

Chapter 3

Interaction in Art and Computing

Abstract The questions surrounding emergence in interactive art necessitate insight from different domains. While the previous chapter established an understanding of emergence, here the focus is on interaction. A selection of contemporary arts practices and computing approaches are reviewed as these can point to new ways of thinking about the relationships between audience, art system and artist. Participation, experience and open interactions form the core of the chapter's discussions, leading to insight into open and emergent digital interactions.

Interactive art is still a relatively new area. Here it can be understood as a system which requires an active audience in order to function and respond to their presence or actions. As interactive arts pioneer Ernest Edmonds describes art as being interactive “*when audience participation is an integral part of the work*” (Edmonds 2011a). Similarly, Digital Art Museum (DAM) founder and gallerist Wolf Lieser describes interactive art as involving external signals—for example, from the body of participant, or from the outside world more generally—to display them in a perceivable form (Lieser 2010). In both cases interactive art involves some sort of active audience participation with the work. An interesting facet of this discussion is the consideration that if the artwork necessitates an active audience to respond to, then it can also be argued that the interactive artwork is only fully realised once someone is participating with it.

Participation and Influence

In 1973 British artists Edmonds and Stroud Cornock were working with computation and audience involvement and, as part of these considerations, they identified four classes of art (Cornock and Edmonds 1973). The first class they identified corresponds to traditional forms of art such as painting, and is termed *static*. Their second class is *dynamic-passive* art. As its name suggests, this changes over time, but does not facilitate active audience involvement. Kinetic art like a Calder mobile

is an example of this type of art. It is an artwork which moves but which is not responsive to the audience.

The other two classes are concerned with audience involvement. The third, *dynamic-interactive* type of art describes work that reacts to a viewer and where they can change its performance. It changes over time like the preceding *dynamic-passive* category, but is also responsive because there is a feedback loop between audience and work such that the audience affects the work directly. Much of the interactive art that we see today would fall in this category.

The last class identified in 1973 is *dynamic-interactive (varying)* work. As its name suggests, this form also changes over time and with audience interaction. However, it has the added aspect of internally modulating the feedback loop. In *Heron* (Edmonds 2002) Edmonds implemented such a feedback loop using a generative software agent. Specifically, the work's vertical line imagery would become thinner as one approached responding to immediate audience presence in a way that seems like 'retreating'. Audience movements throughout the day also accumulate to modify the behaviour of the imagery the next day, through a programmed modification of the threshold of sensitivity to the audience. Edmonds describes the behaviour of this modifying agent metaphorically, referencing the behaviour of the bird: "*One could say that Heron can become tired of people jumping and waving in front of it all day long*" (Edmonds et al. 2004).

The dynamic-interactive and dynamic-interactive (varying) classes focus on artworks that change with participant interaction. Edmonds has continued to explore other ways of thinking about interactive art, including temporal and distributed aspects of audience engagement as well as longer term interaction. *Heron's* capacity to vary its behaviour from day to day is an example of this sort of distended, longer term interaction.

Longer term interaction has become a concern for Edmonds. He differentiates it from the immediate, direct, 'action-response' feedback model that we often see in computer games. Rather, longer-term engagement is more 'influencing' in its character. It may only create an effect, that is, *influence* the performance some time later, and there may not even be an immediately perceivable reaction. In more recent writing he draws on his creative work to describes this as another type of art, that is as *dynamic-interactive (influencing)* art (2011b).

The communicating technology of the internet has also informed understanding of interactive art. *Cities Tango* (Edmonds 2009) constitutes 'nodes' of the artwork at different geographic locations. These communicate with one another and the work is, correspondingly, described as a dynamic-interactive (communicating) artwork. They are affected by people's interaction with them locally but also by each other. In this sense the interaction can also be understood as distributed across the works and geography.

Lieser similarly identifies interactivity in artworks as ranging from 'direct interaction' through to some sort of 'time-delayed action'. He observes that while works can range from "*simple* interactivity, where the visitor only pushes a button, up to complex procedures between the installation and the recipient," it is usually only the latter that retain audience interest (Lieser 2010).

Delayed and influencing interactions can start to move us towards more complex understandings of interaction. They resemble the way in which memory works, and the way in which influence can travel across large system with interconnected elements. In many ways, they evoke similar character to our relationships with other people or animals who remember how we treated them yesterday; or with our world, in which tomorrow's climate is influenced by our behaviour today.

This is not something we typically see in interactive applications. Instead there is a prevalence of the action-response type model of interaction. Similarly, immediate interaction feedback tends to be more common. Explorations of interactions and complex models that challenge the status quo are needed. These can affect the way in which we relate to information and environment. They can help identify the potential for creative expression within interactivity as a medium. Furthermore, it may be that explorations of formal aspects of the interactive medium such as these become increasingly expressive, complex and experimental, in a bid to differentiate themselves from the every growing landscape of interactive applications and devices in our everyday lives.

Rules and Computers

Interestingly, the earlier definitions and descriptions of an interactive artwork seem only to require a feedback loop between the work and the audience, and some sort of change in the work itself. They do not state the necessity for a computer. While much interactive art today does typically use computer hardware and software systems, or a microcontroller chip such as the Arduino (Ivrea Interaction Design Institute 2005) this was not always the case. In fact, interactive art predates the digital computer. It is the involvement of the audience, rather than technology, which has brought us here.

A number of art movements—such as Dada, Fluxus and the Situationists—have influenced this evolution. Marcel Duchamp's *Rotary Glass Plates* (Duchamp 1920) is understood as one of the earliest interactive artworks (Paul 2015). This machine required the viewer to turn the handles then stand back and view the optical effects. Better known as an interactive artwork is Myron Krueger's *Videoplace*. Originally this work also did not use a computer, but was instead reliant on analogue video technology for rendering the audience for interaction. Only in 1985 were computer vision issues resolved, allowing the work to incorporate a computer (Krueger 1974; Krueger et al. 1985).

Edmonds also believes a work may be both interactive art and *not* use a computer. While today we use computers to execute a set of conditional rules, this effort does not, strictly speaking, need to be completed by a machine. It could, albeit slowly and possibly arduously, also be accomplished by a person: it is for example feasible for an artist to 'update' an artwork based on the active audience input, perhaps on a daily basis (Edmonds et al. 2004).

The execution of a set of conditional rules is at the core of much software and hardware technology, but rules have also been used as a part of the process of artmaking. In Dadaist poetry, Fluxus events and conceptual art works, precise instructions are followed to make the work. In 1922 Moholy Nagy ordered an enamel sign by instructing the fabricator over the telephone. Similarly in 1966 Robert Morris sent fabrication instructions to a gallery in Chicago to build his work anew for display there, given this was cheaper than transporting from New York. For art historian and critic Jack Burnham these efforts exemplify a shift *“from an object oriented to a systems oriented culture. Here change emanates, not from things, but from the way things are done”* (Burnham 1968).

The shift in emphasis from product to processes in art making is significant for interactive art. This is because it embraces the conceptual effort behind the rule-making, explicitly acknowledging this as something creative. Here the artist works to procedurally set the boundaries for the art system, which may contain the audience and other people, materials, or ideas, through to aspects of the environment surrounding them.

Integral to this systems view is the relations between all these aspects. As artist Hans Haacke describes it:

A “sculpture” that physically reacts to its environment is no longer to be regarded as an object. The range of outside factors affecting it, as well as its own radius of action, reach beyond the space it materially occupies. It thus merges with the environment in a relationship that is better understood as a “system” of interdependent processes... (Burnham 1968)

A systems art approach emphasises the intangible interactive relations we can have with an artwork. It also reminds us that we can think beyond our immediate interaction with an artwork or device to consider the world more broadly—be it the environment beyond this local interaction between me and my device, or the influence and consequence of today’s actions on my future.

Audience as Participant

Allan Kaprow’s *Happenings* were similarly procedural artworks. They were orchestrated events with a clear sequence of activities. However, they also emphasised a participatory aesthetic: each *Happening* consisted of an environment through which the audience was manipulated to a degree that was *“virtually unprecedented in 20th century art”* (Schimmel 1989). Situationists such as Kaprow and DeBord advocated active audience participation for the political purpose of redefining passive ‘watching’ to instead prioritise ‘active living’. In his 1957 essay DeBord outlines participatory events that require physical involvement, and rejects a passive role for the audience (1957).

Other efforts towards audience involvement challenge the authorship of the work. For example, John Cage’s 1952 performance *4’33”* (Cage 1952) was a turning point for the composer, who subsequently went on to ‘surrender’ authorship

and ‘open’ the form of the work up to other interpretations and meanings. In this controversial performance, the audience heard four minutes and 33 s of ‘silence’. That is, the performer took no action; rather it was the environment—such as the audience—that contributed to the soundscape. This is an example of an open-ended work and, as discussed later in the chapter, the open artwork tends to have greater capacity for creative engagement.

Cage and the Situationists were among the first to initiate active audience participation. In 1963, artist Nam Jun Paik explored critical audience engagement with live television broadcasts in his *Participation TV 1* (Paik 1963). This was the first instance of viewer interaction with the previously passive medium and heralded the start of Video Art (Arns 2004; Daniels 2008). It was around then that artist and theorist Roy Ascott first distinguished the term *participant* to describe the audience of the interactive artwork (Ascott 1966).

The use of the term *participant* is significant. It acknowledges the legacy of contemporary arts practice, including the potential for open-ended interaction. Participation also resonates with the idea of perceptual emergence—that is, that emergence is something that someone can interpret and experience. Inherent in the notion of participation and perceptual emergence, then, is the assertion that meaning is actively constructed through our interaction with the world. In this book the term *participant* is therefore used to describe the active audience of the interactive artwork.

Human-Computer Interaction

We can also gain insight into the experience of interactive systems by looking at human computer interaction (HCI). This field of research is broadly concerned with “*studying humans and computers in communication*” (Hewett et al. 1992). Its focus has shifted from technology implementations, efficiency and usability to more complex concerns, such as more involved or open-ended interactions between the human and computer, and these latter concerns can relate directly to emergence in interactive art.

Early on in HCI the primary concern was with human factors, namely solving ergonomics-type issues and understanding how people could feasibly interact with computers for work. As HCI researcher Liam Bannon explained, addressing those questions was a matter of identifying specifications. The human being in the equation was treated as just one more set of ‘specifications’ (Bannon 1992). Human performance would be evaluated in controlled laboratory tests to determine things like the human eye’s persistence of vision to inform a minimum refresh rate for a screen. The user’s involvement with the design process did not, however, tend to go beyond this passive role of being a ‘factor for design integration’ or ‘test subject’. As research in HCI developed, the end users of the computer became more important. They became more actively involved in the design process—after all, who better to articulate the users’ needs than the user themselves? This ‘second

wave' of HCI would aim to start with the user and solicit their needs in consultation with them, then learn if they are actually able to use the system in the context of use. The emphasis shifted to treating the human as an *actor rather than a factor*, that is, as an active member of the design process.

While the research and development of the first and second wave remain relevant and necessary, in the third wave of computing we see HCI environments that go beyond questions around work, efficiency and usability. Here we're starting to see the sorts of questions art and culture can bring to computer-mediated interactions and consideration of the broader context, not just the device itself (Bødker 2006). As HCI broadens its understanding of interaction design for the human condition we increasingly see philosophical, psychological and social concerns directing enquiry.

Interactive Construction of Meaning In his articulation of embodied computing, computer scientist Paul Dourish argues our ability to make meaning is through being present and participating in the world. Meaning does not reside in the technology; rather it comes about through interaction with the technology, and this is how technology can become re-purposed (Dourish 2001). How we understand the world around us, and the things within it, is through interaction.

This resonates with the theory of affordances put forward by psychologist James J. Gibson. Affordance theory describes the integrated relationship between an actor (such as an animal or person) and environment with its objects, in terms of the actions that those objects can support for that actor (Gibson 1977, 1979). These qualities are, however, subjectively perceived and constructed; they are not fixed in that object—rather, they can differ for different animals. For example, a berry that is food for an insect can be poison for a horse. Gibson argues that when we perceive qualities of objects in our environment, what we actually perceive is the affordances of those objects (Gibson 1979), that is, we see them in terms of how they relate to ourselves.

In the 1990s Tangible Computing (TC) sought to leverage the rich affordances that we have with everyday objects to facilitate a similarly rich experience of human computer interaction. TC researchers argued that the emphasis on graphical user interfaces (GUI) have ignored the rich languages, cultures and design of instruments, physical objects and architecture, that have been informed by haptic interaction with real physical objects and evolved throughout our history (e.g. Fitzmaurice et al. 1995; Ishii and Ullmer 1997; Ishii et al. 2012). These criticisms arguably still apply today given the prevalence of GUIs in everyday computing interactions, such as the ever-present smartphone and tablet.

Ambient Media and Hybrid Places TC researchers Ishii and Ullmer also criticised the focus on designing for tasks that require direct, foreground attention. There are other equally significant ways in which we understand and experience the world. For example, I will know that it is getting late in the day without needing to look out the window, because I inadvertently notice changes in ambient light levels and temperature. Research into ambient media is an aspect of the TC philosophy they proposed and one which would explore design for this sort of background information processing.

Architects Dunne and Raby's *Benches* project demonstrates the idea of an ambient augmentation to every day life. Here an area on one park bench is heated up when that same position is occupied on another park bench, located elsewhere (Dunne and Raby 1996). The *D-Tower* in Doetinchem, The Netherlands is another example. This visualises data about the emotional state of town residents by changing the building's colour at night (NOX et al. 2004).

The layering of digital devices and data into our physical surroundings is growing. We increasingly see smart home and office designs to monitor and moderate temperature, lighting and so on. Data and computation are integrated into our physical surroundings, effecting 'hybrid spaces' (de Souza e Silva 2006). Interaction and experience of these places is also now different, affected by the connectivity to others and the network. Contextual reminders, location-based 'push' notifications and social media and gaming all interrupt and redirect movement. Ubiquitous data and devices change the way we think and act. As MIT media scholar Sherry Turkle's studies have revealed, our behaviour is now affected to the extent that simply the presence of a mobile device will impact a conversation: the tone remains light as there is an expectation of being interrupted (Turkle 2015). Connection to the outside world through social media and email is affecting the depth to which we engage with one another. This connectivity is also changing the meaning of places. The experience of a memorial or temple is similarly less reflective given the expectation of interruption from a mobile device. The data network that overlays a place affects our experience of it and, by extension, its meaning. When my children became enthralled by the internationally popular augmented reality and geo-caching game, *Pokémon Go* (Hwang 2016), a large local tree and landmark for us changed. We started to refer to it as 'the Pokestop', referring to the fact that we could stock up on virtual 'poke balls' at this geocache location. Here the physical location and place was superseded by the gameplay and its virtual associations.

Interface for Experience As data networks and devices increasingly influence our everyday experience it becomes important to think about the quality of these digital interactions and interfaces. Early on in interface and interaction design the emphasis was on ubiquity and seamless integration with the everyday setting (Weiser 1991, 1994). This translated into a design approach that prioritises invisibility of design. It reflects a focus on the task and content over the interface or tool: *I don't want to think about the word processor, I just want to write.*

The emphasis on interface 'transparency' is valuable in many contexts. There are however, other approaches to creating with interactivity. For example, ART+COM are an artistic studio and company who work with interactivity as a medium for expression and not just as a tool (Lieser 2010 on ART+COM). Similar, more complex, expressive approaches may better reflect the rich understanding we already have of interaction with the physical, real world; affording considerations of experience.

It's worth discussing the status quo on interface design, particularly from the perspective of art and creativity. That is, rather than considering the interface as something that should be transparent and the interaction as solely about receiving

information, we can focus on the experience that the interface and interaction can facilitate. Digital media researchers and artists Jay Bolter and Diane Gromala argue that designers have a choice in the role that the interface plays, and that it need not be relegated to ‘transparency’ or so-called ‘natural’ interaction. In fact, they caution against situations where the user believes they are interacting directly with the information instead of realising that there is a mediating, transformative agent—the interface—influencing understanding. At some point in the process of designing an interface, the designer will need to interpret and represent aspects of system functionality and operation, and things are naturally left out of this process. We run risks of error when we think that we actually see through an interface as a ‘window’ to reality, instead of realising that this view is itself a representation:

The instrument is an interface and is never completely transparent.... In fact the glass may be a mirror, reflecting what the user is inclined to believe rather than a transparent window (Bolter and Gromala 2003).

We are actively constructing our process of seeing and sense-making, and maintaining some awareness of this is often useful, if not necessary for digital media.

Bolter and Gromala advocate a second strategy for interface design, which can be used alongside as an alternative to the strategy for transparency. This prioritises audience reflectivity, or active awareness of what they are looking at and seeing. It positions the interface as a mirror rather than a window, as something we ‘look at’ rather than just ‘look through’. Instead of looking “...*through the experience to a world beyond, ... rather ...we look right at the surface*” (2003). Here the experience of engaging with the medium is deliberately crafted and goes beyond the communication of information. The interactive art work *Text Rain* (Achituv and Utterback 1999, discussed in Chap. 4) demonstrates this. Here a participant can see themselves as represented through a live video image. By moving their body and image of it, they are able to capture and direct falling letters and phrases from a poem. It is a compelling, reflective experience—one where the interface (their body) is something they look directly at, not through.

This work demonstrates how the interface can both facilitate information delivery (the goal of the transparent interface) and provide a compelling experience. Emotional design for products and experiences (e.g. Norman 2002) is another example of how one can approach that combination of experience and information delivery. As Bolter and Gromala assert, functionality and beauty need not be considered separate qualities and good interaction design and art can do both.

Researching Experience

The creation of an interactive artwork is a complex process, particularly given the intangible nature of experience. Artists, designers, technologists, curators and researchers are exploring and realising various possible interaction modes and experiences. In some cases the work is a collaborative team effort while in others an

artist may function as technologist and researcher to create more independently. Detailed discussions of artists reporting on their research and practice can be found in the edited collections of Candy and Edmonds (2011) and Candy and Ferguson (2014).

Since a participant is necessary for the interactive artwork to be fully realised, engaging them with the work is a key consideration for artists working in interactivity. One approach is to involve the participant during part of the creative process by facilitating audience observation and interviewing, in an appropriate (e.g. aesthetic, cultural) public setting. The Beta_Space was an experimental public exhibition space that facilitated this type of research enquiry (Muller et al. 2006).¹ From early 2000 for almost ten years, this ‘living laboratory’ provided artists and researchers the opportunity to place near-complete work in a public context and observe or interview the visiting public that engaged with it. *+–now* (Seevinck 2008) was installed in the Beta_Space over a 2 month period in 2008 for the evaluation of audience experiences, as is discussed in Chaps. 5 and 6.

Research at the Beta_Space included studies on creative engagement. In 2006, Beta_Space researchers Edmonds, Muller and Connell came up with a threefold interaction model for looking at participant behaviours and interactive work (2006). These concepts are *attract*, *sustain* and *relate*. That is, the work may be attracting, or drawing participants in. This requires it to be appropriately distinct from its context. Next is the question of how to sustain participant engagement rather than having them lose interest and move on. The participant may also have ‘related’ to the work, in that they want to experience it again and again. Frenetic activity or bright colours are possible means towards attracting audiences to the work, as observed by Edmonds, Muller and Connell (2006). In Edmonds’ work *Absolute_4.5* a participant’s approach would impact the piece to suddenly ‘settle down’, initially puzzling them and sustaining their interest. The concepts of *attract*, *sustain* and *relate* are similar to some ideas developed by Nathan Shedroff for experience design (Shedroff 2001). Here, however, the stages are situated in the context of interactive art and research, and exemplified as such.

Over the years, researcher Zafer Bilda and colleagues from Beta_Space would propose a more detailed Creative Engagement Model (CEM) (Bilda et al. 2008; Bilda 2011), drawing on a longitudinal study of audience experience at the Beta_Space from 2004–7. 10 Case study artworks were researched, investigating creative engagement with those works. Among their findings was a definition of interactive experience as “...a *transformative dialogue between the audience and the interactive (art) system*” (Bilda et al. 2008).

Here the notion of transformation is key—that is, where a participant has an intention to interact. Purpose and system outcome inform this. In the first case there is a particular purpose to performing an action, such as for fun, for pleasure or curiosity. Second, there is an outcome that is expected, such as generation of a

¹Muller pursued a similar project to document audience experience of David Rokeby’s *Giver of Names* at the Daniel Langlois Foundation for Art Science and Technology, together with other researchers. The data produced there has informed discussion of Rokeby’s work in Chap. 4 (Jones and Muller 2008; Muller 2008).

specific response. If a participant's purpose and outcome were not aligned they were often found to become frustrated and sometimes to give up. This is because their expectations and what they understood the artwork to be doing and mean, were not met. However there were also some participants at this stage that became curious about the system instead of frustrated, and would explore it some more. It is at this point that Bilda and his colleagues argue creative engagement has occurred:

The participant might find herself re-thinking about her intentions or the outcomes she expects. Therefore, her intentional behaviour can become 'thoughtful'. If s/he shifts her intention to 'enjoying the moment', rather than focusing on the intended outcome, she will have to make sense of her experience in a different way to what it was before. Therefore, there is a shift in her intention and expectation. We define this process as the 'transformative dialogue' between the self and the object/system (Bilda et al. 2008).

They also found that satisfying audience expectations correlated to feeling in control, but that this could turn into boredom. Participants who engaged with systems that afford more uncertainty and are less predictable were less likely to satisfy their expectations, and there was a greater danger of this leading to frustration. At this point there was, however, also the greatest opportunity for creative engagement.

Open and Emergent Interactions

Participation is arguably necessary for interactive art work to be realised, and perhaps it is even necessary for the work to exist in the first place. This necessity can be explained by the characteristic of open-ness. Umberto Eco describes the 'open-ended' artworks as necessitating a participant or performer for its 'completion' (Eco 1962). For example, a musical composition by Stockhausen is considered unfinished until a performer acts creatively to effect an 'oriented insertion' and thus complete it. Its conclusion is not as predictable as a Bach fugue whose score is far more determinant, or prescriptive, of its performance.

Eco goes on to describe these 'works in movement' as open works that are indeterminate and potentially inexhaustible given the large field of possible solutions they can afford: the Stockhausen piece is inexhaustible in comparison to Bach. Here "*...each performance explains the work but does not exhaust it*".

This also demonstrates a creative interaction by the performer. That is, when the performer makes their deliberate 'oriented insertion' into the work they are contributing to its form. In this sense they may be seen to be working creatively together with the composer: "*the 'open' works... are characterized by the invitation to make the work together with the author*" (Eco 1962). The performer or participant has the capacity to 'complete' this work through a creative insertion. However, the completion is merely one of many that have been facilitated by the artists' creative scoping of parameters, and the outcome remains in the realm of possibilities defined by the artist. For Eco, it remains that artists' work.

We can think of interactive art as open-ended simply by virtue of requiring audience participation. However, participation with work can vary qualitatively, and accordingly the quality of the openness can vary. Interactive artwork such as Peter Weibel's *Observation of the Observation: Uncertainty* (Weibel 1973) is a more 'closed' type of interactive art system. Here closed circuit use of cameras and monitors preclude the spectator/participant from ever seeing their front, no matter how much they twist and turn. The mediation of the image conditions the spectator's behaviour. These installations were highly predictable and defined artworks and in this respect they were relatively closed (Arns 2004; Daniels 2008).

On the other hand, the use of the computer and increasing access to the internet has provided more opportunities for openness and interactive feedback from audiences. For example, in Sommerer and Mignonneau's *Verbarium* (1999) the viewer plays an active role in shaping the work. They send emails that are converted into three-dimensional forms. Another example of an open-ended work is Ken Feingold's *The Surprising Spiral* (1991). This computer-controlled interactive artwork consists of a sculptural interface for a large, hypertext-linked database of travel images. The images are organised into a non-linear montage, affording the eternal, recurrent, interaction structure alluded to by the work's title. Feingold describes the work as embodying an ambiguous interaction, something which the audience at that time found frustrating because they couldn't control the system to get what they wanted. He was disappointed by the desire for control and considers it simplistic, lacking a capacity for the abstraction, metaphor and ambiguity employed when viewing traditional art forms like painting. He goes on to critique work that prioritises such control and predictability as

... Vending-machine menu –driven forms of interaction... [Such as] 'If the viewer does this then computer does that'... [Will result in work that] is too fixed, and as a result lacks mystery, complexity or paradox, which I consider to be essential qualities of a good work of art (Feingold 1991).

The creation of ambiguous, open interaction designs has also been pursued in digital, interactive design research. Through a focus on play, design and interaction researcher Bill Gaver and his collaborators have created open-ended appliances as well as conceptual designs for interactive works (Gaver et al. 2003). Their *Dawn Chorus* is an intelligent bird feeder that would "teach local songbirds the owner's favourite songs" (Gaver and Martin 2000). Where such a bird feeder was installed in a garden, the range of potential outcomes is large and unpredictable, depending on its collaborators. These collaborators—birds and residents—will also of course be providing 'creative insertions', or songs, to the system.

Evaluation approaches for understanding the types of interpretation and ambiguity that open-ended design and research can facilitate have also been proposed (Sengers and Gaver 2006). This includes a taxonomy differentiating interpretation in time, quality, and the occurrence of many different interpretations simultaneously. Here interpretation is the process of assigning meaning. Sengers and Gaver argue that by designing objects of ambiguous use more than one meaning can be interpreted, and this, in turn, facilitates open-ended interaction.

Emergence is another method by which multiple interpretations, or openness, can be afforded in an interactive design. This is particularly relevant when dealing with the deterministic and bounded domain of the computer. Early work by artificial life artists Christa Sommerer and Laurent Mignonneau facilitate an open-ended experience in that context. In their 1997 interactive art system *Life Spacies*, the artwork's participants influence the evolution and emergence of visual forms (Sommerer and Mignonneau 1997) through textual input. The artists' use artificial life algorithms as a basis for their custom text-to-form editor. This then takes email messages from the participants to create visual forms, or 'virtual creatures'. The 'birthed' creatures are then also able to clone or reproduce. The artists describe the work as an

...evolutionary communication and interaction environment that allows remotely located visitors to interact with one another in a shared virtual environment (Sommerer and Mignonneau 1998).

The work is explicitly open: audience participation to create the creatures is necessary. It is different to closed structures of interaction such as choosing options from a finite list, navigating a predetermined set of paths or "*a pre-defined multiple choice interaction*" (Sommerer and Mignonneau 1998). The open-ended interaction here can result in the generation of physically emergent forms, through the evolving virtual creatures. Perceptual emergence could also occur where, for example, participants demonstrate an opportunity for novel, surprising participant interactions.

Video game researcher Jesper Juul provides another perspective of open and emergent interaction. He classifies computer games as progressive or emergent in structure. Progressive structures correlate to closed systems and the emergent structures to open systems. Progressive games are a newer form of game that corresponds to the adventure genre. The player progresses through the game by meeting a series of challenges, with options and solutions explicitly defined:

In progression games, the player has to perform a predefined set of actions in order to complete the game (Juul 2002).

Emergent games are the older game form and include most card and board games and all strategy games. Here "*a number of simple rules combine to form interesting variation*" (Juul 2002). Emergence implies the ability for strategies to surface and for the game-space to extend beyond the rules. For example, the card game of Poker is an emergent game where the game play extends beyond the rules by including the emergent behaviour of bluffing (Salen and Zimmerman 2004).

The computer game with a low replay value is typically progressive and closed because it is often exhausted during play, with nothing left to engage the player. These will tend to have more explicitly controlled and predefined structures, with limited interaction potential. Conversely a computer game with an emergent game structure is typically more open-ended because it facilitates many options at each playful encounter. It will have opportunities for improvisation during the game play, in ways which may not be anticipated by the author. The open and emergent

structures may have more opportunities for interaction, making them more likely to have higher ‘replay’ value.

The ‘replay’ value of game provides some insight into people’s experience of it, namely the interest the gamer has in returning to the game and playing it again. It corresponds to Edmonds, Muller and Connell’s ‘relating’ descriptor of participant experience (Edmonds et al. 2006).

Emergence naturally supports openness in that it supports ambiguity and the act of interpretation while interpretation implies multiple possibilities—a quality of open systems. Emergence and openness also share qualities of creativity (by completing, or closing the open work and creating something new) and unpredictability (of the final solution or emergent form). By contrast, ‘closed’ interactions are predetermined, repeatable, with a finite set of possibilities.

It can be argued that any interactive application will tend to be more open than works in media that do not rely on a participant for completion, such as a medieval painting, since to some extent the participant makes the work along with the author. However a range of openness across interactive designs can also be found, as we saw in Weibel’s closed circuit video artwork from the 1970s. Similarly, some interactive works such as those based on hypermedia can be finite given their limited dataset as well as exhaustible, with a smaller field of possibilities. On the other hand, where participants have the opportunity to move through actions or images more freely, perhaps finding their own path in unexpected and non-scripted ways, there comes a greater field of possible forms, behaviours etc. and new strategies or behaviours not explicitly defined in the interaction are more likely to arise.

Conclusion

Contemporary arts practices and computing each provide insights into creating interactions. The role of the participant as an interactive agent is a key aspect for the arts. It is also a distinguishing characteristic of interactive art. In fact, it may be argued that interactive art is reliant on participation for its realisation.

The quality of participant interaction is a core concern. The CEM model demonstrates that at times, a lack of control can be accompanied by frustration but it can also be accompanied by a creative and engaging experience. At the same time as opportunities for interaction increase, openness will also increase. As Ken Feingold found, audience experience of systems that do not afford complete control can cause them frustration; and this tends to happen with the more open-ended systems. These tend to facilitate more interaction possibilities, more ambiguity, unpredictability. They are overall less defined. Furthermore, when successful, the open-ended interaction has multiple creative outcomes. As Juul would say, they have higher replay value, facilitating continued engagement with the work. And, as Eco has described, this interaction can be creative.

Mechanisms for creating open-ended systems include the theories and models of emergence. Emergence lends rules and structures to guide interaction/gameplay

while still facilitating surprising strategies, such as the perceptually emergent behaviour of bluffing in Poker. Participant input can ‘feed into’ an emergent system as well, working as a way to open it beyond its deterministic domain through the inclusion of the human being in that system. In Life Species audience input at the start was required and it is only after this point that the system could respond to generate the virtual creatures forms and facilitate their interaction (Sommerer and Mignonneau 1997).

The creation of open and emergent artworks, or indeed, any complex interactions, facilitates an awareness of audience experience. TheBeta_Space approach to evaluate audience participation with work, during the process of making these artworks, has been briefly reviewed. It reflects the approach used in this text as well, where interactive artworks presented in Chap. 5 were evaluated in field studies to understand participant experience, described in Chap. 6. Research and prototyping of systems along with audience interviews and observation can facilitate the successful creation of interactive systems, particularly when difficult concepts such as emergence, openness and their inherent qualities of unpredictability and lack of control are concerned. As was found from the CEM model, in some cases participant frustration at lack of control could give way to more exploration and thought and, in turn, to a creative engagement with the system.

References

- Achituv R, Utterback C (1999) Text Rain, interactive artwork
- Arns I (2004) Reception, participation, interaction—from receptive to active participation. http://www.medienkunstnetz.de/themes/overview_of_media_art/communication/. Accessed 18 Jan 2015
- Ascott R (1966) Behaviourist art and the cybernetic vision. *Cybernetica* 9:247–264
- Bannon L (1992) From human factors to human actors the role of psychology and human-computer interaction studies in systems design. In: Greenbaum J, Kyng M (eds) *Design at work: cooperative design of computer systems*. L. Erlbaum Associates Inc., Hillsdale, NJ, USA, pp 25–44
- Bilda Z (2011) Designing for audience engagement. In: *Interacting: art, research and the creative practitioner*. Libri Publishing Ltd., Faringdon, UK, pp 163–181
- Bilda Z, Edmonds E, Candy L (2008) Designing for creative engagement. *Des Stud* 29:525–540. doi:10.1016/j.destud.2008.07.009
- Bødker S (2006) When second wave HCI meets third wave challenges. ACM Press, New York, USA, pp 1–8
- Bolter JD, Gromala D (2003) *Windows and mirrors: interaction design, digital art, and the myth of transparency*. The MIT Press, Cambridge, USA
- Burnham J (1968) Systems Esthetics. artforum.com 7:30–35
- Cage J (1952) 4'33", music composition
- Candy L, Edmonds EA (2011) *Interacting: art, research and the creative practitioner*. Libri Publishing Ltd., Faringdon, UK
- Candy L, Ferguson S (eds) (2014) *Interactive experience in the digital age evaluating new art practice*. Springer International Publishing
- Cornock S, Edmonds EA (1973) The creative process where the artist is amplified or superseded by the computer. *Leonardo*, The MIT Press 6:11–16

- Daniels D (2008) Strategies of interactivity. In: Sommerer C, Jain LC, Mignonneau L (eds) *The art and science of interface and interaction design*. Springer, pp 27–62
- Debord G (1957) *Towards a Situationist international*. In: McDonough T (ed). The MIT Press, Cambridge, USA, pp 44–50
- de Souza e Silva A (2006) From cyber to hybrid mobile technologies as interfaces of hybrid spaces. *Space and Culture* 9:261–278. doi:[10.1177/1206331206289022](https://doi.org/10.1177/1206331206289022)
- Dourish P (2001) Seeking a foundation for context-aware computing. *Human-Computer Interaction* 16:229–241. doi:[10.1207/S15327051HCI16234_07](https://doi.org/10.1207/S15327051HCI16234_07)
- Duchamp M (1920) *Rotary Glass Plates (Precision Optics)*, motorized artwork
- Dunne A, Raby F (1996) *Fields and Thresholds*. In: Pearce M, Spiller N (eds) *Architects in cyberspace*. Academy Press, pp 64–71
- Eco U (1962) *The poetics of the open work*. In: Bishop C (ed) *Participation*. The MIT Press, London, England, Whitechapel, pp 20–40
- Edmonds EA (2002) *Heron*, interactive artwork
- Edmonds EA (2009) *Cities Tango*, interactive artwork
- Edmonds EA (2011a) *Interactive art*. In: Candy L, Edmonds EA (eds) *Interacting: art, research and the creative practitioner*. Libri Publishing Ltd., Faringdon, UK
- Edmonds EA (2011b) *Art, interaction and engagement*. In: Candy L, Edmonds E (eds) *Interacting: art, research and the creative practitioner*. Libri Publishing Ltd., Faringdon, UK
- Edmonds EA, Muller L, Connell M (2006) On creative engagement. *Visual Communications* 5:307–322
- Edmonds EA, Turner G, Candy L (2004) *Approaches to interactive art systems*. ACM Press, Singapore, pp 113–117
- Feingold K (1991) *The Surprising Spiral*, interactive artwork
- Fitzmaurice GW, Ishii H, Buxton W (1995) *Bricks: laying the foundations for graspable user interfaces*. ACM Press, pp 442–449
- Gaver W, Martin H (2000) *Alternatives exploring information appliances through conceptual design proposals*. In: *Proceedings of CHI 2000*. pp 209–216
- Gaver W, Beaver J, Benford S (2003) *Ambiguity as a resource for design*. *Proceedings of CHI 2003*. ACM Press, Ft Lauderdale, Florida, USA, pp 233–240
- Gibson JJ (1977) *The theory of affordances*. In: Shaw R, Bransford J (eds) *Perceiving, acting, and knowing*. Lawrence Erlbaum Associates, Hillsdale, NJ, USA, pp 127–143
- Gibson JJ (1979) *The ecological approach to visual perception*. Houghton Mifflin, London, England
- Hewett T, Baeker, Card S, et al (1992) *ACM SIGCHI curricula for human-computer interaction*. ACM SIGCHI
- Hwang D (2016) *Pokémon GO!* Niantic, USA, <http://www.pokemongo.com>
- Ishii H, Ullmer B (1997) *Tangible bits: towards seamless interfaces between people, bits and atoms*. *Proc. SIGCHI Human Factors*. ACM Press, Atlanta, Georgia, United States, pp 234–241
- Ishii H, Lakatos vid, Bonanni L, Labrune J-B (2012) *Radical atoms: beyond tangible bits, toward transformable materials*. *Interactions* 19:38–51. doi:[10.1145/2065327.2065337](https://doi.org/10.1145/2065327.2065337)
- Ivrea Interaction Design Institute (2005) *Arduino Microcontroller Board*
- Jones C, Muller L (2008) *David Rokeby, The Giver of Names (1991) documentary collection*. The Daniel Langlois Foundation collection: DOCAM (Documentation and Conservation of the Media Arts), Montreal, Canada. <http://www.fondation-langlois.org/html/e/page.php?NumPage=2121>
- Juul J (2002) *The open and the closed: games of emergence and games of progression*. In: Mäyrä F (ed) *Computer game and digital cultures conference proceedings*. Tampere University Press, Tampere, Finland, pp 323–329
- Krueger M (1974) *Videoplace*, interactive artwork
- Krueger M, Gionfriddo T, Hinrichsen K (1985) *VIDEOPLACE—an artificial reality*. ACM Press, pp 35–40
- Lieser W (2010) *The World of Digital Art*. Har/DVD edition. H.F. Ullmann Publishing GmbH, Köln, Germany

- Muller L (2008) Towards an oral history of new media art. In: Daniel Langlois Foundation for art, science and technology. <http://www.fondation-langlois.org/html/e/page.php?NumPage=2096>. Accessed 13 Jul 2016
- Muller L, Edmonds E, Connell M (2006) Living laboratories for interactive art. *CoDesign* 2: 195–207. doi:[10.1080/15710880601008109](https://doi.org/10.1080/15710880601008109)
- Norman DA (2002) *The design of everyday things*. Basic Books, New York, USA
- NOX, Serafin QS, Spuybroek L (2004) *D-Tower*, media architecture in Doetinchem, The Netherlands
- Paik NJ (1963) *Participation TV 1*, interactive artwork
- Paul C (2015) *Digital Art*, Third, edition edn. Thames & Hudson, New York, USA
- Salen K, Zimmerman E (2004) *Rules of play game design fundamentals*. The MIT Press, Cambridge, USA
- Schimmel P (1989) Leap into the void: performance and the object. In: Schimmel P (ed) *Out of actions: between performance and the object*. The Museum of Contemporary Art, Thames and Hudson, Los Angeles, USA, pp 1949–1979
- Seevinck J (2008) *+now*, interactive artwork
- Sengers P, Gaver B (2006) Staying open to interpretation: engaging in multiple meanings in design and evaluation. In: *Designing interactive systems DIS'06*. ACM Press, pp 99–108
- Shedroff N (2001) *Experience design 1*. New Riders Publishing, Oakland, USA
- Sommerer C, Mignonneau L (1997) *Life Species*, interactive artwork
- Sommerer C, Mignonneau L (1999) *VERBARIUM*, interactive artwork
- Sommerer C, Mignonneau L (eds) (1998) *Art as a living system*. In: *Art @ science*. Springer, Austria
- Turkle S (2015) *Reclaiming conversation: the power of talk in a digital age*. Penguin Press, New York, USA
- Weibel P (1973) *Observation of the Observation: Uncertainty*, artwork
- Weiser M (1991) The computer for the 21st century. *Scientific American* 94–100
- Weiser M (1994) The world is not a desktop. *Interactions* 7–8