EXPLORING THE SPACE BETWEEN INSTRUMENT AND CONTROLLER

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ABSTRACT

Electromagnetic sensing systems allow for expressive interaction in electronic music, performance, and time-based media art. REBUS is a machine which emits and receives electromagnetic waves to form a sensing space where human movement and presence can be detected with previously unknown precision. The potential of the system is explored through a workshop and a study targeted to selected groups: whereas the workshop observed the approach of coders and musicians in proposing compositional methods that this electromagnetic field sensing instrument offers, the study inspected the behaviour of classical musicians, mainly trained on strings or keyboard instruments, vis-a-vis that of selected electronic musicians. The terrain between instrument and controller is also explored through a fruitful deception. The paper narrates the conceptual assumptions behind these experiences through an initial analysis and some reflections on the data collected.

1. ELECTROMAGNETIC INTERACTIONS

This research explores electromagnetic sensing systems for expressive interaction in electronic music, performance, and time-based media art [1]. The research has materialised in a series of experiments and the creation of a musical system for audiovisual performance composition using electromagnetic waves (Figure 1).

REBUS is a machine that creates a sensitive space where any subtle interaction is detected independently of external light or sound and where invisible affordances can be touched and manipulated with the hands and the body, almost as invisible strings. The peculiarity of REBUS does not lay in the sonic register but in the original way in which it is possible to manipulate its oscillation, in the musical potential of the vibratory motion of the pressure waves modulated through manipulating electromagnetic waves [2].

Following the creation of this state of the art system for electromagnetic interaction, a series of activities, including a workshop, a public presentation and a user study, were designed to further explore the potential of the system, ultimately mapping the space between musical instrument and controller and considering whether playing with waves can

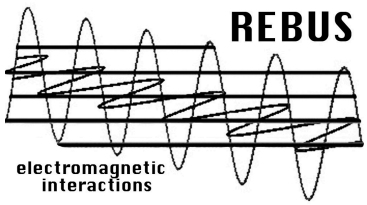

Figure 1. Electromagnetic Interactions logo and sign displaying an electromagnetic wave traversing a pentagram.

be a new way to make music, or the electronic *par excellence* way to interact with sound, and whether an open and programmable instrument like REBUS can display recognisable characteristics that make it a musical instrument.

2. WHAT IS A MUSICAL INSTRUMENT

Starting from the assumption that "*...for a tool to be a musical instrument there must be at least a musician willing to play it...*" [2], the concept of musical instrument can be explored and clarified. According to Kvifte the concept of instrument cannot be disentangled from that of music and any reference to an instrument shall always be understood as part of a cultural context, innervated by economic interest and power relationships [3]. This view expands the understanding of musical instruments beyond the traditional loop *performer - bodily gestures - instrument - musical gestures*. An alternative approach explores the field beyond the limitations of the instrument-as-device evaluation framework, which, borrowing from traditional HCI, evaluates the device's success as a function of the tasks performed by a user-musician, limited by the characterisation of the musician as prototypical user [4]. A more conducive approach is suggested in the interpretation of the instrument as a constellation of processes or affordances which may mean different things to different musicians.

In this view the user is re-described as an ecology composed of agent (or agents) and environment, ultimately defining the coupling musician plus instrument as an interactive system. This approach is in line with the cultural perspective which explores musical instruments as the objects of material culture, which acquire a degree of power and agency in the context of their use: musical instruments are made to make meaning and they are therefore more than *the thing itself*, emerging as part of a continual convergence of meaningful developments in music, culture, design and technology, a relationship which should inform any attempt to answer the question "what is a musical instrument" [5]. Musical instruments as cul-

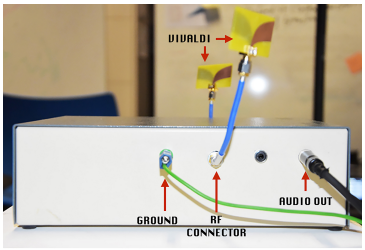

Figure 2. REBUS, first prototype, side view.

tural objects are therefore somewhat colonised by cultural habits of consumption and signification. In proposing a framework for the evaluation of digital musical instruments (DMIs), O'Modhrain proposes to include, along with players and audiences, also composers, instrument builders, customers and manufacturers, remembering that in many cases performers are also composers and eventually designers. This poses a challenge because both frameworks and taxonomies present limits, in particular when the evaluation is made from an audience's perspective, as most DMIs no longer present a perceivable or clear causal link between the gestures required to play the instrument and the mechanism that produces the sound [6]. According to this perspective the most important stakeholder in the process of designing and building a DMI is the performer/composer, although also audience, designer and manufacturer present perspectives that are all valuable at different phases in the design cycle.

In the study that follows, the framework is determined by the prominent presence of the coder, who composes and in some cases also plays the instrument.

3. IDENTITY

Following a long phase of engineering in order to construct the first prototype, the question whether REBUS is a musical instrument or a controller emerged as a consequence of two fundamental properties of the instrument: the form of interaction shapes the identity of the instrument; the sound palette, interaction logic and mappings offer infinite possibilities. REBUS is a machine that satisfies the definition identifying a musical instrument as formed by both interface and sound emitting engine. It is a small metal box with two protruding antennas (Figure 2), and its interface is created and analysed in realtime when the instrument is turned on [1]. The sound is generated by an embedded computer using the electromagnetic data to modulate the sound.

A controller, instead, would be attached to another, computer or device, and it would be used to *control* the other engine to which it is attached. However, the question was wider, and multiform: on the one hand, REBUS had been imagined, designed, enginered, programmed and played only by its author. This proved also the assumption that for an object to be a musical instrument, there should be someone ready to play it. But that is not enough to validate its ontological existence: would any other musician desire this particular instrument? And how would they use it? Can an instrument so ductile in terms of composition (any type of composition can be designed and programmed), but so determined in terms of interaction, be useful and attractive also for others who didn't invent it specifically to satisfy their performance needs? But more specifically, can this machine formally made *as seen in a dream* become a musical instrument with a defined identity and a mark that made it recognisable the way we could possibly identify an acoustic instrument by hearing its sound? In other words, is the identity of an instrument something that you can hear?

3.1 Coders as Agents

These questions provoked a series of activities to come to an understanding of the instrument that goes beyond an individual approach and experience. This phase of the Electromagnetic Interactions research project was targeted to coders, musicians and producers and included a workshop, a public presentation, and a user study to collate qualitative and quantitative data to answer the question whether REBUS can be considered a musical instrument and whether the electromagnetic field, when used as an interface to interact with sound, is not *innocent*, ie it fosters a deeper characterisation of the instrument itself as well as the sound as it is produced independently from the composition devised.

The workshop selected invited participants to write code for the instrument for one day. The target group included coders who are also musicians: some experience with Digital Signal Processing and C++ was a requisite. The group was composed of a combination of students and non-students aged roughly between 20 and 60 years old. Invited participants were divided in small groups, and each group was given a Bela, an integrated microprocessor specialised in real-time audio and interaction, along with the necessary instructions and the code skeleton to get started. Following a demonstration of the instrument and a brief introduction to coding with Bela/REBUS lasting one hour in total, each group had a day to produce an original composition, ie software that, uploaded on REBUS, defines the link between movement and sound (Figure 3). Throughout the day the workshop leader, also author of the instrument, assisted and troubleshot the various groups. The idea to consider workshops as a participatory process and creative practice which can provide more relevant insight than the classic completion of a task of the user-study paradigm is not new, as workshops have already been interpreted as a rich delivery instrument for emergent forms of music [7]. Adding coders to the social framework validates the idea that algorithms, and by extension the code that implements them, can be interpreted as score [8].

This occasion was the first public workshop where participants had the possibility to program and make their hands dirty with REBUS. At the end of the workshop all participants had to respond to the following three questions, the first requested them to comment on their experience ('*How was your experience with REBUS?*'); the second hinged on

[1] https://xname.cc/rebus

Figure 3. REBUS workshop at Goldsmiths, University of London, April 2023.

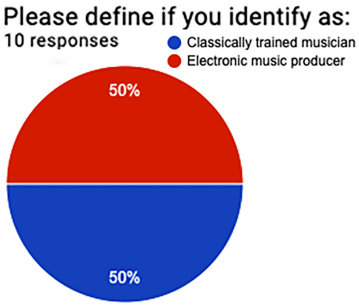

Figure 4. Pie-chart showing the identification of the target groups.

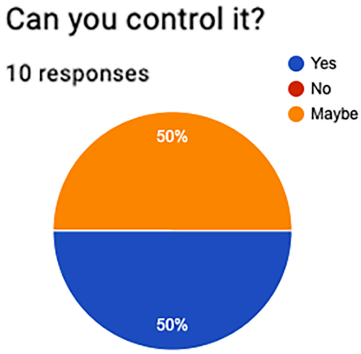

Figure 5. Half of the study participants are unsure whether controllability is a property of a musical instrument.

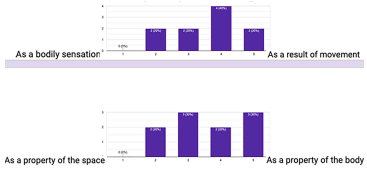

Figure 6. *How did you perceive your interaction with the sound?* As a bodily sensation - As a result of movement. As a property of the space - As a property of the body. Likert-scale answers, Outro form.

expectation (‘*Was it different or similar to what you had imagined and expected?*) and the third explored the question of limits (‘*What do you think are the limits of this form of interaction and music making?*’).

Most users responded that the instrument was exactly as imagined, while one asserted it being “*...something you have to try...*” another said “*it’s the opposite of a predictable experience*” and insisted in the third question that “*unpredictability could look like a limit*” but “*repeatability and predictability should not be part of the definition of a worthy musical experience*”. Some participants expressed a certain enthusiasm, defining REBUS as ‘*a truly new and exciting experience*’ and ‘*a maverick kind of making sounds*’. A participant declared that ‘*the creative dimensions yet to be explored with an instrument that harness something as nebulous as the electromagnetic spectrum are vast*’.

3.2 Musicians and electronic music producers

The user study targeted two main groups: classically trained musicians, and electronic musicians (non-classically trained). The two groups were not necessarily mutually exclusive, however the discremen hinged on the musician’s own identification as either a classical musician or an electronic music producer (Figure 4).

The demographic of the sample subjects in terms of gender, age, ethnicity was sufficiently varied. Ten subjects were invited to test the instrument and comment on it. Participants completed a feedback form before the study (Intro), and another one following the study (Outro), the latter partially reported in Figure 6 and Figure 7.

Outro

They also received background information beforehand, but no instruction regarding the compositions or explanation regarding how to play was offered. The attempt was investigating whether selected target groups would display different approaches in interacting with REBUS, and whether they interpreted the machine as a controller or as a musical instrument. The participants, placed in front of the instrument in an immersive audiovisual performance space [2] , were asked to explore and engage with four different compositions for three minutes each. When the three minutes passed they had to press the only button to move to the next composition.

The study presented a different set of questions, for example whether musicians trained on instruments that are more difficult to play and where the sounds have to be found by subtle adjustments of the hands, as for example the violin, would find REBUS more playable than those who were used to discrete and repeatable instruments such as the piano, where the action-response mechanism tends to be linear (pressing a certain key produces a certain note). Additionally, a number of electronic and noise musicians were invited to participate, in the attempt to find a correlation between habit, expectation and perception of the instrument.

An interesting fortuitous deception was also implemented to explore the element of illusion: how much of our interpretation is an illusion of the senses and perception is modulated by approximation and adjustment to expectation. The first six participants used REBUS with a loose antenna, decreasing its sensitivity of 80% circa.

At the end of the study the participants commented on the different compositions through a questionnaire, explaining how they perceived the results of their interaction, whether

[2] Sonic Immersive Media Lab at Goldsmiths, University of London.

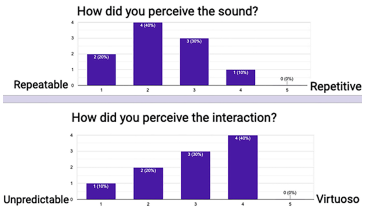

Figure 7. *How did you perceive the sound?* Repeatable - Repetitive. *How did you perceive the interaction?* Unpredictable - Virtuoso. Likert-scale answers, Outro form.

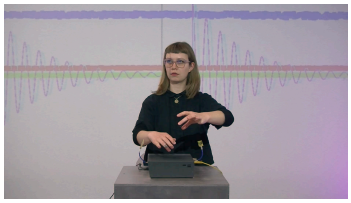

Figure 8. REBUS user study, task 2. Goldsmiths, University of London, May 2023.

they could achieve a form of musical control which would respond to their aesthetics, and if they enjoyed playing the instrument. They were filmed while they explored the four compositions (Figure 8, Figure 9 and Figure 10), which were each addressing a different topic; for example, the fourth composition, a drum machine featuring invisible buttons to turn activate different features, was designed to be almost impossible to control, whereas the second, created by Claude Heiland-Allen, one of the participants to the workshop, was controllable but not predictable at the same time. Composition one was instead designed to generate sounds in a stochastic manner, with user's movement affecting waveforms alterations, while composition three explored complex interaction with simple timbre, mimicking an arpeggiator. All compositions shared the same mapping of the electromagnetic data.

4. OBSERVATION

What emerged from the ethnographic observation of the first study was that, among classical musicians, those who used to play string instrument, like the viola or the violin, appeared quicker in understanding a totally different form of interaction from what they expected. Their approach appeared more experimental, using both hands and ears as feedback and only partially using the visual feedback. The first six users showed signs of frustration and made wide use of the visual feedback that was projected on the three walls surrounding the performance space, with the exception of the violin player who displayed an incredible capability of understanding the interaction using fingers almost as if they had a brain of their own. The violinist managed to produce rhythmic patterns also with the first composition which was designed to be very little interactive and aimed at triggering frustration. They also found the point

Figure 9. REBUS user study, task 3. Goldsmiths, University of London, May 2023.

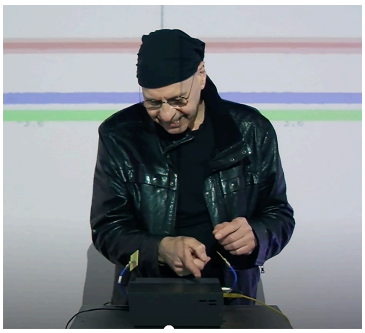

Figure 10. REBUS user study, user 10 task 4. Goldsmiths, University of London, May 2023.

of silence in the second composition which is the most difficult to explore, and only seemed unsure at the fourth composition and it's lack of linearity (the hidden buttons move along with the waves). This was even more surprising given the user tried the instrument with the deception on, but did not show any signs of frustration.

The noise musician, who tested the instrument without deception, approached REBUS slowly and, using fingers and both hands, displayed a greater capability to find borderline places, and spaces where the instability of the instrument could become a compositional strategy. They only appeared hesitant with the fourth composition (Rhythmbus), because of the initial lack of sound while the player was still searching for the invisible buttons.

5. ANALYSIS

Both the workshop's feedback forms, the two study's surveys and the video recorded tasks were passed through reflexive thematic analysis, which started with the familiarisation with the data to progress to the coding process. The process was both *inductive* and *deductive*, on the one hand aimed at giving voice to the data and the participants minimising bias and expectations, on the other remembering the research question underlying the experiment and the overall motivation at conducting it. The coding process was repeated twice, analysing the data in different orders and positioning the researcher's perspective as a component or reflexive aspect of the analysis [9].

Following a first analysis of the audiovisual and textual material collected, the semantic and latent themes emerging were that of 'Experience', which grouped codes de-

scribing the quality of the subjective experience such as 'pleasant', 'exciting', 'frustration'; 'Interaction', which grouped codes exploring the interrelation between subject and object, and 'Ontology', which grouped adjectives attributed to the instrument, such as 'novelty', 'freedom', 'subtle', 'complex', 'dynamic'.

From the answers to the final question,"*Define your performance with REBUS*", which therefore implied a sort of relationship between the subject and the instrument, a series of words appeared to point towards an almost sentimental metaphor; where the pianist said '*I wasn't very satisfied*' with my performance, the viola player asserted '*It was a getting to know between me and the instrument*' and '*I experienced a lot of self-reflection*'. The violin player, on the other hand, despite exploring the composition with decreased sensitivity, declared that the instrument '*has a not so difficult learning curve, very enjoyable*' and '*it feels natural to produce sounds with hand movements*'. User 4, an electronic music producer, said instead that he felt like '*balancing a chaotic system*', something that '*might take time to learn*'. User 5 and User 6, electronic music producers with an interest in novel musical instruments, both performing with the decreased sensitivity, defined the system respectively as '*mysterious and challenging but rewarding*' and '*an exploration of a relationship with something uncontrollable*'. The following users, electronic and noise musicians, described it as '*a hands on experience with a subliminal plane*', with one asserting '*it gave me the desire to continue exploring*', and '*super fun*'. Not only the discrepancy of experiences was surprising, but it almost appeared as if this physical interaction with something perceivable (there was an action-response effect) but impalpable at the same time triggered some forms of emotional response towards the *electromagnetic entity* the subjects were relating to.

6. REFLECTIONS

As the invisibility gives space for the expectation of unpredictability, we used a little deception and conducted the study with the first six participants without fully tightening the receiving antenna, therefore greatly diminishing the sensitivity of the system. Additionally, the four compositions implemented diverse techniques displaying varying reactivity to the interaction, for example the fourth composition was in purpose very difficult to control, if not almost uncontrollable. The idea to introduce deception responded to the need to reduce bias in the participants' answers, offering an extra margin of confrontation and verification of the data collected. Additional themes may include 'Level', where the discussion oscillates between the oppositions difficult and easy, and 'Pleasure', where the quality of the experience is discussed in hedonistic terms.

7. FUTURE

The themes and codes abstracted can model ongoing observation on real word interaction with the instrument through longer workshops culminating in performance opportunities where the users have access to the instrument for an extended time. The space into which practice increases mastery, performers work with composers, and Theremin players make music with waves, will be explored in future research phases over diverse demographics.

The activities described in this paper form the methodological and theoretical backbone of a conceptual grid which will be purported and structured in future experiences. The initial analysis described and the first set of reflections around the workshop already suggested the possibility that REBUS is not only a sound producing device or a controller or a musical instrument, it might rather be a proto instrument (the Theremin is different in that it uses the electric field) proposing a form of interaction whose physical mechanics in the void, translated into acoustic pressure, are so peculiarly identifiable that it may constitute a novel family of musical instruments, exploiting not strings or brass or woodwinds but electromagnetic waves.

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