations (Buzsáki 2006). Started in 2013 as a research project to propose and repurpose representational approaches, in real-time and in creative ways, but with objective empirical criteria and support, it evolved to *EshoFuni@TheAbyss*, a step forward in brain data representation relying on a new approach placing it in ecological contexts – now both literally and metaphorically.

9. It is therefore a method that serves to simultaneously denote and characterize event(s) and place(s)/location(s) of a phenomenon.

10. Eshō-funi is a Japanese Buddhist term: esho is a compound of shoho, meaning life or a living being, and eho, its environment. Funi, meaning "not two," indicates oneness or non-duality. It is short for nini-funi, which means "two (in phenomena) but not two (in essence)." Ho of shoho and eho means reward or effect. At the most fundamental level of life itself, there is no separation between ourselves and the environment.

7.1. ESHOFUNI@THEABYSS

The Abyss is an ecological system inhabited by entities with graphic and sonic forms – inspired by the creatures that constitute plankton, such as, for e.g., zoids[11] – that interact among themselves and with the *Eshofuni* qua performer's avatar, thus allowing the set to denote the performer's brain processes that are hence generated and conditioned within this environment.[12] It uses real-time and longitudinal statistics (e.g., real-time retrieval iterated with analysis, segregation and cumulation), applying filtering (band and multiple order) and Fast Fourier Transforms (FFT). It is based on two models: 1) alpha asymmetry to denote emotional processes;[13] 2) Emotiv COG[14] as procedures to support executive functions, i.e., conscious control.

It is an evolutionary system that co-implements behavioural algorithms to allow autogenesis and independent evolution. Entities that inhabit the *Abyss* have their own *independent* and interactive life. Some of them are connected with different clusters of the brain metaphor (i.e., *Eshofuni* – which is also an entity inhabiting the Abyss). Those clusters are brain sites correlated with the EEG 10/20 system.[15] Evolution happens when specific clusters of the brain – e.g., F3 – are triggered by events that happen in this ecosystem. That is, when spectral and oscillation patterns related to complex brain specific processes – e.g., volition, emotions – are detected, the system denotes these phenomena as changes in the representations (the *all* metaphor). This evolution can be characterized by the recodification of color, changes (complexification) in forms, sounds, or whatever inventive representation we think of insofar as it fulfills our purpose and criteria. This means that a timeframe of longitudinal cumulative changes in a site could be denoted by the consequentially changed character of the constituents related (*connected*) to the respective site.

11. Zoids are the beings that constitute the Siphonophores – the longest animals on the planet.

12. The *EshoFuni@TheAbyss* approach is highly inspired in the "Plankton Chronicles" project (www.planktonchronicles.org), a documentary series based on very short videos about the life and characteristics of planktonic organisms – errant, from Greek planktos.

13. Alpha asymmetry is a theory that proposes that the frontal inter-hemispheric brain EEG differential on this specific band could be correlated with emotional processes. The purpose of this paper is not, however, to discuss the theory.

14. Emotiv COG (Cognitive suite) is a *machine learning* proprietary algorithm by Emotiv Inc that enables volitional control of software functions after training.

15. A standardized physical method to describe and apply the location of electrodes on the scalp, adopted in 1955 by the International Federation in Electroencephalography and Clinical Neurophysiology (Teplan 2002) where brain sites and hemispheres are designated by letters and numbers – e.g., F3, denotes a site on left frontal lobe.

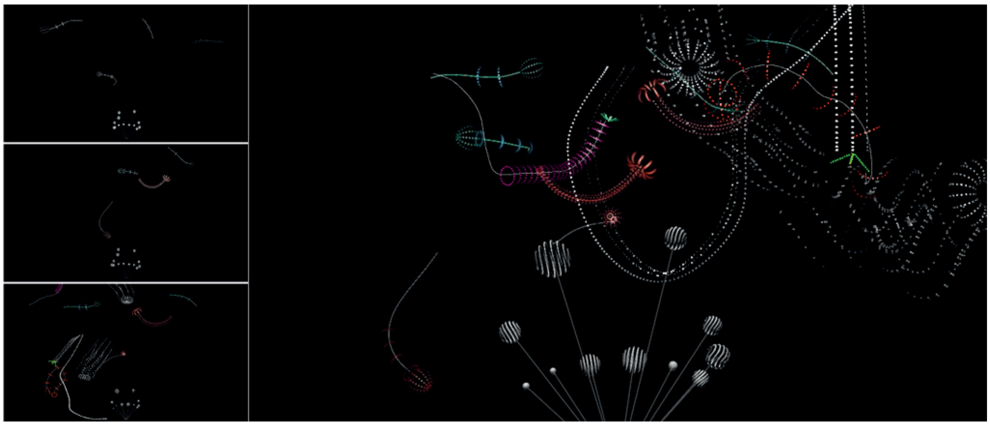

Figure 1 *Eshofuni@theabyss*, four frames of the system.

8. DISCUSSION, PURPOSE AND STRATEGIES OF AN NOVEL APPROACH

When science proposes that the brain has the ability to create the self from sensing one's physiology, maybe we should see this as a kind of low-level computation that deals with hardware parts and details, and the consciousness as a kind of high-level computation that deals with abstractions and pure concepts.

We accept that the brain can have a conscious endo-reality, one that may only communicate with the exo-reality (the environment) via non--haptic abstract interfacing, disassociated from any specific corporeal instance , but which is however embodied in our hardware (i.e., human physical constitutive element). This embodiment has created a complex organism with multiple sensors and sub-systems that are interdependent and fundamental to the procedures it has to operate in order to live. A kind of enactive simultaneity where the entity is dependent on the system and is conditioned by it, but at the same time, has a personal perspective and understanding of the system, its icons and symbols, and acts on it according to this understanding. This means that the complexities of both the environment and the entities are bi-directional and impact each other. We are also empowered with the notion of ourselves as agents that can act in coherence with the available options (*affordances*) derived from the dynamics of the entity-environment relationship, but which can also refuse to act with respect to incoherent deliberations.

Another important aspect related to the brain is that there are brains – millions of them – not only one brain. This means that there are millions of endo-realities, and consequently millions of perspectives about the environment in which each one operates, i.e., there are also multiple exo-realities. All these aspects raise huge problems concerning the ultimate objectiveness of any representational recipe.

Brain phenomena are extraordinarily complex and can be approached, studied and represented from many perspectives, involving multiple methodologies and strategies, but this complexity raises indisputable problems to their decoding. Even within contexts of quantitative empirical approaches, although science has uncovered certain consensual patterns that denote brain specific processes, the findings are far from being secure.

No less important, given that the artistic performative live act is an environmentally-dependent, participatory and multi-contributive event, where the parts share and build a set of interlinked events – as proposed, a dynamic process of aesthetic experience, reasoning and emotions – one can only infer and assess certain phenomena within the context in which they arise, while still running the risk that the complexities inherited from their related environment could compromise the understanding of the data.

As suggested, there are specialized apparatuses and software procedures (e.g., brain-computer interfaces, algorithms) that could transcode brain phenomena into discrete, discernible data, but the fact is that most of the solutions are far from being capable of decoding the immense complexities of the brain's phenomena, comprising thus one of their most important limitiations.

As such, this project is, beyond the quantifiable criterion, relevantly inspired by and anchored in holistic ecological concepts where particles (e.g., humans, entities, agents) and the environment interact and develop in an inclusive and integrated manner, where the all is more than the mere sum of the particles – like a super-organism, but one constituted by heterogeneous parts, i.e., entities that have agency and personality that can impact the course of events in unexpected and uncontrollable ways. We strategically use metaphor, because only through metaphor are we (slightly) capable of suggesting the behavior, characteristics, intricacies, complexities and synergies of the endo-exo *reality* simultaneity and the entities that operate it and within it.

According to our research, this is the first real-time statistical system that is multimodal and which is used as a strategy and methodology to process multiple operations in order to simultaneously access, use and denote (or connote) multiple brain phenomena, namely volition and emotions (in this particular case), as well as *independent* environmental occurrences (i.e., those derived from the interactive behavior of the system constituents other than those that could denote any brain specific phenomenon) and the consequences of all processes (i.e., evolution of the entire system along a timeframe). Therefore, this project becomes a real-time, chronological documentary system.

Finally, among the most important aspects in this context – and for us as artists –, is the urgent need to break rules and abolish assumptions postulated and commited by reductionist and restrictive theories, assuming that breaking rules (and assuming risks) is crucial to opening other novel hypotheses for the same problems addressed in the respective theories and, consequently, find new answers. Even in science nothing should be taken for granted.

9. FUTURE RESEARCH

This does not mean that we do not subscribe to scientific quantitative criteria to process data based on proven and consensual methods. On the contrary, this project is grounded on scientific EEG methodologies and this alignment also makes us highly aware that our approach is far from being perfect. For example, the use of independent component analysis is very *primitive*. Future work will focus on in reviewing, updating and/or applying new methods of real-time analysis and artifact removal in order to achieve a more rigorous data interpretation. We are also working on alternative algorithms such as Hidden Markov Models[16] to help to devise new ways of implementing iterative evolutionary learning (machine learning), as an alternative to the Emotiv COG paradigm (proprietary algorithms).

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INSTRUMENTAL PARASITES: INTERFACING THE FRAGILE AND THE ROBUST

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ABSTRACT

The parasitical relationship between the grand piano and the myriad objects used in its preparation as pioneered by John Cage in the late 1940's is here discussed from a perspective of free improvisation practice. Preparations can be defined as the use of a "non-instrument" object (screws, bolts, rubbers etc…) to alter or modify the behaviour of an instrument or part of an instrument. Although also present in instrumental practices based on the electric guitar or the drum kit, the piano provides a privileged space of exploration given its large-scale resonant body. It also highlights the transgressive aspect of preparation (the piano to be prepared often belongs to a venue rather than to the pianist herself, hence highlighting relationships of trust, care and respect). Since 2007 I have used a guitar-object (a small wooden board with strings and pick ups) connected to a small amplifier to prepare the grand piano in my free improvisation practice. This paper addresses the different relationships afforded by this type preparation which is characterised by the fact that the object for preparation is in itself an instrument (albeit a simplified one), and the preparation is transitory and intrinsic to the performance. The setup explores an instability created by the relationship between the resonant spectrum of the soundboard as activated by feedback and the equal tempered pitches accessed by the keyboard. The parasitical is explored as a metaphor with the aim of providing an alternative to concepts of "meta" or "hyper" instruments. The paper also reflects on the process of designing an interface from and for a particular practice and in collaboration with a guitar luthier.

KEYWORDS

Interface Design, Prepared Piano, Live-Electronics, Improvisation, Performance.

1. THE POLITICS OF PREPARATION

John Cage's infamous invention – the prepared piano – is well known for emerging out of the very logistics of musicking rather than any pre-calculated efforts to transgress specific established practices. This is evidenced by the pragmatic dynamics surrounding the development of piano preparation. In 1940, while working as a dance accompanist, Cage was primarily composing percussion music. When asked to write a score for Syvilla Fort's dance *Bacchanale* (1940) the expectations were that the music would be percussion based although all Cage had available for performance was a piano. Experimentation involving wedging objects between the strings led him to transforming the equal temperate pitches of the piano into more complex inharmonic sounds.

> "The Cornish Theatre in which Syvilla Fort was to perform had no space in the wings. There was also no pit. There was, however, a piano at one side in front of the stage. I couldn't use percussion instruments for Syvilla's dance, though, suggesting Africa, they would have been suitable; they would have left too little room for her to perform. I was obliged to write a piano piece."
> Cage, 1979: 7

After the premier of the work, Cage went back to his percussion music only to revisit the idea a couple of years later. By 1942 he had committed himself to write primarily for the new instrument in the context of his dance compositions. By 1944 his collaboration with Merce Cunningham was fully established with the prepared piano at the centre of a new soundscape of timbral exploration, which ranged from dry low register thuds to percussive gamelan piercing tones and rich inharmonic gongs. Considering the new world of timbres opened through a practical approach to expanding on such an ubiquitous instrument, the prominence of the prepared piano in Cage's output is surprisingly short lived (he practically abandoned the instrument by the early fifties). His 1948 *Sonatas and Interludes* remain the exemplar of the most thorough exploration of the implications of preparations on the piano for composition. The piece is meticulously notated, specifying the placement of different sized screws, bolts, rubbers and nuts with their distance from the dampers for each affected string. Although Cage is forever linked with the prepared piano, other approaches to using the instrument with its full timbral possibilities were explored by Henry Cowell, notably in the piece *Banshee for String Piano* (1925) presumably an influence on Cage himself. Cowell's use of the inside of a piano by directly plucking and scraping strings became known as "string piano" and was also used by composers such as George Crumb. The more broadly named inside-the-piano techniques have since become core vocabulary for improvisers such as Denmann Moroney and Keith Tippet. Tippet explicitly states he does not play the prepared piano and often opts for an exploration of the inside the piano which, although based on direct access to strings and placement of objects, is much more transitory, ephemeral and fragile than Cage's methodical, fixed placement of preparations.

This key difference between the fixed and the transitory in the context of piano preparations is the focus of this paper. Even though similar timbral worlds might be at play in both approaches there is an intrinsic difference in how the moment of preparation relates to performance action. For Cage, preparing a piano is clearly an activity of making ready; something that happens prior to performing or rehearsing the music. Cage clearly defined the boundary between works for *prepared piano* and works for *piano*, never seeming tempted to add aspects of preparation for standard piano works during performance. This is not the case for improvisers such as Tippet, as the state or preparedness is replaced by temporary actions that have an acoustic affect on the behaviour of the piano mechanism but are in themselves performative. This type of "live preparation" invites the listener to witness the gradual making and unmaking of the instrument, whereas in Cage the prepared piano is presented as an already modified instrument. Both approaches touch on the transgressive action of intervening with the otherwise sacred and normally out of bounds environment of the instrument's inside. Although beyond the scope of this paper, instrumental modification as an approach to music making, is in itself a fascinating way of understanding the development of experimental music throughout the 20th century. Even more than half a century after Cage's preparations, the act of directly touching, let alone placing screws on the piano strings still causes anxiety to endless festival directors and concert managers around the world.[1] From this point of view, the piano stands at the centre of power struggles and relationships of trust. As one of the very few instruments that is very much of the venue rather than of the musician, inside-the-piano techniques are seen as intrusive, possibly damaging and often capricious.

The notion of "live preparation" is the cause of even more suspicion given its unpredictability and the risk of leaving the inside of the instrument exposed to an array of actions during the performance itself. For the public however, the inside of the piano, or rather the changes in playing position between the standard seating on the keyboard and leaning over the strings represents a powerful set of cues for articulating two different sound worlds. The placement of objects, often causing a sound event in its own right, is at the core of a dialogical relationship between the stability / robustness of the pianist at the keyboard and the transitory and at times uncomfortable fragility of the pianist leaning over the strings, where the physical leaning-over of the pianist is in itself somewhat precarious. Not only it is impossible to reach the entire surface of a grand piano by leaning over, hence ergonomically limiting the resonant portions of the instrument that can be accessed, it is also difficult to maintain this leaning position for a very long time. Although some of the strings can be accessed by seating, it is sometimes the choreography

1. Pianist Denmann F. Maroney has compiled a website listing his own techniques and includes a number of testimonials by both piano technicians and concert promoters addressing perceived harm on instruments (*http://www.denmanmaroney.com/Hyper.html*).

associated with these two positions that play a rather more structural and formal role in music making by creating relationships between two sonic worlds. These relationships can range from subtle timbral variation (e.g. a middle C played on the keyboard followed by a pluck of one of the middle C strings) to highly contrasting textures between the pure pitched keyboard sounds and the noise and visceral scrapping of strings.

Thinking of the relationships involved in all aspects of physical preparation and modification in my own improvised piano practice has led to the reflection presented here. At the core of this work is the development of an interface – the 'Plank' – derived from a practice-based research process that in turn leads to the reflective conceptual framework introduced later.

2. THE PLANK

I have started exploring the resonance of the piano through feedback mechanisms since 2007. The simple use of omni-directional microphones and small amplifiers (placed inside the instrument) created a rich spectral world as the piano soundboard provided body, resonance and some unpredictability to the standard microphone-amplifier feedback loop. In this setup, the manipulation of the sound world relied on the position of the microphone (often moved gesturally with one hand), the amplifier settings, the use of the sustain pedal and, perhaps most intriguingly, the relationship between the acoustic feedback of the system and the pitches played on the keyboard. For example, an established feedback tone close to a high C could be made unstable by playing the high C on the keyboard. This instability created by the clash between the resonant spectrum of the soundboard as activated by feedback and the equal tempered pitches accessed by the keyboard became the core of an exploratory practice focusing on the establishment and dismantling of feedback tones as can be heard in the improvised piece *Inside/Out*[2] with saxophonist Franziska Schroeder.

This manipulation of feedback led to further experiences with the ultimate feedback machine – the electric guitar. As one can predict, the placement of a small electric guitar with its strings facing the piano strings led to a much richer, complex and unpredictable feedback loop. This time articulated by all of the elements mentioned above with the microphone system, plus the non-linear relationship between the strings of the guitar and the strings of the piano. After exploring this technique with a small commercial electric guitar as can be heard in the trio FAINT (Creative Source Recordings 088) a number of possibilities began to emerge. Most of these, in Cage's vein, fuelled by pragmatism leading to something that could be carried in a suitcase instead of using a regular-sized guitar.

A hacked together guitar-like object using a piece of floor board and four strings served as a first iteration of a portable and more easily

2. *https://pedrorebelo.wordpress.com/2012/07/25/concert-in-salvador-bahia-31-july-2012/*

manipulated object. The increased flexibility in terms of positioning in relation to piano strings afforded by the smaller size translated in more possibilities for influencing feedback. A range of "prepared sounds" results from the interaction between the piano strings and guitar strings when a key in a specific register is pressed – a kind of electric prepared piano sound.

In collaboration with Irish luthier John Catherwood,[3] in 2013 we developed the 'Plank' which retains enough guitar like characteristics to perform the feedback and preparation functions described above but is rather more ergonomic and has a characteristic sonority related to its wooden solid body, two pickups (coil and piezo) and a moveable bridge.

Figure 1 Current version of the Plank

In addition to conventional electric guitar behaviour the Plank also has a built-in x-OSC, a wireless I/O board with on board gyroscope, accelerometer and magnetometer for use in a live-electronics/laptop setup, mostly used to detect the position of the board in relation to the piano and affect live processing accordingly.

The Plank is then a simplified guitar, which attempts to optimise contact points between its own strings and the piano's string surface. It does however afford the quasi-instrumental status of a table-top guitar and associated techniques. The practices of prepared guitar explored by Keith Rowe, Fred Frith and others come into relevance here. When the guitar is positioned strings up on the piano frame, it provides access to a timbral range close to the sound of prepared objects on the piano strings. This allows for a set of timbral relationships between the two instruments when played separately (albeit that the guitar amplification is coming from inside the body of the piano to maximize resonant proximity).

To a greater extent than the array of objects used to prepare a piano, the Plank affords a performative engagement that lives off both the performer and the piano itself. As it integrates an improvised performative practice, it provides opportunities for what Owen Green has called *livedness*:

> "Navigating such folds, such as those between designing and practising, emphasises the extent to which the concerns of practice are diachronic and, as such, lived."
> Green, 2014: 5

3. *http://new.catherwoodguitars.com/*

3. PIANO PARASITES

The inside-the-piano practices described above go beyond Cagean preparation and are characterized by the inter-relationship between objects (in this case the Plank and the piano soundboard). The notion of the parasite is an apt and suggestive metaphor for describing the field of relationships discussed here. Deriving from the Latin and Greek *parasitos* for a person eating at another's table (*para* – alongside, *sitos* – food), the term has since the mid 16th century been associated with the biological notion of "an organism which lives in or on another organism (its host) and benefits by deriving nutrients at the other's expense". The notion of parasite suggests a hierarchy and a system of values. Although some parasites can be inoffensive or even beneficial to the host, the term is normally applied in a derogative manner to articulate the "taking advantage of" that much defines the parasitical. The parasite also defines a relationship of scale; it is always smaller than its host. As Serres puts it in "The Parasite" – a sequence of fables articulating the nature of human relationships according to this very metaphor: "The animal-host offers a meal from the larder or from his own flesh; as a hotel or a hostel, he provides a place to sleep, quite graciously, of course." (Serres, 2007: 6)

In the case of live inside-the-piano techniques, the piano acts as a host and provides its rich resonant world and acoustic fingerprint to lesser objects, objects that often do not have the status of instrument (or organism to carry out the biological metaphor) even though they play a crucial role in the production of a particular "inside-the-piano" sound. The parasitical object can be attached to a string in a way that it will radically change the sonic character associated with the action of playing the corresponding key. It can also inhabit the piano in a freer manner, being affected by the physical forces at play at any given moment (e.g. ping-pong balls bouncing on top of strings as the keyboards is played). The reason the parasite is a pertinent metaphor for the kind of preparations and modifications discussed here is because it deals with the notion of how a smaller entity (a screw or object of some sort) can utilise resources of a larger, established entity (the piano) to create relationships of interdependence which musically give rise to possibilities of both ambiguity and contrast between parasite and host. This complex relation is again described by Serres:

> "We parasite each other and live amidst parasites. Which is more or less a way of saying they constitute our environment. We live in that black box called the collective; we live by it, on it and in it."
> Serres, 2007: 10

4. THE FRAGILE, THE ROBUST AND THE ANTI-FRAGILE

With a parasitical environment constituted between the piano and its preparation with devices like the Plank, there is the dialogical relationship between fragility and robustness suggested in the act of modifying the piano in a live context. The parasitical relationship addresses a key element of the instrumental ecology discussed here, namely the grand piano being "live-prepared" by a guitar-object which has its own agency and musical history, or at least to a greater extent than a screw or a bolt. This guitar-object is a musical parasite because it *lives* off the piano resonance. The emphasis on *living* is key here, as this is a musical device that positioned over the piano string surface generates feedback inside the piano soundboard, in an active, generative and to some extent unpredictable manner, given the non-linear system created by multiple sets of strings touching at numerous points. The scale and identity of the guitar-object is, to some extent, hosted by the piano at the same time as it has the power to modify the piano's musical identity. The parasite and its host, create, through their symbiotic relationship, an interdependency that is at the core of a musically rich system. I will explore this interdependency in musical terms by categorising a number of "inside-the-piano" techniques according to three descriptors: Fragile, Robust and antifragile. These three conditions are investigated by Nassim Nicholas Taleb to describe notions uncertainty and risk. Taleb's notion of the *antifragile* addresses those things that need chaos and uncertainty to flourish and thrive.

> "Some things benefit from shocks; they thrive and grow when exposed to volatility, randomness, disorder, and stressors and love adventure, risk, and uncertainty. Yet, in spite of the ubiquity of the phenomenon, there is no word for the exact opposite of fragile. Let us call it antifragile."
> Taleb, 2012

Both the fragile and the robust can be measured in terms of the reaction to external events; the fragile being more affected than the robust, which is often characterised by redundancy. "Recall that the fragile wants tranquillity, the antifragile grows from disorder, and the robust doesn't care too much" (Taleb, 2012). The antifragile then stands as a category, which deals directly with the unpredictable, with the unknown, a pertinent quality in the context of a complex, improvised musical situation. In order to make these descriptors more concrete and to clarify how they relate to the notion of the parasite, I will present some illustrative examples based on improvised musical practice "inside-the-piano", relating fragility and robustness to the "re-action" of the piano to parasitical forces.

Fragile (piano changes its character based on parasite influence)	**Robust** (piano remains largely unchanged upon parasite influence)	**Antifragile** (piano and parasite are engaged in unpredictable interdependency)
Screw wedged between two mid-register strings	Sheet of paper over mid-register strings	Ping pong balls bouncing on the string surface
Rubber wedged between two low-register strings	Light metal chain over high register strings	Stochastically touching string/soundboard at high speed
Strings made vibrate by an electromagnetic field (e.g. e-bow)	Strings plucked directly with nail or plectrum	Feedback inside the soundboard
Pressing a key while sliding a metal bar over corresponding strings	*Flageolet* (stopping strings with finger while pressing corresponding key to get a harmonic)	The inside-the-piano surface replete with objects in ad-hoc positions resulting out of a session of live preparation

Table 1 Examples of inside-the-piano techniques

The three categories are associated with different types of preparation or inside-the-piano techniques. Under the fragile category we see a radical change of sound quality achieved by, for example, stopping a setup of two or three strings with a wedged object to create an inharmonic tone (the piano's fragility giving in to the introduction of an external object which radically modifies its character). The robust category deals with techniques, that subtly affect the piano timbre but do not fundamentally change its character and spectral envelope (frequency/amplitude curve characterising timbre). The antifragile appears here as a distinct category given a more complex and unpredictable parasitical relationship, in which both host and parasite are working together to create something they could not achieve independently. The Plank interface has been designed to somewhat optimise (if that's not a contradiction in terms with the notion of the antifragile) these complex interdependencies. The mere placement of the guitar-object strings down on the piano's string surface will cause each pressing of the correspondent keys to be prepared in an almost Cagean manner but with the additional complexity of the amplified response of each of the four Plank strings, themselves resonating within the piano soundboard. The key element of this antifragile condition emerges, of course, due to the introduction of microphones or pickups in the system, moving from a one-way condition in which parasitical objects affect the piano to one in which the piano and the object are affecting each other.

5. CONCLUSION

This paper presents practice-based research associated with the practice of free improvisation performance on the piano with inside-the-piano, or extended piano techniques. The lineage of Cage's prepared piano is here set in contrast with practices of live-preparation in which the making and unmaking of the instrument becomes performative. These assemblages that take place during performance are aligned with Bowers and Hass' research in their hybrid resonant assemblages project (Bowers and Hass, 2014) through the notion of instrumenthood. Here, the complex interactions between the piano and the Plank become a mechanism for making and unmaking instrumental entities. This type of relationship, described here as parasitical, given the interdependency established between two instrumental entities, is in a way alternative to the notion of interface and certainly distinct from concepts of meta or hyper-instruments. The case for alternative approaches to the ubiquitous instrumental *enhancement* through interfacing with the digital is eloquently put forward by Bowers and Archer (2005) in the notion of infra-instruments. As with the inside-the-piano strategies discussed here, Bowers and Archer are primarily concerted with emergent interactions rather than mapping. Whereas the interface presumes interactions between two or more distinct systems (e.g. human vs computer), the parasitical lives off interdependency and resists mapping. This interdependency is a type of interaction that offers rich ground for musical exploration in the context of inside-the-piano techniques. The particular example presented here – the Plank – acts as a way of defining certain qualities of improvised practice (here associated with the notion of the antifragile) favouring uncertainty, complexity and emergence. These qualities translate sonically into the interdependent resonant worlds of the piano and the guitar-object. The more conventional interfacial element of the practice presented here is the digital inputs the Plank incorporates through its sensors. The sensor signals (accelerometer and gyroscope) are intended to contribute to the system as another parasite (the computer) which feeds off the piano resonance and the physical placement of the Plank to pick up and re-inject further sonic layers into the system.

By exploring the parasitical as a metaphor for describing a set of relationships between instrumental entities, we open possibilities for re-thinking the prosaic mechanics of inputs and outputs. Instead, the parasite encourages the design of instrumental conditions, which through improvisation, emerge their own behaviour and resist the determinacy of control, as they revel in the antifragile.

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INTERACTING WITH TEXT AND MUSIC: EXPLORING TANGIBLE AUGMENTATIONS TO THE LIVE CODING INTERFACE

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ABSTRACT

This project is an exploration of musical expression in relation to live coding. It examines the way in which performers interact with code, and highlights some tensions and dualisms that exist when interacting with live coding systems. The notion of *approximate programming* is proposed; where the performer can interactively manipulate, explore and discover algorithms with a multiparametric controller. Approximate programming focuses on code as the medium and the coding environment as the key focus. It uses genetic programming representations to translate the output of a controller into code. This system is trialed with a new interface, *Inflorescense*, highlighting some design challenges for interacting with this type of system.

KEYWORDS

Live Coding, Multiparametric Control, Tangible User Interfaces, Musician-Computer Interaction, Genetic Programming.

1. INTRODUCTION

Creating and performing music though coding can be a very liberating experience but it can also be genuinely frustrating. Code gives the musician the freedom and power to engage very closely with digital sound synthesis processes, to create constructs and abstractions that relate to their own musical style and thought processes, less encumbered or constrained by preset and prescribed patterns, assumptions and structures that are often built into music creation software. Code puts the musician at the bare interface to the sound synthesis process, where the points of engagement are the programming languages, and the interactive system used to manipulate the language. This is a huge space of musical possibilities, although with a heavy reliance on the skill of programming and understanding of digital music theory to effectively realise ideas. Code can also draw the musician away from the instantaneous and engaged interactive loop that is conventionally associated with playing a musical instrument and with musical expression. This creates a dissonance where the coder-musician has the power and flexibility to engage with musical process and realise ideas, but these ideas can't always be created in a musically expressive way.

An expressive musical instrument can be thought of as one that allows the player to transmit their feelings and thoughts into the music being performed (Jordà, 2005). Whether coded music should be played expressively is of course a matter of opinion and personal preference of the musician or performer. Part of the essence of live coding (A. Ward et al. 2004; N. Collins et al. 2003) is to engage with and manipulate the algorithm, in whatever of many forms this may take. Also, as Magnusson and Mendieta (2007) and Bertelsen et al. (2009) have shown, musicians enjoy engaging with resistances and limitations in musical systems, whether these are part of a physical system or whether they are conceptual resistances as you might find in the design of a programming language. There's no such thing as a perfect instrument, even a broken toy can sound good and be engaging to interact with. With these issues acknowledged, it's still pertinent to ask whether there are ways of writing and manipulating code that are more musically expressive than current methods commonly used in livecoding? Are there ways to code musical processes that allow the programmer to directly and intuitively realise their ideas while still retaining the inherent advantages of the medium of code? To investigate this question one can focus on both the language and the way we manipulate it. With so many varying programming languages used for musical programming, and with much less variance in the manner in which we typically interact with code, it is the intention of this paper to be language-agnostic, and focus on the aspects of musical coding concerning human-machine interactivity. This project sits firmly within the context of live coding practice, focusing on dynamically interpreted programming languages being used performatively for music composition, performance and improvisation.

The paper begins by examining the conventional live coding interface, focusing on how the process of musical coding matches with the affordances of the laptop and text editor. A key question is asked: how precise does the act of coding need to be? And is this task context dependent? When programming a device driver or nuclear power plant safety system, precision and reliability is paramount. In music, expression rather than fine precision and reliability may often be an overriding priority. In this case, is it possible to use new interactive methods to produce code more expressively at the expense of precision? The concept of *approximate programming* is introduced, and a tangible interface (Ishii and Ullmer 1997), *Inflorescense*, is used in tandem with a conventional laptop interface to create and manipulate code, with novel expressive possibilities whilst retaining code as the medium. This setup is used in three experimental scenarios that are evaluated from an autoethnographic perspective (Magnusson 2011). This raises cognitive issues concerning production and comprehension of code, which are addressed in the discussion.

2. RELATED WORK

Several projects have explored the use of Tangible User Interfaces (TUIs) for programming. Blackwell (Blackwell 2003) provides a theoretic analysis of the possibilities in this space. Horn and Jacob (2007) and Sapoundis and Demetriadis (2011) show examples of implemented systems. A musical example is *AudioCubes* (Schiettecatte and Vanderdonckt 2008). These systems typically use movement and linking of objects to configure programming logic, and are self-contained. This project's focus varies from these projects by attempting to augment rather than replace the coding environment, and by using continuous instead of discrete control. Biegel et al. (2014) and Raab et al's (2013) *RefactorPad* explore augmentation of programming IDEs with gestural control using multitouch interfaces. Both studies find this approach to be promising. There's some work in this area specific to live coding. Collins and Blackwell (2005) focus on the programming language as a musical instrument, outlining the task demands of live coding interfaces. McLean et al. (2010) explore how we perceive code and stress that techniques for augmenting code with visual cues are central to live coding and effective comprehension of code. In terms of interaction with computers, Armstrong (2006) studies the interactive possibilities offered by conventional computers and argues that they preclude the embodied modes of interaction preferred by musicians. Magnusson (2009) provides a detailed analysis of how we interact with screen based musical instruments.

3. INTERACTING WITH CODE

This section analyses the interactive possibilities of conventional live coding systems, and argues that an understanding of time within live coding is key to understanding musical expression through code. This paper considers a conventional setup to be a standard laptop. It is acknowledged that many performers extend their computer with different controllers, which are typically mapped to musical parameters (which may have been set up using code). This study focuses on augmentations to the coding environment rather than control of musical parameters, and so does not take this type of control into consideration.

McLean (2014) proposes three live feedback loops that are created in live coding performances: (1) manipulation feedback, between performer and code, (2) performance feedback between the performer and music and (3) social feedback between performer and audience. These loops are arguably co-dependent with common paths, and can be combined as in Figure 1. The shared paths within these feedback loops highlight a tension that exists in live coding systems; the system must fulfil three functions: musical performance, musical creation and support for programming. The tension between the requirements of the instrument for fulfilling these functions can preclude musical expression. Another important factor affecting musical expression is timely interaction. Armstrong (2006) presents an analysis of the *computer-as-it-comes* (which we can consider to be the standard setup for live coding) from an enactive perspective. He finds a disconnection where the *computer-as-it-comes* precludes embodied modes of interaction normally associated with musical expression. He presents a set of five criteria for embodied modes of interaction, two of which are especially relevant for discussion in the context of live coding. Firstly, embodied activity is situated; the performer must be able to adapt to changes in the environment without full prior knowledge of the environment. Secondly, embodied activity is timely; the performer must have a capacity for action within real-time constraints. These requirements can be seen as co-dependent; it would be ideal if the performer could react to the audience or other musicians in a timely manner. The audience expectation of what is timely in a live coding context may not be the same as for musicians playing controllers or acoustic style instruments, however there's no doubt that it can be difficult to code large structures and make large changes quickly. To analyse this further, we need to examine the concept of time in live coding performance, and take a closer look at how the interface affects the speed of interaction.

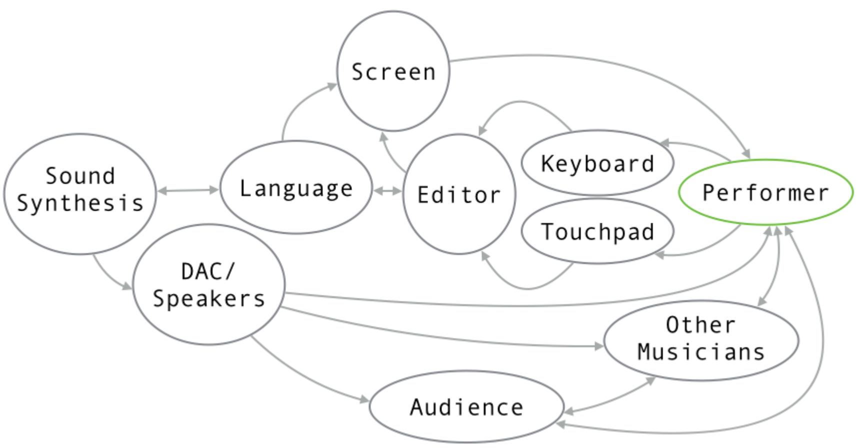

Figure 1 Manipulative, Performative and Social Feedback Loops

The live coding performer must move in and out of real-time, and this is consistent with the act of live coding which is to manipulate a running system rather than directly play it. In fact the performer may very rarely or maybe never directly trigger a musical event in realtime. Many performance activities may involve tasks that move further and further away from the possibility of being conducted in musical time, for example queuing events to run at specific points in the future, editing code before compiling it, writing new code structures, debugging, planning structural changes and so on. Despite the variation in time constraints for different tasks, there can still be a need to react in a timely manner, to be able to express musical ideas in musical time. This highlights another dualism within the live coding setup. Many features of live coding systems are partial solutions to this issue of timely interaction with code, primarily the use of dynamic programming languages but also features of integrated development environments (IDEs) and text editors that allow fast and intuitive access to functional code management tasks such as selection and execution, navigation within and between documents, and code visualisation techniques that act as cognitive supports for the programmer.

Putting these threads together, two dualisms are highlighted in the live coding instrument, which must try to satisfy competing requirements. While it must support the performer in interacting with musicians and audience members in the external environment, it must also support interaction between the performer and programming IDE. While it would ideally allow the performer to interact with the audience in a timely manner, in musical time, it does this through a system with a range of functionalities and time constraints, mostly occurring in non-musical time. The next section asks if there are possible solutions to bridging this variation in time constraints.

4. APPROXIMATE PROGRAMMING

This section proposes the notion of *approximate programming*, an exploratory method for producing code quickly to satisfy musical time constraints at the cost of losing accuracy. One possible way to program more quickly is to use a high level process to produce code, which generates solutions within a limited search space. If the process can generate an approximate solution, then this can be fine-tuned by the coder; this would provide a method for creating large structures quickly according to broad requirements. The notion of an approximate program is somewhat incongruous to conventional computing scenarios; many computing tasks such as safety critical systems require very high accuracy and testability. Musical improvisation has a different set of constraints where accuracy and formal testabliity need not always be so important; this is especially relevant in computer music when the musician cannot always accurately predict how a change in code will change the sound, given the complexity and variation of sound synthesis processes. The performance may take the form of an evaluative loop where the performer experiments with new synthesis processes as it evolves, so approximation is already built into this process. Assuming that the constraint of accuracy can be relaxed in musical coding, how could the process of approximate programming work? The system proposed here takes continuous input from a multiparametric (Kiefer 2012) controller, converts this into code, which is built from a set of livecoded component functions, and plays the result in realtime. The use of a physical controller and realtime synthesis allows musical-time interaction in the style of a conventional musical controller. The performer is interacting through the medium of code in two ways; firstly by observing the textual output of the system and exploring this space with the controllers, and secondly by livecoding the component functions that are the building blocks of the system. The code medium puts this system in a hybrid domain of musical controller and code editor where the performer can interact with code at different levels of abstraction.

To convert a set of continuous parameter streams into code, the system borrows representations from the field of genetic programming (GP) (Poli, Langdon, and McPhee 2008). GP researchers have developed numerical representations for algorithms, and methods for translating these representations into code, so that solutions to computational problems can be discovered though evolutionary methods. There has been a small amount of previous work in this area, for example Poli and Cagnoni (1997) used interactive GP to search for image processing algorithms. The difference in this project is that the code is retained as the medium; this is an extension to the IDE and interaction with the code remains central to the search process In GP, an algorithm is represented as a tree of functions, and the choice of functions and their parameters is determined by a set of numbers in a gene.

The system in this project works as follows: a set of component functions is decided upon that will be *ingredients* for the algorithm being generated. The system takes a set of , as input. The first number is used as an index into the set of component functions, to are used as parameters for this function. When parameters are added, a list of their determine this function's parameters. This process continues while more values are , thereby building a tree of functions that represent an algorithm

In use, the multiparametric controller generates multiple streams of numbers, and the system takes snapshots of these and converts them to a code tree, which is then evaluated and run as a digital signal processing unit at audio rate. The system is implemented in SuperCollider (McCartney, 2002), and the algorithms are built as unit generators. The set of component functions can be modified or live coded while using the system, allowing the performer to shape the search space. For example, to try and find FM-style sounds, the component functions could be multiplication, addition and sine wave generation. To generate rhythmic sounds, the component functions could be delays, impulses and resonators. This system allows the performer to specify a high-level concept through component functions and then explore this by using a physical controller and interacting with the code, in order to find an approximate solution. This system is controller-agnostic; any multiparametric controller will work with it, given that the parameter count is large enough to represent the complexity of the desired outcome. To explore the use of the system, it was paired with a new controller, *Inflorescense*, and trialed in a number of scenarios.

5. INFLORESCENSE

Inflorescence is a modular multiparametric controller, which is based around the form of a plant. It consists of a number of stalks that end with a flower, housing a motion sensor and a multicolour LED. The stalks are made from braided armature wire, which keeps its shape when deformed. This allows the motions sensors to be moved into different configurations and formations. Up to sixteen stalks can be used in the instrument, with each one sending out measurements from a 3-axis accelerometer and a 3-axis gyroscope. A microcontroller board collects data from the stalks, and controls the LED colours. The board connects to SuperCollider via a serial interface. The design of *Inflorenscense* aims to be organic and uneven, with varying shaped stalks that affect each other's movement. This makes it a compelling interface and research tool for exploring approximate programming; it embodies opposing interactive qualities to the *computer-as-it-comes*: imprecision, sensitive continuous control and gestural interaction. Three scenarios were designed to test the controller with approximate programming, with particular emphasis on interacting with the code and code editor: (1) a basic scenario where code was generated with a static set of component functions, and visual inspection of the code guided interaction, (2) the component functions were live coded while using the interface and (3) a mechanism was built where a subsection of the generated code could be selected and manipulated by the controller, allowing selective editing of the function tree.

5.1. OBSERVATIONS

The use of a controller for code generation gives an interesting option of either ignoring the code and treating the controller as a self-contained instrument, or using the controller as an extension to the code. It's the author's opinion that keeping the code as the central focus adds significant value to the system. The interplay between visual inspection of the generated algorithm and movement of the controller is an engaging process of discovery. With the addition of coding the component functions, it's possible to move the algorithm into an approximate target area, and selection of code in scenario (3) enables a fine-tuning process that still uses the approximation system. There are a few challenges in use. The way the algorithm is encoded from the GP representation is quite non-linear in places and very linear in others, so the mappings can be unintuitive in some areas. Also, the system requires fast comprehension of the generated algorithm, which can be difficult; visual cues are a huge help in this respect.

6. CONCLUSIONS

This paper has analysed the way in which live coding performers interact with conventional live coding systems, and highlighted the tension between interaction in musical time and non-musical time. Approximate programming has been suggested as a method for creating large but imprecise code structures in a timely and embodied way. In use, the system seems promising, although there are some design challenges to overcoming concerning code comprehension and numerical representation.

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SHORT PAPERS

USER INTERACTION

CYBERFORMANCE – INTERFACING THE ACTUAL AND THE VIRTUAL

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ABSTRACT

For two decades performers have been using the Internet to create cyberformance, live performance in between physical and virtual spaces, reflecting, at the same time, on the conditions of production of this art form, whether it focuses on the text, the code or the body. All these manifestations, from chat room performances to avatars animated by motion tracking sensors, have common characteristics: they are presented live, connecting through the Internet remotely distributed performers and audiences, in actions that use mostly low cost and freeware technology and develop new paradigms in performance art.

Cyberformance develops through tangible and visible interfaces that allow for an understanding of virtual worlds and platforms not as immersive but rather as augmented and hypermediated environments. In this poster/article I briefly reflect upon this *topos* of cyberformance and its implications for this practice and for distance communication in general. I also explain the typology of cyberformance with examples that may help to understand the line of reasoning developed previously.

KEYWORDS

Cyberformance, Digital Performance, Multi User Virtual Environments, Human Computer Interaction, Immersion, Augmentation, Hypermedia.

1. INTRODUCTION

This article derives from the research for my PhD thesis in Communication Sciences «Cyberformance: performance in virtual worlds» (Universidade Nova de Lisboa, 2013) in which I analyse the contribution of this genre for the contemporary arts, for Human Computer Interaction (HCI) and for changes in everyday distributed communication.

Cyberformance is performance art that links physical spaces with virtual worlds, environments and platforms, characterized for being live, mediated, intermedial, multimodal, hybrid, liminal, collaborative, aesthetically and socially interventional, being low cost while using, mostly, freeware technology.

This kind of performance has been developing for the last two decades connecting remote performers and audiences. Chat rooms and Multi User Dungeons (MUD) were the first cyberspaces where this artistic practice happened. However, soon it transited into graphic environments (The Palace) and virtual worlds (Multi User Virtual Environments, MUVE), like Second Life[1] (SL). Today cyberformers also use Massively Multiplayer Online Role Playing Games (MMORPG), like World of Warcraft, and they created platforms and festivals dedicated to the practice (UpStage, Odyssey).

Cyberformance happens live, in cyberspace and its performers and audience are distributed physically, sometimes around the globe, developing a form of telepresence. It deals with the subjects that arise from its own technology and it is liminal (Broadhurst, 1999) in its experimentation. Cyberformance uses different media but it is mainly dependent on the computer and tends to never be finished and, so, to be an open work.

Based on my own artistic practice on the referred virtual environments and on recent academic research on digital performance, I proposed a theoretical framework by working on an updated definition of the term cyberformance (coined by cyberformer Helen Varley Jamieson in 2000) for a better understanding of this artistic genre, that has been evolving for the past two decades.

Cyberformance is an expression we (both me and Jamieson) do not impose on the artists or anyone: it is an operative term that allowed me to approach the practical and theoretical questions involved in live performance that happens in between physical and virtual places, allowing performer and audience participation through the Internet, usually using accessible low cost communally produced technology.

1. Other virtual worlds are Reaction Grid, Avination or Open Cobalt. Although also referred to as a virtual world, Open Simulator is in fact a cross platform to lodge virtual worlds. *http://opensimulator.org/wiki/Main_Page*. Accessed 15-10-2014.

2. CYBERFORMANCE TAKES PLACE IN HYPERMEDIATED INTERCREATIVE ENVIRONMENTS

Inquiring into the relation between virtual and actual and analysing the spaces where this kind of art takes place I came to the conclusion that the openness of virtual communities creates a *topos* that is beyond simulation and allows for the rise of the «virtually human» (Boellstorff, 2008) that integrates cyberformance. This practice develops through tangible and visible interfaces that allow for an understanding of those virtual platforms not as immersive but rather as augmented and hypermediated environments.

The work of Piérre Lévy (1998) is crucial to the affirmation that virtual and real more than opposing each other, converge, that the virtual is real and that while experiencing it, we are «even more human». The interpretation of Second Life (SL) by Tom Boellstorff (2008) made me favour the expression «actual world» in detriment of real world as opposed to virtual world: the experiences of the residents of this environment are real and have consequences in their real lives; they are not a mere game play in a fantasy world: beyond each avatar is a person. Boellstorff's anthropological research as well as other investigations in the area of cultural studies are crucial to understand the psychological aspects of human relationships in this collective virtual environments as well as aspects of identity and embodiment.

Although some previous feminist and post-modern theories like the post-human (Hayles, 1996) or the metaphor of the cyborg (Haraway, 1991) are of necessary reference, when it comes to embodiment in the spaces of cyberformance, I prefer recent perspectives like the «virtually human» (Boellstorff, 2008). This contemporary human is phenomenological augmented (Merleau-Ponty, 1945) in virtual worlds, those places which are no mere simulations but topoi generated by personal and collective creativity, much like cyberformance is.

The «transparent immediacy» that would happen when there is a supposed immersion in a simulation (Bolter and Grusin, 2000) is but an illusion that can easily take us to dangerous notions of disembodiment. Virtual worlds are not simulations but creative augmentations of our everyday life in which they exert concrete effects (Bitarello, 2008). This characteristic of the environments where cyberformance takes place, favours a performance that does not hide its technological means, that believes the body is always present during the performance, aware, and that it can be kinaesthetically (and even synesthesically) enriched by virtual augmentation, as testified by some projects where embodiment goes beyond keyboard, mouse and screen, like Senses Places (Cochrane & Valverde) and Stelarc's experiments with Second Life and various sensors (see the next section).

Thus, rather than seeking an impossible immediate immersion in a simulated environment, cyberformance is an activity that takes conscience of that impossibility, underlining, instead, the hypermediation of the virtual places and tools used, denying simulation in favour of collectively creative non-simulated environments. This kind of performance metamedialy reflects upon its own production techniques and conditions of existence, creating interfaces that, rather than taking the senses into a disembodiment, develop a sense of the body here and now, a body that can be augmented through the performance leading to a corporeal consciousness in connection with the virtual.

In terms of the interface of cyberformance, the questions arising from the intercultural produsage of tools and environments (Bruns, 2008), the problems of liveness in the mediated (Auslander, 1999 and 2011) and the – still – very limited interactivity (Birringer, 2011), are crucial to understand the way this kind of performance crosses the actual and the virtual, which is the object of this article. However limitations of space force me to leave a debate around this subjects for another opportunity.

3. WORD, CODE AND CORPOREAL CYBERFORMANCE

The analysis of the creative process of some specific performances lead me to the conception of an operative typology for cyberformance where the types only exist dialogically and take effect through either the Word, the Code or the Body. These were defined according to their formal characteristics and their main mode of interface (although all of them are multimodal). Participation can happen by writing in a text window; animating a 3D avatar or animating an avatar with your body in movement. Each type develops conceptually around the idea that defines it.

Word Cyberformance chooses the poetics of text, spoken and written in somewhat more theatrical and script based acts. Code Cyberformance uses avatars, animation and scripts of code to question the same virtual worlds where it enfolds, manifesting a strong connection with the visual arts. Corporeal Cyberformance uses the body in interface with virtual environments to augment it beyond the limitations of the keyboard, mouse and screen, posing questions that are similar to those of dance-technology, but taking participation further with the live interaction of the audience through the Internet.

Examples of Word Cyberformance are the first performances in chat rooms, text games and MUD like Hamnet by the Hamnet Players (1993) or Stephen Schrum's Netseduction (1996); Desktop Theatre using the graphic rooms of The Palace;[2] the Plaintext Players (1994-2006) making a bridge between the stage and virtual platforms and the works of Avatar Body Collison, a troupe that is at the origin of the platform for cyberformance UpStage[3] which organizes a festival every year. More recent Word Cyberformances are: *make-shift* (Jamieson and Crutchlow 2010-2013) and we have a situation (Jamieson, 2013).

2. *http://www.thepalace.com/*. Accessed 12-10-2014.

3. *http://www.upstage.org.nz/*. Acessed 16-10-2014.

In the CyPosium, a web conference organized by Jamieson in late 2012, different kinds of cyberformance were presented and analysed by their authors and several academics, demonstrating that this practice moved beyond the original platforms, extended itself to virtual online games and virtual worlds or MUVE, like Second Life, and began using other interfaces, like 3D avatars, or different kinds of sensors in connection with the body (Chatzichristodoulou, 2014; Gomes, 2014)

Since the beginning of the MUVE Second Life, several artists began using it for performance: Gazira Babeli[4] and the group Second Front[5] are at the origin of Code Cyberformance, a tradition continued nowadays by Save Me Ho[6] and the performers of the Odyssey platform. Others, used that popular virtual world for cyberformance, like the hacktivists Eva and Franco Mattes with their *Synthetic Performances* (2009-2010) or Joseph DeLappe with his *Salt Satyagraha March* (2008),[7] in which his Gandhi avatar, animated by the artist walking on a treadmill, roamed Second Life, distributing walking sticks of peace and good will. These artists and others used the code spaces of games (like World of Warcraft, the SIMs, Quake or American Army) to question the formal and social rules of these environments through cyberformance. Third Faction,[8] a movement that rebels against the organization of World of Warcraft, echoes recent worldwide political movements, with performances where avatars of opposing hordes get together to demonstrate against the rules of the war game.

In Corporeal Cyberformance older technologies (chromakey, for instance), in connection with the Internet, are used in «portals» by artists like Paul Sermon,[9] to question the limitations of a body that crosses physical and virtual. These portals, also used by Second Front to connect Second Life to physical spaces, like galleries and theatres, were taken a step further with Extract/Insert (2012)[10] by Chafer, Upton and Stelarc: thruogh 3D and infrared technologies the visitor to a gallery is transferred to SL while the avatars visit the physical space of the gallery. Stelarc has been using the Internet in connection with the body for several years. He began with Ping Body (1996) and *Movatar – Inverse Motion Capture* (1997-2002); in these, the Internet participants animated an avatar that, then, animated the performer's body. Lately, this artist

4. *http://www.gazirababeli.com/GAZ.php*. Acessed 10-10-2014.

5. *http://www.secondfront.org/*. Accessed 11-10-2014.

6. *http://savemeoh.wordpress.com*. Accessed 14-10-2014.

7. *http://www.delappe.net/game-art/mgandhis-march-to-dandi-in-second-life*. Accessed 20-10-2014.

8. *http://www.thirdfaction.org/*. Accessed 19-10-2014.

9. *http://www.paulsermon.org*. Accessed 17-10-2014.

10. Videos with the virtual world and the gallery perspectives: *http://www.youtube.com/watch?v=vKanHILj6X4* and *http://www.youtube.com/watch?v=UNtHSS_gcrQ*. Accessed 21-10-2014.

developed performances like *Involuntary*, *Improvised and Avatar Arms* (2012), within the same logic but using avatars in Second Life.

Senses Places (2011 to present),[11] a project I integrate, takes the role of the body in connection with virtual spaces created by the Internet even further: in a hybrid environment participants interact physically and virtually through their avatars using motion tracking through the computer's webcam, remote controls from game consoles and wearable sensors that capture the heart beat and breath rhythms.

4. CONCLUSION

Cyberformance is an example of a hybrid multimodal practice that converges de actual and the virtual in non-immersive non-simulated environments, reflecting upon the technological conditions of its own production and taking distance communication and performance art further. Evidencing the tools and techniques used, cyberformance denies disembodiment, immediacy and immersion, evidencing a body that is always present in the liveness/mediation of performance and that is changed and augmented in this convergence of instances.

Lending us *prodused* tools (Bruns, 2008) and, above all, presenting creative ways for a distance intercultural collaboration, cyberformance opens possibilities for the development of new interfaces and for a more participated Human Computer Interaction.

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REIMAGINING TALEMPONG AS A DIGITAL MUSICAL INTERFACE

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ABSTRACT

Talempong is one of the most important traditional musical instrument of Indonesia. With the growth of mobile devices, this project aims to make use of current mobile interfaces, such as mobile phones, to allow easy access to experience the musical instrument and to motivate interests to the sound and to learn about the traditional musical instrument. This paper describes the design and development of a mobile instrument interface inspired by Talempong. The digital talempong is implemented as an iPhone application. It explores the iPhone's motion sensors so as to simulate the physicality of playing the traditional Talempong; using the body of the mobile phone as the beater of the instrument to play the instrument. The application detects each hit in real-time and synthesise appropriate sound output.

KEYWORDS

Talempong, Mobile Music, Iphone, Motion Analysis, Sensor.

1. NTRODUCTION

The traditional Talempong is an Indonesian percussion instrument. It is an important symbol and identity for the West Sumatran cultures. It is used in large social events such as wedding and other ceremonies, and it is a key musical instrument to accompany traditional dance and theatre shows. The instrument consists of a set of small knobbed gongs, each producing a different pitch. To play the instrument, the player holds one or two gongs with one hand, using the other hand to hit the Talempong, with a stick/beater (Kartomi, 2008).

The word Talempong applies to both the instrument and the ensemble. Usually the ensemble consists of three players. With typically two gongs per player, the ensemble can produce five to six notes. Talempong's material produces a short sustain sound, which requires its players to play fast and interlocking patterns. The playing is fast and dynamic in nature, which makes its simulation challenging.

Figure 1 Playing two notes on a talempong

2. RELATED WORKS

There are many mobile music developments that can be related to this project, including : The Ocarina (Wang 2009), Zoozbeat (Weinberg, Beck and Godfrey 2009) and Sound Bounce (Dahl and Wang 2010). All of these projects use iPhone's motion sensors to control the sound output.

This project aims to contribute for 'computational ethnomusicology' (Tzanetakis 2007), offering a simple but useful function to capture and analyse physical gesture. Related works in this aspect that simulate other Asian musical instruments are Indian hyperinstruments (Kapur 2004) and the sensor-enabled taiko drum sticks, Aobachi (Young and Fujinaga 2004).

There are several works that apply technology to Indonesian instruments, examples including : Elektrika (Pardue 2011), Gamelan Sampul (Wiriadjaja 2013), Gamelatron (Kuffner 2014) and E-Suling (Erskine 2011).

3. DESIGN

3.1. INTERFACE

To recreate the playing experience, we use the phone body as the beater for playing a ‘virtual’ talempong. The player would produce a sound by hitting the talempong gong with an iPhone, but without the real physical gongs.

3.2. DATA ANALYSIS

We conducted studies to understand motion data as the participants hit a ‘virtual’ talempong using an iPhone. They were asked to move as if they were hitting a talempong, using their right hands, while playing along with pre recorded audio of musical patterns. This task was used by Dahl’s experiment on hit detection of air drumming gestures (Dahl 2014). Fourteen participants were asked to play three patterns, each with two different speeds. Each pattern has its own pre recorded audio that guided participants’ playing. The experiment used a cutout cardboard, so as to provide visualisation for the hit areas.

3.3. HIT DETECTION

To design the hit detection algorithm, we studied the device’s motion sensors data when the device is playing along to a pre-recorded audio. Various peak detection algorithms were tested to study their accuracy and performance. We measure the performance by the average distance (in time) between the perceived hits and the audio onsets. Perceived hit is the local maxima (peak) from the motion data. Audio onset is acquired from reading the audio file’s waveform.

The result of these simple experiments found that the rotation rate on Z axis of the accelerometer sensor produces the best result. Rotation on Z axis can be explained with the right hand rule; if tip of the thumb points toward positive Z, a positive rotation is one toward the tips of the other four.[1] Rotation rate on z axis produces the best result because the majority of participant move the iPhone in similar fashion when they intended to make the hit motion. Although no clear instruction were purposely given, generally participants made similar hammering-like motion on its side of the iPhone (with the screen facing upward to the user).

Using rotation rate of Z axis of accelerometer sensor, the system receives peaks that are not related to a hit. We use a threshold, t, to eliminate noise that can mislead the detection. To configure the value of the threshold, we compute mean and standard deviation of the data using a sequence of recordings using several different phones. From

1. *https://developer.apple.com/library/ios/documentation/EventHandling/Conceptual/EventHandlingiPhoneOS/motion_event_basics/motion_event_basics.html#//apple_ref/doc/uid/TP40009541-CH6-SW22*

the data, we set threshold with 2.5 times of standard deviation. Figure 2 show the good signal to noise ratio of the Z axis in contrast to the other data and their relation to the audio onset.

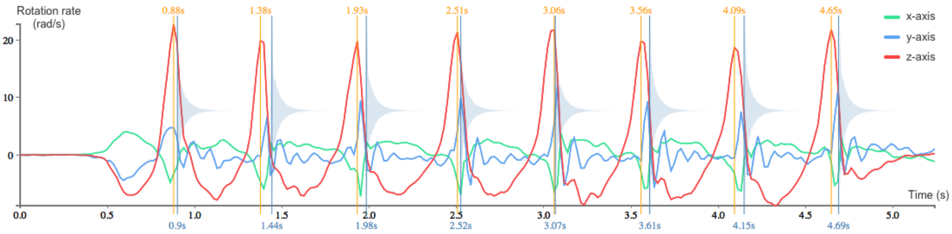

Figure 2 Graph for rotation rate with audio onset

3.4. ANGLE DETECTION

When detecting a hit, the system need to choose which note was hit, i.e. was it the top gong or the lower gong. To classify which area was hit, the system opts for a simplistic approach using the value of the device's gravity sensor. We divide the hit orientation by 45° segments. By comparing the angle, we can roughly separate the hit angle into two quadrants (Q1 and Q2): Q1 with the orientation angle < 45°, and Q2 with the orientation angle >= 45° Orientation within Q1 suggests hit on the lower gong and Q2 suggests hit on the upper gong.

3.5. USER INTERACTION DESIGN

The device's orientation will mapped to which note to play; the low note or high note. Besides the hit detection and classification, other sensors values are mapped onto additional musical characteristics. For example, the value of rotation rate on Z axis determines the loudness of the sound. All these sensor data and analysis are translated into parameters to synthesise appropriate resulted sound in relation to the player's motion.

Although user may not be able to see the screen closely, visual feedback is provided through the device's screen. The screen is useful to show clear visual cues and animations. Another way for providing feedback is by vibrating the device. Figure 3 shows the different kind of interactions that the system provide.

3.6. AUGMENTING TALEMPONG

Being a digital instrument, the system could offer different ways to control and manipulate the sound synthesis engine by changing parameters and applying effects. A note would be presented as a node in screen, which its position can be mapped to sound parameters. Users could drag and drop nodes in the screen to shape the sound of the notes. We mapped x and y values to beater hardness and modulation frequency respectively. The mapping could easily be changed to any other sound parameter. The system also offers five sets of frequency ranges, with the lowest set is one octave below and the highest set is one octave above the normal set of frequency.

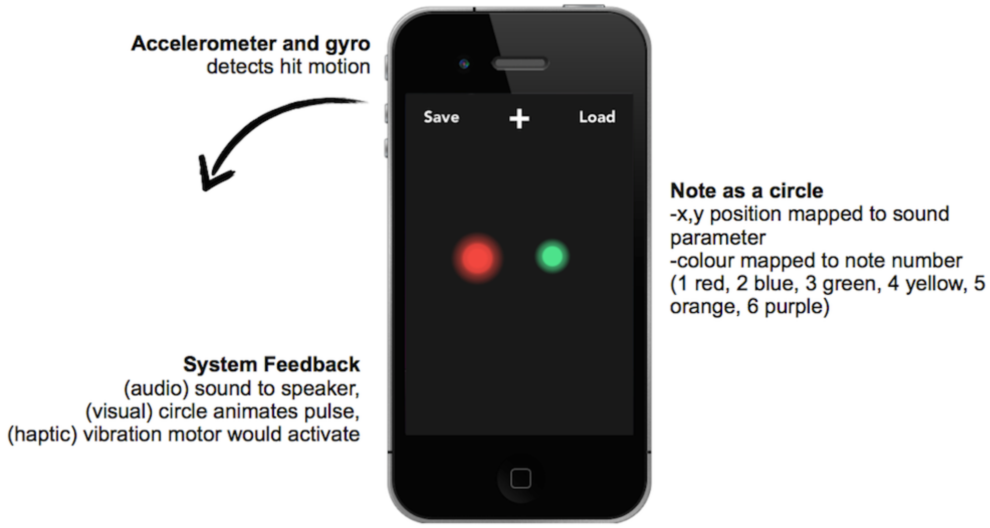

Figure 3 The instrument's user interaction design

4. DEVELOPMENT

4.1. SYSTEM ARCHITECTURE

The system is divided into three main parts; user input, data processing and system output. The flow starts from getting the data stream of user's motion from the built-in motion sensors of the iPhone. Multi-touch input is used to provide an additional controls to configure the final sound synthesis. Every time the system receives new data, it applies the algorithm to check if there is a hit. When the algorithm detects one, the system will pass the information to the sound synthesis engine for producing the sound. All the parameters are also used for visualisation.

The system outputs three different types of feedback. Sound synthesis produces the sound of talempong through audio speaker (or plugged headphone). Graphics renderer renders and animates shapes to visualise the sound on the device screen. Device also vibrates based on the loudness of the sound being played. Figure 4 illustrates an overall architecture of the system.

To recreate the talempong sound, we use Cook's Synthesis Toolkit (STK) (Cook and Scavone, 1999). There are other audio synthesis libraries that we considered, including libpd[2] or JUCE.[3] After comparing all of the options, STK was chosen because it has ready-to-use sound synthesisers and has easier integration for iPhone platform.

2. *http://libpd.cc*

3. *http://www.juce.com*

4.2. USER INTERACTION

The system support various way of interaction. See http://www.ikhsan.me/digitaltalempong for a step-by-step video demonstration of user interaction features. One talempong note is presented visually as a circle shape with different colours for each note. The note's position is mapped to two sound parameters, which user can drag and drop to move the notes around the screen. The system chooses which talempong note to play using the device's orientation towards the ground. The system extends the range of the base frequencies, which is obtained from the talempong of 'Talempong Pacik Ateh Guguak' (Darlenis 2006), with the lowest set is one octave below and the highest set is one octave above. Each hit is presented as a pulse animation that radiates from the note according to its amplitude.

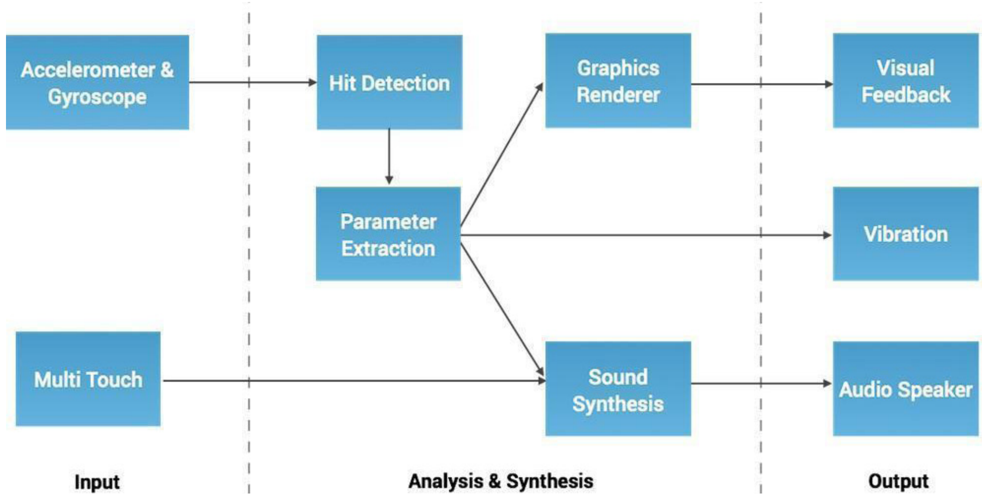

Figure 4 System architecture design

5. EVALUATION

We measure the performance of the hit detection in slow and fast tempo (90 bpm and 240 bpm). Both tempo represent the tempo range of talempong music. From ten evaluations, the system detects 320 out of 320 hits. Evaluation has also been carried out to measure the accuracy of note classification, i.e. which gong was hit. With 480 hits, the current prototype was able to classify the hits at 99.2%, with 98.75% for the top gong and 99.58% for the lower gong.

Qualitative evaluation was conducted using questionnaires with a small group of participants. The majority (85%) of the participants believe that the interface is easy to use and responsive. For almost half (43%) of the participants, the system's feedback was helping to them and they can use the interface to learn or practise playing the musical instrument. The evaluators commented on some inconsistencies on hit detection for very fast tempo.

Several evaluators suggested that it will be more fun to learn if the users have learning objectives rather than a free to play interface. Other suggestions include: (i) to offer brief history and tutorial on how to play the real instrument inside the application; (ii) to offer social interaction features that allow multiple players collaborate in person or remotely; (iii) to support recording and sharing to social media channels.

6. CONCLUSION AND FUTURE WORK

This project shows that available commercial devices could be transformed into an expressive digital traditional musical instrument. We received feedback that indicates appreciation of the system capacity to offer a new and fresh presentation of the traditional percussion performance. The evaluators believe that the approach enables talempong to be more accessible and appealing to younger generation.

With the current prototype, there are many exciting aspects to further expands and to add new functionalities. We are currently investigating the use of such interactive system to provide technology-enhanced learning for musical tempo and rhythmical patterns which is the important aspect of musical learning. We plan to use machine learning and clustering techniques to classify rhythmical pattern of talempong. It can be used for recording, classifying and archiving, but also to create an interactive system that can improvise, which can interact and perform with the musicians and support self-learning. Lastly, we are also considering 'In-the-wild' studies to test the system by talempong experts. Testing the system in a real situation (performance or classes) would bring new feedback and improvements to the system.

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SYNCHOTRON: DESIGNING AN INTERACTIVE SEQUENCER

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ABSTRACT

In this paper, we describe the results of a collaboration between an artist and computer music researcher to design an interactive synthesiser system. The performance of live music which requires the integration of technology can involve many constraints that inhibit how the music is performed. Traditional bands made up of human musicians listen and respond to each other and each has complex abilities to understand high-level structural properties about the music played that enables them to improvise successfully. When computer sequencers are introduced into such a scenario, there tend to be concessions in order for this technology to be utilised. We examine the potential problems with the use of sequencer technology and examine solutions to overcome these limitations.

KEYWORDS

Beat Tracking, Synthesizer.

1. INTRODUCTION

Computer-based music software offers many possibilities suited to studio production. The development of the digital workstation increases the ease of editing and overdubbing parts, automating effects and offline sequencing. The natural integration of computer studio technology into live performance requires machine listening capabilities on the part of the computer, and computational creativity (Papadopoulos & Wiggins, 1999) if it is required to compose musical parts which fit into an ensemble. Csikszentmihalyi (1991) defines 'flow' as a state of absorption in the present activity, of full engagement in the moment. The design of the interactive synthesiser aims to enable a state of flow in the performer. Our focus has therefore been on identifying problematic aspects of computer-aided performance in which flow might be inhibited and developing solutions to these problems.

One major difficulty is the difficulty of integrating the capability to listen within the computer system. Vercoe (1984) defines the three stages of his accompaniment system as: listen, perform, learn. Listening is essential to understanding the musical structure of what is happening, thereby gaining musical knowledge of all aspects of the music.

Another difficulty is the tendency of laptop performers to be absorbed by the required interaction with the computer software. Often they will require the visual feedback from the screen and interact using the mouse and keyboard. In human-computer interaction, the WIMP paradigm refers to the use of windows, icons, menus and pointer in order for the user to interact with a software program. Collins (2003) questions the aesthetic success of performances where the attention of the performers is on the laptops rather than the audience. From the audience's point of view, he suggests that a musician using a so-phisticated SuperCollider or Pure Data patch might not be readily distinguishable from someone checking their email or playing iTunes. Clearly the visual feedback of the monitor plays an important role in live performance with laptops, but the exploration of alternative interfaces and assistive technology can bring about a more direct interaction between musicians their audience.

2. MODULES FOR INTERACTION

Our collaboration took the form of a succession of idea generation and development, with testing in between. The focus was on creating a minimalist rock music, such as the pieces by Kosmiche or Krautrock bands such as Harmonia, Cluster, Neu!, Kraftwerk and Can, which often have repetitive melodies. The sound of these bands is characterised by a combination of acoustic instruments, such as guitar and drums, with synthesizers and drum machines, playing linear song structures at a roughly steady tempo. There is considerable use of repetitive motifs.

A central goal was to enable a naive player to have control over parameters that affected the composition, without the traditional difficulty of having to play all the notes. The software implements a form of map between gesture and musical output. A high-level controller would offer control over parameters which subsequently affect the notes created, whereas lower-level controllers offer a more direct mapping between aspects of the interface and musical output.

Since the musical content makes use of analogue synthesisers, we looked at methods to work with MIDI data. This is convenient and has no detrimental effect upon the sound quality, as might be heard through the use of audio effects such as time-stretching.

2.1. BEATTRACKING

Much music requires an interaction between performers. This might manifest itself through gestures and eye contact, and also musical interaction, whereby the actions within the performance and the modification of the way each instrument is played depend on the environment and the other musicians within it. The introduction of a computer into a group of human musicians is necessarily problematic. The computer needs to be programmed to simulate the functions of listening and reacting. In particular, most sequencing software tends to make use of an internal metronomic clock, the tempo at which the sequencer plays, and yet this is unlikely to correspond in both tempo and phase to the beat of the music. One simple solution is for the musicians to play to the machine. However, unless the computer's part features a strong rhythmic element, human musicians can find it hard to remain in time. In rock, dance and other steady beat genres, it is common for musicians, typically the drummer, to play to a click track. The result is that one of the musicians is listening to an alternative musical scene in which the click is loud and persistent, most likely through headphones or in-ear monitoring, and dominating their subjective experience of the music played. This prevents the drummer from being fully and freely engaged in the music that the players naturally create, and instead forces him or her to play to the metronomic beat dictated by the machine and thereby restricting the temporal movement of the entire group. In the context of categories proposed by Dannenerg (2007), this necessitates that the performance has a fixed tempo rather than being of steady tempo, where fluctuation is permitted.

To resolve this problem we looked to employ beat tracking techniques. There have been many approaches to beat tracking, including the use of multiple agents representing different tempo and phase hypotheses (Goto & Muraoka, 1994; Dixon, 2001), and the use of comb filter resonators (Scheirer, 1998) and autocorrelation (Davies & Plumbley, 2007). Previously (Robertson & Plumbley, 2014), we have made use of an event-based beat tracker, B-Keeper, which uses responsive regions around expected beat locations to adapt the tempo and phase. A heuristic system of rules adapts the parameters that control this behaviour. The result exhibits similarities to the ways in which humans respond in sen-sorimotor synchronisation tasks (Repp, 2005) and proposed neural models for phase syn-chronisation (Large & Kolen, 1994). We have also made use of another beat tracker, BeatSeeker, which incorporates the dynamic programming approach of Ellis (2007) and the autocorrelation approach of Davies and Plumbley (2007), with a pre-processing stage using median filtering, based on the work of Fitzgerald (2010). The process of predicting the beat using a cumulative detection function, which acts as a form of recent memory, is shown in Figure 1.

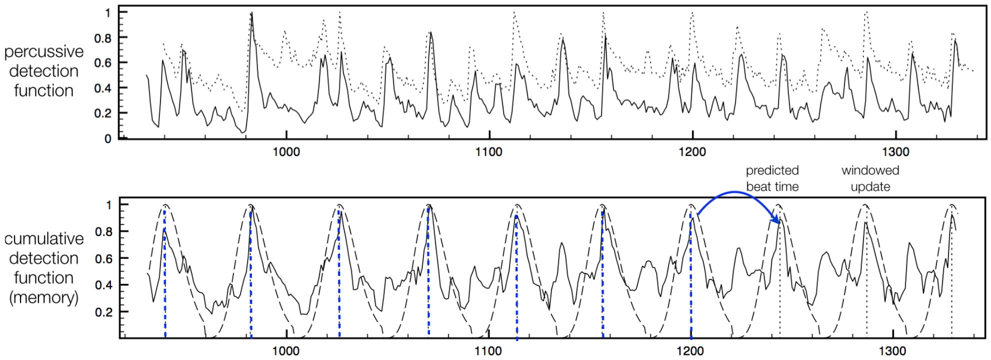

Figure 1 Predictive beat tracking using the cumulative detection function on a percussive detection function. The percussive filtered detection function is shown in bold and the standard onset function using complex spectral difference is shown as a dotted line.

2.2. AUTOMATIC LOOPING

An additional difficulty with the use of computer technology is the requirement of en-gagement through the use of laptop computer screens. The Windows, Icons, Menus and Pointer (WIMP) paradigm in human-computer interaction refers to the ways in which in-formation and interactive possibilities are presented to the user by software. Whilst this may be successful for offline studio recording where time is less critical, in live performance this demands that the attention of the musician is diverted from the instrument to controlling the pointer via a mouse or track pad and interacting with the icons such as 'arm track', 'record', 'playback', 'mute', or triggering these functions via a footpedal.

Whilst the footpedal offers the most sensible hands-free alternative to the mouse pointer, it requires additional sophisticated mapping. Ableton Live is one of the most versatile software programs to offer MIDI-mappable functionality, such that a mapping is possible that could allow a foot pedal to function in this way. If a track is armed, an audio loop recording can be started and triggered to stop using MIDI commands. But care must still be taken over how to arm tracks and setting up which recording loop will be triggered by which MIDI message. Max for Live offers additional possibilities for functionality using a footpedal design, whereby it could be possible to program a device to start and stop a loop, utilizing the next available clipslot if a previous recording has been made. A fixed loop length setting could be used to automatically trigger the end loop message and thereby reduce the interaction required to a single start loop message, triggered by a pedal or keypad. Here we will examine ways to minimise the additional interaction even further.

The manual performance of note onsets is traditionally what is considered to constitute the creative act in keyboard playing. However, this necessarily requires the player to be dedicated to scheduling notes and removes the possibility of the player's manual and ges-tural control of other controllers. In guitar playing, there has been a prevalence of using stomp boxes since the early sixties [8], including continuous controllers such as the wah-wah pedal. Keyboard players tend to have many knobs controlling synthesis parameters on the keyboard, but the playing of notes inhibits their ability to fully engage in the subtle manipulation of sound, and thus could be considered to inhibit flow. In this module, we investigated the ability for a keyboard player to create loops with no additional interaction, in order that this would allow them to focus on modulating sound parameters through other means.

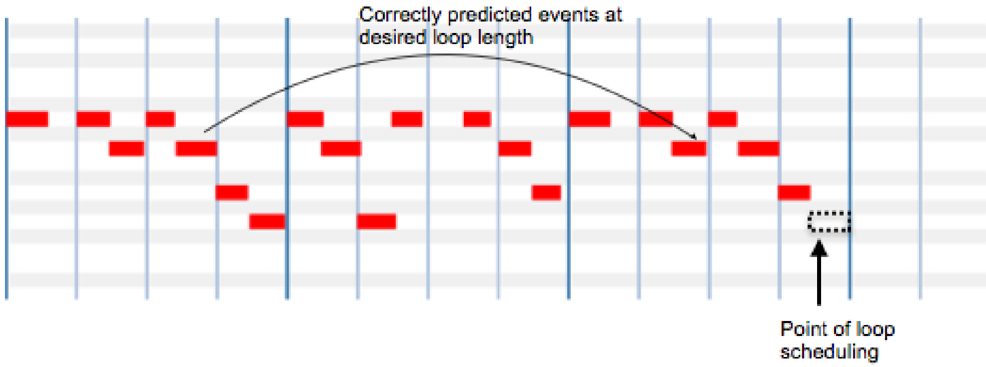

Figure 2 Predictive automatic looping: the dotted note was predicted but not observed at the point of loop scheduling, causing the loop to be automatically instantiated.

In order to record a loop of MIDI note events, the track must be started and stopped at the correct place by the musician. Whilst DAW programs such as Ableton Live[1] have looked to make this process flexible through the use of the MIDI-map whereby MIDI control events can interact with icons that control processes in the program, it is still not simple to start and stop a loop successfully in time. A rock group employing live looping would require a sophisticated system whereby functions within each of their Live sets are mapped to MIDI controllers, such as a foot controller. However, first each instrument track must be armed, requiring pressing one pedal, and then the loop must be started and stopped. The deletion of an unwanted loop is also problematic as there is no icon that performs the task.

One guiding principle in the collaboration is to create software that can follow the in-struction to 'honour thy hidden intention', as found in Brian Eno's Oblique Strategies.[2] The original strategy is "Honour Thy Er-

1. *www.ableton.com*

2. *http://www.rtqe.net/ObliqueStrategies/*

ror as Hidden Intention".[3] Whist playing the loop, the musician might explore possibilities to find a suitable repetitive pattern that suits the piece at that point. Once the pattern is determined, the player repeats the loop. Traditionally, software requires further interaction after this point. The recording must be started, the loop played; the recording must then be stopped and the loop should be edited to create the desired form. The program Ableton Live has adjustments to make this process as simple as possible by ensuring the loop then plays at the correct phase relative to the bar. However, the interruption still inhibits an immersive state of 'flow' within the performer. They must take on the two roles of musician and software operator. The 'hidden intention' of the performer is to create a loop, and from that assumption, we can design a method in software to automatically execute these additional tasks.

Here we propose a solution to enable the software to 'understand' the intention of the performer. Assuming a two or four bar loop is desired, the musician plays the loop and simply stops playing once the loop is complete, thereby triggering it to play automatically. The advantage is that if wrong notes are played, there is no requirement to call deletion functions or to re-arm and re-schedule the recording of the loop. In effect, the existing method in which loop recording's are started requires that the player commits to performing the loop correctly before they have even done so. By specifying that the required action for the recording of a loop to be simply that of stopping playing, a performer can improvise without interrupting the flow of the performance or using any triggers other than the notes involved.

The real-time recognition of the point at which the loop is completed is not straightforward. We examine the expected note on events in relation to the observed performance. A loop is specified to have a determined length, such as one or two bars. In Figure 2 we can see how the pre-determined loop length can be used to identify when a repetitive musical phrase is being played. In order to automatically determine the point at which the musician considers the loop finished and no longer wishes to manually play the loop, we look out for a predicted note event that is not played. Due to the possibility of expressive timing on the part of the performer, we allow a small window after the expected note on event time, in which the performer might still play this note. The timing of this window is set to be close to the threshold for the "just noticeable difference" determined to be approximately 30ms for successful performances over a network (Mäki-Patola & Hämäläinen, 2004). Subject to the requirement that the previous note was successfully predicted, at the point of loop scheduling, once no event has been observed within the window, the module automatically stops recording and sends out the expected, unheard note and begins to play the loop.

3. *http://en.wikipedia.org/wiki/Oblique_Strategies*

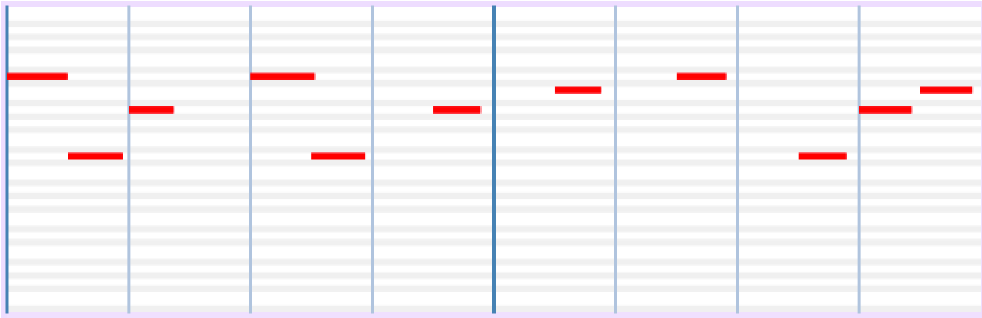

Figure 3 (a) Original MIDI loop

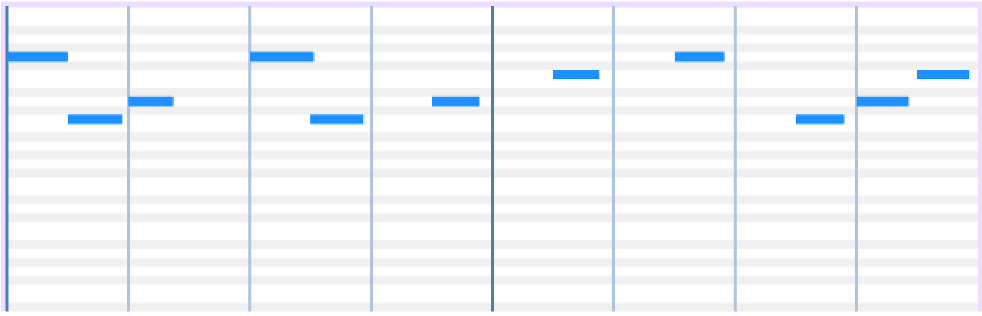

Figure 4 (b) Transformed MIDI loop

A naive musician might know piano chords, but find the playing and modulation of patterns to be technically challenging. An automated method of creating well-timed musical patterns is using a step-sequencer. Traditional step sequencers formed part of modular synthesisers bringing about an automated sequenced of pulsed notes, each occurring at a fixed interval, typically on sixteenth or eighth notes. It is possible to turn each note position on or off, to modify the pitch with a rotary knob and to create dynamics through accenting. Controllers such as Monome[4] and Ableton Live's Push[5] use a grid of LEDs which allow the user to see and modify the pitches of all notes.

Having recorded a loop, consisting of a combination of a rhythmic and melodic pattern, the performer might wish to rearrange the material to generate a new pattern. Once a MIDI loop is recorded, one possibility for interaction might be to perform transformations on the pitches of the notes whilst retaining the rhythm and dynamics of the original loop. We have implemented a simple method to input a new set of notes by playing a chord. This would result in similar effects to the traditional modulation of a sequence, whereby all notes are transposed by a fixed interval, but there are no constraints on the set of new notes that can be chosen. Where there are less notes in the new chord than the old, the notes are replaced from the lowest note upwards.

2.3. GRID PLAYER

One other module investigated during the collaboration is the Grid Player. This uses a sequence of squares, similar to those in the Monome

4. *www.monome.org*

5. *https://www.ableton.com/en/push/*

and Push, but whereas in the former the x-axis denotes the rhythmic position in the bar, in our design the x-axis represents the speed at which the sequence of notes is traversed. The vertical axis represents the pitch of the note within a chosen scale, and the output is automatically generated as the notes follow a trajectory up or down, with possibilities to mute, repeat and skip notes and reverse the direction of travel. The grid player design can easily linked to available hardware controllers, such as the Monome, that provide two-way communication from a grid of squares. Our implementation is available to download.[6]

3. DISCUSSION

Whilst technology exists to manipulate parameters for sound generation, a vital component for a generative music system is the ability to listen to both the surrounding audio and its own output. A semantic description of these audio streams must be available for such a system to have an analogue of 'musical awareness' that human players have. Whilst beat trackers might respond to the regular pulse of an incoming stream, under current designs, they often do not learn the drum pattern or have a representation of the audio content to be synchronised with the band. Similarly, semantic knowledge of key, bass lines, chord progressions and timbral descriptors, is often lacking in the design of these interactive systems. Current work on integration of semantic audio within the music studio (Fazekas & Sandler, 2011) could be applied to the performance of live versions of these works, making possible the ability of music systems which improvise within a musical context, beyond the currently existing improvisational system such as GenJam (Biles,), Voyager (Lewis, 2000) and IRCAM's Omax.[7] Genre-specific cultural trends within music creation will then play a role in the appropriate choice of voice, part played and automated effects used.

4. CONCLUSIONS

In this paper, we have described a selection of modules developed as part of a collaboration between musical artist and researcher. The aim of the project is to enable designers of musical systems to make use of a variety of modules. Motivated by the idea of promoting and preserving a state of 'flow', we have described a tempo module so that computer software stays in time with drums, an automatic looper that does not require manual in-tervention for the recording of loops, and an alternative to the step sequencer to create new patterns from a loop through the substitution of new pitches in a chord. The code for these latter two modules, implemented using the JUCE framework, is available.[8]

6. *www.github.com/venetian/MidiGridPlayer*
7. "The Omax Project Page" *http://omax.ircam.fr/*
8. *https://github.com/Venetian/JuceAutomaticLooper*

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IMAGE SONIFICATION APPLICATION TO ART AND PERFORMANCE

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ABSTRACT

An application for image sonification originally developed to aid blind users to infer colors and light through sound, is used to convey a sound-image synesthesia effect at installations in art exhibitions, for paintings sonification and live performance. These recent artistic applications and the specific improvements for this purpose are presented. As digital images are compositions of pixels (elementary picture elements) they are converted into a composition of elementary sounds, related to each pixel, by a robust straightforward mapping of pixels position and color parameters to sound parameters. This allows to produce informative sound from any image and to detect particular shapes. The audio output is customizable by the user. The software is open-source, therefore open to contributions. It allows to generate an immediate synesthetic effect from any visual piece. Potential implementations include smartphone and web apps, games for blind users, image monitoring and color/sound therapy.

KEYWORDS

Audiovisual Systems, Data Sonification, Image Analysis, Sensory Substitution, Art Technology, Synesthesia.

1. INTRODUCTION

This research follows a project[1] that looked for digital means to provide information on surrounding colors and light to blind people through sound [1]. It improved a software tool able to convert a digital image into a characteristic sound composition. Empirical tests and experiments with artists unveiled its potential as a performance art instrument focused on synesthesia: a neurological phenomenon in which stimulation of one sensory or cognitive pathway leads to automatic, involuntary experiences in a second sensory or cognitive pathway. Such phenomenom is apparently associated to a sense of wellness by synesthetes, people who report this kind of experiences. Historically the relation between visual and auditive realms, color and sound, has inspired composers [2] and scientists [3]. The evolution of digital technology has made available a variety of software and devices to link sound to image for two main purposes: to aid blind people [1,4-12] or people with vision flaws [13-14] and for pure artistic pleasure [15-22]. Data Sonification studies how to exploit the sense of hearing to analyze information from data, allowing a different perception of these than through common visual methods (graphs, histograms, etc.) [23-25]. Images are a particular data set, therefore the application described here is an Image Sonification tool. A search for an informative and attractive output sound based on the correlation between the physics of light and sound has led this study to its actual state. The first known machine for the real-time performance of color 'graphics' was Louis-Bertrand Castel's "Clavecin oculaire" (1734). Many machines have since followed, to produce either compositions of animated colors, dubbed color music, or moving compositions of color and form, like "Lumia" by Thomas Wilfred, the developer of the "Clavilux" organ (1922). In the digital era we find several attempts to explore the generation of audio by visual data; from very simple to highly sophisticated software like *Metasynth* [16] which reads images from left to right, maps the colors by stereo placement (pan) and brightness to volume, able to allow to choose which instrument to play. In *Coagula* [17] images are played from left to right as if they were spectrograms of an audio signal. In *Audio Paint* [18] each line of the picture is an oscillator, and the taller the picture, the higher the frequency resolution. While the vertical position of a pixel determines its frequency, its horizontal position corresponds to its time offset. In 2012 a new sensory substitution device, the *EyeMusic* [12], was introduced to the public. It conveys color information by using different musical instruments for each of the five colors: white, blue, red, green and yellow (black is represented by silence). An auditory cue (beep) is sounded at the beginning of each left-to-right scan of the image. The higher musical notes on a pentatonic scale represent pixels that are located higher on the y-axis of an image. The time offset after

1. See-Through-Sound, funded by FCT, the Portuguese Fundation for Science and Technology (UTA-EXP/MAI/0025/2009).

the cue indicates the x-axis location of the pixel. Many other software applications have been released as research projects or independent productions, as discussed in [4], like the *Voice* and *Kromophone*. Given the current context we implement an alternative mapping of the light spectrum into sound, to convert images into informative audio for art.

2. SOFTWARE UPGRADES AND APPLICATIONS

The principal purpose of this work is to describe collaborations with visual artists in art performances and installations and the upgrades of the original software implemented for these. The actual user interface facilitates the live control of parameters: scales for color-sound mapping options to the default "just intonation" scale, ground note, scan/loop speed and new timbres for Hue and Brightness mapping. As shown in [1,4] the horizontal position and color information (Hue, Saturation and Value) for each pixel is mapped respectively to Pan (stereo placement), Pitch, Timbre and Loudness and the vertical scan, which is in accordance with the way our brain processes an image at first glance from the whole horizon at once [25], provide a functional and real-time responsive system. The major improvements were:

Scale – The light spectrum is mapped by default to a "just intonation" scale spanning two octaves, the lower one for the cool colors (hues from blue-green through blue-violet) and the higher for the warm colors (red through yellow, browns and tans included). This mapping was defined as a best compromise between quantity of played colors and quality of output sound. It has been introduced for the sonifications of visual artworks by Sylvia Carolinne De Andueza which resulted in an audio-video installation of sonificated pieces at C.C.J.F. (Centro Cultural Justiça Federal), Rio De Janeiro in March-May 2014 [26]. It easily results in harmonious sound to the human hearing, as it associates the intervals of hues to simple "natural" intervals of frequency which tend to minimize the beatings in the sound.

White threshold – In the described mapping all the gray pixels are meant to be silent or, as an option, played as white noise whose intensity is proportional to the brightness. To define gray pixels in an image a customizable interval of threshold for saturation was introduced, because usually what we consider gray in digital images is not "real" gray (zero saturation). This was introduced to silence the white background, like in [26].

Timbre – The timbre of sound is used to convey information about saturation of color. There are three available options: 1 – the sound is a pure tone mixed with white noise inversely proportional to saturation (more gray means more white noise with a volume proportional to its brightness); 2 – the sound varies from pure tone to a saw tooth wave proportionally to saturation; 3 – the sound varies from pure tone to a "vocal waveform" proportionally to saturation. The association of white noise to grays has shown to have synesthetic impact during the Festival Bang Awards (Torres Vedras, Portugal, May 2014) where the sonification of the scene was the soundtrack of the digital dance performance Senses Places [27-28] and at exhibition “Entre o 6 e 8A” (AMAC – Auditorio Municipal Augusto Cabrita, Barreiro) [29]. In the first, multicolored avatars projected onto hanging tulles served as a perfect input imagery to create responsive sounds which were complemented with live singing and percussion, enhancing the contact/contrast between virtual and real world. In the second, paintings sonifications of pieces created particular ambient music for the opening of the exhibition.

Resize – The recent visual art sonification experiences showed that the coarse horizontal resolution attenuated the impact of significant visual details present in the scene. After the last publication [4] the image was resized horizontally from 12 to 15 in order to have a central pixel, but actually, the image is resized to 45 pixels. These contain the average values of 45 segments of horizontal lines of the image, and control the parameters of 45 sound generators. The sound produced is richer in harmonics and can capture smaller details of the sonificated image. it has been useful at the performance of live painting “De Cor&Som” [30], which consisted in creating a visual piece from scratch while musicians (voice, guitar, clarinet and percussions) improvised with the sounds generated by the visual artwork. The visual artist, the musicians and the audience were involved into a synesthetic environment that influenced the act of the creation of a visual product with an extra audio significance.

Scan – The scan line moves vertically on the image at a constant speed, producing a regular “loop”. It now can also be manually controlled by the user with a slider in the main GUI. This option is useful to verify the details of a sound generated by an image and it can also be used in performance controlled by a smartphone accelerometer.

3. CONCLUSIONS AND FUTURE WORK

This software was created to provide means for sensory substitution to aid blind people, and has been used afterwards to provide a link between music and light based on their physical properties, able to let common people experience synesthesia in interactive installations and performances. The simple image analysis system provides robustness and a quick sound response to any input image: a body moving in front of the camera or colors being painted on a canvas. The effect during a performance has shown to be attractive even to who is unaware of the installation. Future tests will try to scientifically quantify and prove these empirical considerations, with tests on blind and not blind volunteers. Ideally our attempt was to formulate a coherent link between the physics of sound and light. The range of light frequencies corresponds approximately to an octave 4-8×1014 Hz so the initial test was to map any frequency of the light spectrum to sound frequencies ranging an octave. This is still an available option but the Hue is now by default discretized, for functional reasons. Future objectives include also exploring synesthetic environments, able to provide and mix color and sound therapy [31]. Another focus is on design a more user-friendly GUI, in order to stimulate contribution by other artists/scientists in an open-source framework. Introducing depth information acquired by Kinect cameras, more advanced image processing algorithms, Midi and other types of audio output to add informative sounds are also possible future developments.

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SHORT PAPERS

AUTHOR INTERACTION

HYPNAGOGIA AND IMPROVISATION: INTERFACING WITH REFLEXIVE/VOLITIONAL BEHAVIOUR

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ABSTRACT

This paper draws on discourse from psychology, cognitive science and neuroscience to present a theoretical framework with which to explore the notion of interface from the perspective of deep interaction, interaction which is initiated at the threshold of conscious awareness and volitional control. The context for this work is improvised musical performance and this paper describes an experimental methodology which will be employed to explore procedural memory and readiness potential by using a combination of EEG and hypnosis, as a means of interfacing with the reflexive/volitional behaviour of an improvising musician. This paper describes the motivation for this work as seated in the anecdotal experience of many professional improvisers and puts forward a theoretical rationale for this particular approach to addressing their concerns. The issues they identify reflect a desire to enhance the sense of 'liveness' in their performance by circumventing mechanical modes of playing.

KEYWORDS

Improvisation, Hypnagogia, Biofeedback, Reflex, Volition.

1. INTRODUCTION

The term programming is used ubiquitously when applied to inanimate technological devices, it is rarely applied to humans and when it is, although it can have positive connotations for those aiming to achieve peak performance in a particular field for others the implication is that the effect is, in some way or another, dehumanising. To describe a human as having been in some way programmed to behave in a certain way, implies their own sense of agency has been subverted. Much of our behaviour is, of course, programmed genetically and culturally and to a certain extent we programme ourselves, by undertaking activities designed to leave a repository of encoded behaviour. Musicians spend many hours encoding motor skills in order to give access to a wide range of functionality on their instrument. Through precisely controlled repetition, instrumental facility can be encoded in implicit procedural memory (Smith, 1897). This slow and cognitively demanding encoding process requires focused attention to develop fine motor skills, particularly at the outset. As the process of encoding develops over a period of time the cognitive burden of accessing the stored functionality is lessened and efficiency gains start to accrue. As William James notes, "Habit diminishes the conscious attention with which our acts are performed" (James 2007, 115). An important area in the brain for the regulation of procedural memory is the striatum, which helps coordinate motivation with body movement and is the primary input to the basal ganglia. Using additional inputs from other parts of the brain, the basal ganglia controls voluntary motor movement, procedural learning and routine behaviours or 'habits' (Haber et al, 2000). Once motor skills have been acquired and stored in procedural memory their use or enactment, when initiated consciously, is controlled more as an executive function rather than detailed control over the various elemental components of the initiated action. The acquisition of fine motor skill leads to the development of motor programs stored in the premotor cortex for later activation by the motor cortex.

Unlike inanimate devices, humans can access their programmed functionality consciously or unconsciously. In the late 17th century the nature of reflexive behaviour was explored by Willis and Descartes when they put forward their dualistic interpretation of cerebral activity as controlling either the mechanistic aspects of human behaviour or the volitional. By the mid 19th century Marshall Hall had developed the idea that the spinal cord is responsible for involuntary behaviours, while the cerebral cortex was responsible for voluntary behaviour. He has been attributed with creation of the term 'reflex arc' and proposed an excito-motor nervous system located in the spinal cord responsible for stimulating highly stereotyped behaviour. Hall's hypothesis essentially maintained a dualistic approach which is now rather redundant. The binary distinction has been replaced by a sliding scale , "the reflex/voluntary distinction derived from the sensorimotor hypothesis of neuroscience is not absolute; all behaviours fall on a continuum from purely reflex to purely voluntary and none is purely one or the other" (Prochazka et al. 2000).

2. IMPROVISING WITHIN COGNITIVE LIMITS

In 1998 Jonathan Wolpaw asked, "are the words reflex and voluntary useful scientific concepts or are they prescientific terms that should be discarded?" (Prochazka et al. 2000). Musical improvisation is an interesting domain in which to explore this contentious notion of reflexive and volitional behaviour. Simple and elemental motor skills are compounded into units of musical activity where, for the most part, conscious consideration is given by the performer to higher level musical gestures rather than to fundamental physical actions. Consider, that at a moderate speed of 120bpm a performer playing semiquavers is executing notes at a rate of 8 per second or one every 125ms. A competent instrumental improviser could significantly exceed this rate before it became a taxing operation, either mentally or physically. The performer's perception is likely to be that they maintain a complete sense of agency during an extemporisation, as the rate at which they produce musical material naturally and intuitively rises and falls. However, it seems that individual actions at this speed (semiquavers at 120bpm) exist on the edge of volitional control, despite the perception of the instrumentalist. Pressing identified that "speeds of approximately 10 actions per second and higher involve virtually exclusively pre-programmed actions. An informal analysis of jazz solos over a variety of tempos supports this ball-park estimate of the time limits for improvisational novelty" (Pressing 1988, 129-178). For the majority of improvisers this is of no concern but there are many accounts of musicians expressing frustration when the interface between their intent and their actions is restricted by cognitive limitations. Lee Konitz remarks that "playing mechanically suggests a lack of real connection to what you are doing at the moment. We learn to play through things that feel good at the time of discovery. They go into the "muscular memory" and are recalled as a matter of habit" (Hamilton 2007, 102).

In 1965 Kornhuber and Deecke discovered a phenomenon they called Bereitschaftspotential (readiness potential). Their discovery suggested that, when undertaking a self initiated act, the brain becomes active anything up to 1.5 seconds before the act is undertaken, in preparation (readiness) for the act to be performed. This research was developed further in the 1970s by Benjamin Libet who set out to see when conscious engagement took place, relative to RP in a self initiated act. Libet discovered that on average readiness potential started 0.55 seconds before the act, while the subject becomes conscious 0.2 seconds before the act. Libet concluded that "cerebral initiation even of a spontaneous voluntary act ... usually does begin unconsciously" (Libet 1985). From Libet's findings it became evident that there is 0.35 second latency (sometimes longer) between the cerebral initiation and conscious initiation of a volitional act. This field can now distinguish different event-related potentials, small voltages generated by the brain in response to specific stimuli. These are time locked to sensory or cognitive events down to the millisecond, with ones which peak earlier (<100 ms) relating more to sensory stimulation and later ones relating to cognitive evaluation (Shravani 2009). This field could potentially provide a mechanism to quantify the latency between the act of improvisation and the improviser's sense of agency, across the spectrum of reactive and responsive musical behaviour.

Contrasting the sense of frustration expressed anecdotally by some improvising musicians at the perceived mechanical aspects endemic in their art form, are the more positive and aspirational sentiments of musicians who have experienced modes of engagement in their practice that are emancipating. Derek Bailey relays a different experience of improvisation, which embraces disorientation and distraction as a means of developing methods of provoking novel musical behaviour, not limited by conscious intent.

> "A lot of improvisers find improvisation worthwhile. I think, because of the possibilities. Things that can happen but perhaps rarely do. One of those things is that you are 'taken out of yourself'. Something happens which so disorientates you that for a time, which might only last for a second or two, your reactions and responses are not what they normally would be. You can do something you didn't realise you were capable of or you don't appear to be fully responsible for what you are doing."
> Bailey 1992

3. THE HUMAN API

Many musicians suffer from stage fright and other anxiety related issues. These afflictions are, for the most part, driven by an inappropriate subconscious response to a situation, initiated by areas of the brain controlling instinctive behaviours such as the anterior cingulate cortex and the amygdala. Hypnotherapy is effective in reducing anxiety in a performer by substituting a defective behavioural template for an effective one and may also provide a tool for improvisers to explore the reflex/volitional dilemma (Stanton, 1993). In therapeutic contexts the presenting symptomology is a reasonably clear indication of the underlying dysfunction but in the case of the positive intervention proposed here, the desired cognitive state is not clearly defined. For the purpose of this initial study we have decided to focus on hypnagogia as the target state. Hypnagogia can be broadly defined at the cognitive state which exists between wakefulness and sleep and has long been association with creativity. Koestler, in The Act of Creation (1964) documents a substantial amount of anecdotal evidence from artists and scientists who have experienced and embraced this cognitive state. People such as William Blake, CG Jung, Jean Paul Sartre, Salvador Dali, Ludwig Van Beethoven, Richard Wagner, Salvador Dalí and Isaac Newton have all reported this psychological phenomena to have had a profound and positive effect on their creativity.

“When I improvise and I’m in good form, I’m like somebody half sleeping. I even forget there are people in front of me.”
Stéphane Grappelli (Nachmanovitch 1990, 14)

Electroencephalograph (EEG) technology has been used to examine cerebral activity during sleep onset in several studies. To understand the features of hypnagogia, this transitional phase has been divided into 9 stages of brain activity, in which the alpha and theta brain waves crossover (Hori 1994). In 1977 Green and Green attempted to use biofeedback to volitionally initiate and control a hypnagogic state, in order to enhance creativity (Green 1977). More recent studies have used the alpha/theta neurofeedback training protocol to improve the performance of musicians and dancers, objectively verified by an expert audience (Gruzelier 2009).

4. PROPOSED METHOD

Although the act of improvised musical performance often involves various stages of preparation, when the actual work is conceived and delivered in real-time, in front of an audience, the potential for intervention in the process is limited. Our intention in this project is to investigate the use of EEG in conjunction with hypnotic techniques, to create audio material designed to be played back via an in-ear monitoring system during a performance, rather like a sonic ‘score’. The material presented to the performers in the score will be audio recordings of verbal instructions, based on the work undertaken prior to the performance. Three musicians have been invited to attend three preparatory sessions and undertake a performance in front of an invited audience. The participants have a background in freely improvised and experimental music and have been fully informed about the nature of the study and the techniques being used and have given full consent. No issues relating to performance anxiety or apprehension about the psychological techniques being used have been identified. The three preparatory sessions will take place weekly before the performance and will comprise a 30 – 45 minute hypnotic induction. Each participant will be assessed on the SHSS-C scale of hypnotic suggestibility (Weitzenhoffer1963). This Stanford Hypnotic Susceptibility Scale measures how easily a person can be hypnotized and is administered to individuals. The Scale consists of 12 items of progressive difficulty and usually takes fifty minutes to complete. Each form consists of motor and cognitive tasks but vary in their respective intended purpose. During each preparatory session the participant’s brain activity will be monitored on screen via a map of delta, theta, alpha and beta waves. The EEG equipment in use will be a low-cost commercially available 14 channel system using the EPOC Brain Activity Map software. During the hypnotic induction the hypnotherapist and an assistant will view the participants level of intensity of alpha and theta activity on a graphical interface, that colour codes the various frequencies and shows in which brain areas they are most intensely occurring. By monitoring the EEG activity the hypnotherapist will endeavour to induce and maintain a hypnagogic state at the point of alpha–theta crossover. Once this condition has been achieved a variety of post-hypnotic suggestions will be delivered to create an association with the feeling perceived by the participant, of this cognitive state. During sessions two and three these suggestions will be tested and reinforced to see if the hypnogogic state can be re-established using post-hypnotic suggestion. It is anticipated that all sessions will take place on the same week day, at the same time and in the same location, including the performance. The preparatory session will essentially provide a form of neurofeedback, which is mediated through the hypnotic induction. The triggers for the post-hypnotic suggestion will be verbal cues, which will be embedded into the sonic 'score' which the performer will listen to during performance. The rationale for the development of the sonic score using spoken material has a relevance to the issue of cognitive load and reflex response discussed earlier, and will be explicated further in a subsidiary paper. The preparatory sessions will be recorded to document each performer's EEG response to the hypnotic induction, after which a short interview will be filmed and questionnaire completed, which will be used to evaluate their subjective experience. After the performance in the fourth week a final interview will be filmed and questionnaire undertaken. The participants will be contacted one month after the performance by email and asked to reflect anecdotally on their experience in free writing.

5. SUMMARY

Inspiration for this project has been the anecdotal evidence of improvising musicians of high professional standing, expressing an internal conflict or dilemma which arises from a desire to produce fresh and original musical material when they improvise. The roots of this dilemma can be traced to biological systems which have evolved to limit the performance of behaviours under conscious control, compared with more efficient subconscious initiation of behaviour. In the context of creative expression Gruzelier asserts that "artistic performance requires the integration and expression of past learning and expertise, the imbuing of this in performance, and the communicating of this artistry to the audience. Theta is an ideal candidate for this wide ranging integrational role" (Gruzelier 2009). This assertion supports the endeavour in this project to induce a state where alpha–theta crossover occurs and in so doing stimulate in the participants the perception of hypnogogia, as described in section 2. Through filmed documentation and structured interviews this project will endeavour to capture the performer's subjective experience of undertaking the project and their perception of the resulting performance. This projects attempt to evoke a theta brain state by monitoring an EEG signal during an hypnotic induction, as a means of harnessing the creative potential of hypnagogia in live improvised performance. The experimental work proposed here is due to be undertaken in the coming months and the results published accordingly.

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POIETRY: COMMUNICATIONAL PROSTHESIS TO SEEMINGLY OVERCOME LONELINESS

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ABSTRACT

This paper presents results from an artistic research process on methods to seemingly overcome the loneliness of operationally closed psychological systems. This is achieved through a musical interface powered by brainwaves and their interpretation, based on a novel way to translate emotions into compositorial sound structures in real time. *Poietry* is an artistic experiment that serves as a communicational prosthesis, which appears to enable accessing another human entity's internal operations. It a real time sound improvisation tool based on a cellular automata triggered by emotion.

KEYWORDS

Brain-Computer Interface (BCI), Emotions, Psychological System, Brainwaves, Artistic Mapping, Musical Performance.

1. INTRODUCTION

As individuals we are not able to look through somebody else's eyes; we are not able to feel, what someone else feels, because every feeling we are capable to produce will ultimately remain our own. What really happens in another person's consciousness will necessarily stay an eternal mystery.

Communication allows us to externalise what happens in our inner world, but it inevitably implies a transformation followed by a decodation of this transformed information. Furthermore, not everything that happens in our consciousness is communicable, just as not every part of communication can be captured by our consciousness. Communication simply allows us to draw analogies, to interpret meaning and our approach of the inner world of somebody else can therefore only ever be indirect as we simply can not verify it conclusively. (cf. Baraldi, 1997, 89) An immediate access to the inner world of another person is denied by our reciprocal boundaries, so we remain in solitude within these boundaries.

Whereas tools traditionally served as extensions and amplifications of the human body, digital interfaces extend the human mind and can consequently enrich the communicational process. (cf. McLuhan, 2001) Both – physical and mental extensions – serve as prosthesis, which add something to the original abilities of a psychological or social system.

The technical ability to measure brain activity and the ongoing research of its interpretation promises growing access to the correlates of consciousness. This doesn't imply that we can access consciousness itself as the mind mustn't be understood as being a trivial machine, which finds itself biologically encoded within the brain and invariably creates the same specific output when presented with the same specific input. (cf. Maturana, 1987, 101, or Bökmann, 2000, 72) Given that one of the if not the most important disposition of consciousness is experiencing it, it is actually questionable altogether whether consciousness will ever be accessible from outside the organism that it happens in. Neural correlates of consciousness however can be measured and it is feasible to examine reoccurring patterns of neural activity to draw certain analogies about their meaning even if the results of these measurements might be equivocal. These measured correlates allow certain access to another human entity's internal operations and thus involve them directly in the communicational process, which per system theoretic definition is simply impossible and hence creates its own paradox – it communicates the incommunicable – what happens in an operationally closed consciousness. (cf. Luhmann, 1995, 26)

Following the implications of Antonio Damásio emotions can be triggered and executed entirely non-consciously and have to reach the state of a feeling made conscious to even be communicable. (Damásio, 1999, 37) What they share in their biological core is being a complex yet stereotyped collection of chemical and neural responses, which are biologically determined and can be externally observed through bodily display. (Damásio, 1999, 52ff.) Lying underneath the level of consciousness, they are particularly hard to control even though it is possible to prevent their expression at least partially. Damásio phrases it this way:

> "We can educate our emotions but not suppress them entirely, and the feelings we have inside are a testimony to our lack of success."
> Damásio 1999, 49

Whereas neural activity *per se* is entirely neutral and therefore doesn't give any information about the function it fulfils, other parameters like localisation and temporality of neural activity allow certain conclusions about the content of the operation the activity is related to. (cf. Roth, 2005, 27) Roughly one can differentiate between parts of the brain that are free to react to irritations of the organisms surroundings and parts that represent the organisms own state and are consequently fully tied to keeping the organism alive. (cf. Damásio 1999, 21) States of consciousness are – to our current knowledge – tied to the activity of the neural cortex and consciousness vanishes as soon as there is no activity detected within the neural cortex anymore. (cf. Roth, 2005, 132f.) Depending on the specific part of the neural cortex and the precise pattern of the activity we are told by researchers like the molecular biologist, biophysicist and neuroscientist Francis Crick and the neuroscientist Christof Koch, that we can gain a specific idea about how cognitive and emotional processes are related to their neural representation within the brain. (cf. Crick/Koch 2003)

2. METHOD

Based on the theoretical considerations outlined herein a brain-computer (BCI) interface system, which transforms live EEG data into sound, was developed. EEG-based technology offers easy access considering wearability, price, portability and ease-of-use, and more importantly the EEG is a highly temporal method allowing to collect and process real-time data, which is necessary for the desired analogy to the operations within a psychological system. The data collected by the EEG is transformed into OSC signals and sent to a Pure Data patch, where it is expressed in five basic emotions, namely Anger, Fear, Happiness, Sadness and Tenderness.

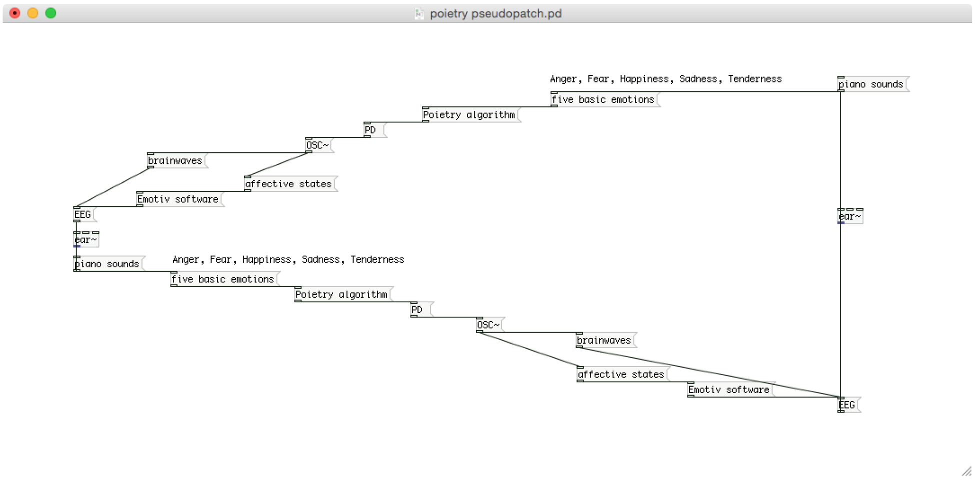

Figure 1

The categorisation of emotions is generally controversial and even more so decoding them from neural patterns or brainwaves. The number of research activities on EEG-based emotion recognition algorithms increased within the last years, yet it remains a new area of research and its effectiveness and efficiency are somewhat limited. (cf. Liu/Sourina, 2014, 199) If one understands science as a fluent process to generate suitable findings rather than revealing an ultimate truth, categorisations of this sort can nevertheless be productive. Even more so when applied in an artwork, which in itself, following the definition of Niklas Luhmann, is the result of a self-binding process evolving along its own code of suitability. (Cf. Luhmann 1995, 328f.)

The quantification of five basic emotions Anger, Fear, Happiness, Sadness and Tenderness, which are the foundation for the transmission into sound, are derived from a combination of measurements: Raw brainwaves – alpha, beta, theta and delta – are correlated with the interpretation of the Emotive EPOC EEG software – instantaneous excitement, long term excitement, frustration, engagement and meditation – based on a matrix of calculations developed through artistic experimentation and tested qualitatively. The developed algorithm is not aiming to deliver scientific accuracy, but deemed suitable for the *Poietry* project through the results of the experiment and for the reason that the artwork is about raising questions within spectators and subjects rather than giving definitive answers.

The term *Poietry* is a neologism etymologically based on the terms Poiesis and Poetry. This neologism is a consequence of the consideration that the experiment is created through a poietic instead of a practical approach and further, that the created prosthesis expresses something without literally translating it in order to unfold an effect beyond a literal translation, which is according to the definition of Schopenhauer, the classical characteristic of poetry. (cf. Schopenhauer, 2012, 856)

The data, which is collected by the EEG and transformed by the algorithm, is consequently translated into sound in realtime. Sound as a medium seems to be preferable over visualising the data in this case, given that the visual sense is strongly relying on a reduction of complexity, whereas the auditorial sense is hyper-aesthetic and therefore more sufficient to the analogy to operations of complex psychological systems. (Cf. McLuhan, 2001, 96) The transformation aims to increase complexity rather than to reduce it, which does not imply that it is formed arbitrarily. The algorithm used is based on a set of rules adapted from a meta study of the psychologists Patrik Juslin and Petri Laukka. (cf. Juslin/Laukka 2003) This meta study analyses 104 studies on vocal expression and 41 studies on music and compares the accuracy with which discrete emotions were communicated to listeners and the emotion-specific patterns of acoustic cues used to communicate each emotion. Their results centred on six categories of cross-modal patterns of acoustic cues for discrete emotions, which served as the initial basis of the *Poietry* interface algorithm. The following table summarises these results.

EMOTION	ACOUSTIC CUES (VOCAL EXPRESSION/MUSIC PERFORMANCE)
Anger	Fast speech rate/tempo, high voice intensity/sound level, much voice intensity/sound level variability, much high-frequency energy, high F0/pitch level, much F0/pitch variability, rising F0/pitch contour, fast voice onsets/tone attacks, and microstructural irregularity
Fear	Fast speech rate/tempo, low voice intensity/sound level (except in panic fear), much voice intensity/sound level variability, little high-frequency energy, high F0/pitch level, little F0 pitch variability, rising F0/pitch contour, and a lot of microstructural irregularity
Happiness	Fast speech rate/tempo, medium–high voice intensity/sound level, medium high-frequency energy, high F0/pitch level, much F0/pitch variability, rising F0/pitch contour, fast voice onsets/tone attacks, and very little microstructural regularity
Sadness	Slow speech rate/tempo, low voice intensity/sound level, little voice intensity/sound level variability, little high-frequency energy, low F0/pitch level, little F0/pitch variability, falling F0/pitch contour, slow voice onsets/tone attacks, and microstructural irregularity
Tenderness	Slow speech rate/tempo, low voice intensity/sound level, little voice intensity/sound level variability, little high-frequency energy, low F0/pitch level, little F0/pitch variability, falling F0/pitch contours, slow voice onsets/tone attacks, and microstructural regularity

Table 1 Summary of Cross-Modal Patterns of Acoustic Cues for Discrete Emotions
Note. F0= fundamental Frequency
Source: Juslin/Laukka 2003, 804

The collected data transformed by the *Poietry* algorithm is expressed in classical piano sounds using the principals of twelve tone scale music, major and minor. During the performance of *Poietry* the sound generated by the apparatus is being transmitted to a different person wearing the same kind of prosthesis and vice versa. This way a communication feedback loop is established as the transmitted sound influences the collected neural data starting a continuous process going back and forth.

This primarily theoretical prediction is supported by the results of the neurologists Greg Stephens, Lauren Silbert and Uri Hasson, who discovered similar neural patterns of communicators in the process of communication due to neural coupling and furthermore finds itself realised in the recurring syncing of the two generated audio streams. (cf. Stephens/Silbert/Hasson 2010, 14425-14430)

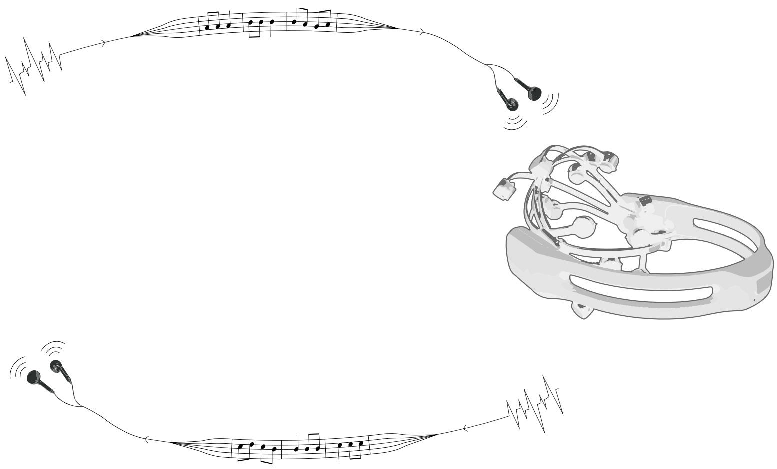

Figure 2

3. CONCLUSION

The application of algorithms, which detect emotions via EEG data, is surely questionable when it comes to accuracy, yet so is the feasibility of objectively quantifying and detecting emotions in general and whether consciousness will ever be accessible from outside the organism that it happens in, given that one of the if not the most important disposition of consciousness is experiencing it. The created interface system *Poietry* doesn't claim to directly access another human's consciousness nor to decode emotions, but it allows to externalise correlates of internal operations of a consciousness system, by translating them into something, which is accessible from outside this system and artistically staging exactly this process. Through that, *Poietry* adds a component to the communicational process and serves as prosthesis, which creates the impression of seemingly overcoming reciprocal boundaries of psychological systems and therefore the source of our loneliness.

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RECONSIDERING PROCESS: BRINGING THOUGHTFULNESS TO THE DESIGN OF DIGITAL MUSICAL INSTRUMENTS FOR DISABLED USERS

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ABSTRACT

Digital musical instruments (DMIs) are subject to drastically fewer design constraints than their acoustic predecessors, and the possibility of minimizing physical interaction has inspired numerous interfaces intended for disabled users. However, the potential of DMIs remains only partially fulfilled. Informed by personal experience as a DMI designer and performer with a disability, concepts of affordances and repurposed technologies are used to make a case for the adaptability of users and durability of established instruments. Examples of unconventional performer-instrument fit are identified and a modified design process is proposed. This contemplates the suitability of established instruments before initiating new designs. Finally, some implications of this change are considered.

KEYWORDS

Digital Musical Instruments, Instrument Design, Affordances, Need-Finding, Assistive Technology.

1. INTRODUCTION

Many of the acoustic instruments present today have been subject to hundreds or thousands of years of refinements (Paradiso 1998). If, over this extended period, they appear to have reached highly optimized states, it is significant that many were developed for reasons of acoustical power rather than their fit for the body of the performer. Therein lies the inherent trade off of acoustic instrument design; the performance interface must physically act on the sound generation mechanism. Thus, to ensure their compatibility, these two aspects must be considered simultaneously and some combinations may be mutually exclusive. DMIs, by contrast, can use almost any performance interface and produce any sound imaginable. Moreover, it is possible for a designer to select these elements independently, and then join them in software after the fact. This shift to a virtual connection produces a loss of haptic feedback, but, at the same time, dissolves many traditional design constraints (Marshall 2008). The NIME community has enthusiastically embraced these freedoms. For instance, easy-to-use hardware such as the Arduino microcontroller, novel sensor technologies, and intuitive software such as MaxMSP have increased the accessibility of DMI-building, particularly for composers and musicians. Concomitantly, these technologies have also reduced barriers to performance. This has had particular effect on those previously excluded because they lack the physical dexterity required by most conventional instruments. Where once considerable manual effort was needed, the sensor-based interfaces of DMIs can co-opt almost any physical stimuli as input, from a blinking eye to brainwaves.

However, for all their possibilities, the potential of DMIs remains largely unfulfilled. For Jordà (2005) this relates to a tendency to focus on isolated parts of the problem to the detriment of the whole. Elsewhere, Magnusson and Hurtado (2007) found users of digital musical systems to be concerned about the limitations of software environments and the need for constant upgrades. For the pessimistic, this propensity for endless upgrades may imply that novelty is seen as a justification in and of itself. Thus, this paper tries to take a balanced view of DMIs; particularly those intended for disabled users, to consider them objectively, and as part of the same space as their predecessors.

2. PERSONAL BACKGROUND

The themes of this paper are in many respects highly personal. Born with a rare orthopedic condition, the initial prognosis was that I would not be able to walk at all, or even sit up. Thankfully, after extensive surgery and a year in a cast, I took my first steps aged 4 and by age 5 wanted to play a musical instrument. This was complicated by also missing my left arm below the elbow, except for a small "thumb" located near the top of the joint. The trumpet was deemed suitable on the basis that it could be played using only the right hand. It was also relatively inexpensive and thus would not matter if it were quickly abandoned. If the first few years of practice, instrumental grades and concerts were enjoyable, by age 13, hours spent listening to the John Peel show on late night radio fuelled a desire to play the guitar. The ostensible mismatch between bodily and instrumental affordance prompted skepticism. However, my body proved unexpectedly adaptable to the instrument. Just as importantly, I had exceedingly little desire to mimic the instrument's most jaded tropes and soon developed an interest in extended techniques; an interest that ultimately led to exploration of digital systems. Even after a decade creating DMIs for others and myself, these early experiences remain formative.

3. TOWARDS PERFORMER-INSTRUMENT FIT

The notion of performer-instrument fit developed here is built from two concepts: affordances (specifically the intersection of bodily and instrument affordances), and repurposed technologies.

While the idea of unexpected (and perhaps largely incidental) fit between established instrument and unconventional physical affordance is of personal significance, it is also more widely relevant and applicable. Of specific interest are so-called unconventional users; in other words, users who may typically be considered unable to access or fully exploit the possibilities afforded by conventional instrument designs. This notion of affordance is particularly pertinent. As developed by J. J. Gibson (1979), affordances concerned the action possibilities brought about by the natural relationships between living things and their environment. In a design context, affordances initially referred to the actions made possible by an object's physical form and properties (Norman 1999). In this respect, many traditional musical instruments can be thought of as complex objects that, while highly specialised, offer rich and diverse action possibilities. However, the intangible properties of software quickly limited the tenability of an object-based model. Thus, Norman (1999) revised the concept to emphasize a distinction between "real" affordances (i.e. actions that are actually possible) and "perceived" affordances (i.e. actions users perceive to be possible).

If, in their separation actors from environments and objects (respectively), the notions of affordance proposed by Gibson (1979) and Norman (1999) appear to discount the action possibilities of the human body, bodily affordances have been discussed elsewhere. For instance, Shapiro (2014 p. 289) considers the representation of body parts in terms of their movement possibilities. Thus, while rooted in the notion of affordances developed by Norman (1999), this paper considers instrumental and bodily affordances simultaneously. This departure appears necessary: if several authors have considered the affordances of musical instruments, it is notable that these instruments were in many cases designed around conventional bodily affordances pertaining to stance, motor skills, and breath control (etc.). Thus, in cases of serendipitous fit between specific unconventional bodily affordance and conventional instrument, the resultant combination of affordances may differ from those arising out of more conventional performer-instrument relationships (i.e. those intended by the designer). Indeed, in some instances these differences have resulted in distinctive musical features.

An obvious distinction can be made between changed bodily affordances (i.e. those that occur after already learning to play an instrument) and unconventional bodily affordances that are present prior to learning to play an instrument. The common assumption is that those who learn to play an instrument before acquiring a disability may be more driven to persist. Notable cases in the first category include pianist Paul Wittgenstein (Howe 2010), jazz guitarist Django Reindhardt (Dregni 2004), and the deaf percussionist Evelyn Glennie. The case of guitarist Tony Iommi is more complex in that, after an industrial accident, rather than relearn the guitar right-handed, he chose to iteratively modify the affordances of both body and instrument (Iommi 2011, pp. 35–43). There are also cases where unconventional bodily affordances are present before learning an instrument. Examples include the visually impaired Moondog, Stevie Wonder and Jeff Healey, one-handed pianist Nicholas McCarthy, and the asthmatic saxophonist Kenneth Gorelick. However, Bogart (2014) warns that there is likely substantial variation in adaptability between individuals, and thus the above distinction between disabilities occurring before and after instrument learning may be too simplistic.

If the above represent cases of apparently serendipitous but effective matches between specific unconventional bodily affordances and conventional instrument designs, the repurposing of existing technologies for new users has been explored elsewhere. Perhaps the most notable example of a repurposed technology in a musical context is the turntable. Originally intended as a sound playback technology, it was subsequently repurposed for performative use by John Cage in the 1930s and the hip-hop turnablists of the 1970s. In the hands of the latter, the turntable was recast an expressive quasi-instrument capable of supporting long-term engagement (Mudede 2003). Earlier still, the humble washboard underwent an even more radical transformation: released from its domestic duties, it provided the rhythmic underpinning of the British Skiffle revival of the 1950s.

4. A MODIFIED DESIGN PROCESS

The cases mentioned above are diverse and no claim is made as to their completeness. Instead, the suggestion is that they at least provide food for thought. However, typical DMI methodologies (e.g. Whalley 2010) tend only to consider input, the creation of software elements, the mapping of performer input to output, and user testing. While some have also included assessment of user needs (Farrimond et al. 2011), there has been little attempt to critically reflect on the suitability of existing designs, and new instruments are produced essentially by default. Thus, the main contribution of this paper is the proposition that needfinding be followed by systematic evaluation of established instruments to assess if they fit the physical, conceptual, and musical requirements (etc.) of the intended user (Fig. 1). Indeed, to include the identification of untapped opportunities (Patnaik and Becker 1999), it appears implicitly necessary to also identify relevant existing solutions.

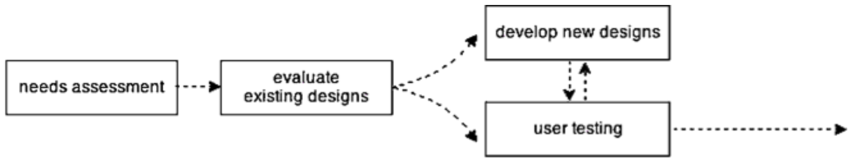

Figure 1 The modified design process.

The potential benefits of considering DMIs as part of the same design space as their predecessors (and creating new instruments only when established designs can reasonably be ruled out) are numerous. For instance, qualities such as the potential for deep engagement have so far proved elusive in DMIs. Also, if the clamor for uncritical novelty can be tamed, users are less likely to be naively provided with designs that, relatively untested, may be inferior to more established predecessors in terms of offering capacity for rich and subtle expression, tiered or managed complexity (i.e. a balance between accessibility and depth), and so on. There are also potential benefits for DMI identify. For instance, if applications already well served by established instruments can be identified DMIs may be free to explore different and more distinct directions.

5. CONCLUSIONS AND FUTURE WORK

The notion of producing fewer, more carefully considered new instruments is not intended to discourage designers, but rather, instill a more balanced mode of production that is simultaneously mindful of the past, and critical and analytical in relation to new developments. Perhaps the most significant advantages relate to testing and evaluation. For example, if DMIs remain poorly understood (at least compared to their predecessors) and it is therefore desirable to learn more about their prospects and limitations, a smaller number of designs is much more concertedly tested; especially if a pool of designs were to be openly shared to encourage their reproduction. Moreover, if truly innovative paradigms remain scarce; particularly in DMIs intended for disabled users, there are at least some moves towards more domain-specific models (e.g. Samuels, 2014). While this development will take time, a more immediate focus is the creation of a more formal framework for considering the intersection of bodily and instrumental affordances, and matching the two together.

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POSTER-DEMONSTRATION
USER INTERACTION

NEW MEDIA AS TECHNOLOGIES OF SELF

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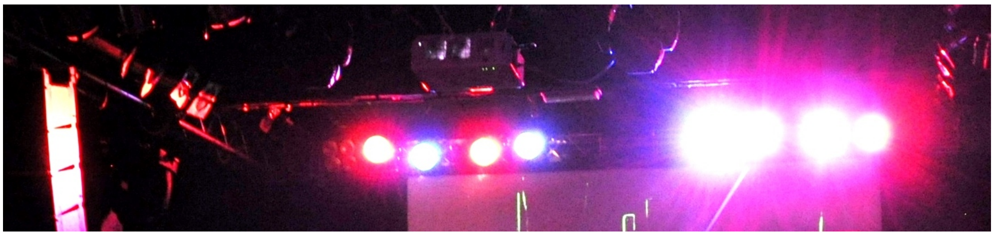

ABSTRACT

An argument concluding that the manipulation of new media is an activity interesting in itself, so that content becomes irrelevant.

Interactive technologies bring to light questions of agency and individual conduct, which previously belonged solely to the realm of philosophy. For example, in order to eliminate the Cartesian subject, Michael Foucault connected these questions to the one of embeddedness. Foucault described practices of self-mastery by means of which the Ancient Greek individual sought to transform himself into a work of art (“aesthetics of existence”). Ancient Greeks developed an entire activity of speaking and writing in which the work of oneself on oneself and communication with others were linked together. Foucault called these practices Technologies of Self. Ubiquitous interactive media of our times intensify those practices in number and frequency, which brings back to agenda the urgency of conceptualisation of individual conduct. Polina Dronyaeva and Alexander Senko propose to use Foucault’s notion of “Technologies of Self” when we need to focus on the conduct rather than content of human activities, for example, when describing interactive arts’ audience behaviour. Their artist-run laboratory ‘Acoustic Images’ created a series of art projects that bring to light these practices ‘of self’ by making people conscious of the activities, which would normally go unnoticed.

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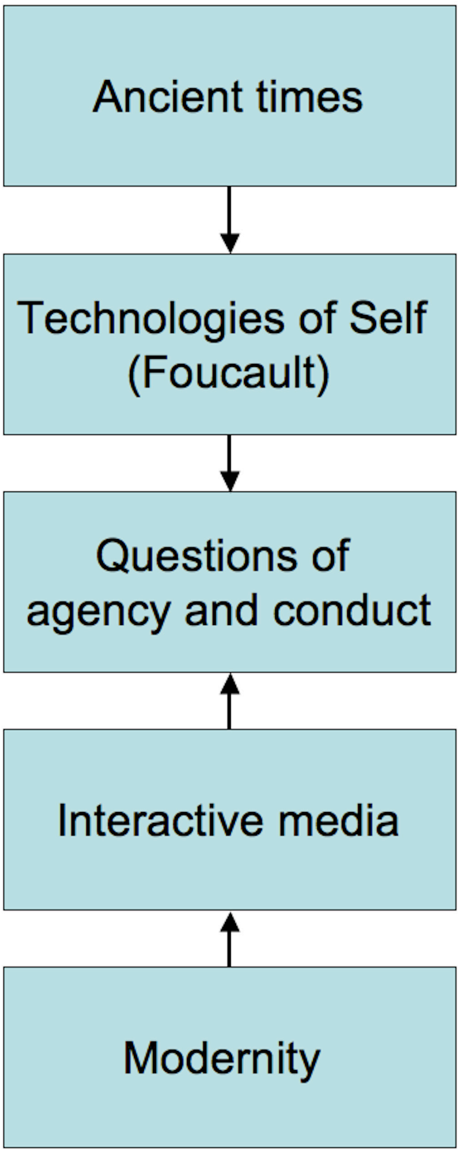
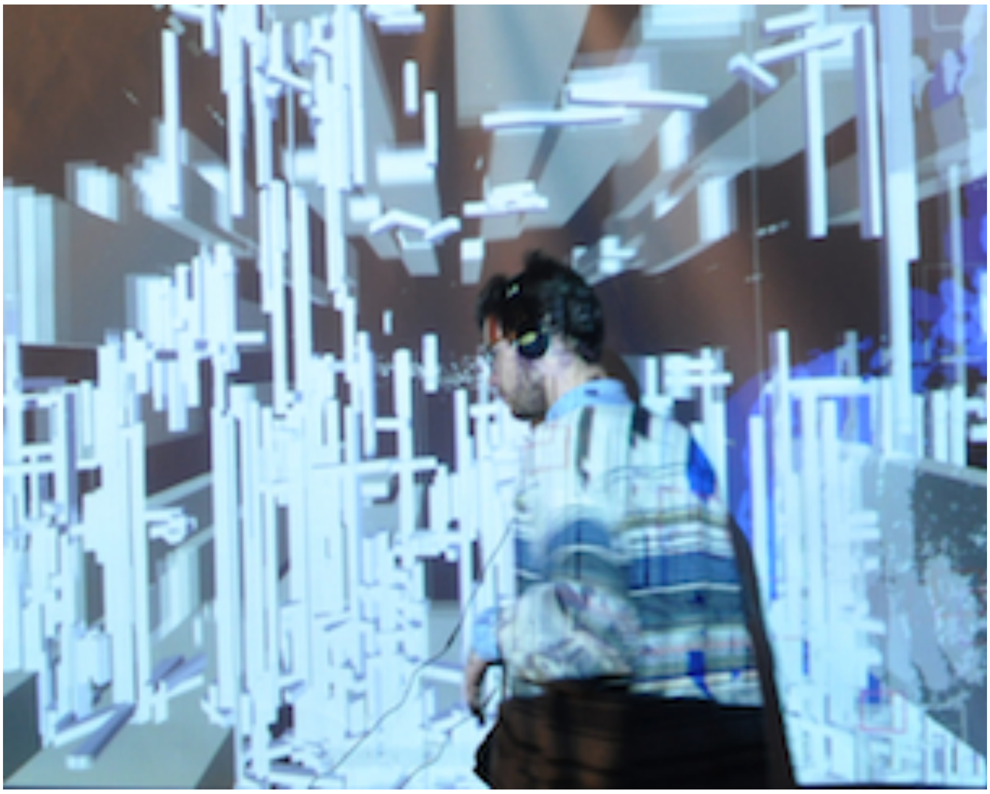
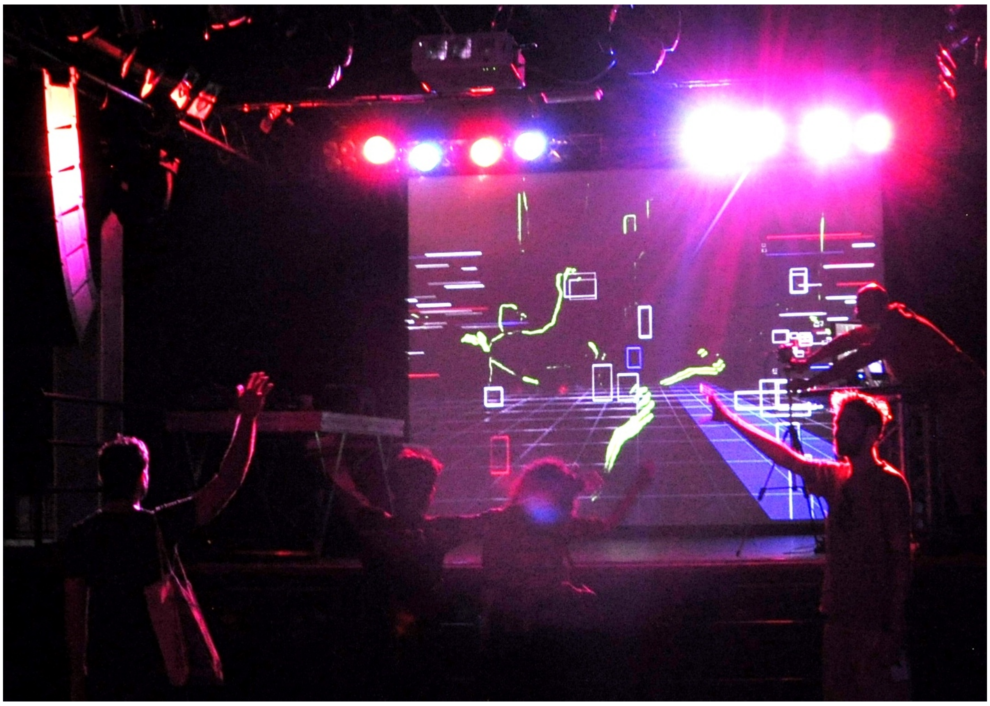

Ancient times
Technologies of Self (Foucault)
Questions of agency and conduct
Interactive media
Modernity





"A WINDOW INTO THE PAST": DEMONSTRATION OF AN IMMERSIVE INTERACTIVE EXPERIENCE AT THE CASTELO DE SÃO JORGE

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ABSTRACT

Software enabling multiple narratives about the Castle of São Jorge in Lisbon.

A window into the past is a mobile application that creates interactive multi-linear narratives as the user explores the Castle of São Jorge in Lisbon. The final perception of the story depends on the trajectory of each user and how they choose to discover the physical Castle itself. Several versions of each micro-narrative were recorded, accommodating for different trajectories and pathways that users can take. Video contents from specific points of the Castle will be displayed automatically whenever the user enters into certain predefined GPS locations, inadvertently creating their own narrative sequences. Not asking users to take explicit decisions regarding their own 'narrative paths', we can avoid breaks in the audio-visual immersion experience.


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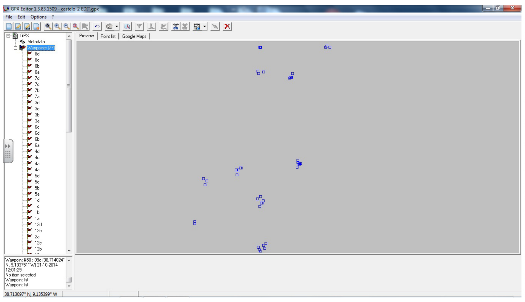

SONIK SPRING: REAL-TIME SCULPTING OF SOUND AND VIDEO

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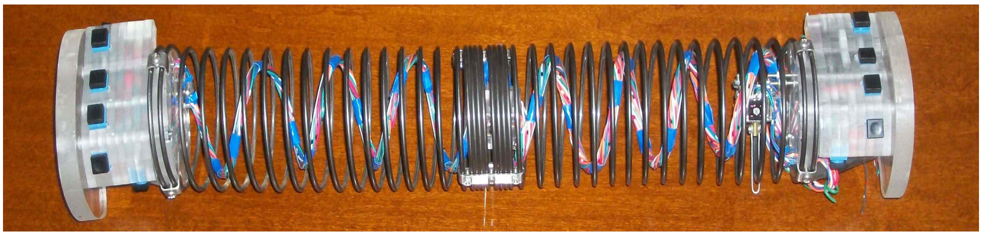

ABSTRACT

Handheld wireless controller, designed for electronic music performance, real-time sound processing, DJing and Video-DJing.

The Sonik Spring is a handheld wireless controller, designed for electronic music performance, real-time sound and video processing, DJing and VJing. It is a tangible interface built on a 15-inch metallic spring that can be compressed, expanded, twisted, shaken or bent in any direction, prompting the user to combine different types of intricate manipulation, using hand, wrist and arm motions. The interface tracks and maps changes in the spring's shape and motion into sonic and visual parameters, and uses a computer for real-time synthesis and processing of audio and video data.

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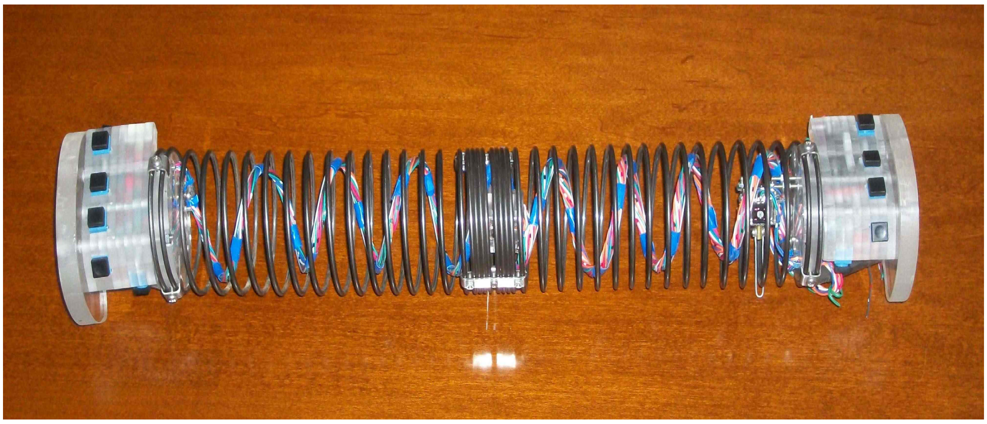

Figure 1 The Sonik Spring can be compressed, expanded, shaken, twisted or bent in any direction, prompting the user to combine different types of intricate manipulation.

Figure 2 Complex twisting of the spring.

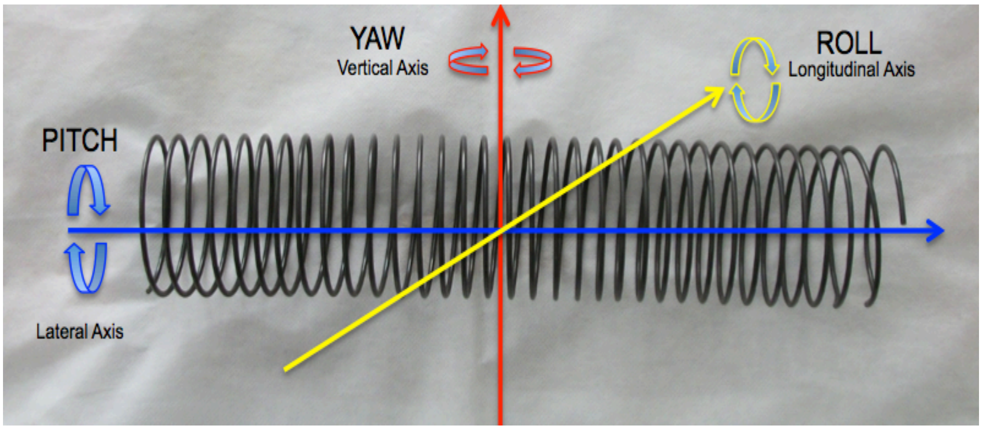

Figure 3 Spring's 3-axes of rotation.

POSTER-DEMONSTRATION

AUTHOR INTERACTION

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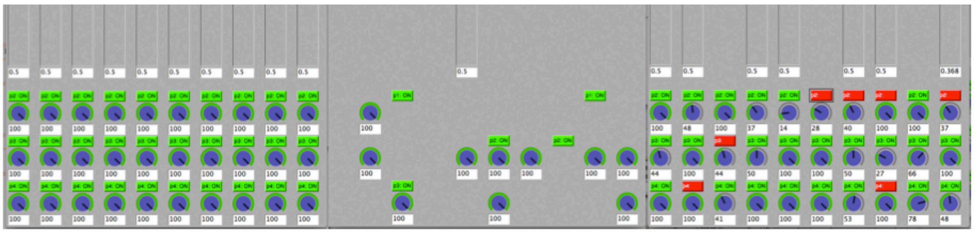

ABSTRACT

An interface that varies the level of control of participant performers during collective improvisation.

Controller is a networked interface for group improvisation, where performers' actions are mediated by a central control mechanism, which modifies (and subverts) their ability to contribute to a group performance. The interface itself consists of three basic types of control: sliders which can be used to control elements of the shared sound space; buttons which switch on and off the sliders of other performers; and knobs which effect the number of control data messages per second sent from a player's slider to control the shared sound space. Changing the setting of an interface element on one laptop changes the setting accordingly on all other laptops. The status of other performers (i.e. how many controls they have relevant to other players) and therefore the overall social hierarchy is not revealed to performers. Neither is any indication given as to whether changes to elements of the performers' interfaces are the result of computer or performer action.

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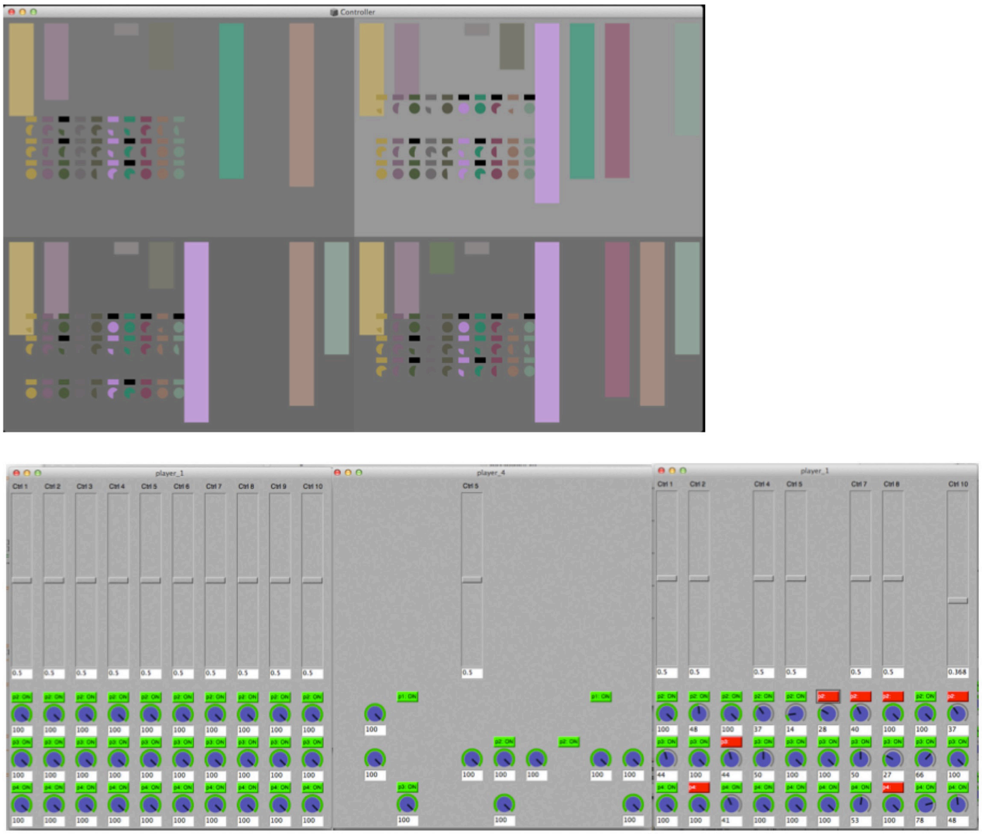

Figure 1 Composing Social Spaces in *Controller*.

PULSE: AMELIA AND ME

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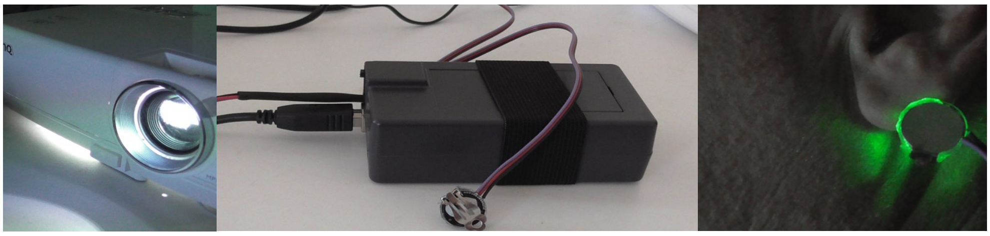
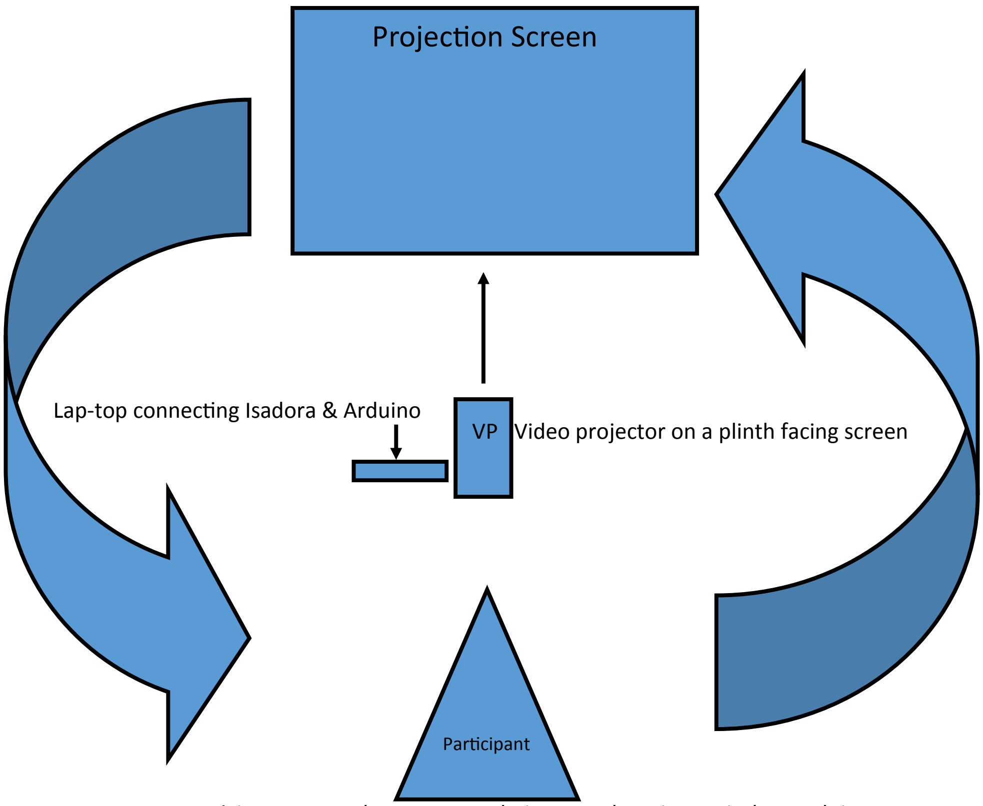


ABSTRACT

An interface for dance performance, where video images from the landscape of Amelia (Italy) are controlled via a biometric heart rate monitor.

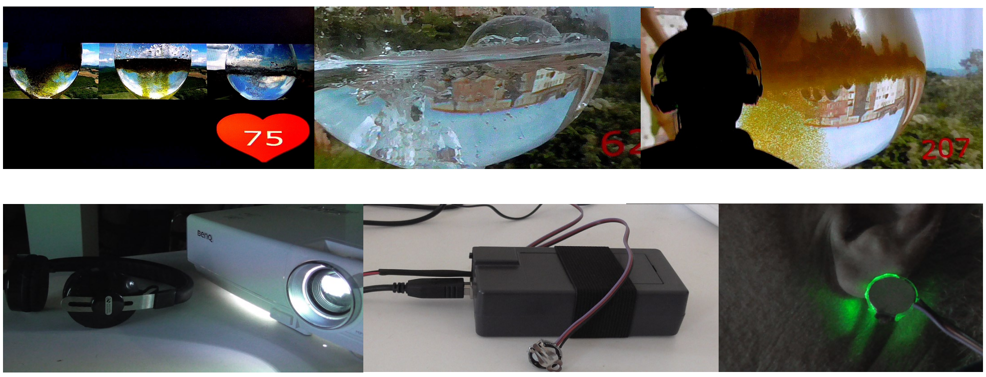
PULse is a performance that choreographs a relation between the spectator and the landscape of Amelia. It creates an ensemble of sound, vision and movement, involving the participant's body and projected video images from Amelia. The spectator's pulse is measured with a wireless biometric heart rate monitor, which connects to a computer. It triggers video images of Amelia, controlling the volume and speed of sound, as well as the transparency and size of the images. In the video, olive oil and water are mixed and controlled with a heart rate sensor depending on the beats per minute (BPM). The solutions dissolve into each other at 70+ BPM; and they separate below 70- BPM. In turn, Amelia's images and sounds affect the performer. PULse becomes a live third space in[between] the physical body and the video images.



Participant wears the sensor on their ear and carries a wireless Arduino

In a belt bag around the waist

The arrows indicate a bio feedback system between the video & participant



FLUID CONTROL

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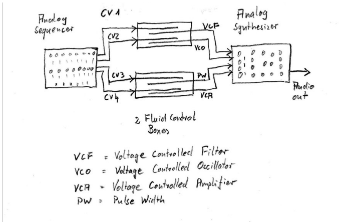

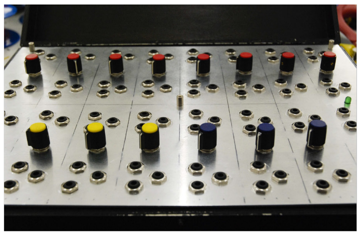

ABSTRACT

A tool for controlling electronic sounds through water.

Fluid Control is a water based interface, which can control electric current in a very fast, dizzy, sophisticated and sometimes chaotic way. With this tool it is possible to control analog and software synthesizers as well as video software and all kind of electronic devices especially microcontroller based platforms like Arduino or Raspberry.

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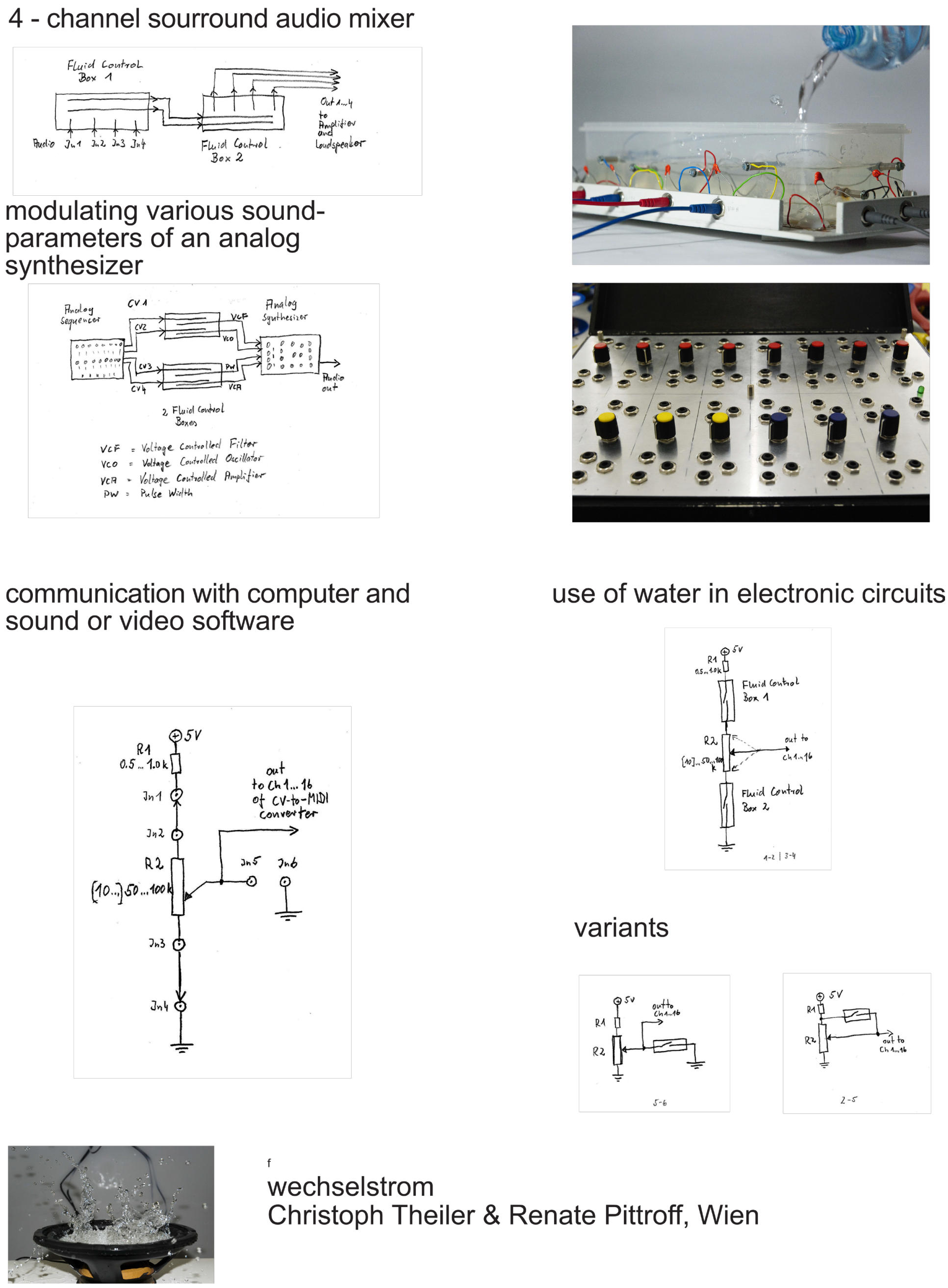

Figure 1 Modulating current by water.

PERFORMANCES

INTERFACING FRAGILITY

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ABSTRACT

Franziska plays saxophone, Ricardo plays cello, and Pedro plays piano with a custom interface that modifies the acoustic behaviour of the piano: a small wooden board with strings and pick-ups connected to a small amplifier, placed inside the piano.

Rooted in free improvisation practice, this performance explores the intersection of acoustic instruments and interfaced objects. It features saxophone, cello and a piano with a custom-built interface called *Plank*. *Plank* is a small wooden board with strings and pick-ups connected to a small amplifier placed inside the piano; it modifies the acoustic behaviour of the piano, while allowing for a "parasitical" relationship with it. *Plank* retains enough guitar-like characteristics to perform feedback and preparation functions, but it is more ergonomic and has a characteristic sonority related to its wooden solid body. It is a simplified guitar, which attempts to optimise contact points between its own strings and the piano's string surface. In addition to conventional electric guitar behaviour the *Plank* has a built-in x-OSC, a wireless I/O board with on board gyroscope, accelerometer and magnetometer, mostly used to detect the position of the board in relation to the piano and affect live processing accordingly. *Interfacing Fragility* explores the practice of free improvisation between the three players who will also use improvisation strategies to perform a graphic score by Pedro Rebelo, entitled "Trio".

LINKS TO AUDIO EXCERPT 1 & AUDIO EXCERPT 2

FuXi

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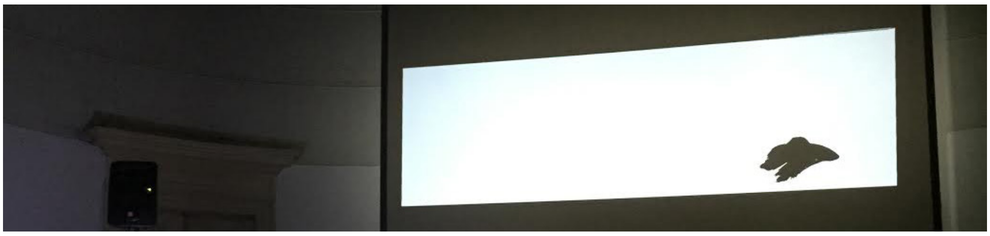
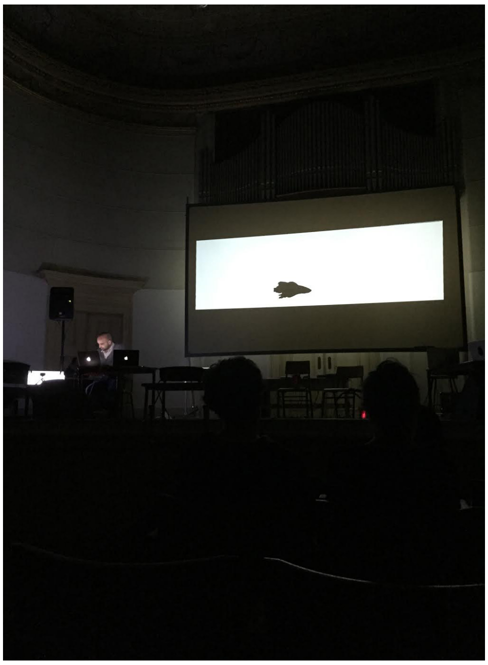


ABSTRACT

The position of a fish in a fish tank is used as performative input. The fish's unexpected (but somehow predictable) movements provide a challenging stimulus to the performer. A camera is used to track the fish's behaviour. The image is also projected on the screen, combined with graphics influenced by the fish's behaviour.

This performance presents an audiovisual world inhabited by a fish. The world is created with a system named *FuXi*, after the culture hero in Chinese mythology credited for the invention of fishing and repopulation of humanity. The system combines an aquarium with a fish, a computer vision module for tracking the fish' movements, a visual display of the fish's image juxtaposed with graphical elements, a sound generation module and a set of hardware devices for controlling the system. By synchronising different visual elements (backgrounds, living creatures, man-made objects) to corresponding sounds, the performer defines the world in which the fish is immersed, gradually generating a fantastic audiovisual narrative in which the fish plays a leading role.

LINKS TO VIDEO & EXTENDED TEXT

PUSHPULL – BALGEREI

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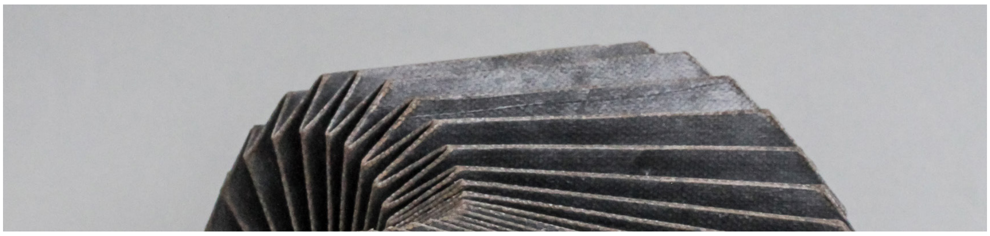
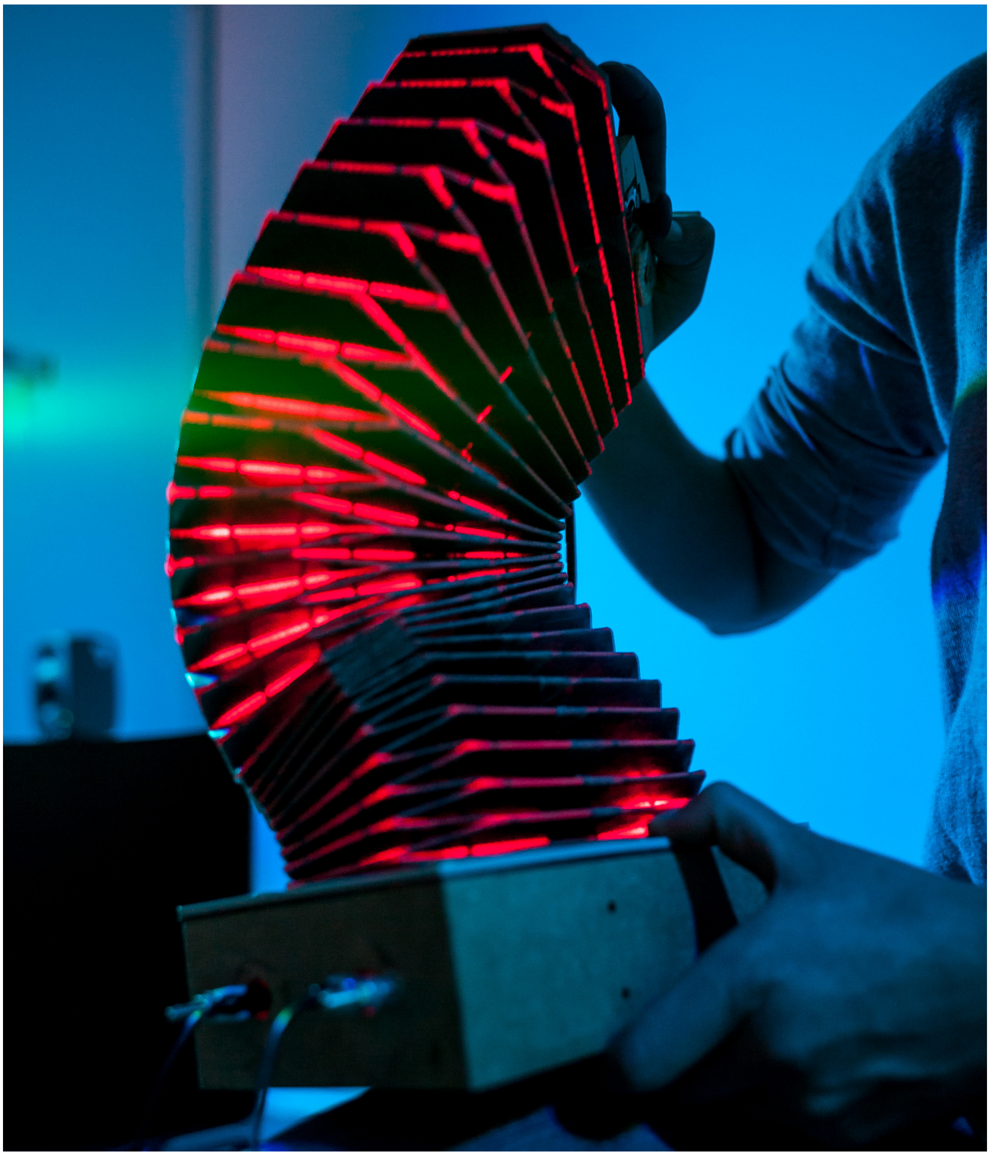


ABSTRACT

Balgerei is a performance piece for three PushPulls. The central control element of the PushPull instrument is a bellow combining inertial sensor data with mechano-analog sound input and digital synthesis. During the performance, the trio combines chaotic musical elements and rhythmic patterns whilst shifting between audio feedback and harmonic structures.

PushPull is a new musical instrument developed by 3DMIN. Drawing inspiration from such traditional instruments as the blacksmith's bellow and the accordion for its exterior appearance, PushPull aims to trigger the imagination and engagement of both the musician and audience. As a tangible object, PushPull encourages a physical relation to its sonic character, allowing players to establish their own movement patterns as they work with the instrument. PushPull's central element is a bellow combining inertial sensor data with mechano-analog sound capturing and digital synthesis. Moving the hand piece generates air flow captured by two microphones within the bellow. Movements, however, are limited by the construction, turning into flowing gestures. The combination of inertial sensors and a thumb stick built into the hand piece allow for continuous sound shaping. Four buttons complete the setup to trigger the switching of sounds between synthesis engines. During the performance, the trio combines chaotic musical elements and rhythmic patterns whilst shifting between audio feedback and harmonic structures.

LINKS TO VIDEO & EXTENDED TEXT



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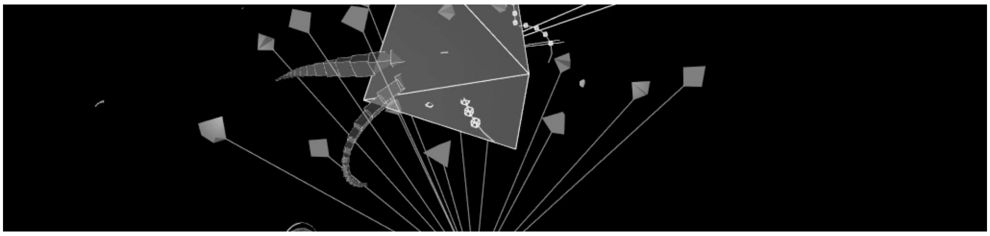
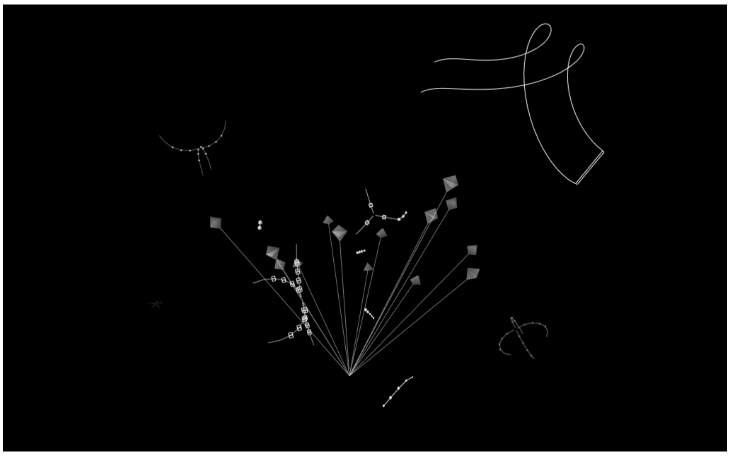


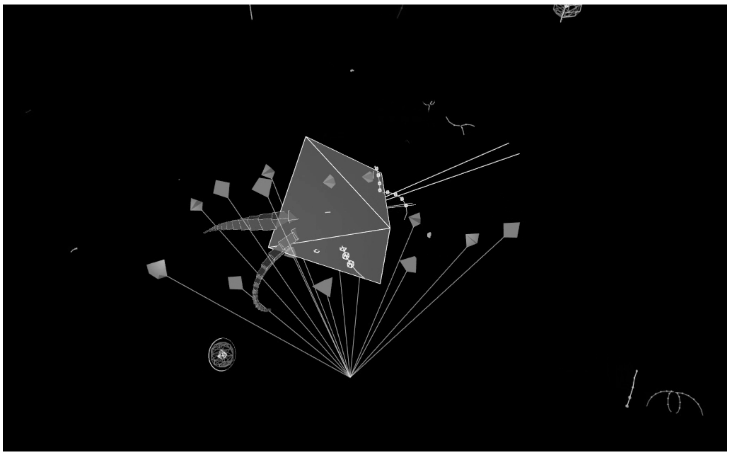
ABSTRACT

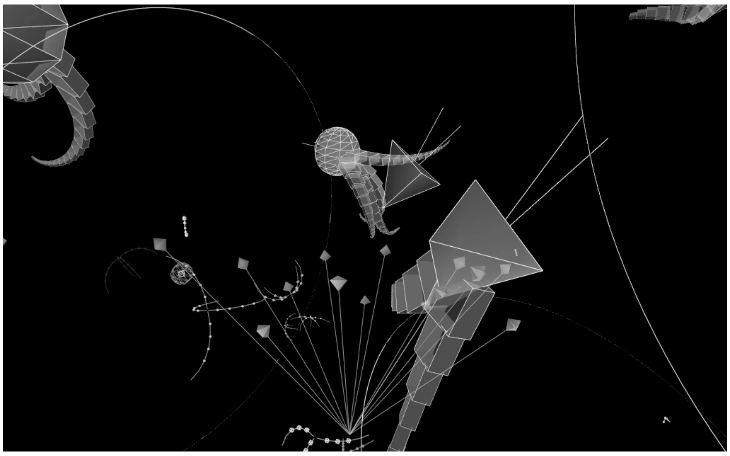
Audio-visual performance with real-time representation of brain data (EEG). The interface uses a virtual physics engine (made with Max/MSP) to process EEG signal.

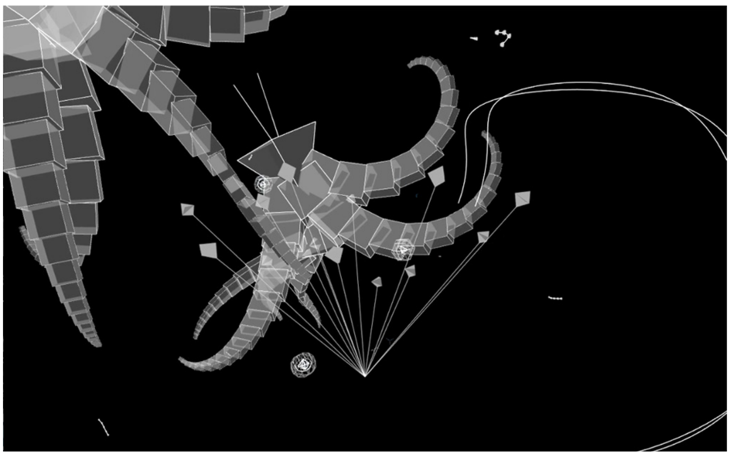
EshoFuni@TheAbyss is an audio-visual performance that presents a metaphor of the brain's phenomena, fed by brain data (EEG) which is collected with a brain-computer interface (BCI) worn by a performer. The system uses a virtual physics engine made with Max/MSP to process the EEG signal. It implements an ecosystem inhabited by entities with graphic and sonic forms, as well as by the performer's avatar. The entities have their own independent and interactive life. The performers' brain processes – generated and conditioned within this ecosystem – are denoted by real-time and longitudinal statistics (e.g., real-time retrieving iterated with analysis, segregation and cumulation), filtering (band and multiple order) and fast transforms (FFT). Different entities are connected with different clusters of the brain metaphor. Evolution happens when distinct clusters of the brain are triggered by events that happen in the ecosystem. When specific spectral and oscillation patterns are detected, the system re-codifies colours, forms and sounds.

LINKS TO VIDEO & EXTENDED TEXT









FERMATA

THOR MAGNUSSON
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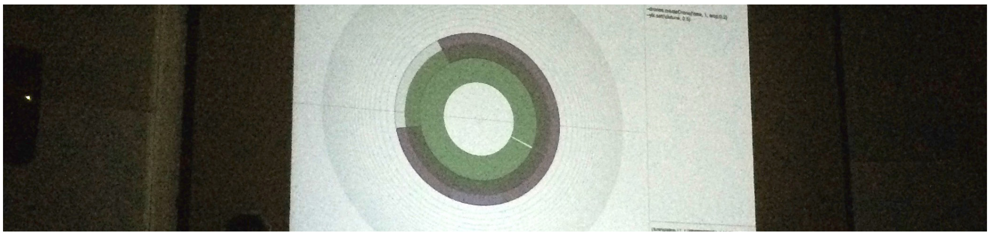
MIGUEL MIRA
Musician
Lisbon

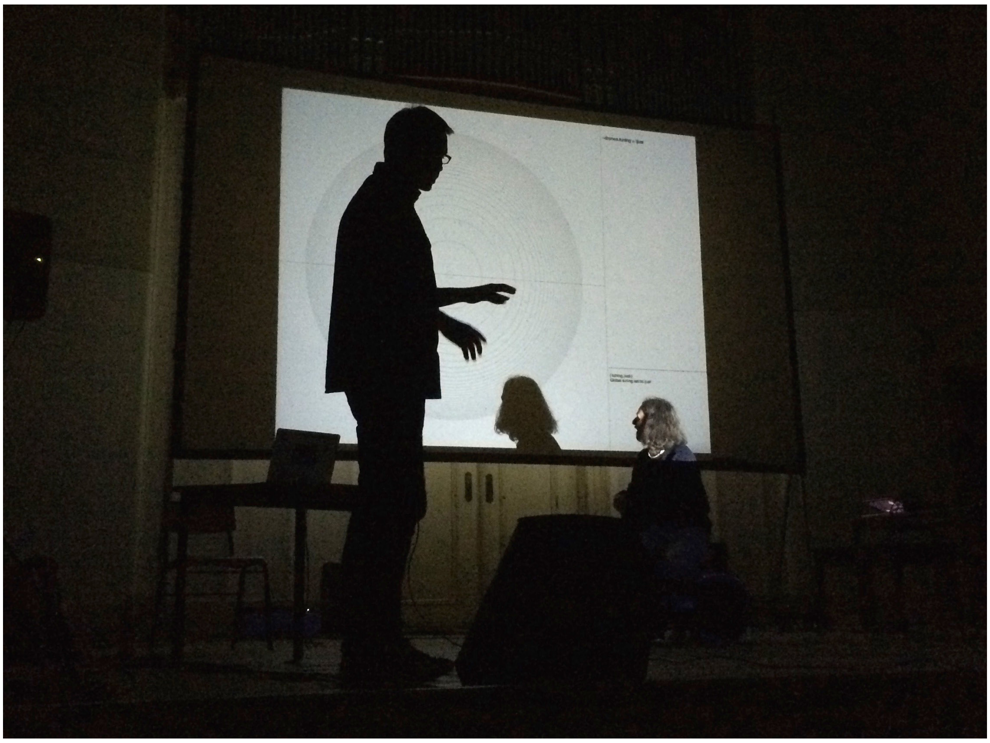


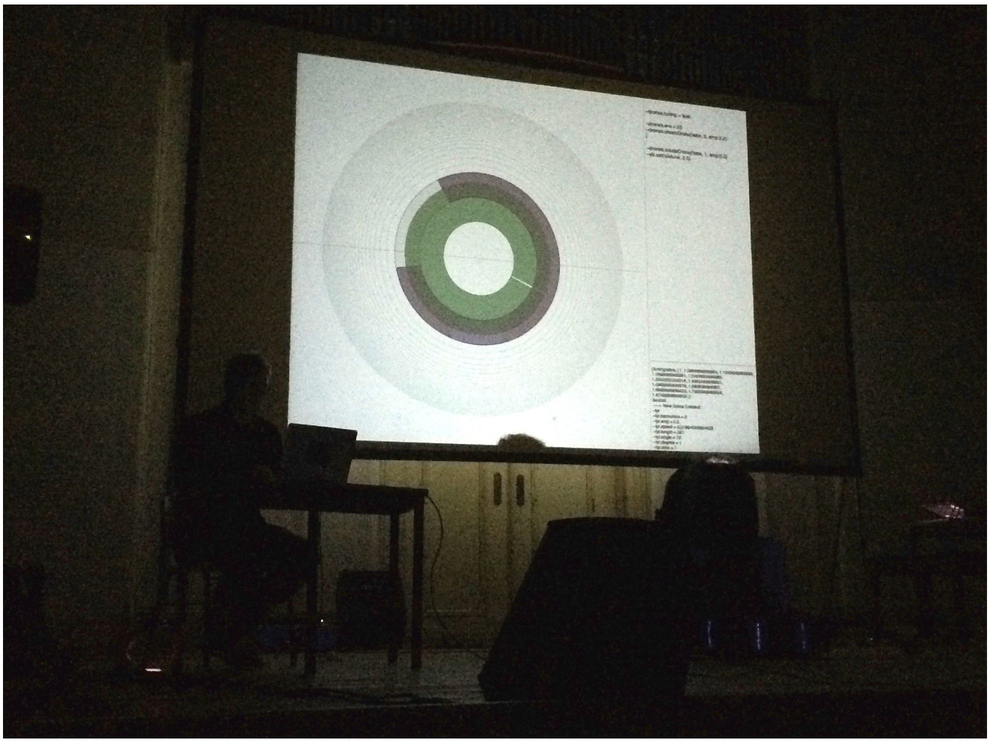
ABSTRACT

This audiovisual performance is a collaboration between Thor Magnusson (Threnoscope) and Miguel Mira (cello). The Threnoscope system scores and visualizes harmonic relationships between extended notes, which can be spatialised in multichannel sound. The kaleidoscopic textures of Miguel's cello are an ideal accompaniment to the non-percussive and moving sonic landscapes.

Fermata is a performance by Thor Magnusson, with his *Threnoscope*, and Miguel Mira, on the cello. The *Threnoscope* is an audiovisual compositional system focusing on drones, microtonality and spatial sound. It has a strong capacity for microtonal composition by implementing support for the Huygens-Fokker Scala format, accompanying over 4000 microtonal scales and tunings. It serves as a representational notation, visualising harmonic relationships between drones as well as spatialisation through multichannel audio. Its performance involves live coding, live mapping of controllers, interacting through the graphical user interface, and creating virtual agents that engage with the performance process. The acoustic qualities of Miguel's cello intertwine with the digital sounds, emphasising stasis or circularity.

LINKS TO VIDEO 1, VIDEO 2 & EXTENDED TEXT





AA SOUNDSYSTEM

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ABSTRACT

Atau performs with the BioMuse, which captures neuron impulses resulting from muscle tension (EMG), allowing the musician to sculpt sound synthesis through concentrated movement. Adam performs using a single-board computer, distilling the laptop to a single circuit board, working bass heavy grooves from Pure Data patches.

Adam & Atau bring a gestural physicality to their duo collaborations. In this incarnation, Atau performs using the BioMuse, which places gel electrodes on the performer's forearms, analyzing EMG biosignals. This system captures physiological neuron impulses resulting from muscle tension, allowing the musician to sculpt sound synthesis through concentrated movement. Adam performs using a single-board computer, distilling the 'laptop instrument' to a single circuit board with neither screen nor keyboard, working bass heavy grooves from stuttering Pure Data patches. Atau and Adam connect the abstract and the sensual, as glitched shards of pop collide with fragmented drums, creating a music that is utterly digital and yet anchored to the human body.

LINKS TO VIDEO 1 & VIDEO 2

STREAM DYE

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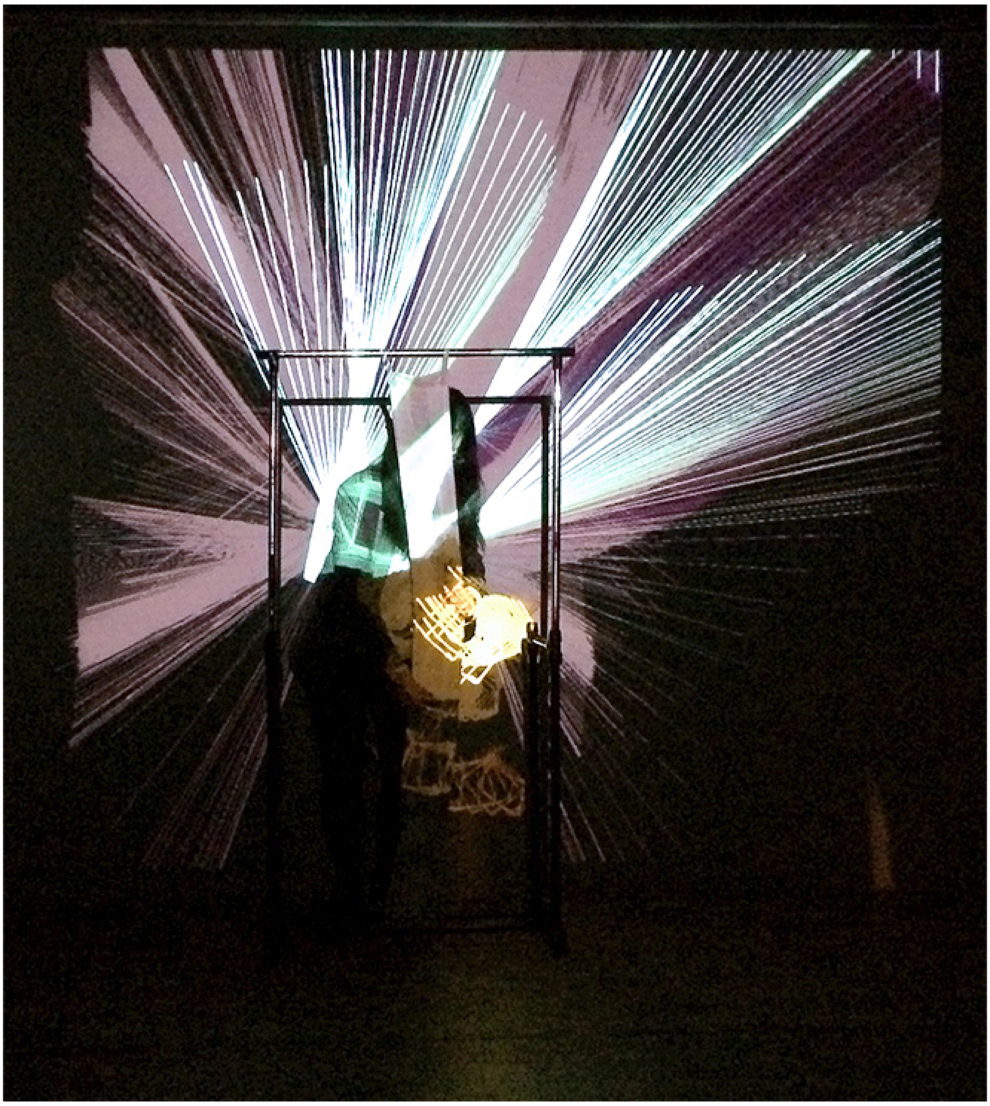
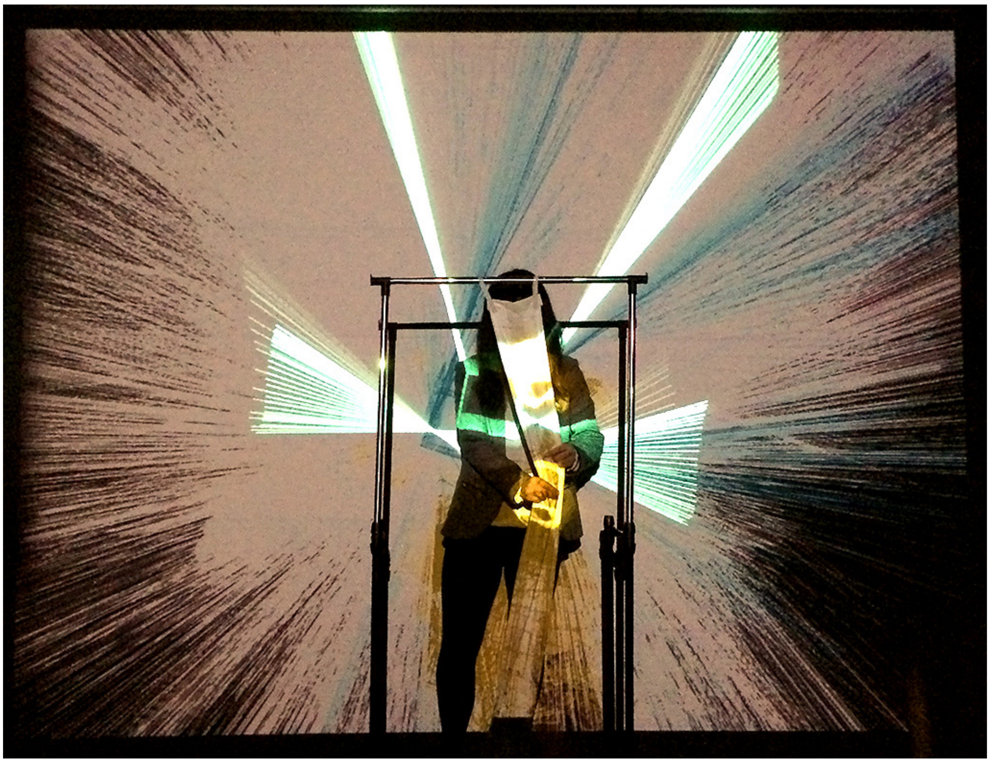
ABSTRACT

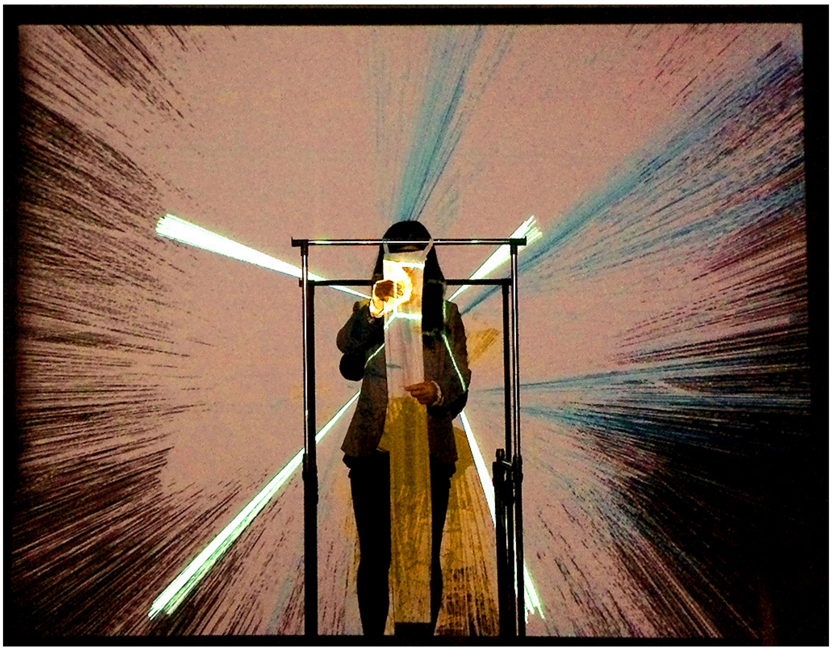
Frances plays a textile interface called Fluiiid, which collects data through 3D positional tracking, and processes the data to control sound and motion graphics. Videomapping enables the visuals to appear at the exact position where the gestures are performed.

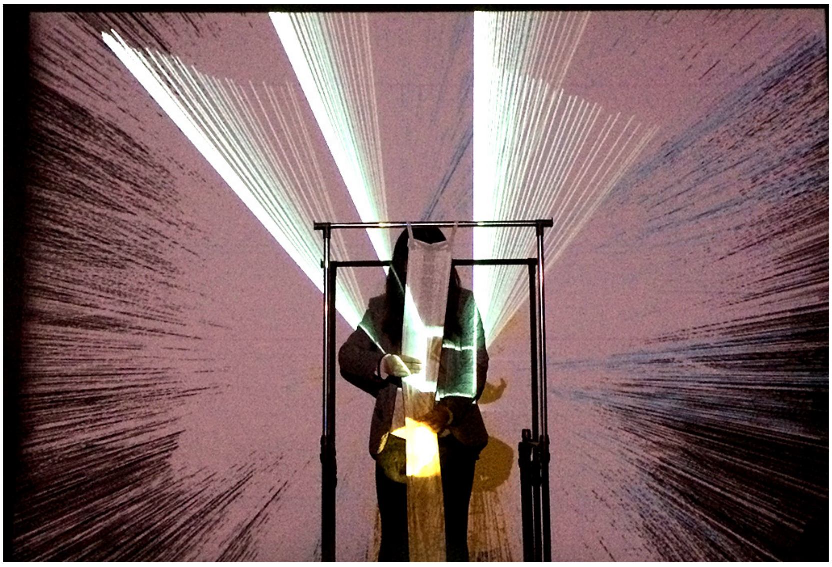
This performance is centred on a textile interface, *Fluiiid*, which aims at intuitive interaction. Its conductive fabric provides a set of twenty-four capacitive touch sensors. Conductive threads are used to connect the sensors to the main circuit board. A motion-tracking device collects the quaternion data. The raw data is collected through a micro-controller, Arduino, and then translated into positional information. The performer improvises with synthesized sound as well as pre-recorded samples. By moving her hands along the interface body while pulling the fabric in different directions, she manipulates sound effects and visuals in Max, Ableton Live, and Processing. The visuals are videomapped to where the gestures are performed on the interface body.

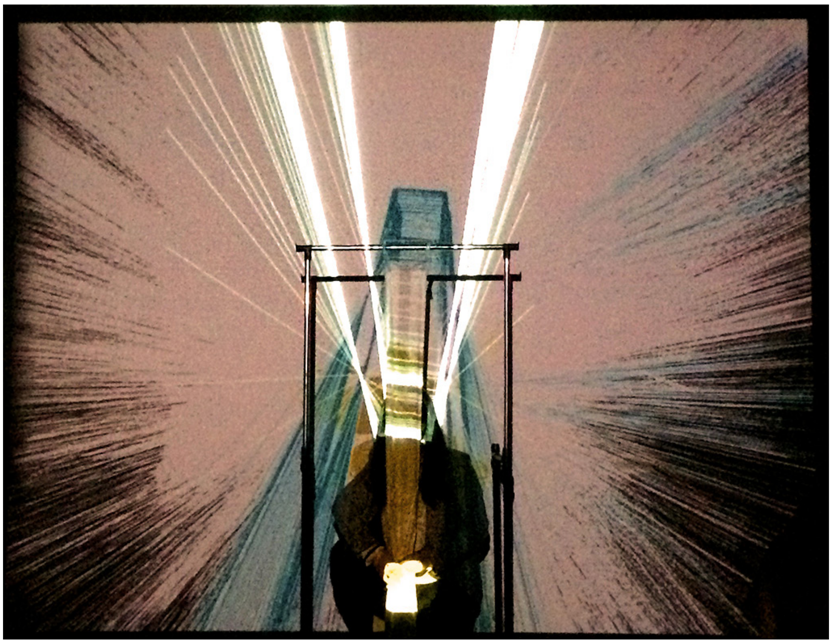
LINKS TO VIDEO & EXTENDED TEXT











INTERSECTION

MARKO CICILIANI
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and Acoustics, University of Music
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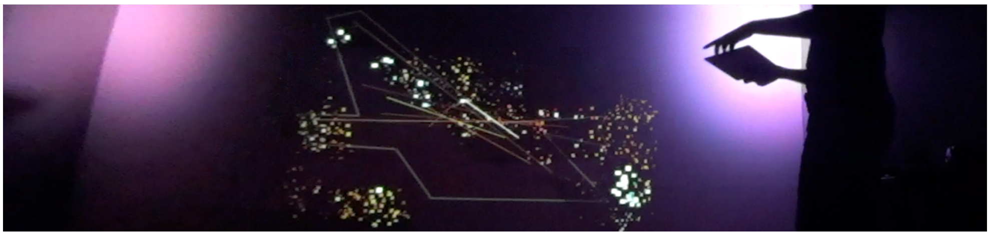
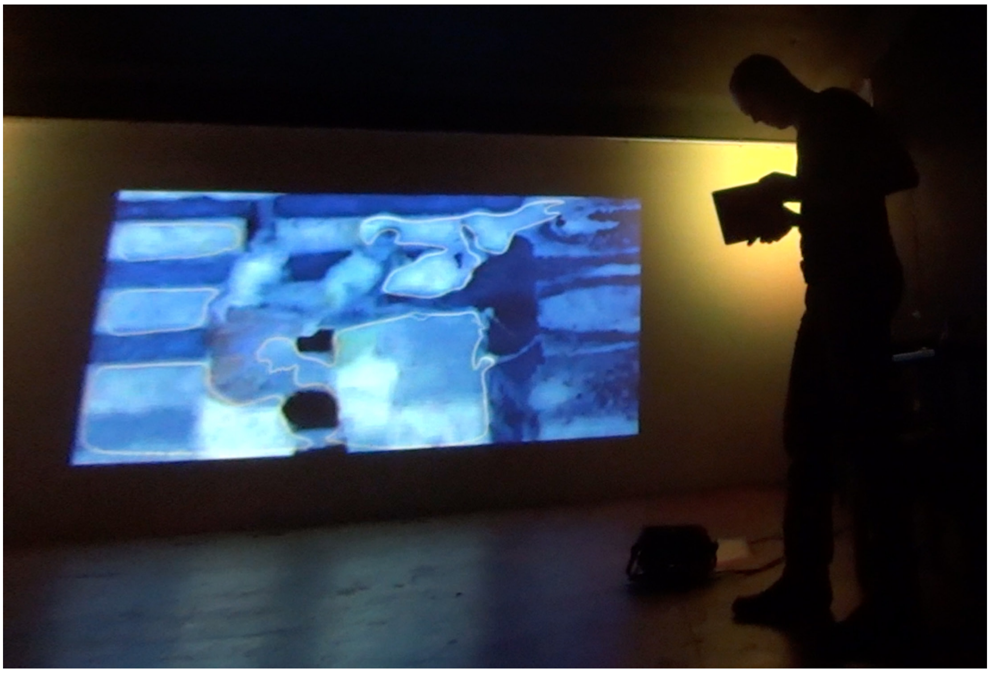


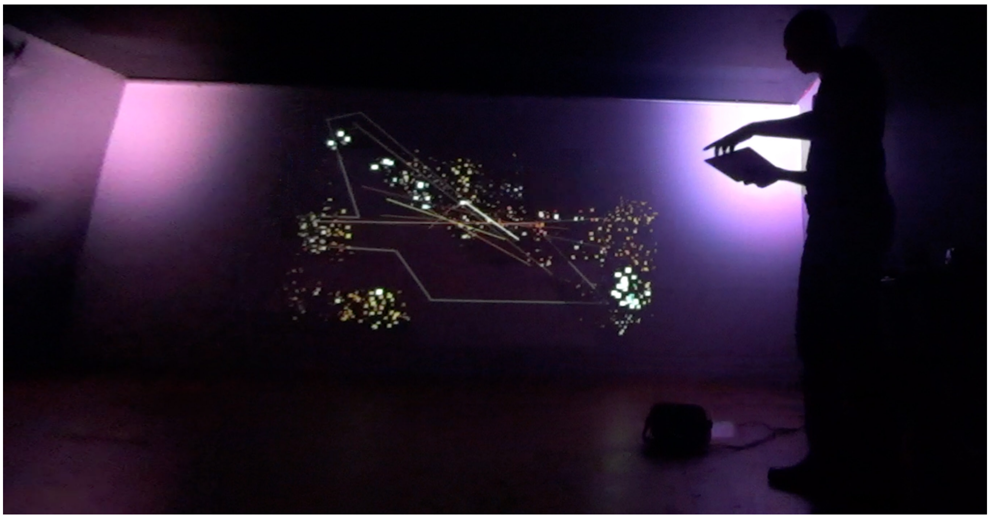
ABSTRACT

An audio-visual performance with two juxtaposed images of people in transit. The video source material was captured in Zurich, with the camera placed in the exact same position. Marko uses a tablet to affect both the visual and the auditory aspects of the work, creating new dynamics with rapid chromatic inversions and light fixtures.

This performance involves sound and image processing as well as audio synthesis. The performer is on stage, controlling sound and visuals with a wireless tablet. The visual source material consists of two video recordings from people in transit; as pedestrians, on bicycles, in cars or public transportation. Image processing is made with OpenFrameworks and OpenCV. An audio recording of police radio transmissions serves as a basis for waveset granulation. SuperCollider is used for additive synthesis and waveset granulation. At the core of the program lies a pattern-generator, which affects sound and image. All rhythmic changes happen according to the pattern-generator, but often not in synchrony with each other.

LINKS TO VIDEO 1, VIDEO 2 & EXTENDED TEXT





INFLORESCENCE

CHRIS KIEFER
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ABSTRACT

A live-coding performance with a plant-like interface consisting of motion sensing wire stalks, which Chris manipulates to control code and sound. This work explores a dissonance in live-coding: code is a flexible medium to express musical ideas and structures, yet the conventional means of writing code tend to be very inexpressive.

Inflorescence is a live-coding performance, in which Chris Kiefer writes code using a plant-like multiparametric controller as well as a keyboard and touchpad. A live coder can engage directly with a sound synthesis engine, free from the confines of predetermined mappings and patterns. While code gives the musician this expressive power, the physical act of programming with a keyboard interface is far from how a musician would typically interact with a musical instrument. The coder moves between time constraints rather than being bound to the moment. There is a dissonance: code gives flexibility and power, but the conventional means of writing code can be very inexpressive, both in terms of how the musician interacts with the computer, and from an audience perspective. Inflorescence faces this dissonance as creative material.

LINKS TO VIDEO & EXTENDED TEXT

KESSEL RUN

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RYAN SMITH
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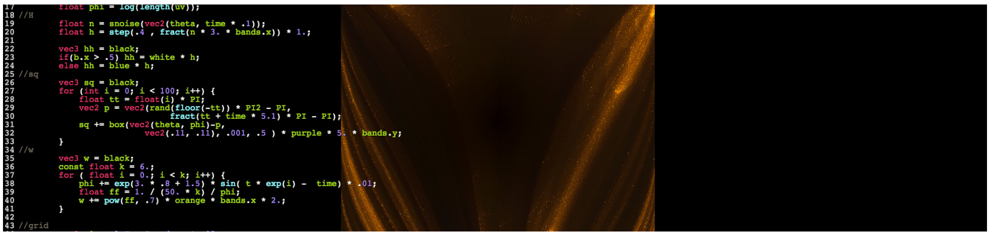
ryanrosssmith@gmail.com

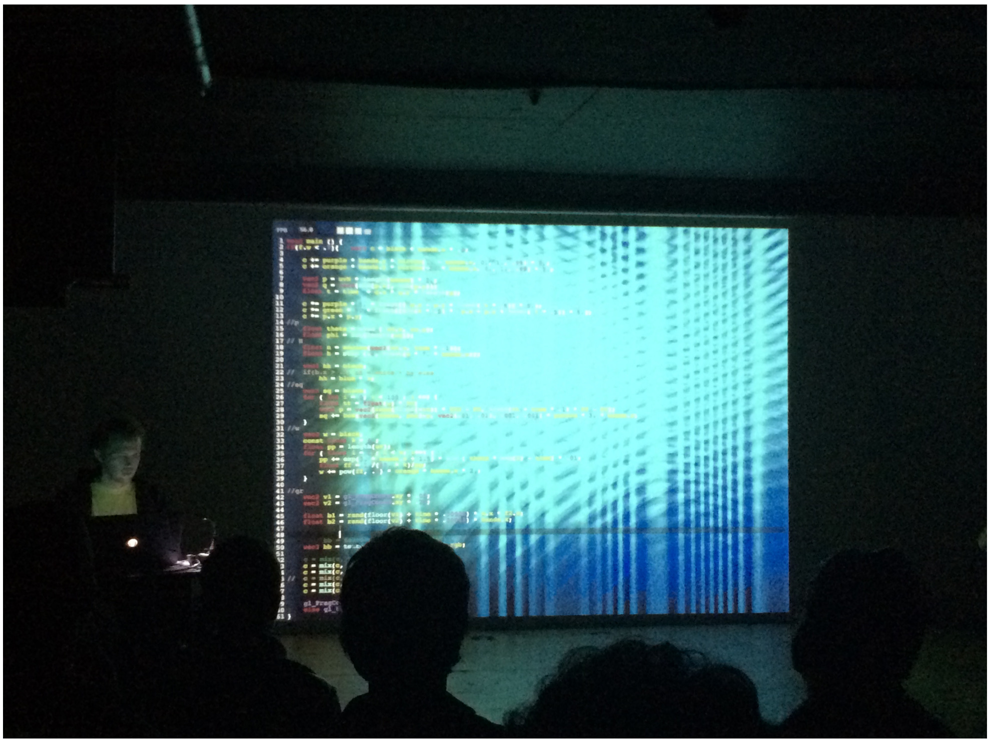


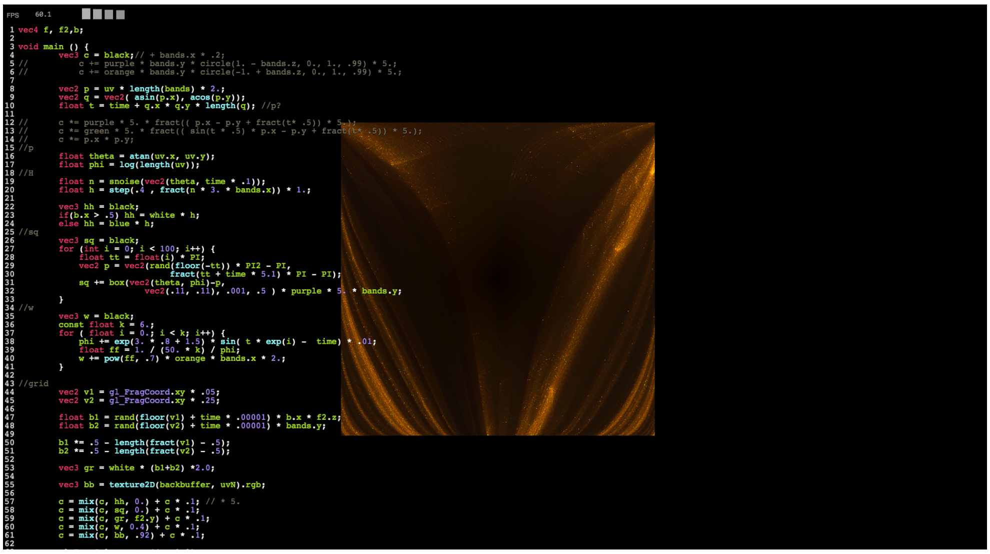
ABSTRACT

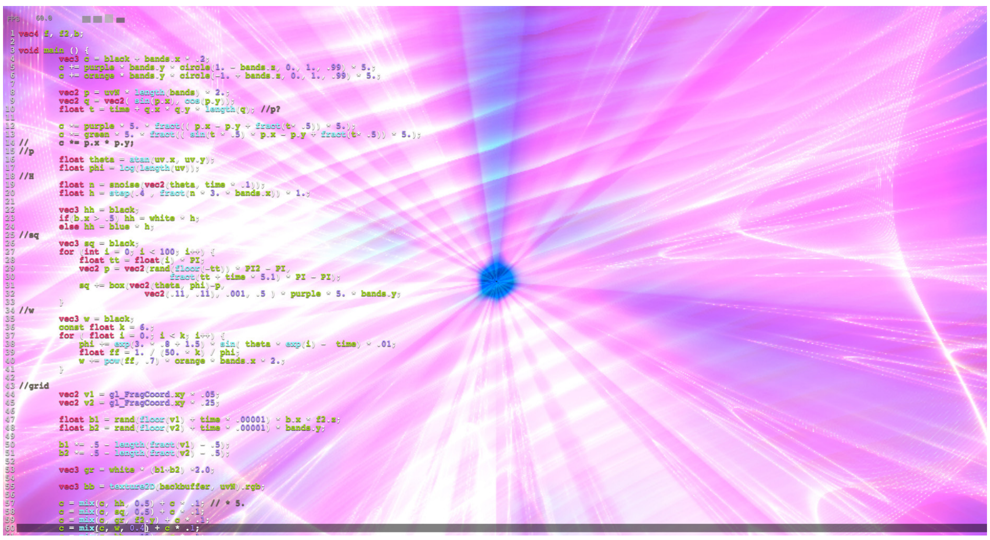
A live-coding performance where the generative coding is integrated into the visuals. Shawn and Ryan's thought processes are on display: their successes, struggles, and failures substantiate in the intertwining of signal and logic.

Kessel Run is a live-coding performance where the graphics are created in Google Chrome using OpenGL fragment shaders. The code is automatically compiled after 200ms have lapsed with no key or mouse input. If the shader compiles successfully it is automatically swapped onto the graphics card and used to draw the window's framebuffer. If the shader does not compile, error lines will appear showing where to check for problems. The audio is produced in a combination of Ableton Live and Max/MSP. It mostly consists of an on-the-fly assemblage of previously defined sonic elements, which were created using a diverse collection of homegrown software and hardware. The integration of Open Sound Control and FFT allows for both performers to exert control over timing, while responding to accident and glitch.

LINKS TO VIDEO 1, VIDEO 2 & EXTENDED TEXT

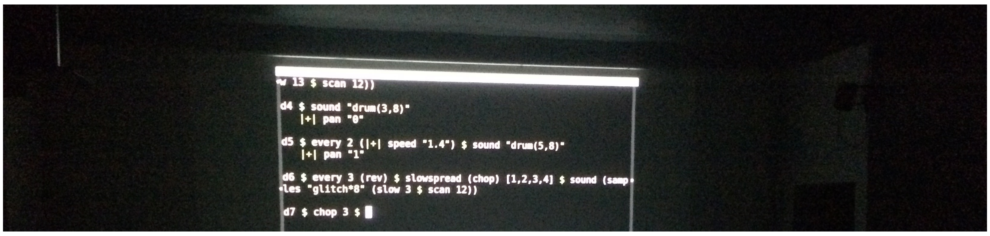



FPS 60.1
vec4 f, f2,b;
void main () {
vec3 c = black;// + bands.x * .2;
// c += purple * bands.y * circle(1. - bands.z, 0., 1., .99) * 5.;
// c += orange * bands.y * circle(-1. + bands.z, 0., 1., .99) * 5.;
vec2 p = uv * length(bands) * 2.;
vec2 q = vec2(asin(p.x), acos(p.y));
float t = time + q.x * q.y * length(q); //p?
// c *= purple * 5. * fract((p.x - p.y + fract(t* .5)) * 5.);
// c *= green * 5. * fract((sin(t * .5) * p.x - p.y + fract(t* .5)) * 5.);
// c *= p.x * p.y;
//p
float theta = atan(uv.x, uv.y);
float phi = log(length(uv));
//H
float n = snoise(vec2(theta, time * .1));
float h = step(.4 , fract(n * 3. * bands.x)) * 1.;
vec3 hh = black;
if(b.x > .5) hh = white * h;
else hh = blue * h;
//sq
vec3 sq = black;
for (int i = 0; i < 100; i++) {
float tt = float(i) * PI;
vec2 p = vec2(rand(floor(-tt)) * PI2 - PI,
fract(tt + time * 5.1) * PI - PI);
sq += box(vec2(theta, phi)-p,
vec2(.11, .11), .001, .5) * purple * 5. * bands.y;
}
//w
vec3 w = black;
const float k = 6.;
for (float i = 0.; i < k; i++) {
phi += exp(3. * .8 + 1.5) * sin(t * exp(i) - time) * .01;
float ff = 1. / (50. * k) / phi;
w += pow(ff, .7) * orange * bands.x * 2.;
}
//grid
vec2 v1 = gl_FragCoord.xy * .05;
vec2 v2 = gl_FragCoord.xy * .25;
float b1 = rand(floor(v1) + time * .00001) * b.x * f2.z;
float b2 = rand(floor(v2) + time * .00001) * bands.y;
b1 *= .5 - length(fract(v1) - .5);
b2 *= .5 - length(fract(v2) - .5);
vec3 gr = white * (b1+b2) *2.0;
vec3 bb = texture2D(backbuffer, uvN).rgb;
c = mix(c, hh, 0.) + c * .1; // * 5.
c = mix(c, sq, 0.) + c * .1;
c = mix(c, gr, f2.y) + c * .1;
c = mix(c, w, 0.4) + c * .1;
c = mix(c, bb, .92) + c * .1;



LAUNDERETTE

YAXU (ALEX MCLEAN)
ICSRiM, University of Leeds
alex@slab.org

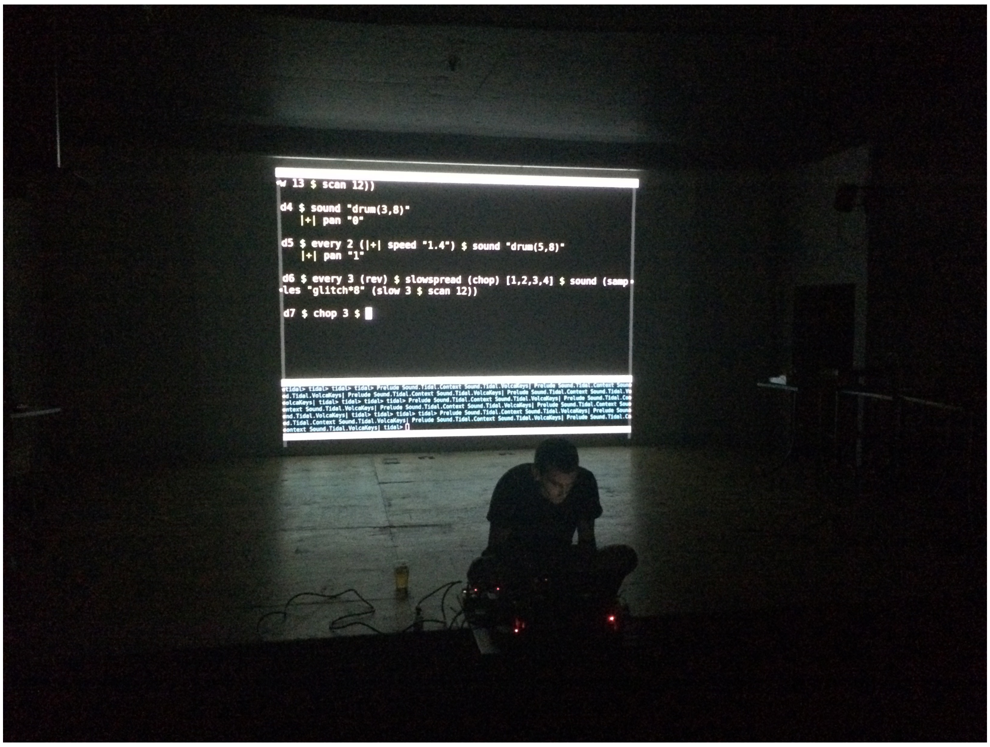


ABSTRACT

Yaxu (Alex McLean) works with the innards of software to generate live "algorave" beats from code, projecting his screen so audience members can see how the music is made, while dancing to it. Alex is co-founder of the algorave movement, a portmanteau of "algorithm" and "rave", reclaiming computer languages from industrial productivity, and sharing it for useless communal pleasure.

Yaxu (Alex McLean) performs solo with Tidal, a mini-language for improvising with (mostly musical) pattern, which was originally created by him. The performance is fully improvised, an approach known in the live coding community as 'blank slate' performance, where the code begins and ends with nothing. Tidal is free/open source software and is available to download from *http://tidal.lurk.org/* Musical patterns improvised during the performance will be saved to be fed into Peak Cut EP, his upcoming release on the Sheffield label Computer Club.

LINKS TO VIDEO 1 & VIDEO 2


w 13 $ scan 12))
d4 $ sound "drum(3,8)"
|+| pan "0"
d5 $ every 2 (|+| speed "1.4") $ sound "drum(5,8)"
|+| pan "1"
d6 $ every 3 (rev) $ slowspread (chop) [1,2,3,4] $ sound (samp-
-les "glitch*8" (slow 3 $ scan 12))
d7 $ chop 3 $

FIELDS

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TIM SHAW
Culture Lab, Newcastle University
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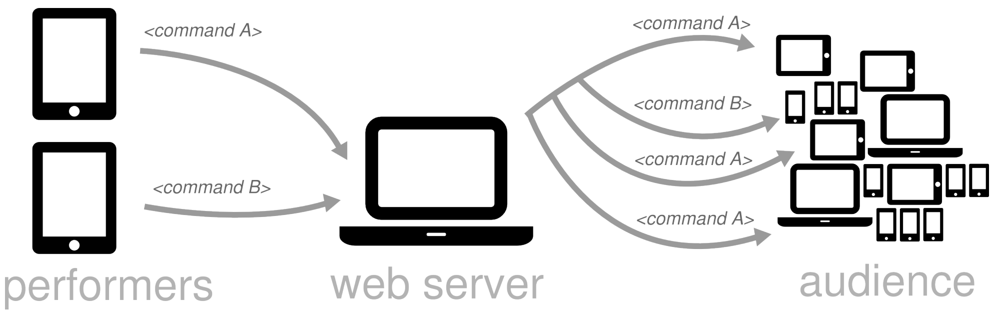
ABSTRACT

Sébastien and Tim explore mobile technology as a medium for sound diffusion. Audience members can join in by simply connecting to a specific website with their mobile phone, laptop or tablet. The connected devices become an array of speakers that the performers can control live, resulting in an omni-directional sonic experience.

Fields is an exploration into the use of mobile technology as a medium for live sound diffusion. It is presented simultaneously as both a digital system and bespoke composition. Audience members can join in at any time by simply connecting to a specially designed website with their mobile phone, laptop or tablet. The connected devices become an array of speakers that the performers can control live, resulting in an omni-directional sonic experience. Fields is an attempt to show the potential for technologically supported communal listening experiences through the exploration of new aural contexts opening up new possible paradigms within musical performance and sound diffusion.

LINKS TO VIDEO & EXTENDED TEXT


<command A>
<command B>
<command A>
<command B>
<command A>
<command A>
performers
web server
audience

BETAV09 – AUDIENCE INTERACTION / PERFORMER REACTION

LEON MCCARTHY
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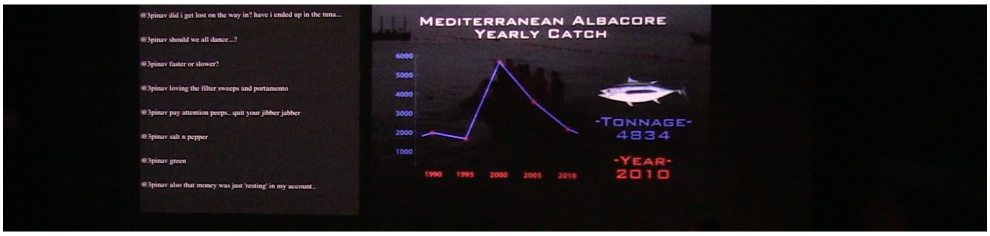


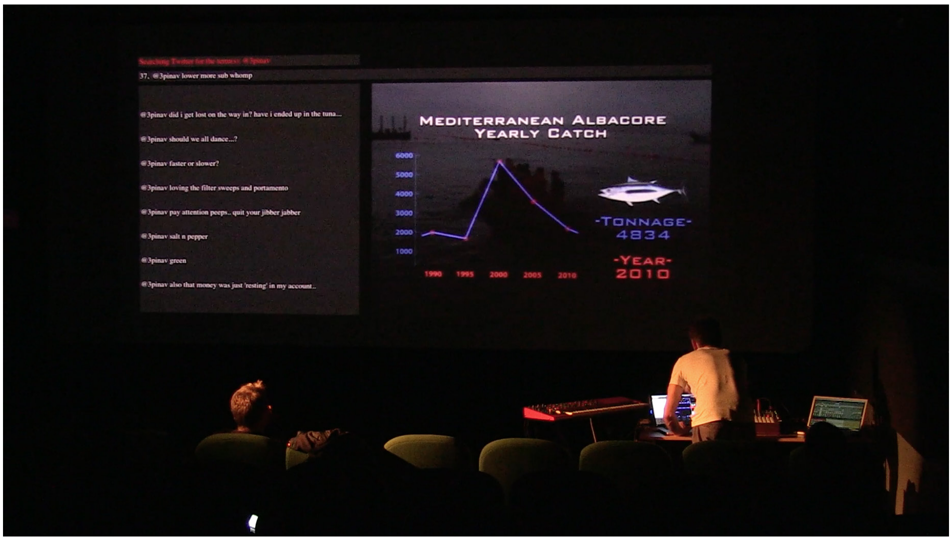
ABSTRACT

Leon presents an audio-visual performance during which the audience will use twitter to post comments that appear alongside his projections. While tweeting, it could be said that focus shifts between watching & writing. Through the dynamics of his performance and the 'latencies' that arise from looping audio-visuals, can Leon play a game of cat-and-mouse, shifting focus between his screen and theirs?

This performance could be described as a form of live documentary in which the topic of sustainable-fishing is presented. The audience is encouraged to converse 'virtually' by tweeting from their smartphones, hopefully to post their thoughts on the topic. An application built on the Twitter API incorporates tweets with the projected visuals. Leon is investigating whether he, the performer, can guide audience behaviour via the dynamics of his performance – he will attempt to have the audience focus on the visuals at certain moments and on tweeting during others. Ultimately, will the conversations that emerge lead to a deeper engagement with the topic or will they merely act as a distraction?

LINKS TO VIDEO 1, VIDEO 2 & EXTENDED TEXT


/// I BELIEVE ALL PEOPLE CAN SAY WHAT THEY WANT WHEN THEY WANT
#10 LIFE IS SHORT - TAKE IT EASY
#09 SAY WHAT YOU LIKE EXCEPT TO BE TOLD WHAT YOU DON'T LIKE
#08 LIFE IS SHORT - LOVE THY NEIGHBOUR - ACCEPT DIFFERENCE
#07 I BELIEVE ALL PEOPLE CAN SAY WHAT THEY WANT AND ALL PEOPLE MUST ALSO THEN LISTEN TO AR>>>
POLICE


37. @3pinav lower more sub whomp
@3pinav did i get lost on the way in? have i ended up in the tuna...
@3pinav should we all dance...?
@3pinav faster or slower?
@3pinav loving the filter sweeps and portamento
@3pinav pay attention peeps.. quit your jibber jabber
@3pinav salt n pepper
@3pinav green
@3pinav also that money was just 'resting' in my account..
MEDITERRANEAN ALBACORE
YEARLY CATCH
6000
5000
4000
3000
2000
1000
1990
1995
2000
2005
2010
-TONNAGE-
4834
-YEAR-
2010

SOFT REVOLVERS

MYRIAM BLEAU
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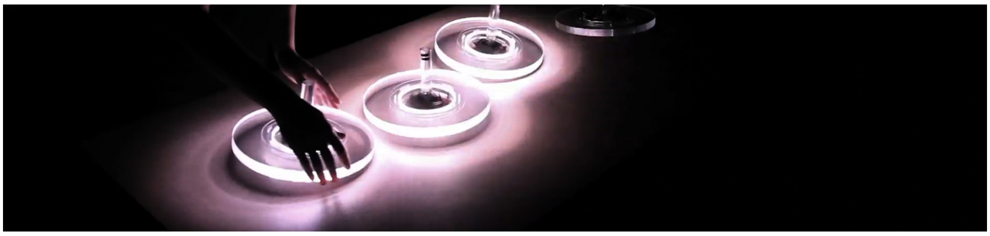

ABSTRACT

Myriam plays 4 spinning tops built with clear acrylic, creating shifting rhythmic soundscapes. The tops are equipped with gyroscopes and accelerometers that communicate wirelessly with a computer, informing Pure Data algorithms. A camera placed above the performance table provides video feed that is manipulated and projected back on the screen.

Soft Revolvers is a music performance for 4 spinning tops built with clear acrylic by the artist. Each spinning top, 10' in diameter, is associated with an 'instrument' or part in an electronic music composition. The tops are equipped with gyroscopes that communicate wirelessly with a computer where the motion data collected (speed, unsteadiness at the end of a spin, acceleration spikes in case of collisions) informs musical algorithms designed in Pure Data. A camera placed above the performance table provides video feed that will be projected back on the screen behind the artist. LEDs placed inside the tops illuminate the body of the objects in a precise counterpoint to the music, the positioning of the lights creating visually stunning halos around the tops.

LINKS TO VIDEO & EXTENDED TEXT

SONIC DRAWINGS

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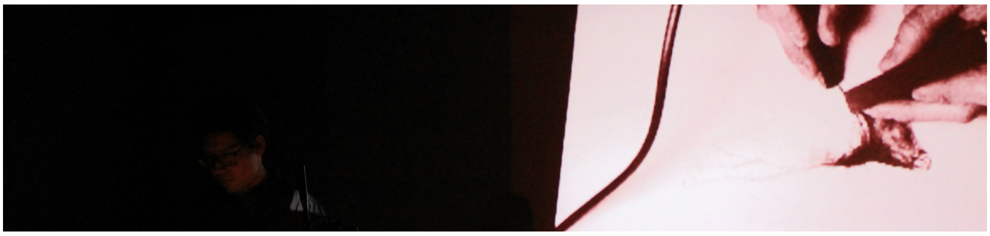
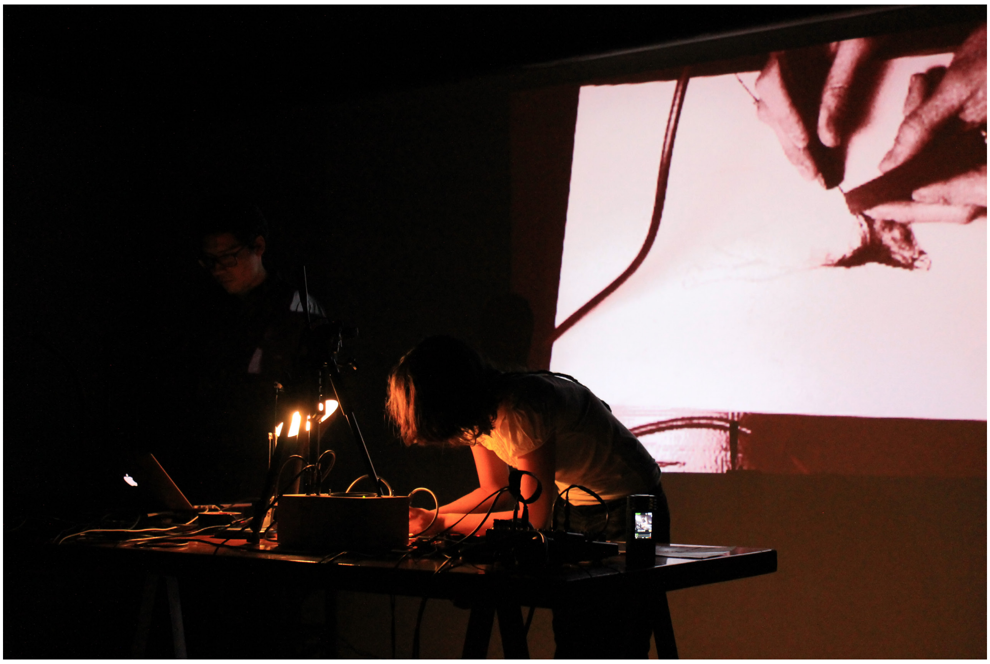


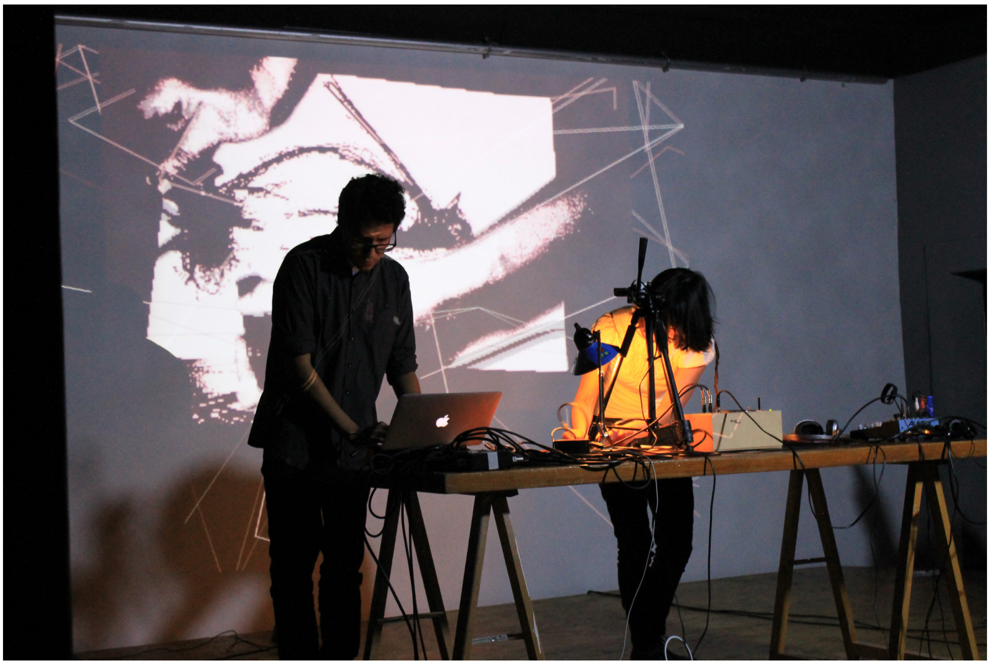
ABSTRACT

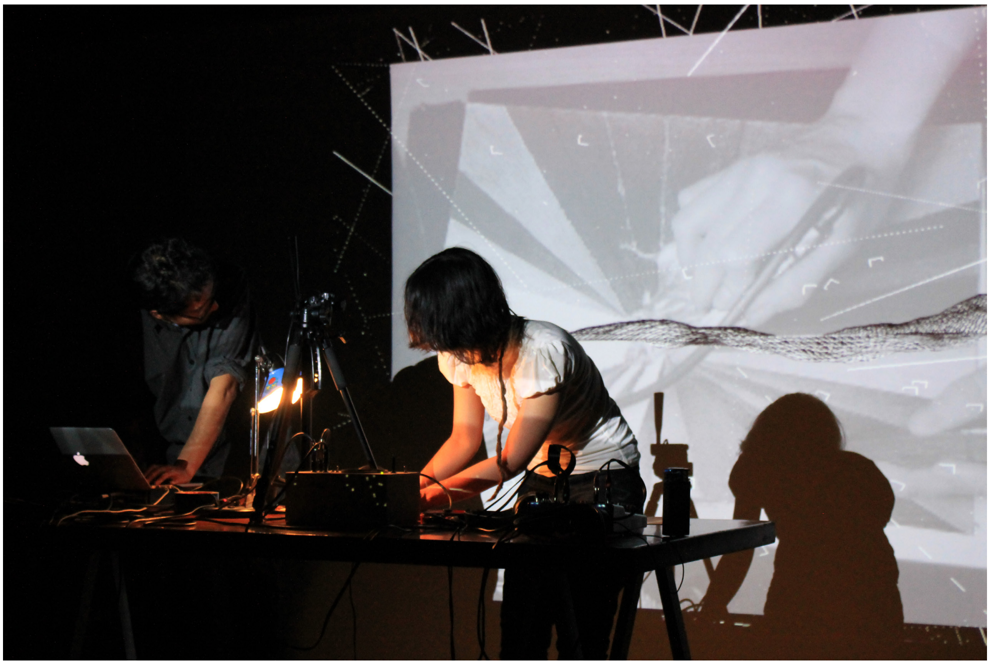
Juan and Ana synthesize sound and image by drawing on a paper with graphite pencils and conductive ink tools. The interface measures conductivity from graphite traces. A camera is used for motion tracking of the performers' hands.

Sonic Drawings is an audio-visual performance with an interface that enables real time sonification of drawings on a paper canvas with graphite pencils and conductive ink circuits. An electronic oscillator circuit measures electrical conductivity through the graphite traces along the canvas, modulating pitch accordingly. The performers' hand position and speed of gesture is tracked through a camera. Image analysis is made with custom-made software. The software generates live visuals, namely particle systems and geometric figures, with content sourced from both the camera and sound inputs. The set-up also includes digital sound modules based on Pure Data patches and other live electronic instruments.

LINKS TO VIDEO & EXTENDED TEXT







GRUNTCOUNT (BASS CLARINET EDITION)

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MARTIN PARKER
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System and Product Design
Faculty of Engineer and Architecture
Ghent University
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ABSTRACT

An improvisation for bass clarinet and computer, in which aspects of timing, flow, duration and effort are controlled by the performer, who negotiates a plotted and nuanced journey through sound processing modules which have been specifically designed around his individual playing style.

Martin Parker's *gruntCount* is a multi-version, configurable composition for improvising musician (or musicians) and computer. Pete Furniss is the musician here. He embarks on a journey through sound processing modules that are specifically customised to his individual playing style. gruntCount exists in no fixed state, yet it allows for a growing set of rehearsable, replicable and configurable pieces, in which all musical material, timing, overall duration and levels of effort are managed by the live musician. gruntCount challenges traditional definitions of 'piece', 'system' and 'instrument', establishing an environment for humanmachine improvisation that serves the musical result and not the system itself. The authors investigate formal time-shaping possibilities within a structured performance, while exploring the environment's qualities of coaction and configurability in an era of new score types.

LINKS TO AUDIO & EXTENDED TEXT

ROOM OF MIRRORS

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WISKA RADKIEWICZ
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soundsonproject@yahoo.com

ABSTRACT

Andrea and Wiska will use audio recordings made throughout the conference to create a collaborative composition, documenting the intensity of this gathering. Living in different countries, they will exchange sounds through the internet and make the resulting piece available online.

Room of Mirrors aims to create a setting where individual perceptions merge in search of collective sensitivity and expression. In the first stage of this project, the authors made audio recordings building a bank of sounds – a kaleidoscopic portrait of the event. The recordings include soundscapes, spoken voice and music; they were made at the installations, exhibitions, paper sessions, performances, workshops, discussions, intermissions, meals, and cityscapes surrounding the conference buildings. The second stage of this project takes place after the conference. The authors use this audio material for a collective composition, in collaboration with several artists involved in the conference. The participants collaborate over the internet, and the composition grows slowly over time.

LINK TO WEBSITE & EXTENDED TEXT

INSTALLATIONS

TRĀṬAKA

ALESSIO CHIERICO
Interface Culture
Kunstuniversität Linz
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ABSTRACT

The visitor is invited to wear a brain-computer interface, and concentrate his attention on a candle flame. The level of attention controls the airflow under the flame; the highest level of attention makes the air flow strong enough to extinguish the flame.

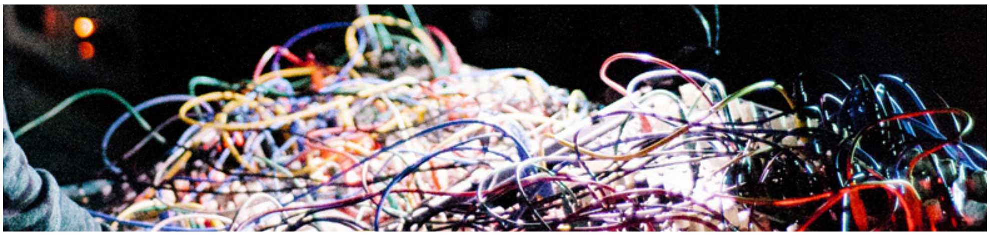
Trāṭaka is a Sanskrit term which means “to look” or “to gaze”. It refers to a meditation technique, in which one focuses attention upon a small object, usually a flame. This technique is used to stimulate a certain point of the brain, the ājňā chakra. In the Hindu tradition, this chakra is one of the six main centres of vital energy. It is considered the eye of intuition and intellect. In this installation, the visitor is invited to wear a brain-computer interface, and concentrate his attention on a candle flame. The level of attention controls an airflow under the flame; the highest level of attention makes the flow become strong enough to extinguish the flame. This work creates a conceptual loop: brain activity related to attention leads to a meditation technique, which in turn is meant to stimulate the chakra responsible for brain activity.

LINKS TO VIDEO & EXTENDED TEXT


mindwave
NeuroSky

DISPLACED ACTS OF (UN)RELATED CAUSALITY

ANDRÉ GONÇALVES
ADDAC System / UCP
ctrl@undotw.org

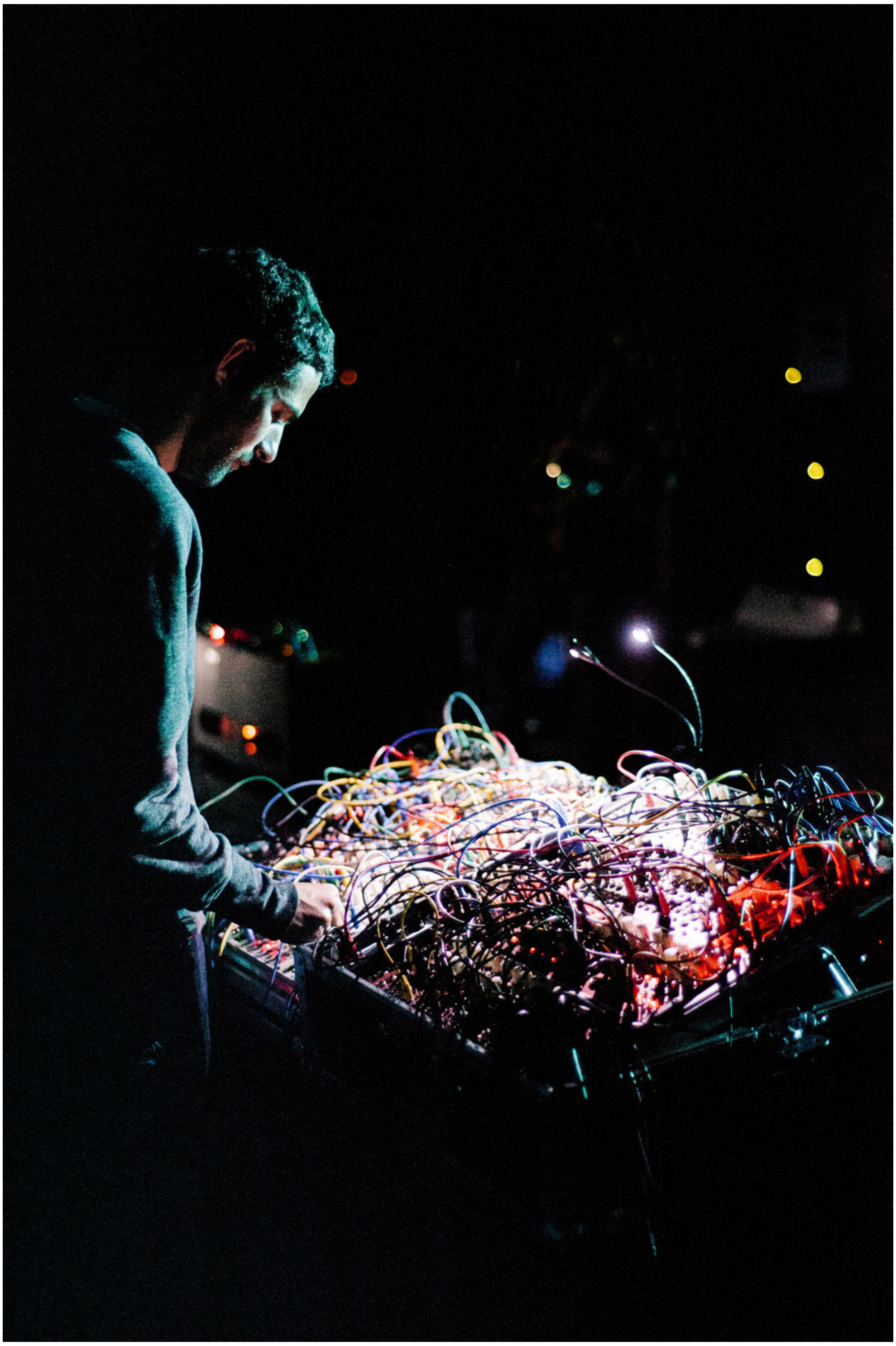


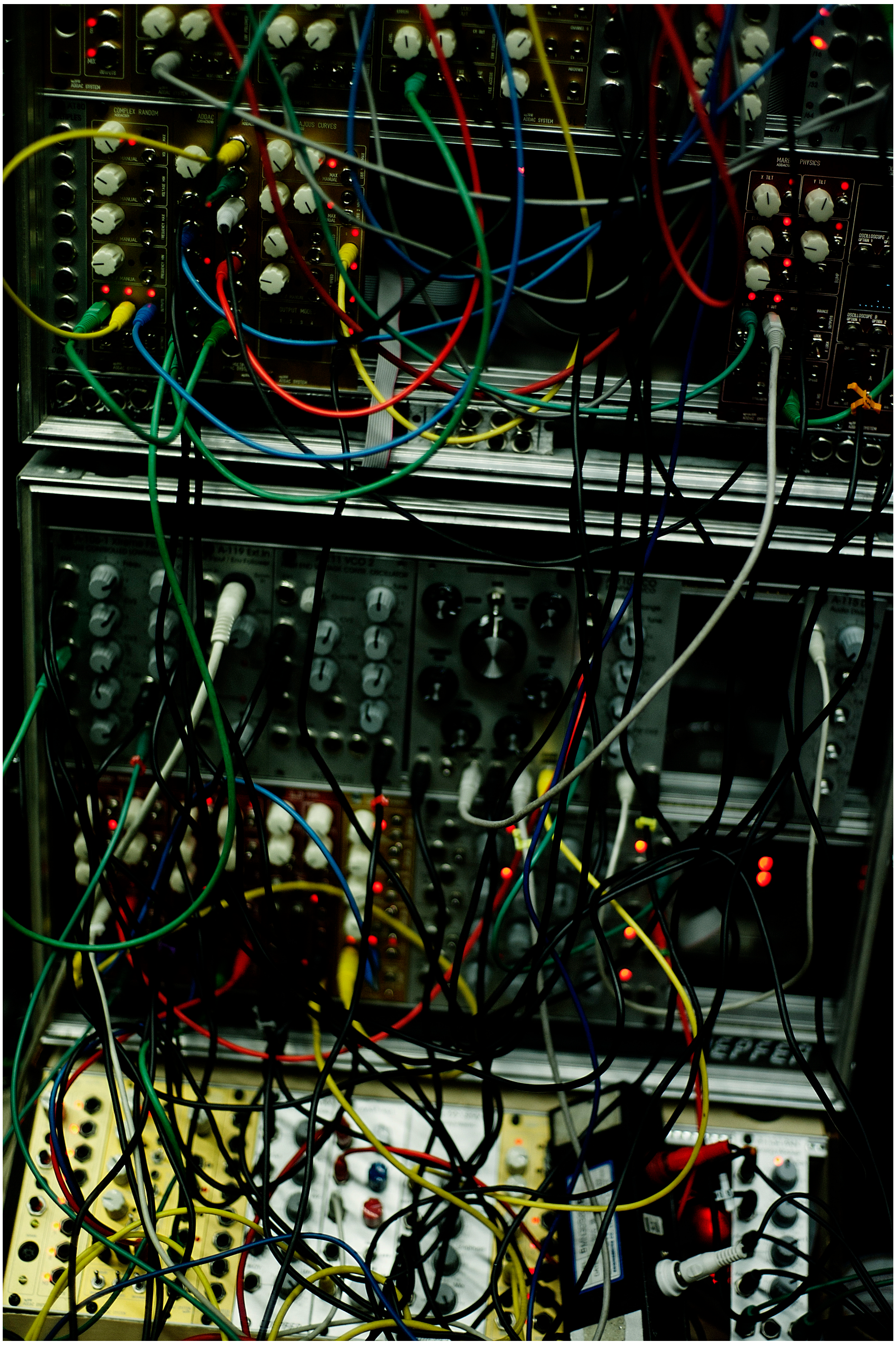
ABSTRACT

This work incorporates and intertwines some of André's best visual and sound explorations transposed to performative and installation contexts. Considering the site-specificity of the space, it makes use of a modular synthesizer system to generate landscapes of ever changing musical patterns leading to a contemplative state.

Displaced Acts of (Un)Related Causality incorporates and intertwines some of André's best visual and sound explorations transposed to performative and installation contexts. Considering the site-specificity of the space, it makes use of a modular synthesizer system to generate landscapes of ever changing musical patterns, leading to a contemplative state. André performed at the exhibition opening, and left the system working in an autonomous way.

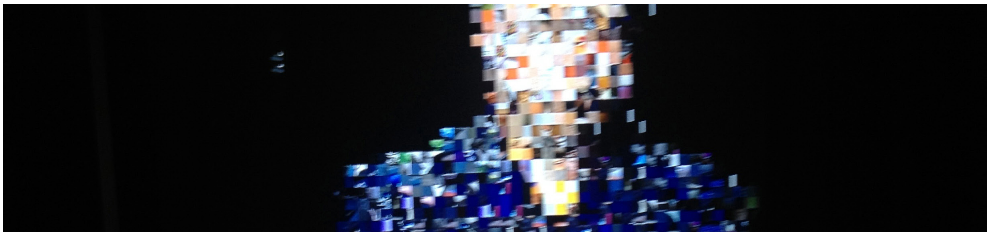
LINKS TO WORK 1 & WORK 2





YOU. HERE. NOW.

IAN WILLCOCK
University of Hertfordshire
ian@willcock.org

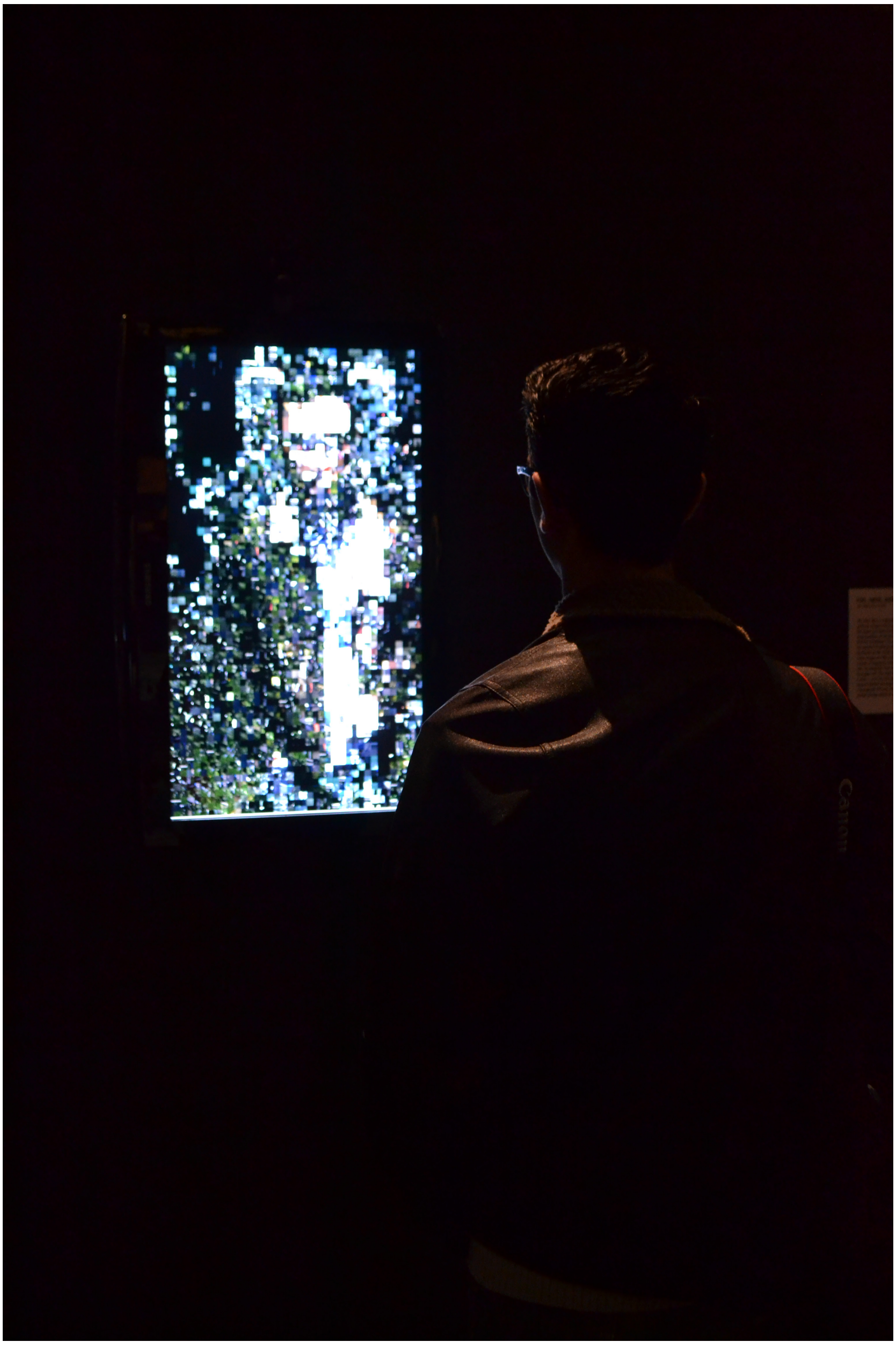


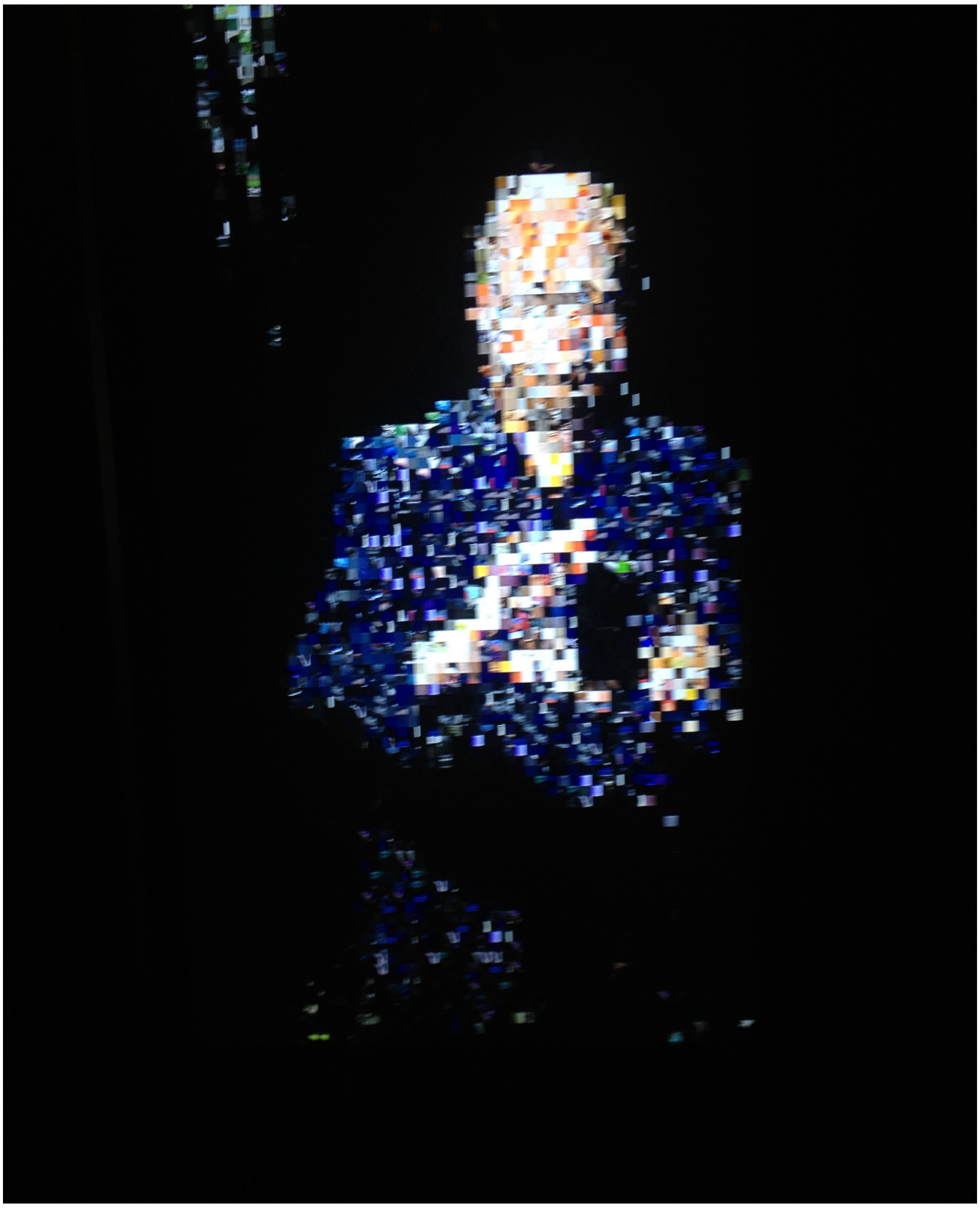
ABSTRACT

The work constantly trawls the websites of news organizations, sampling all visual imagery it comes across. As the passer-by examines the piece, their portrait emerges from several hundred tiny fragments of collected data.

The work constantly trawls the websites of selected news organisations and downloads all the visual imagery it comes across. These images are then sampled to provide a large number of fragments, each reflecting the preoccupations and priorities of the news gathering organizations. The small size of these samples prevents them from functioning iconically; each is a fragment, which will usually suggest a larger context, but which will almost never present its references fully formed. The fragments are all catalogued; stored, together with their average colour value in a constantly evolving database. This is the palette from which the work constructs its portraits. To engage with the work, the visitor needs to invest some time. As they examine the piece, their portrait will gradually emerge from the background presentation of several hundred tiny fragments, which are in a continuous state of flux.

LINKS TO PROJECT SITE





THE INTERPRETER

RODRIGO CARVALHO
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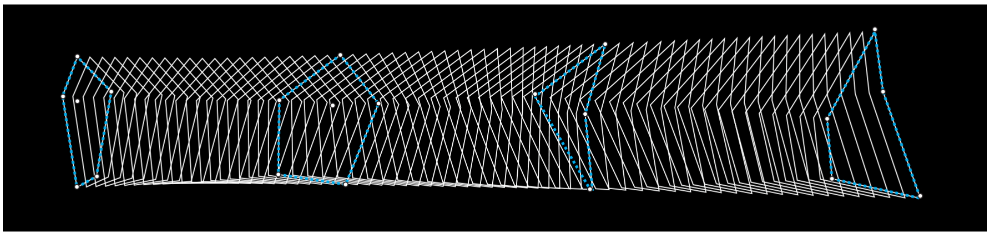
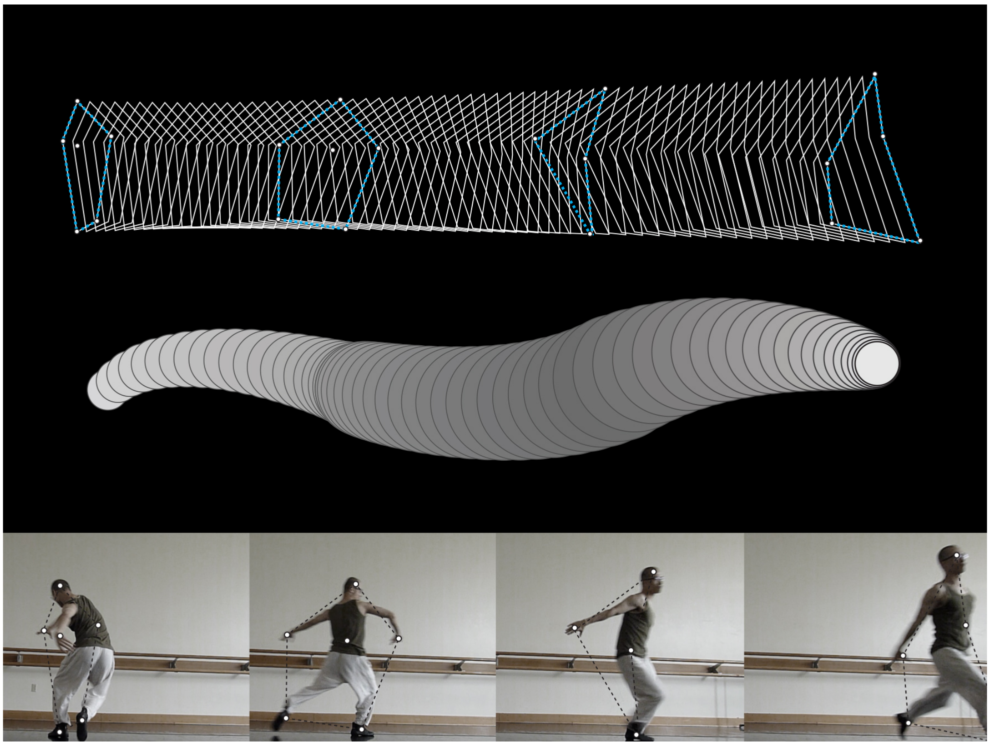


ABSTRACT

Glitch ambient sounds and visual patterns are generated from pre-recorded dance motion data. The visitor creates new interpretations by manipulating the data through a touchscreen.

This work explores dance movement sequences, visualizing and sonifying motion data, creating new perceptions, interpretations and outcomes. It generates glitch ambient sounds and visual flow patterns from pre-recorded dance motion data and a touchscreen interface made available to visitors. The goal is to deconstruct the dancer's movements and encourage participants to experiment with different kinds of audio-visual mappings. Visitors are invited to explore and interact with the installation through a console with various parameters that affect the visual and sonic interpretation of pre-recorded movement sequences.



WORKSHOPS

HUMAN ENTITIES... AN ARTISTIC APPROACH TO THE IOT

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SOFIA OLIVEIRA
CADA
sofiaoliveira@cada1.net

ABSTRACT

Participants were asked to imagine a personal 'lifeworld' seen from an object's perspective; using a set of exploratory questions and practical exercises they entered the logic of their projection from the inside out.

This workshop explores a world where human and nonhuman entities have an equal claim to existence. It actively examines the class of technologies described as the Internet of Things (IoT), exploring its problematic implications for the notions of human agency and social identity. Equally seeing it as an opportunity to provoke new ideas and ludic experimentation, the tutors asked the participants to imagine a world seen from an object's perspective. Using a set of exploratory questions and practical exercises, the workshop participants entered the logic of such a projection from the inside out. What would it be like to see the world from an object's point of view? How would such a 'thing', a computational object, sense and interpret human action? How much of our autonomy are we prepared to share with such objects? Participants worked toward creating near-future scenarios; existing configurations of human beings to everyday objects, and objects to objects were comprehensively rethought. Not just in the sense that things enter into autonomous communication with each other – they already do. But also because as they start to form their own societies, our relationship with them becomes increasingly more entangled.

CADA is a Lisbon-based art group that collaborates to make mobile software: *www.cada1.net*.

DETECTION

MARTIN HOWSE
micro_research
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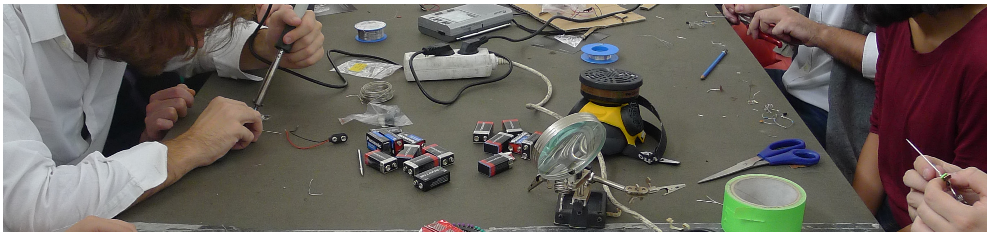

ABSTRACT

This workshop examines how to make audible minute material change and process. It aims to equip the sonic archaeologist with a range of DIY performance and installation techniques for forensic examination of both material and immaterial domains (electromagnetics).

Sound can be conceived as the expression of material undergoing specific physical stresses. As the earth is tapped with the back of the shovel, or as the cast metals of rail tracks are subjected to immense forces by the wheels of an arriving high speed train, information is revealed concerning the often less than visible strains and molecular interactions of the material world. It's a strictly epistemological investigation, equally providing forensic material concerning an immaterial, invisible world; material for a certain psychic detective seeking to make sense of the world. This sonic archaeology can be summarised as excitation followed by detection. *Detection* is a hands-on workshop aims to equip the sonic archaeologist with a range of DIY performance and installation techniques for forensic examination of both material and immaterial domains (electromagnetics). Participants learnt how to: a) build devices to play back and decode surface marks and inscriptions using a custom designed FM radio transmitter playback head, and learn to use a simple reflecting laser pickup; and b) make audible fluctuations in laser light and sonify electrochemical reactions (construct an interferometer using DIY materials).

LINK TO VIDEO

WORKSHOP ON VISUAL PROGRAMMING WITH PURE DATA

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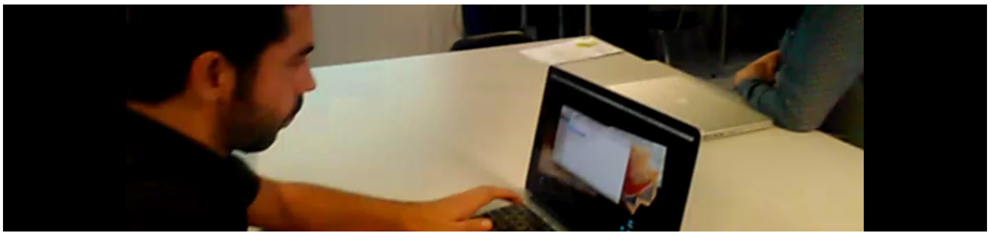
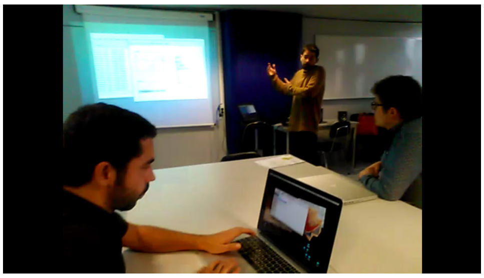
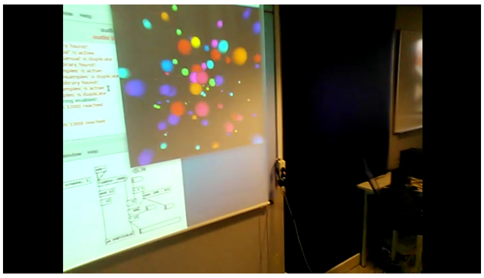
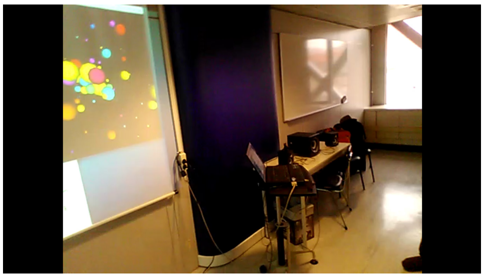
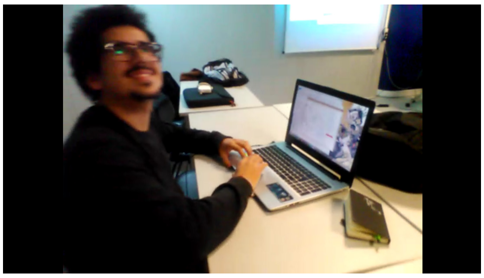
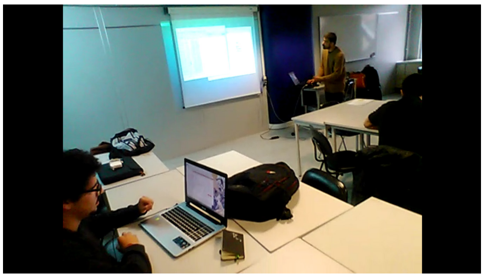


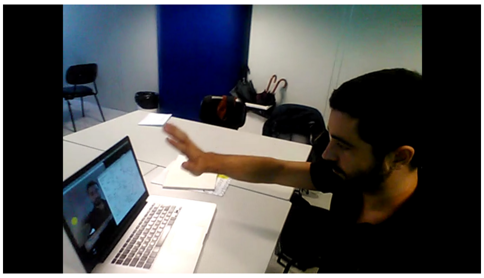
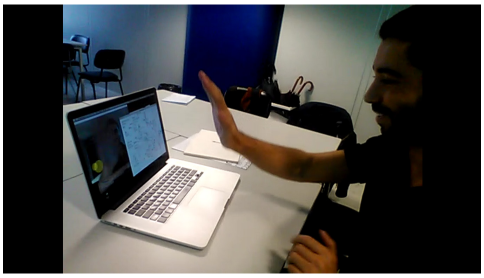
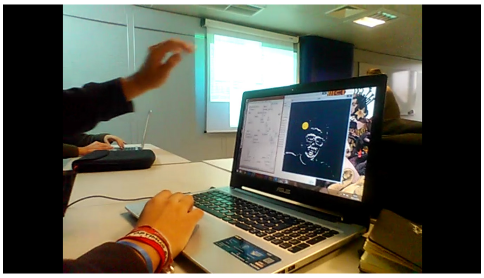
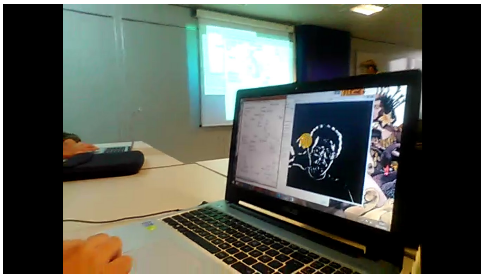
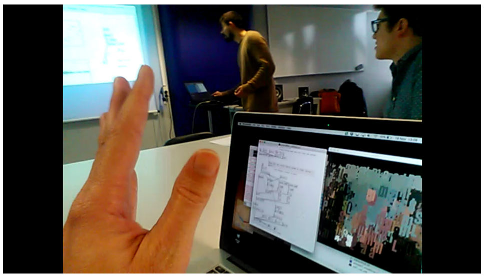
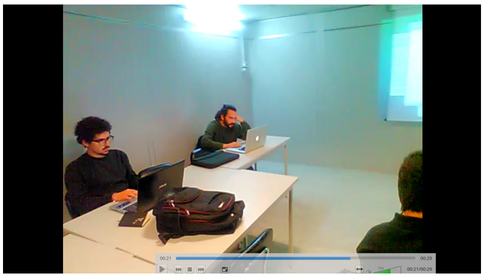
ABSTRACT

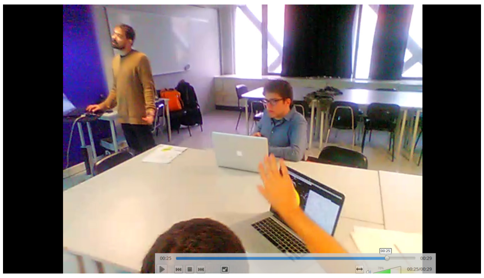
This workshop teaches how to create multimedia applications of interaction between sound and image, using Pure Data.

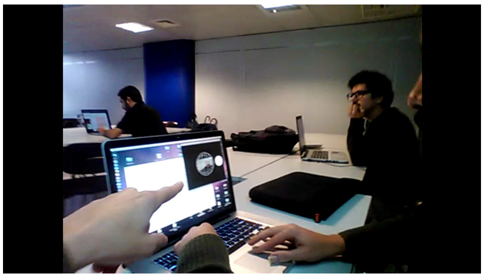
This workshop introduces visual programming with Pure Data. The basics of digital sound and video processing were introduced in order to create interactive multimedia applications where image data is used to control sound parameters and vice versa. During the intensive 4 hours workshop at the conference the participants learned how to build patches for mathematical calculation, display of text, 2-D and 3D shapes, video effects, audio generation and audio effects. In the final part each participant modified a few simple patches, which had been prepared to show ways of controlling visuals with sound and vice versa; they changed the source materials and the digital behaviours to their liking.

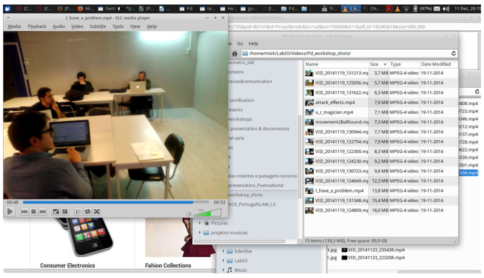
LINK TO VIDEO






Consumer Electronics
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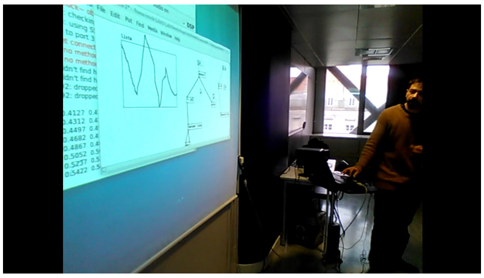
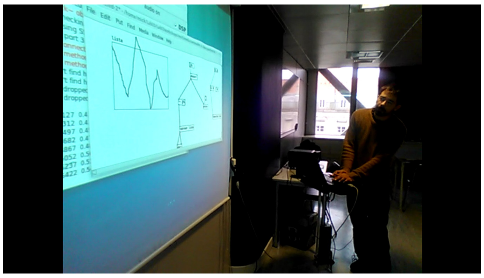




BIOGRAPHIES

MIGUEL AMARAL

Miguel Amaral holds a PhD in Industrial Engineering and Management from the Technical University of Lisbon. Miguel also holds a MSc in Engineering Policy and Technology Management and a degree in Economics. Presently works as an Assistant Professor at the Instituto superior Técnico (IST) – Technical University of Lisbon and as a Research Associate at the Center for Innovation, Technology and Policy Research, IN+/IST, where he directs the Laboratory of Technology Policy and Management. His research interests and teaching focus mainly on Technological Change and Entrepreneurial Dynamics. Additionally, Miguel holds an Advanced Diploma in Communications Science/Cinema (ongoing MSc thesis) from Universidade Nova de Lisboa and a 3-years Course in Plastic Arts/Painting from Sociedade Nacional de Belas Artes.

TIAGO ÂNGELO

Tiago Ângelo is a composer and sound artist focused on the use of technology to promote and improve musical creativity and interaction, delving into such areas such as automatic music generation, human-computer interaction and physical computing. He is also a creative coder and open-source contributor using programming environments like MaxMSP, Processing or Arduino, as well as a developer of augmented and alternative musical instruments and interfaces. He has been lecturing workshops and presentations as well as performing and premiering in venues, conferences and festivals.
Tiago has MA [2012, Multimedia, FEUP] on the development and performance of digital musical instruments. Currently he is a freelancer and active member of the Digitópia Collective at Casa da Música.

JOANNE ARMITAGE

Joanne Armitage is a researcher and composer based in the Interdisciplinary Centre for Scientific Research in Music, University of Leeds. Her interests' lie within computer aided instrumental and electronic composition, alongside visual art. Her work has been performed both nationally and internationally. Most recently, Her research interests lie in gesture recognition and auditory perception for performance environment enhancement. Her compositional and technological interests are combined in her PhD candidacy at the University of Leeds, supervised by Kia Ng and Michael Spencer. She is also active as a live coder and synthesist.

https://soundcloud.com/joannnne

IKHSAN ASSAAT

Percussionist and mobile developer who received his master degree in computer music at University of Leeds. His vision is to fuse Indonesian traditional percussions with computer technologies, such as motion recognition and sound synthesis.

MATT BENATAN

Researcher in computer science at The University of Leeds, with specific interests in multimodal gesture control systems, audio processing and information retrieval. Over the years I've been involved in a number of projects with the Interdisciplinary Centre for Scientific Research in Music. These have included the development of numerous musical interfaces, including mobile device-based systems, augmented musical instruments and gesture-based computer music interfaces. My current work focuses on research in speech and audio processing, and on developing software solutions for multimedia post-production workflows.

MYRIAM BLEAU

Montreal native Myriam Bleau is a composer, digital artist and performer. Exploring the limits between musical performance and digital arts, she creates audiovisual systems that go beyond the screen, such as sound installations and performance-specific musical interfaces. Her presence on the popular music scene influence her hybrid electronic practice that integrates hip hop, techno, experimental and pop elements. Her work has been presented across Canada, in the US and in Europe in festivals and conferences such as AKOUSMA, Sounds Like, NIME, Earzoom, Circuit Bridges and Network Music Festival.

www.myriambleau.com

TILL BOVERMANN

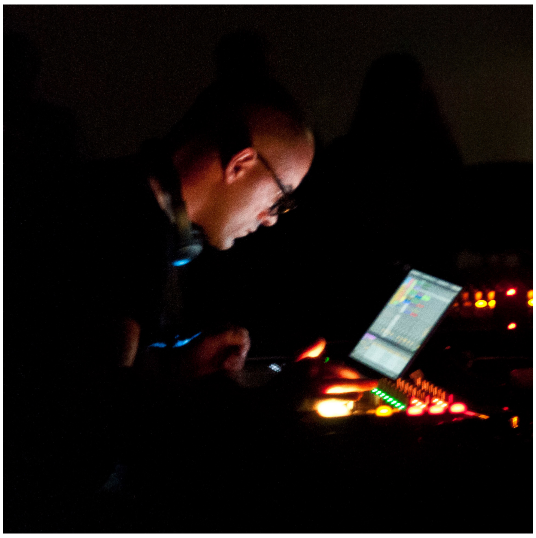
Since the beginning of 2014, Till Bovermann is a post-doctoral researcher at 3DMIN (Design, Development and Dissemination of New Musical Instruments), an Einstein research project between the Berlin University of the Arts and the Technical University Berlin.
From 2010 to 2013, he worked as a post-doctoral researcher on tangible and auditory interaction at Media Lab Helsinki, School of Art, Design and Architecture, Aalto University, Helsinki, Finland.
He completed his PhD in Computer science in the natural sciences on Tangible Auditory Interfaces at the Ambient Inteligence Group of Bielefeld University, Germany.
Till taught at various international institutions, among others the Institute For Music And Media of the University of Music, Duesseldorf; the Department of Media of Aalto University, Finland, and the Institute for Time-based media, UdK Berlin.
His art works are mostly concerned with the relations of art and science, noise and harmony, nature and artificiality.
Alongside his academic and artistic work, he also develops software in and for SuperCollider.

PEDRO CARDOSO

Pedro Cardoso is a designer, and a researcher at ID+, Research Institute on Design, Media and Culture. He graduated in Communication Design, has a MA on Image Design, and currently is a PhD student on Art and Design at the University of Porto, pursuing studies on video games in the context of new media, interaction and game design. He has been developing experimental work in this scope, and recently has been exploring diverse relationships between games, music and sound. He is currently a guest lecturer in the Department of Design at the University of Porto.

pcardoso.tumblr.com

MIGUEL CARVALHAIS



Miguel Carvalhais (Porto, 1974) is a designer and a musician. He is an assistant professor at the Design Department of the Faculty of Fine Arts of the University of Porto, where he teaches and researches interaction design and new media. In his musical practice, he has been collaborating with Pedro Tudela in the @c project (*www.at-c.org*) since 2000 and has helped to found the Crónica media label (*www.cronicaelectronica.org*), which he has been running since 2003.

www.carvalhais.org

RODRIGO CARVALHO

Rodrigo Carvalho is designer & new media artist from Porto/Portugal. Graduated in Design (Aveiro-PT.2005) and with a Master Degree in Digital Arts (Barcelona – ES.2009). He is nowadays a PhD student in Digital Media in the University of Porto/FCT under the UT Austin/Portugal Program. His work is focused in the relations and the synergies between sound, movement and image in audiovisual real time systems and environments.

PAUL CHAPMAN

Dr. Paul Chapman is Acting Director of the Digital Design Studio (DDS) of the Glasgow School of Art where he has worked since 2009. The DDS is a postgraduate research and commercial centre based in the Digital Media Quarter in Glasgow housing state of the art virtual reality, graphics and sound laboratories. Paul holds BSc, MSc and PhD degrees in Computer Science, he is a Chartered Engineer, Chartered IT Professional and a Fellow of the British Computer Society. Paul is a Director of Cryptic and an inaugural member of the Royal Society of Edinburgh's Young Academy of Scotland which was established in 2011.

ALESSIO CHIERICO

Alessio Chierico is currently a MA candidate of the Interface Culture department in the Art and Design University Linz. Former student of the art academies Urbino, Carrara and NABA in Milan, in courses related to the new technologies of art production, design and media theory. In the last eight years he had about fifty exhibitions, including: ArteLaguna prize in Venice (2014), Victoria Art gallery in Bucharest (2014), Speculum Artium festival in Slovenia (2013), Ars Electronica festival (2014, 2013), Museo di Scienze Naturali of Torino (2013), MLAC of Rome (2012), MAGA in Gallarate (2011), Fabbrica del Vapore in Milan (2008)

www.chierico.net/

MARKO CICILIANI

Marko Ciciliani, PhD (* 1970, Croatia) is a composer, audiovisual artist and researcher based in Austria. He is professor for computer music composition and sound design at the IEM (Institute of Electronic Music and Acoustics) of the University of Music and Performing Arts Graz in Graz/Austria. Ciciliani's music has been performed in more than 30 countries in Europe, Asia, Oceania and the Americas. It has been programmed by festivals and concert series of electronic experimental music like Experimental Intermedia/NYC, Ibrasotope/São Paolo, SuperDeluxe/Tokyo or the NowNow Series/Sydney, just as much as by festivals for instrumental music as Maerzmusik, Huddersfield Contemporary Music Festival, Wien Modern, Zagreb Bienale and many more. He received numerous project-residencies at Villa Aurora, STEIM, ESS, ICST and ZKM.

RUI COELHO

Rui Avelans Coelho is a Digital Media researcher doing a PhD in the field of interactive film. Recently he created two public funded (DGArtes) projects: the interactive musical installation “e-maestro” and a mobile fiction “A window into the past”.Coordinated several cultural projects like the multimedia guides for the National Tile Museum (a project for the inclusion of hearing and visually impaired visitors), the interactive sound environments at the Portimão Museum (Museum of the Year award from the Council of Europe in 2010) and the audio guides for the Batalha Museum (voted best Portuguese museum of 2012). As film director, his works “Footmobile”, “The champion” and “15 frames” were awarded in several festivals (Germany, Brazil, Croatia, France, Greece).

ANDREA COHEN

Andrea Cohen, born in Buenos Aires, Argentina, was classically trained at the Ecole Normale Superieure de Musique in Paris. In 2005 she received a doctorate at the University Paris-Sorbonne (theses' title: Composers and Radio Art). She is a sound artist and radio author/producer; she created and performed in several pieces of experimental music theater, and developed educational media for school and university-level students. She lives and works in Paris.

http://www.music.columbia.edu/soundson

PETER CONRADIE

Peter Conradie is researcher at Ghent University - Department of Industrial System and Product Design, where he focuses on user involvement strategies for new product design, with an emphasis on tangible and interactive products beyond the desktop. He has previously worked at the Rotterdam University of Applied Science in Rotterdam, researching data publication by local government.

JOÃO CORDEIRO

João Cordeiro has been developing his artistic, scientific and professional work around the subject of sound, mostly as a researcher, sound designer and musician. He holds a Master degree in Sound Design and a PhD in Science and Technology of the Arts – Computer Music granted by the Catholic University of Portugal. His research interests include soundscapes studies, sonic interaction design, sonification and music performance. He is currently an Assistant Professor at the Faculty of Creative Industries in the University of Saint Joseph – Macau and researcher on the Research Centre for Science and Technology of the Arts, Catholic University of Portugal – Porto.

www.joaocordeiro.eu

NUNO CORREIA

Nuno N. Correia is a researcher, media artist and musician. He is interested in enabling interactive multi-sensorial experiences. Since 2000, he has been teaching and conducting research in media art and design, in universities in Portugal, Finland and the UK. Nuno holds a Doctor of Arts degree in new media from Aalto University (Media Lab Helsinki), with the thesis "Interactive Audiovisual Objects", and an M.Sc in innovation management from the Technical University of Lisbon. Currently, he is a researcher at Goldsmiths, University of London (EAVI group), working on the project "Enabling Audiovisual User Interfaces", for which he obtained a Marie Curie EU fellowship.

http://www.nunocorreia.com

TERESA CRUZ

Teresa Cruz teaches at Universidade Nova in Lisbon. She is a researcher in Image Theory, Media Aesthetics and Media Art Theory. She is the director of the Research Center on Communication and Language. Her research interests focus upon cultural techniques, contemporary art and post-media aesthetics.

http://www.cecl.com.pt/pt/investigacao/investigadores/99-maria-teresa-cruz?catid=39%3Ainvestigadores-integrados

MAT DALGLEISH

Born near Birmingham, UK, Mat initially studied fine art at the University of Northumbria and interactive media with composer Rolf Gehlhaar at Coventry University. He is currently a Senior Lecturer in Music Technology and Course Leader for MSc Audio Technology at the University of Wolverhampton. Before this he was a visiting researcher at The Open University Music Computing Lab. His research interests include music interaction, generative musical systems and hybrid analog/digital synthesis. Beyond academia he has created interactive sound and audiovisual works for clients across the UK and Europe.

NICK DALTON

Dr. Nick Dalton is a founding member of the pervasive computing group at the Open University. He is a lecturer in computing at the open University department of computing and communications. His area of research is Human Computer Interaction, specialising in pervasive interaction systems. His current region of focus is that of integrating building architecture with human computer interaction in pervasive computing. Nick has organised two CHI workshops in the area of space and human computer interaction, and is currently working on a book Architecture and Interaction soon to be published by springer.

POLINA DRONYAEVA

Polina Dronyaeva was born in Moscow, lives between Moscow and Barcelona. Studied Journalism in Moscow, Arts Management in London and Sociology in Edinburgh. Her soundscapes were exhibited at Moscow Biennials 2011 and 2015, Ars Electronica 2015, awarded at the Imagen festival 2010. Also Polina participated in conferences Amber'12, "Cultural Research in the Context of Digital Humanities" (Saint Petersburg, 2013), Pro & Contra symposium (Moscow, 2013), ISEA 2014. Since 2007 she runs a laboratory "Acoustic Images" in collaboration with a composer A. Senko. The main research theme: interplay of inner and outer worlds of human beings in the interactive environments.

www.acousticimages.net

ANA FIGUEIREDO

Ana Carina Figueiredo is a researcher at engageLab / University of Minho, where she works on blending tangible artifacts with digital computing. She holds a Master in Technology and Digital Arts from University of Minho, with a degree in Communication New Technologies, in Aveiro University. Worked already as a multimedia developer, designer and programmer.

PAULO FONTES

Paulo Fontes is a researcher in digital media, with special interest on the blending of new media environments with social-marketing settings. At the moment, he is pursuing a PhD in Digital Media, at the Faculty of Engineering of University of Oporto, focusing on the synergy between marketing and new media for the public engagement with science and health. He holds a degree in Communication Technologies from the University of Aveiro, and another in Cultural Heritage from the University of Évora. He worked as a teacher of multimedia, as a programmer, and as a communication's manager in a NGO for development.

PETE FURNISS

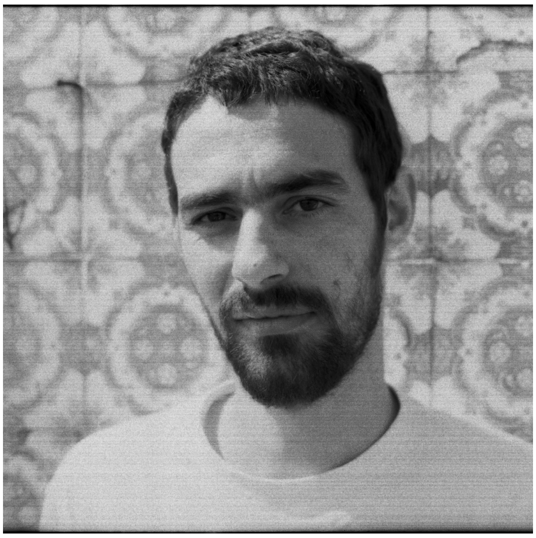
Clarinettist and improviser Pete Furniss lives in Edinburgh and performs internationally, as well as with many of the UK's leading ensembles and orchestras. He has given electro- instrumental performances in the UK, Germany and South Korea with Richard Dudas, Martin Parker, Sarah Nicolls, Gilbert Nouno and others. In 2013 he collaborated with Alex Harker on 'New York Counterpoint' Re-imagined, a re-mix for live clarinet and electronic fixed media. He recently began a practice-based Ph.D in live electronic performance at the University of Edinburgh.

www.petefurniss.com

CLARA GOMES

Clara Gomes is a researcher of CECL (Centre for the Study of Communication and Languages) Universidade Nova de Lisboa. Develops post-doctoral research on the uses of virtual platforms and multimodal interfaces for the arts and netactivism. Ph.D, Communication Sciences, Universidade Nova de Lisboa (thesis: Cyberformance: performance in virtual worlds, 2013) with scholarship by F.C.T. - Science and Technology Foundation, Portugal. Post-grad. in Fine Arts, Universidad de Barcelona, Spain. M.A in Mass Communications, University of Leicester, UK. Honours Degree in Communication Sciences, Universidade Nova de Lisboa, Portugal. Gomes is journalist; director (video-art, documentary), actress and performer; as well as university lecturer in communication sciences (Universidade de Macau, currently in Escola Superior de Educação de Coimbra).

ANDRÉ GONÇALVES



André Gonçalves works across the fields of visual arts, music, video, installation and performance. His works have been presented in several galleries and festivals such as Nam June Paik Art Center, Seoul; FILE, Sao Paulo; Experimental Intermedia Foundation, New York; ICA, London; Steim, Amsterdam; Museu Vostell Malpartida, Cáceres; Fundação Calouste Gulbenkian, Lisbon. His music work, solo or in collective projects, include more than 15 editions in several recording labels Over the past few years he has also built a solid reputation developing widely praised modular hardware synthesizers under ADDAC System brand, which are now being used by many musicians throughout the whole world.

http://www.andregoncalves.info

ANA GUTIÉRREZ

Ana Gutiérrez (Gutieszca) is a visual artist from Monclova, Mexico. She is currently completing the MA in Fine Arts at Aalto University in Helsinki, Finland. Her work is centered in the field of drawing as a contemporary artistic practice and its deconstruction through performance and sound art. Her background is in visual arts but her projects tend to connect with music technologies and interaction features. She is a co-founder of Third Space; a gallery located in the center of Helsinki where curates the Sound Room project.

http://www.anagutieszca.com

SARAH-INDRIYATI HARDJOWIROGO

Sarah-Indriyati Hardjowirogo is a Research Associate in the Einstein research project 3DMIN (Design, Development and Dissemination of New Musical Instruments) at the Technical University Berlin. Her main interests are in the areas of music and technoculture, audio media and musical instruments, as well as the conceptual history of culture. She is a PhD candidate at the ((audio)) division of the Institute of Culture and Aesthetics of Digital Media at Leuphana University Lüneburg, working on a dissertation entitled "Cult Objects, Sound Generators, Body Technologies. The Musical Instrument in Flux", which explores the musical instrument as a cultural concept and its transformation through changing media.

JARED HAWKEY

Jared is an artist who founded CADA with Sofia Oliveira. He studied Fine Art BA (Hons) at Goldsmiths College, London (1993).
CADA is an art group that makes freeware for mobile phones for exhibitions and the public realm. Formed in Lisbon in 2007, it also organises events and workshops to promote the development of digital cultural practice. CADA's goal is to expand conventional understandings of software. Its works are intentionally playful, designed to activate a space for questioning and reflection on the ways in which action emerges from the entanglement of people and technology.
CADA has exhibited and led workshops across Europe and in Brazil.

http://cada1.net

EDWIN VAN DER HEIDE

Edwin van der Heide is an artist and researcher in the field of sound, space and interaction. Beside's running his own studio he's assistant professor at Leiden University, and the head of the Spatial Interaction Lab at the Royal Conservatoire and Arts Academy in The Hague.

http://www.evdh.net

TOMÁS HENRIQUES

Tomás Henriques is a Ph.D. composer and researcher. He won First Prize at the 2010 Margaret Guthman Musical Instrument Competition with the invention of the "Double Slide Controller," a slide trombone-like electronic instrument. His "Sonik Spring", a device that maps, in real time, force feedback and 3D gestural information into sound and visual data, was granted a full US patent.
Dr. Henriques teamed up recently with Yamaha engineers to develop a 52.1 surround sound system, installed at SUNY Buffalo State's music department, where he is the head of Music Theory and also the Director of the Program in Digital Music.

AMELIE HINRICHSEN

Amelie Hinrichsen is a Research Associate in the Einstein research project 3DMIN (Design, Development and Dissemination of New Musical Instruments) at the Berlin University of the Arts.
After accomplishing an apprenticeship as a carpenter she completed her studies in Product Design at the Berlin University of the Arts in 2012. With her final project she won the DMY Young Talents Jury Award in 2013.
After working as a freelancer for Friedrich von Borries she joined the 3dmin Team in 2013.
Amelies work ranges from film over product- to interface design. It reflects her interest in combining theoretical research with a practical approach, always physicalness and personal experience in focus.
Currently she is working on her dissertation dealing with “Attitude and Posture - Performing Life with electronic musical instruments”.

SIMON HOLLAND

Simon Holland is Creator and Director of the Music Computing Lab at the Open University. He was a co-founder of 80’s Liverpool electronic band ‘Ex Post Facto’, in which he sang, wrote, and played bass and analog synthesizers. He has devised numerous human-centred computing innovations, including The Haptic Bracelets, the Haptic Drum Kit, AudioGPS, Harmony Space and Direct Combination. He was awarded the PyrusMalus Award in Stockholm for the most influential paper in Mobile HCI over the ten years from 2001- 2011. He is currently collaborating with neuroscientists and physiotherapists on new approaches to stroke rehabilitation.

MARTIN HOWSE

Martin Howse is occupied with an artistic investigation of the links between the earth (geophysical phenomena), software and the human psyche (psychogeophysics), proposing a return to animism within a critical misuse of scientific technology. Through the construction of experimental situations (performance, laboratories, walks, and workshops), material art works and texts, Howse explores the rich links between substance or materials and execution or protocol, excavating issues of visibility and of hiding within the world.
For the last ten years he has collaborated on numerous open-laboratory style projects and performed, published, lectured and exhibited diversely. He is equally the creator of the skin-driven audio divination module, aka. The Dark Interpreter.

http://www.1010.co.uk

RICARDO JACINTO

Born in Lisbon /1975. Lives and works in Lisbon and Belfast. Working as a sound artist and musician mainly focusing on the relation of sound and space. Phd researcher at Sonic Arts Research Center, Belfast. Since 1998 has presented his work at individual and group exhibitions, concerts and performances, in Portugal and abroad and has collaborated extensively with other artists, musicians, architects and performers. Presented his work in solo and group exhibitions such as Project Room CCB_Lisboa, Circle Fine Arts in Madrid, MUDAM_Luxemburgo, Centre Culturel Gulbenkian_Paris, Manifesta 08_European Bienal of Contemporary Art in Italy, Loraine Frac-Metz, OK CENTRE_Linz_Austria, CHIADO 8_Culturgest_Lisbon, Casa da Musica / Porto and Venice Architecture Biennale 2006. As a musician-performer has shown his work at: Fundação de Serralves / Porto, Palais Tokyo / Paris, SARC / Belfast, Festival VERBO / São Paulo, Festival Temps d'Images_Lisbon, Festival Rescaldo_Lisbon, Festival BigBang_CCB_Lisbon, Culturgest_Porto and Lisbon, ZDB / Lisbon, Dance Base_Edimbrugh, Kabinett 0047_Oslo, Calouste Gulbenkian Foundation / Paris_Lisbon.

http://www.ricardojacinto.com

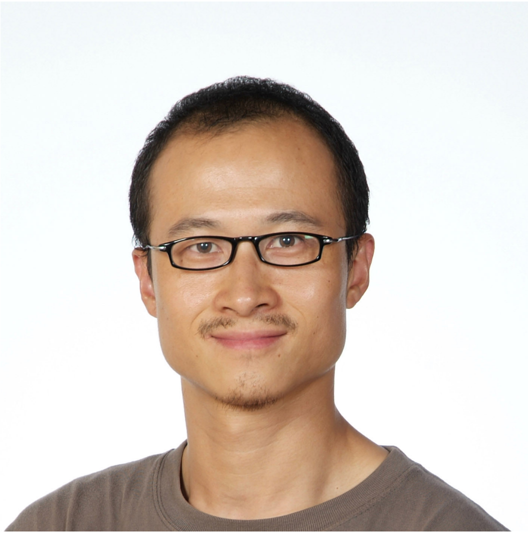
LAURIE JOHNSON

Laurie Johnson is a computer music researcher from the University of Leeds. His interests include generating pattern, audio domain mapping strategies, and audiovisual interaction for the creation of composition and performance systems, to be consolidated into immersive installations in future. He also co-runs the cassette label 'Don't Drone Alone' for the proliferation of the ambient strands of music.

RUI JORGE

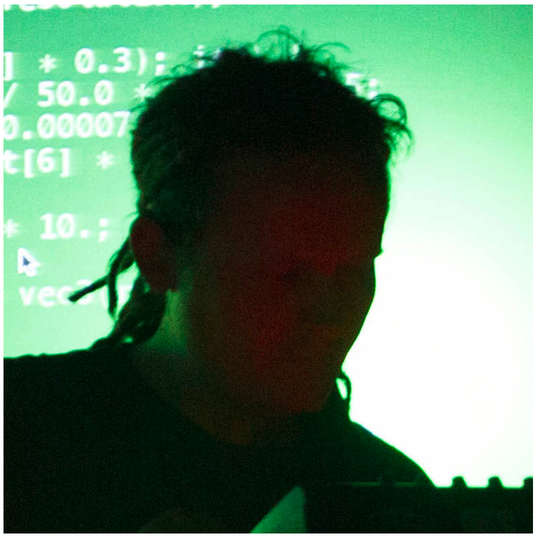
Rui Pereira Jorge has a degree in Philosophy, a master's degree in Communication Studies and is currently finalizing a PhD dissertation on Music and Technology. He has also musical education and training in editing and sound production.
He has done work as a musician and sound designer. He worked on music for films, music for children, electronic music and sound experimentation. He has also done some work in the area of music videos, documentaries and multimedia projects. Parallel to this activity, has conducted research on music, sound studies and aesthetics. He has published articles and participated in national and international conferences. He teaches in Lisbon, on music, sound culture, sound design and music video.

SHEN JUN



Shen Jun, Jiang Yin, China. He attended Wuxi Culture and Arts School to learn dance in 1995, danced in Wuxi's Song and Dance Troupe in 1998. Admitted into Beijing Capital Normal University as a dance major in 2001, graduated with a Bachelors of Fine Arts degree and became a modern dancer and choreography for Beijing Dance/LDTX Company in 2005, going on tour with the company worldwide. In September 2009, he left Beijing Dance/LDTX to become an independent dancer and choreographer. In 2013, he earned the full scholarship and fellowship of UT Austin and became a Graduate student of MFA in Dance.

CHRIS KIEFER



Chris Kiefer is a computer-musician and researcher in the field of musician-computer interaction. He teaches computing at the University of Sussex and is part of the Embodied AudioVisual Interaction research group (EAVI) at Goldsmiths. He's interested in designing digital music instruments using large scale multiparametric sensing. Chris performs as Luuma, and has recently been performing at Algoraves with custom made instruments including malleable foam interfaces and touch screen software. His music has been released on algorithmic music label Chordpunch.

http://luuma.net

SHELLEY KNOTTS

Shelly Knotts is a Newcastle, UK-based composer, performer and improvisor of live electronic, live-coded and network music. She performs solo and as a member of various collaborations and presents her work across the UK and Europe. She is currently studying for a PhD in Live Computer Music at Durham University where her focus is on interaction in Network Music. Past affiliations have included BEAST (Birmingham ElectroAcoustic Sound Theatre) and sound art collective SOUNDkitchen. Her work has been published on Chordpunch record label, Absence of Wax netlabel and in Leonardo Music Journal. She has received commissions and residencies from PRSF and Sound and Music.

http://shellyknotts.wordpress.com

SHAWN LAWSON

Shawn Lawson is an experiential media artist exploring the computational sublime with technologies like: stereoscopy, camera vision, touch screens, game controllers, mobile devices, random number generators, live-coding, and real-time computer graphics. His artwork has exhibited in museums, galleries, festivals, and public space in England, Denmark, Russia, Italy, Korea, Portugal, Brazil, Turkey, Malaysia, Iran, Canada, and the USA. Lawson's collaborative, Crudeoils, critiques structures of power: surveillance, economic exploitation, and authoritarian corruption. The collaborative is represented by Dean Jensen Gallery. He has been awarded grants from the Electronic Media and Film Program at the New York State Council on the Arts and the Experimental Television Center's Finishing Funds Program. Lawson studied fine arts at Carnegie Mellon University and École Nationale Supèrieure des Beaux-Arts. He received his MFA in Art and Technology Studies from the School of the Art Institute of Chicago in 2003. He is an Associate Professor of Computer Visualization in the Department of Art at Rensselaer Polytechnic Institute.

http://shawnlawson.com

DOMINIK HILDEBRAND MARQUES LOPES

Dominik Hildebrand Marques Lopes has a degree in audio and video engineering from the Institute for Music and Media Düsseldorf. Furthermore he studied Arts and Media at the University of the Arts (UdK) Berlin, focusing on multichannel sound installations, improvised electronic music, building kinetic/cybernetic (sound-)objects, musical recording, and live-coding. He also holds a "Meisterschüler" (distinguished graduate) degree in Arts and Media.

Currently he is working as a Research Associate in the Einstein research project 3DMIN (Design, Development and Dissemination of New Musical Instruments) at the Berlin University of the Arts. He is also lecturer at University of the Arts Bremen (Digital Media).

As a computer musician, his main focus is on developing and performing with physical musical interfaces whose constraints and functionality are chosen to exhibit unique behaviour (or life of their own) arguably equally rich as many acoustic instruments. This approach leads to very direct bodily control of computational processes which hopefully can also be experienced as such by the audience.

Dominik is a member of "Trio Brachiale", "Republic111", and the "Society for Nontrivial Pursuits".

MINHUA EUNICE MA

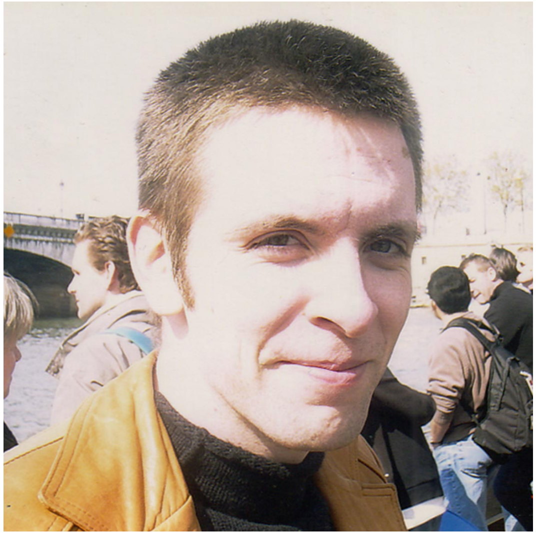
Professor Minhua Ma is a Professor of Digital Media & Games and Associate Dean International in the School of Art, Design and Architecture at University of Huddersfield. Professor Ma is a world-leading academic developing the emerging field of serious games. She has published widely in the fields of serious games for education, medicine and healthcare, Virtual and Augmented Reality, in over 100 peer-reviewed publications, including 6 books with Springer. She received grants from RCUK, EU, NHS, NESTA, UK government, charities and a variety of other sources for her research on serious games for stroke rehabilitation, cystic fibrosis and autism, and medical visualisation. Professor Ma is the Editor-in-Chief responsible for the Serious Games section of the Elsevier journal Entertainment Computing.

http://www.hud.ac.uk/ourstaff/profile/index.php?staffuid=sdeseem

THOR MAGNUSSON

Thor Magnusson's background in philosophy and electronic music informs prolific work in performance, research and teaching. His work focuses on the impact digital technologies have on musical creativity and practice, explored through software development, composition and performance. Thor's research is underpinned by the philosophy of technology and cognitive science, exploring issues of embodiment and compositional constraints in digital musical systems. He is the co-founder of ixi audio (*www.ixi-audio.net*), and has developed audio software, systems of generative music composition, written computer music tutorials and created two musical live coding environments. Thor Magnusson lectures in Music and convenes the Music Technology programme at the University of Sussex.

LÉON MCCARTHY



Léon (aka 3pin) is an audiovisual artist, PhD researcher at Northumbria University and lecturer at the University of Limerick. His background spans classical music, architecture and music technology. His first foray into digital performance was as a VJ. He has produced and performed as a musician, featuring as one half of the once renowned Irish electro outfit, Les Bien. He co-founded the Irish video production company, MercuryBoy. With his current performances he hopes to engage audiences intellectually, forcing an interrogation of their live experience.

ALEX MCCLEAN

Alex McLean is research fellow of human technology interaction in the University of Leeds. His interests surround music interaction, particularly live coding, the use of programming languages in exploratory work and improvised performance. Alex works across several areas of research and practice including music improvisation, computational creativity, programming language experience design, computer vision, cognitive psychology, textiles and dance. He makes music with his Tidal live coding environment, performing widely for over 15 years including at Sonar, ISEA, Tate Modern, Sonic Acts and Transmediale. He co-founded the Live Coding Research Network and TOPLAP organisations, and the Algorave movement. He is currently co-editing the Oxford Handbook on Algorithmic Music with Prof Roger Dean.

ANDREW MCPHERSON

Andrew McPherson is a Senior Lecturer in the Centre for Digital Music at Queen Mary University of London. His research focuses on new musical instruments, especially augmented instruments. He was an undergraduate at MIT and completed an M.Eng. in Barry Vercoe's group at the MIT Media Lab. He subsequently completed a PhD in music composition at the University of Pennsylvania in 2009. Before joining Queen Mary in 2011, he spent two years as a postdoc at Drexel University supported by a Computing Innovation Fellowship. He is the creator of the magnetic resonator piano, an augmented acoustic piano which has been performed worldwide and used in over 20 pieces, and his TouchKeys multi-touch keyboard was featured in a successful Kickstarter campaign in 2013.

FRANCISCO MEDEIROS

Francisco Medeiros studied Film, Video and Multimedia Communication at the Universidade Lusófona de Humanidades e Tecnologias. Since 2003 he attended several workshops and Master-classes. His professional and artistic activity is centered on producing and creating Multimedia projects where he develops the expressive use of contemporary technologies trough the use of software aplications. Since 2005 he has been collaborating with several artists in the field of performance arts, interactive installations, music and scientific research. He is part of the art collectives Dancingfoot, Crew Hassan, LabIO and DARC where he helps in teaching and implementing solutions with free and open source software.

JOÃO MENEZES

João Menezes is a Composer and Sound Artist, working at the intersection of Sound, Interaction and Media. João has lead workshops and presentations at festivals, universities and conferences, such as: Code Control Festival, Get Set Art Festival, Semibreve Festival, London College of Communication - University of the Arts London, Faculty of Engineering as well as the Faculty of Fine Arts of the University of Porto, Leicester College, Artech - International Conference on Digital Arts, and the xCoAx Conference, among others. Born in 1989, he graduated with a degree in electronic music and musical production. In 2012, he earned his MSc in Interactive Music and Sound Design with high distinction from the Faculty of Engineering of the University of Porto. From 2010 to 2014 João was an active member of the Digitópia Collective at the Casa da Música Foundation, Porto. Additionally, he has composed music for Dance, Theatre and Film. Now, João is the Technical Specialist of Music in the Music Program at New York University Abu Dhabi.

MICK MENGUCCI

Mick Mengucci is Italian/Swedish, resident in Portugal. Mine Engineer and researcher with MSc in GeoSystems, PhD in Engineering Sciences with experience in Image Processing. Composer, singer, guitarist and percussionist specialized in Brazilian, African, jazz and Italian music. Performer and organizer of Slam Poetry events and performances. Multimedia programmer for performance and artistic installations. Founder and coordinator of the collective project LabIO – Laboratory for Interaction and Orality, dedicated to research, performance and educational services in 'Creative Programming', 'Slam Orality' and 'Musical Expression'. He is just another human believing in art and science to explore the beauty of nature and life.

MIGUEL MIRA

Miguel Mira is musician, university professor, architect and painter. He played contrabass, acoustic bass guitar and electric bass, but has been focused on the cello in the last years. Played with countless Portuguese musicians, including Carlos "Zíngaro", Rodrigo Amado, Paulo Curado, Ernesto Rodrigues, Abdul Moimême and Rodrigo Pinheiro. International musicians include Joe McPhee, Evan Parker, Jeb Bishop, Scott Fields, Joe Giardullo and Patrick Brennan.

DAVID MOORE

Currently working as a a teaching fellow in the School of Electronic and Electrical Engineering at the University of Leeds, David Moore acts as a technical consultant on projects conducted through ICSRiM, the Interdisciplinary Centre for Scientific Research in Music. His main interests lie in the development of embedded systems for musical applications, as well as wireless and internet-connected hardware. David has worked with ICSRiM on a number of different projects, with their work appearing at a number of different conferences over the years, as well as exhibitions at the Maker Faire.

LORNA MOORE

Dr Lorna Moore is a video performance artist and works with real-time video, HMDs and bio sensors. She currently completed her PhD at the University of Wolverhampton, UK. Her research explores ways to suspend the corporeality of participants' within the digital Other as an In[body] experience afforded by real-time video technologies. In[body] is articulated as being in the body of the work/ subject in the moment. Her work has been exhibited nationally and internationally where she has collaborated with many artists and co-ordinated a number of art festivals.

http://lornam77.wix.com/lornamooreartist
http://lornam77.wix.com/lornamooreartist#!current-sketchbook/c65q

TOM MUDD

Tom Mudd is a researcher, musician and programmer interested in relationships between software, composition and improvisation. His current research and musical work explores the role of nonlinear dynamics in musical interactions, leading to new synthesis methods through the use of Duffing oscillators coupled with banks of resonant filters. The resultant systems have many properties in common with acoustic systems found in reed or bowed instruments. He has presented performances, talks and installations at places such as Tate Britain, the Queen Elizabeth Hall, MS Stubnitz, STEIM, Café Oto, the Huddersfield Contemporary Music Festival, and the Ether Festival.
He is an associate lecturer at Goldsmiths, University of London, at the University of East London, and at City Lit, teaching courses relating to music, programming, interactive media, and live performance.

PAUL MULHOLLAND

Paul Mulholland is a Research Fellow in the Knowledge Media Institute (KMi), The Open University, UK. His research interests include technology enhanced learning, digital narrative and knowledge visualisation. He has been an investigator on a number of international and UK research projects in which he has been involved in the design, development and evaluation of technologies in formal education, museum and work contexts. Previous work has included: innovative applications for use by museum staff and visitors; mobile applications for formal and informal learning; automated narrative generation tools for education and entertainment; and semantic and knowledge technologies for learning in organisations.

KIA NG

BSc(Hons), PhD, MIEEE, MBCS, FIoD, FRSA, FVRS, CITP, CEng, CSci.
Kia is a senior research lecturer at the University of Leeds where he is co-founder and director of the Interdisciplinary Centre for Scientific Research in Music (ICSRiM). Kia's research links together work in the School of Computing and the School of Music on Multimedia, Computer Vision, Computer Music and digital media.

CARLOS OLIVEIRA

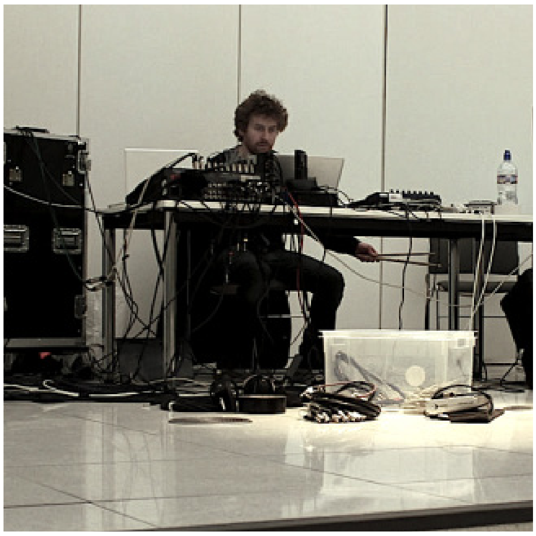
Director of Communication and Cooperation at the Faculty of Engineering, University of Porto, since 2005. Invited assistant professor at the Department of Informatics Engineering, teaching in the Master in Multimedia since 1996.
I have a Degree in Electrical and Computer Engineering (1991) and a Master (1995) in the same field with a specialization in Telecommunications.
From 1991 to 1995, I was a researcher in telecommunications and multimedia at INESC Institute for Systems and Computer Engineering of Porto. Then, I was a co-founder of the start-up company Imediata - Communications and Multimedia, SA, where I assumed the technical direction for three years.

SOFIA OLIVEIRA

Sofia is an artist who founded CADA with Jared Hawkey. She studied Sociology at Universidade Nova de Lisboa (1993).
CADA is an art group that makes freeware for mobile phones for exhibitions and the public realm. Formed in Lisbon in 2007, it also organises events and workshops to promote the development of digital cultural practice. CADA's goal is to expand conventional understandings of software. Its works are intentionally playful, designed to activate a space for questioning and reflection on the ways in which action emerges from the entanglement of people and technology.
CADA has exhibited and led workshops across Europe and in Brazil.

http://cada1.net

MARTIN PARKER



Martin studied composition at the University of Manchester and completed a Ph.D in Composition at the University of Edinburgh in 2003. He is currently Programme Director of the University of Edinburgh's MSc in Sound Design, Artistic Director of Edinburgh's Dialogues Festival and one third of free improvisation trio Lapslap. Some of his music is available on Ein Klang, Leo Records and sumtone, which also publishes some of his scores and performance resources.

http://www.tinpark.com

ADAM PARKINSON

Adam Parkinson is a musician and researcher in EAVI. He likes running Pure Data music software on anything he can get his hands on - from mobile phones to single board computers. As a musician and programmer, he has worked with Arto Lindsay, Caroline Bergvall, Phill Niblock, Rhodri Davies and Kaffe Matthews. His music ranges from glitchy techno to skewed electronic 'pop', and he has released on Entr'acte records. He did his PhD at Culture Lab, Newcastle University on 'Encountering Musical Objects', using Gilles Deleuze and Object Oriented Philosophy to explore the way we interact with sounds and musical instruments. His current research interests include increasing accessibility of audio tools through DIY haptics, and how we understand liveness in contemporary laptop performances.

http://cargocollective.com/manwithfeathers

BRUCE PENNYCOOK

Bruce Pennycook is the Director of the Center for Arts and Entertainment Technologies in the College of Fine Arts, Professor of Music in the Department of Theory and Composition in the Butler School of Music and Panel Chair for the Digital Arts and Media, at the University of Texas at Austin. Born in 1949 (Toronto, Canada), Master in Music in Theory and Composition (1974), received a Canada Council Doctoral Fellowship for graduate work at the Center for Computer Research in Music and Acoustics (1976, Stanford University). He pioneered programs in Music, Media and Technology, including the The Music Library of The Future.

SÉBASTIEN PIQUEMAL

Sébastien Piquemal is a computer engineer obsessively exploring the artistic capabilities of machines. He has created sonic and experimental web sites, and is the author of several music open-source libraries such as WebPd (Pure Data for the web). His work focuses on the potential of new technologies, both in shifting the hierarchic structures in live music and create new computer generated sonic experiences, borrowing from the field of computational creativity. Sébastien's work has been shown at a number of international venues and conferences, such as CTM, N.K., cafe OTO, NIME, ICMC among others.

http://funktion.fm

ISABEL PIRES

Composer and performer of acousmatic music, Isabel Pires is PhD in Esthétique, Sciences et Technologies des arts - spécialité musique, from Paris VIII University. She is professor at Department of Ciências Musicais At Universidade Nova de Lisboa and director of LIM (Computer Music Laboratory) at the same University. Isabel Pires is a researcher from CESEM.
His research interests are related to cognition and auditory perception, as well as physical sound phenomenon and space ideas in musical composition. She works with the composer François Bayle on acousmatic music analysis and acusmographic representations of sound (graphical listening music).
Her musical works and performances, as well as her research have been shown internationally.

RENATE PITTROFF

Renate Pittroff works as a freelance director in the areas of experimental theater and acoustic art (audio drama, radio art, sound installation). She is a lecturer at the Department of Theatre, Film and Media Studies, University of Vienna Since 1995, she designed and directed the projects of “theaterverein meyerhold unltd.” In the areas of radio plays and acoustic art she works primarily with Austrian authors like Friederike Mayröcker, Peter Rosei, Franz Schuh, Brigitta Falkner and Lisa Spalt. In recent years, she presented some art projects that deal with interactive methods. The result was “finalbluten” an interactive radio sound installation or projects “bm dna: Ministry of DNA Hygiene, Department: Hair - a theatrical usurpation”, “Tracker Dog” and “Samenschleuder”, last: “Re-Entry - life in the Petri dish. Opera for Oldenburg “ 2010.

www.wechsel-strom.net

FRANK POLLICK

Professor Frank Pollick is interested in the perception of human movement and the cognitive and neural processes that underlie our abilities to understand the actions of others. In particular, current research emphasises brain imaging and how individual differences involving autism, depression and skill expertise are expressed in the brain circuits for action understanding. Research applications include computer animation and the production of humanoid robot motions. Professor Pollick obtained BS degrees in physics and biology from MIT in 1982, an MSc in Biomedical Engineering from Case Western Reserve University in 1984 and a PhD in Cognitive Sciences from The University of California, Irvine in 1991. Following this he was an invited researcher at the ATR Human Information Processing Research Labs in Kyoto, Japan from 1991-97.

YAGO DE QUAY

Yago de Quay is a musician who performs with sensors on his body. His work with sensors and electronic music started in 2010 with a grant by the European Union to implement interactive music sensors in night clubs. In 2013 he received the Audience Favorite Prize at West By West Campus Film Festival for the film NOLA and the Critics Table Awards nomination for the Best Video Design for the multimedia performance 3D[Embodied]. In 2014 Yago was commissioned a live performance piece that uses brain waves and a 3D sensor for the Ammerman Center for Arts and Technology at Connecticut College.

WISKA RADKIEWICZ

Wiska Radkiewicz received training at the Conservatory of Warsaw, Poland (composition), the University of Paris-Sorbonne (musicology), the Groupe de Recherches Musicales - Conservatory of Paris (electronic music composition), the City University of New York (composition), and at Princeton University (doctorate degree in music composition). She is an electroacoustic composer and sound artist who has explored various fields (pedagogical studies, audio-visual composition and creative writing). She lives and works in Roosevelt, New Jersey, USA.

PEDRO REBELO

Pedro is a composer, sound artist and performer working primarily in chamber music, improvisation and sound installation. His writings reflect his approach to design and creative practice in a wider understanding of contemporary culture and emerging technologies. Pedro has been Visiting Professor at Stanford University (2007) and senior visiting professor at UFRJ, Brazil (2014). At Queen's University Belfast, he is currently Director of Research for the School of Creative Arts, including the Sonic Arts Research Centre. In 2012 he was appointed Professor at Queen's.

JUAN DUARTE REGINO

Juan Duarte Regino is an audiovisual artist from Mexico City. He is currently completing the MA in New Media at Aalto University in Helsinki, Finland. His artistic work and research is related to sonic interaction design, physical computing, custom made electronics, live visuals and sound coding. He is a co-founder of Third Space; a gallery located in the center of Helsinki where curates the Sound Room project.

http://juanduarteregino.com

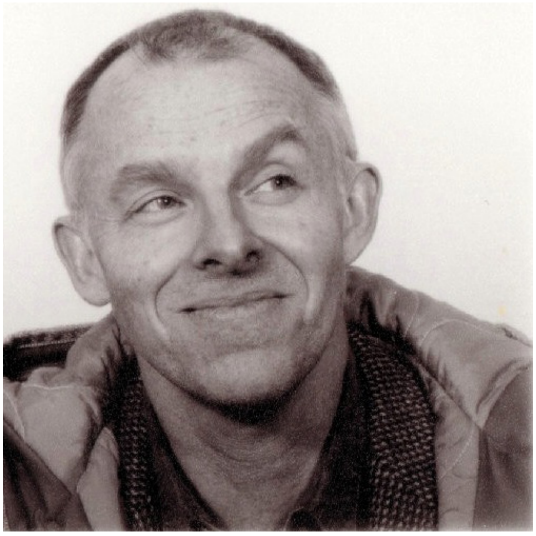
LUÍSA RIBAS

Luísa Ribas holds a PhD in Art & Design (2012), a Master in Multimedia Art (2002) and a Degree in Communication Design (1996) from FBAUP (Faculty of Fine Arts, University of Porto). She is a member of ID+ (Research Institute for Design, Media and Culture), researching sound-image relations and audiovisuality in digital interactive systems, having contributed to several international events and publications with articles on digital art and design. As a professor at FBAUL (Faculty of Fine-Arts, University of Lisbon) she teaches Communication Design, with a focus on print and digital computational media, namely in the domains of editorial design and audiovisuality, and is currently the scientific coordinator of the Master in Communication Design and New Media.

ANDREW ROBERTSON

Andrew Robertson is a researcher at Queen Mary University of London, School of Electronic Engineering and Computer Science. Andrew's research focuses on the development of new performance systems for rock and pop music, aiming to create dramatic effects through the use of engineering technology in the fields of live music performance. He has been awarded the prestigious Royal Academy of Engineering Research Fellowship for 2009.

JOEL RYAN



Joel Ryan is a composer, inventor and scientist. He pioneered the application of digital signal processing to acoustic instruments. He taught philosophy, physics, and mathematics. He belongs to the 1st generation of computer music hackers from Silicon Valley, and has been a key-element at STEIM since 1984. Now he advises on live electronic performance at the Institute of Sonology.

http://jr.home.xs4all.nl

ADRIANA SA

Adriana Sa is a transdisciplinary artist, musician, performer/ composer. Around 1995 she started using sensor technologies to explore music connected to light, movement, architecture and weather. Currently she explores disparities between human perception and digital analysis as creative material. She is finishing a PhD in Arts and Computing Technologies at Goldsmiths. Adriana performed and exhibited worldwide, in venues such as Calouste Gulbenkian and Rivoli (Portugal), Experimental Intermedia and PS1/ MoMa (US), Caixa Forum and Arteleku (Spain), ICA -Institute of Contemporary Arts (UK) or Aomori Contemporary Art Center (Japan). Her scientific research has been published by MIT Press, xCoAx, NIME and CITAR journal. The research is funded by FCT-Foundation for Science and Technology (EU/ Portugal).

http://adrianasa.planetaclix.pt

JELLE SALDIEN

Jelle Saldien received his M.S. degree in Industrial Science ICT at DeNayer Institute in 2003 and an additional M.S. degree in Product Development at Artesis in 2005. In 2009, he received his Ph.D. at the Vrije Universiteit Brussel on the design and development of the social robot Probo. From 2010, he was lecturer in Industrial Design at the Howest University College West Flanders. Since 2013 he is appointed as Assitant Professor Industrial Design at Ghent University and since 2014 steering member of Flanders Make VD4. Jelle Saldien is author of over 30 technical publications, proceedings, editorials and books. His research interests include mechatronic design, interaction design, human computer interaction and social robotics.

KOICHI SAMUELS

Koichi is a PhD candidate at Sonic Arts Research Centre, Queen's University Belfast and an electronic musician. He is currently conducting an ethnographic study with Drake Music Northern Ireland, an inclusive music charity that aims to enable people with physical disabilities and learning difficulties to compose and perform music. Research interests include: inclusive music; enabling technology; DMIs; assistive music technology; human computer interaction; DIY/making/hacking; democratisation of technology

TIM SAYER

Faculty Director (Research) for the Faculty of Culture and Language Sciences at the University of St Mark and St John Plymouth and a senior lecturer in the psychology of sound, composition, new media and sound design. His research interests centre on human computer interface design in the context of improvised musical performance, exploring the perceptual parameter space that exists between performer and technology as a means of investigating cognitive/behavioural mappings. He has written a number of published articles and papers relating to this research, most recently presenting work at the 9th Conference on Interdisciplinary Musicology – CIM14. Berlin and the International Conference on Live Coding 2015 at University of Leeds, UK.

FRANZISKA SCHROEDER

Franziska is a saxophonist and theorist, originally from Berlin/Germany. She trained as a contemporary saxophonist in Australia, and in 2006 completed her PhD at the University of Edinburgh for research into performance and theories of embodiment.
Her research is published in diverse international journals, including Leonardo, Organised Sound, Performance Research, Cambridge Publishing and Routledge. Franziska has published a book on performance and the threshold, an edited volume on user-generated content and a volume on improvisation in 2014 (Cambridge Scholars Publishing). Her recordings include several CDs on the creative source label, a recording on the SLAM label with a semi-autonomous technological artifact, guitarist Han-earl Park and saxophonist Bruce Coates and a 2015 pfmentum recording of free improvisation with two Brazilian musicians. Franziska is a Lecturer at the School of Creative Arts, Queen's University Belfast, coaching students in improvisation, digital performance and critical theory.

www.sarc.qub.ac.uk/~fschroeder

ALEXANDER SENKO

Alexander Senko was born in Moscow, Russia. Graduated from Gnesins Institute as a sound engineer. Composer, sound producer, Alexander runs a laboratory "Acoustic Images" (research and production of interactive installations). Alexander's interests include visual programming language Pure Data, electronic and electroacoustic music, sound art, audio-visual interaction. Selected exhibitions and performances: 9th Festival International De La Imagen, Manizales, Colombia Pure Data convention, Weimar, Germany PIKSEL[X], Bergen, Norway Prepared Environments 5, Moscow, Russia FILE 2014, Sao Paulo, Brazil (h)ear XL II, Heerlen, the Netherlands Radical dB festival, Zaragoza, Spain "The Engine Room" sound art exhibition, London, UK Ars Electronica 2015.

http://www.acousticimages.net

TIM SHAW

Tim Shaw has worked extensively as a professional composer, performer, sound designer and musician based in the North-East of England. His practice incorporates diverse approaches to sound capture and processing, and includes creating immersive and responsive sonic installations. He is currently studying a PhD in Digital Media at Culture Lab alongside managing Newcastle based record label Triptik. Tim has created commissions for Warp Records, Transmediale, The British Council, Arts Council England, The British Science Association, Pacitti Company, Tender Buttons and GIFT Festival. His current research-practice is looking into how sound can support the unearthing (bringing to light) of phenomena outside of human perception and how new technologies can allow a deeper understanding of real world environments.

RYAN ROSS SMITH

Ryan Ross Smith is a composer and performer currently based in Troy, NY. His music ranges from the pop and the rock [Power Player, Twin Thousands], to the functionally dependent [various music for modern dance, film, television and radio], from fre[(e)ak] fo[(rm)lk] [Stars like Fleas, Matt Lavelle, Zeena Parkins]. While these facets of Smith's musical life continue to some degree, his focus has shifted primarily to the development and research of animated notational practices, in particular to discover its potential for compositional innovation and invention. Smith is interested in the creation of rhythmic complexity with an economy of means, the stasis of an active non-accomplishment, the expression of concept over form or development. Smith earned his MFA in Electronic Music from Mills College in 2012, and is currently a PhD candidate in Electronic Arts at the Rensselaer Polytechnic Institute in Troy, NY.

http://ryanrosssmith.com

IAN SYMONDS

Ian Symonds is a digital support systems designer and analogue film maker with an interest in collaborative projects. He spent ten years working on the Music, Multimedia and Electronics course at the University of Leeds as a member of the School of Electronics and Electrical Engineering. He later worked as an embedded systems designer for a small mechatronics company. He returned to his interest in music and electronics as an external member of two projects with former colleagues from the University of Leeds. He designed, built and programmed some of the system used in the last project and is now editing a documentary film that he made of it.

http://www.edutronic.co.uk

ATAU TANAKA

Atau Tanaka creates musical instruments using sensing technology to capture movements and gestures of musicians. His first inspirations came upon meeting John Cage during his Norton Lectures at Harvard. Atau then studied at CCRMA Stanford, and conducted research in Paris at IRCAM, Centre Pompidou. He has been artistic ambassador for Apple, was the first artist to be engaged as researcher at Sony Computer Science Laboratory (CSL), and has been mentor at NESTA UK, and Artistic Co-Director of STEIM Amsterdam. His work is funded by the European Research Council (ERC). He is Professor of Media Computing at Goldsmiths.

http://ataut.net
http://eavi.goldsmithsdigital.com

CHRISTOPH THEILER

Christoph Theiler lives in Vienna since 1982. Working as freelance composer and media artist.
His last works are established in the area multimedia and sound installation. GATE II+III are the works, in which new forms of interactive sound design were developed.
As in the case of MEMBRAN II (for e-guitar, sax and medium wave transmitters), M.O. - HERZ + MUND (sound installation with 3 bass loudspeakers and very low frequency waves) and HF 114 (electronic composition for 7 transmitters) more and more means from the area of the electronic music, the sound design, the high-frequency engineering and the internet are included in his artistic conception. The electronic composition NEARNESS was published on the “Sonic Circuit” festival CD 2001.
He got the composition price of the city of Stuttgart (1982) and the composition price “Luis de Narvàez” Granada (1993) for the 1st and 2nd string quartet. Recordings made by WDR, ORF, Deutschlandradio, radio Koper, Ljubljana-TV and BR? Compositions for chamber ensemble, orchestra, electronics, theatre and radio play.

www.wechsel-strom.net

HORÁCIO TOMÉ-MARQUES

Horácio Tomé-Marques is an artist and researcher in digital media, multimedia content, interactivity, virtual and immersive environments (photography, 3d). His PhD project is about the relationship between Music, Reason and Emotion. It uses brain computer interfaces and real-time artistic representational methodologies grounded on scientific quantitative criteria to denote the dynamics of the electrophysiology occurring in the brain in the ecology of the performing arts environments. EshoFuni and EshoFuni@TheAbyss are among the most interesting of his projects to date in this context. Born in 1960, communication designer by the Faculty of Fine Arts, University of Porto, teacher at the Superior School of Music and Performing Arts - ESMAE, Porto, he has a long and established career as designer, composer/performer (music), teacher/lecturer, creative/art director and curator. Horácio holds a PhD Scholarship by FCT- Fundação para a Ciência e Tecnologia UTAustin | Portugal Program.

CESAR VANDEVELDE

Cesar Vandevelde graduated as M.Sc. Industrial Engineering – Industrial Design at Ghent University in 2012. Immediately following his graduation, he started his PhD under prof. Jelle Saldien, which he is currently still pursuing. His research focuses on the design of a low-cost, hackable toolkit for social robotics. Other research interests include robotics in general, 3D printing, human-computer interaction and mechatronics.

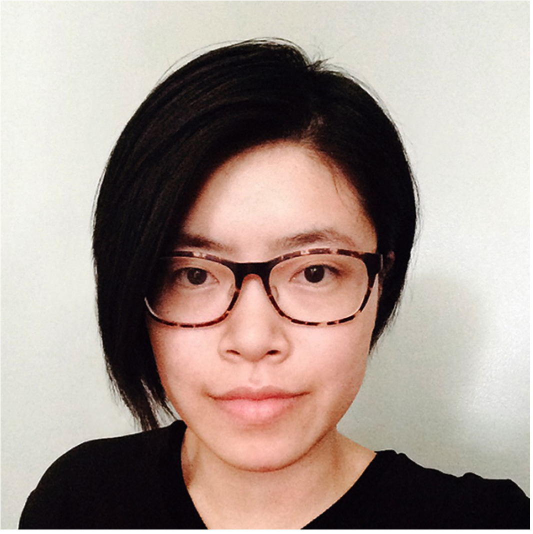
JOLIEN DE VILLE

Jolien De Ville was born in 1987. She received her masters degree in Product Development at the University of Antwerp in 2010. Her recent publications include “Drum Duino: a Tangible Interface to Create Rhytmic Music with Everyday Objects.” (2013) and “Playful Interaction: Designing and Evaluating a Tangible Rhythmic Musical Interface.” (2014). Her research interests include user experience design, intelligent textiles, tangible user interfaces and the internet of things. She is currently working as a user experience designer at KBC bank, Belgium.

SOPHIE WAGNER

Sophie-Carolin Wagner, born 1984, is an artist and post-doctoral researcher at the University of Applied Arts Vienna, Austria. She holds a master’s degree in Economics and Social Sciences, a master’s degree in Digital Arts and a PhD, graduated in 2014 under the supervision of Prof. Elena Esposito and Prof. Peter Weibel. Her work investigates epistemological consequences for communicational processes in functionally differentiated systems, i.e. the contingent nature of decision-making due to levels of complexity and concomitant limits of probability. Further, she focuses on how media transforms society and individual and serves as a prosthesis to extend the human body and mind and does so in theory and artistic practice

FRANCES WANG



Frances Wang received the B.F.A (Honors) degree from Northumbria University, Newcastle, UK in 2008, and the M.Mus. degree in music technology from New York University, New York, NY in 2014. Her Master's degree work focused on developing novel musical interfaces that provide multidimensional gestural control of sound and imagery.

http://francesyw.com

STEVE WEBSTER

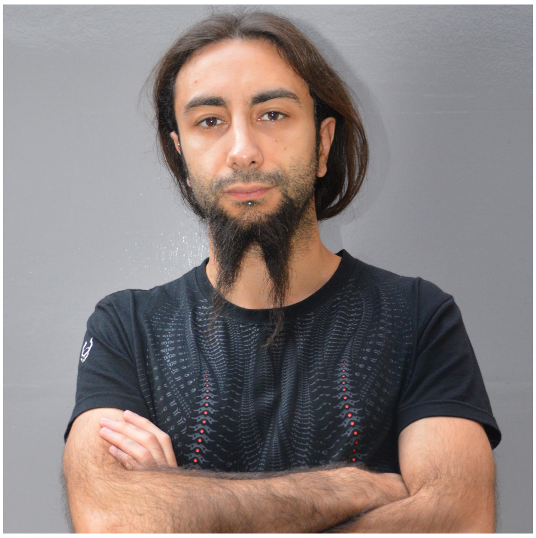
Steve Webster is a writer, producer and performer in Higamos Hogamos (DC Recordings): *http://www.dcrecordings.com/* Higamos Hogamos is a stoney and experimental electro duo that blends modern electronic sounds with '70s glam, psychedelia, and Krautrock -- especially Krautrock. Formerly paired together in Fort Lauderdale, Steve Webster (the Black Neon) and Toby Jenkins (Zan Pan, the Squire of Somerton) started a recording project in London over the winter holidays of 2006. Heavily influenced by the driving electro-rhythms of Motorik German groups Neu!, Kraftwerk, and Harmonia, Webster and Jenkins recorded a few songs together before DC Recordings' Saul Kane realized the group's potential, and signed them to DC, who released their first album in March of 2009.

IAN WILLCOCK

Ian Willcock is a digital artist, researcher and lecturer in Interactive Media and Live Performance. His musical, multimedia and digital-performance pieces have been presented internationally and he has received many prizes and scholarships. Several of his pieces are published and his work is available on commercial recordings. He has collaborated on a number of large-scale digital performance and mixed-media installation projects and in 2012 completed his doctorate in Multimedia and Live Performance at De Montfort University. Ian Willcock is a Principal Lecturer in Interactive Media at the University of Hertfordshire, where he leads the PG Media programme.

www.willcock.org

VICTOR ZAPPI



Victor Zappi is a Marie Curie Post Doctoral Fellow between MAGIC Lab, University of British Columbia, and the Department of Advanced Robotics, Istituto Italiano di Tecnologia. As an electronic engineer and a New Media artist he is focusing on Music Technology, blending research and teaching activity in this inspiring multidisciplinary field. His interests and skills include the design and development of new musical instruments and their effects on musicianship, and the exploration of novel Virtual and Augmented Reality technologies in the context of live performances.

POLINA ZIOGA

Polina Zioga is a multimedia visual artist and currently a PhD Candidate at the Digital Design Studio of The Glasgow School of Art, awarded with the Global Excellence Initiative Fund PhD Studentship. She has previously been awarded the Scholarship for Excellence in Studies by the State Scholarships Foundation. Her interdisciplinary background in Visual Arts (Athens School of Fine Arts) and Health Sciences (National and Kapodistrian University of Athens) has influenced her artistic practice and current research in the field of brain-computer interfaces and applications development for real-time audio-visual and mixed-media performances. Her work has been presented since 2004 in Europe, North America and Asia, in solo and group art exhibitions, international art fairs and museums, centres for the new media and the digital culture and international video-art and film festivals. Polina is also an affiliate member of national and international organizations and platforms for the visual and new media arts (Chamber of Fine Arts of Greece, ArtUP! Digital Collection of the Goethe-Instituts in Ankara, Athens and Sofia, Northern Video Art Network, NOVA).

www.polina-zioga.com