Emergence and Artistic Visualization
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ABSTRACT
This research draws on theories of emergence to inform the creation of an artistic and direct visualization. This is an interactive artwork and drawing tool for creative participant experiences. As is discussed, emergence is characteristically creative. It is also debated across and within disciplines, resulting in a range of understandings as well as models. This paper shows how one field’s understanding of emergence (complexity theory) can be used to facilitate emergence in another domain (design research) and, importantly provide the opportunity for someone to act creatively. This paper begins with a brief review of some theories of emergence to show how they interrelate and can effect the perception of emergent structures in an observer, and, correspondingly, the design for creative experience. This is subsequently demonstrated in the second section of the paper where an interactive artwork and drawing application, Of me with me, is presented. This artwork by the author was created during collaboration with community artists from Cerebral Palsy League. The discussion covers the application of emergence theories to create this visualization in order facilitate the perception of structures and creative behaviours in a participant and to facilitate self-efficacy in the community artist user group.

Categories and Subject Descriptors
H.5.1 Information Interfaces and Presentation: Multimedia Information Systems H.5.2 Information Interfaces and Presentation: User Interfaces J.5 Arts and Humanities: Fine Arts.

General Terms
Design, Human Factors

Keywords
Art; cerebral palsy; creativity; design; drawing; emergence; interactive art; visualization.

1. INTRODUCTION
This paper describes an interactive art system for creative participant experiences. Specifically, it is an artistic visualization that facilitates creative drawing (‘Of me with me’, Seevinck, 2013). The design of the system has been informed by a collaborative process of working with community based artists at Cerebral Palsy League, as well as the characteristics and theories of emergence. In this paper the artwork is described as well as contextualized within emergence and visualization literature. The discussion aims to both add to the understanding of artistic visualization and exemplify the potential of emergence for facilitating creative interactions.

2. EMERGENCE
Emergence is a highly debated concept both within, and across, domains. Here it is understood as occurring when a new form or concept appears that was not directly implied by the context from which it arose. This new ‘whole’ is more than a simple sum or grouping of its parts. For example, in Figure 1 two squares intersect to afford interpretation of a new shape: a triangle. The triangle is the whole that emerges from the interaction between the squares (the parts).

![Figure 1 A triangular shape emerges perceptually from the intersection of 2 squares.](image)

Literature on emergence describes something ‘new’ as occurring during emergence. For example, the “creation of new properties” [1]. Also, “an emergent form [is one which] displays characteristics not present in its source.”[2]. It is heterogeneously new [3, 4] and as described by physicist Crutchfield, this newness occurs when something different to a system’s defining (pre-existing) character has occurred. That is, it is ‘new’ because it is different from what was there before [5]. This new structure is a ‘whole’, something which is more than a simple sum or grouping of its parts. This notion of the whole draws on the concept of Gestalt theory [6]. For example, the perception of the whole musical melody and how it is inconceivable from exposure to separate tones, as well as being heterogeneously new and not deducible from those musical notes (von Ehrenfels experiment described in [6]).
Emergence is also integrally related to creativity. The relationship is mutually informing and necessary, but not adequate for each. Firstly emergence logically implies creativity when the heterogeneously new whole arises, relatively unpredictably, from the parts. Conversely, creativity necessitates emergence: "Emergence is fundamental to creative thought in the sense that we find it hard to qualify an idea as creative if it is clearly implied by the preceding conditions" [7].

Other qualities of emergence described in literature from a range of domains the inability to explain it and whether or not the emergent whole has been influenced by feedback from its parts back into the whole. These qualities have previously been reviewed and assimilated to inform a taxonomy of emergence in interactive art [8, 9]. One additional factor is the role of the observer. This latter point has been highly debated in the literature and is a key differentiator that is also highly relevant to this paper.

2.1.1 The observer
The reliance on an observer for emergence to exist (or not) is a key differentiator between the disciplines and their relative understandings of emergence. That is, we can look at emergence as being one of two kinds: firstly it might rely on an observer’s perception of the emergent structure in order to exist, as is the case with the emergent square shape above. This ‘Perceptual emergence’ includes emergence research from the design and Gestalt communities. Secondly, there are those forms of emergence which are argued in some disciplines, such as physics and biology, as independent of an observer. This ‘Physical emergence’ includes research contributions from the complex science and physics communities. Physical emergence relates to the occurrence of emergence in the natural, physical world, as well as simulations of this process.

The emergence of physical structures in nature includes the ordered formations of interacting individuals or parts; as opposed to groups of them. For example, the typical V-Shape of snow geese flying in formation is an emergent structure or behaviour that becomes physically manifest and can be differentiated from a disorganized group of birds [10]. The tendency toward self-organisation in systems that are not living is also an example of emergence [11]. Processes such as these are also often simulated using algorithms and models that can re-create, at least in part, some of the complex behaviours we see in the natural world. Artificial Life (AL) is one common example, as in the use of cellular automata to describe ant behaviours and Lindenmayer systems to describe organic structures such as trees or the crystalline structure of snowflakes [12-15].

As shown, the understandings of emergence vary across disciplines. Key characteristics of newness, the whole that constitutes parts, relative unpredictability and creativity are, however, common characteristics across domains. There is therefore a potential to map from emergence theory in one domain (such as the simulation of physical processes) across to effect emergence in another domain (such as design research and the interpretation of new forms). The art system presented here has been designed in this respect, as is discussed later.

3. ARTISTIC VISUALIZATION
Visualization research encompasses data or information visualization through to architectural, scientific, function-based and artistic visualizations. These areas intersect in that all sustain a transformation, or mapping, of information to image. This information can be numeric, geometric or logical data [16] and the resulting visual form is intended to facilitate audience understanding: visualization “is a process enabling the user to observe, digest and make sense of the information” [17].

Information visualization researcher Robert Kosara identifies further criteria for something to qualify as visualization. Of particular relevance here is the need for the visualization image to be actively readable and recognisable as a visualization [18]. That is, the image should clearly be a visualization and it should provide for unambiguous readings even if this requires training. While the former criteria can be satisfied by artistic visualization, the ability to read and recognize are more of a challenge. Art is inherently ambiguous, offering multiple meanings and interpretations to different contexts and audiences. This very nature of art compromises a work’s readability. Similarly, works of art may not make the denotive aspect dominant, for example the priority may be an evocative aesthetic that serves to intrigue and engage the audience who could then ‘decipher’ or ‘read’ one or multiple meanings in the work. Kosara has proposed a gamut of visualization with pragmatic, clearly readable, recognizable visualization at one end and the sublime or artistic work which is more multifaceted/plural in its meaning, at the other end [18].

3.1.1 Direct Visualization
A concern of information visualization and one which is prevalent in much artistic visualization is the reductive aspect of much information visualization. That is, when data is transformed and mapped to geometric primitives, there is a loss of information and a change of meaning. In 2010 Lev Manovich identified a counter trend in artistic visualization, one which he describes as ‘direct visualization’ or ‘visualization without reduction’. Here the data is itself directly evident the final visualization outcome: it is “reorganized into a new visual representation that preserves its original form.” The data may be sampled to reduce the size, but it is not translated or qualitatively changed into another form. In this sense it is not subject to ‘qualitative reduction’, and the result is the “preservation of a much richer set of properties of data objects” [19]. Examples include Cinema Redux by Brendan Dawes (2004). Here film stills, sampled from a movie at one frame per second, are presented as a grid layout with frames adjacent to one another on a static, wall size installation. Similarly, in Touch by hint.fm, data for erogenous zones are directly visualized in a way that is similar to tag cloud. In an exploration of sensuality this web-based interactive consists of photographs of areas of the human body which are used to navigate those same areas of the human body.

In certain situations methods of direct visualization may serve to increase visualization attraction for audience. Edmonds et al. describe a model for understanding the engagement of museum audiences with interactive artworks [20]. They have identified the initial attraction that the audience may feel towards a work as integral to their subsequent engagement with the work. In the context of information visualization, it may be that when data is visceral, evocative or in some way personally relevant to the audience, the use of direct visualization methods can serve to increase the initial attraction of a design for the audience. In so doing, these methods may increase audience engagement and the success of works, such as for lay audiences and museum contexts.
The use of direct visualization is not, however, without its drawbacks. That is, the increased specificity can also inhibit the ability to generalize to other contexts. For example by focusing observer attention on data there is a danger of detracting from their ability to generalize or interpret higher order patterns. Furthermore, reductive approaches to visualization are exactly this focusing and abstraction to highlight any new trends, even though these may be restricted to that abstract domain.

4. **OF ME, WITH ME (2013)**

*Of me, with me* (2013) is an interactive art system and creative drawing tool created by the author. In terms of the theory discussion here, it can be considered an artistic and direct visualization that facilitates creative experiences by employing a complex model for emergent structures.

![Figure 2 Drawing with the stylus during interaction with ‘Of me with me’ (Seevinck 2014) at studio installation (top) and prototype install at ArTel with collaborator Saunders (below).](image)

**Figure 2** Images are automatically published to a weblog.

*Of me, with me,* comes out of collaboration with community artists at the ArTel Cerebral Palsy League facility. ArTel is a fully functional print and visual arts studio for local artists with Cerebral Palsy, the neurological disorder that affects physical abilities. ArTel is also a part of the large non-profit organization Cerebral Palsy League [21]. Saunders and Oakman are key print artists in this community with regular exhibitions locally. We have collaborated over a year and half timeframe to exchange ideas and concepts to inform an overall body of work, *Iterative Intersectioning* [22]. This has resulted in both the interactive art system *Of Me With Me,* Seevinck (2014) described here, as well as a series of static paper-based works. The project has been documented on a blog since inception in 2012 (see Figure 3 [23]) and is described and demonstrated in a brief video online [24].

4.1 **Description of the artwork**

The installed artwork *Of me with me* consists of a drawing tablet and stylus interface, with a monitor, personal computer, internet connection and weblog for publishing (see Figures 2, 3, [24]). Participants draw with the stylus and the positional, angle and speed of gestural movement data is collected to feed the visualization running on the screen, in real time. On screen buttons and keystroke input for saving images and ‘resetting’ the screen have also been implemented. Participants are therefore able to clear the screen as well as save images out. Saved images are automatically published to the project weblog, pictured in Figure 3 (see also [23]).
4.1.1 Design agenda

Conceptually, the work originates from our process of working collaboratively where we would share and exchange ideas and static creative artefacts. The collaborative process was therefore creative on a number of levels. The success of this process, which began before the creation of Of me with me began, subsequently informed the design brief for that interactive artwork. That is, our creative behaviours became a core focus for the interactive art system. In addition to facilitating creative experiences, the design brief was also concerned with self-efficacy and accessibility. For instance, the collaborating artists are very diverse in our means of creative expression, varying in the ways we hold a pencil or paintbrush from handheld to using a head stylus.

In the next section the use of emergence for supporting creative interaction is described. The discussion that follows relates this more deeply to participant creativity as well as design for self-efficacy.

5. EMERGENCE FOR CREATIVE PERCEPTION

As discussed earlier, physical processes such as snowflake crystals or birds flocking can be simulated using computational systems. While such systems are instances of physical emergence, they also often hold a meaning for an observer. For example, the perception of the ‘V’ shape of a flock of snow geese can be classed as an instance of perceived or perceptual emergence, similar to the emergent square example in Figure 1 and consistent with the understanding of emergence in the design research domain. This is in addition to the fact that the system is also an instance of flocking behavior, benefitting each individual bird through reduced wind resistance. The ability to draw on mechanisms for modeling emergence in one domain, such as complexity theory, in order to effect emergence in another domain is the underlying design intent behind Of me with me. Specifically, in this creative work the participant gestural data (point positions etc.) function as a mathematical set for a fractal simulation. This fractal simulation affords recurrence as well as patterning to support creative behaviors. This is analogous to the Koch curve fractal model for snowflakes. In the software for Of me with me, an artists’ initial gesture is recorded as a series of points in space. This mark is then scaled and iteratively copied onto that original curve, as shown in Figure 4.

![Figure 4 Of me with me (Seevinck, 2014). The self-replicating quality of the Koch fractal informed the visualization process.](image)

![Figure 5 Series of still images captured during participant interaction with the work. From the top left, reading left to right depicts drawing and responses in chronological order.](image)
The drawing stylus is tracked over time and across the screen so that the X and Y coordinates for its position are stored in a two dimensional array. As the participant drags the stylus across the surface, subsequent positions are sampled and added on to the array, to a maximum set length. These positions (vertices) are connected as lines, using the Processing shape class but without filling it. The array itself is also copied for translating, scaling and rotating of the recurring, smaller curves. These transformations occur in object space before the copies are returned to world space and rendered back alongside the original mark. Translation destinations are calculated by sampling from the source curve (breaking it into a predetermined set of span lengths). The system runs in real-time so that the iterating curves, including their position, size and rotational values are continually changing. In this way the participant’s drawing movements occur simultaneously with the ‘echoing’, fractal imagery of system response. A series of screen captures from interaction over time is pictured in Figure 5 and a still image from participant interaction with the work is shown in Figure 6. The artist’s gesture is in black with the fractal ‘echoes’ in a lighter tone.

6. DISCUSSION

The theoretical understandings of emergence and how it is inherently creative, as well as the images that can be created with this system, indicate a strong potential for this work to effect emergence and creativity. Future work will, however include evaluations to determine if this is in fact the case. Evaluating for emergent participant interaction with an interactive artwork has been conducted previously [26, 27] and a similar qualitative approach relying on observation of participant interaction and interviews with video cued recall techniques to understand what the participant was thinking during their interaction, will be used. Future evaluations will specifically aim to determine the value of the creative interactions experienced by the participants, as well as what type of emergent behaviors occurred. Participant and collaborator feedback has, however, been positive to date. For example, collaborating artist Saunders has described her intent to embed aspects of drawings created with this system into a print that she is currently working on. A video of her interaction with the work is available online along with images that she has created on the project blog [23].

In addition to creativity, the design agenda for this work also included self-efficacy. This has been addressed by maximizing the accessibility of the work. In the first instance, there has been an effort to address the cost of the system: early (2013) versions of the system were constructed using Derivative Inc. proprietary software but in 2013/14 it was rebuilt using Processing, a free and open source software environment. Secondly, the design of the interfacing modality has been informed by what is currently in use by the ArTel artists i.e. paintbrushes and pencils. The choice of a tablet with stylus is intended to support the same grasping by hand or taping to a head pointer or elbow scaffold as a pencil would, and in this way facilitate similar movements for creative activity. Thirdly, the application also facilitates immediate publishing of images online. While this facilitates quick and easy access to those images for further work or sharing them with peers, friends and family, it is also a form of exhibiting. It is anticipated that this is empowering as it facilitates a wider reach for these artists and access to the wider internet community to show their work in public as well as an ability to work with digital online technologies.

Finally, given that Of me with me visualizes audience gestures and renders these back to the audience as part of the final drawing output, this work can be described as an instance of direct visualization. As discussed, a participant’s own gestures are echoed back to them, but remain recognizable as their own. The recognizability and immediacy of the systems’ response to user gesture are anticipated to increase usability, user confidence and sense of self-efficacy. Furthermore the direct presence of the original data may also increase the attraction of the work than if the artists’ original mark and identity not been as clearly evident to him or herself.

7. SUMMARY

Emergence has been described and shown how to imply creativity. The artwork presented has been facilitated through a complex sciences understanding of emergence, namely fractal theory. It demonstrates that while there remain debates across domains of emergence theory,
there are still some common characteristics of emergence and these have the potential to inform design. Specifically, there is a design potential for taking emergence theory from one domain to effect it in another. Similarly, as is the case here, emergence theory from one domain can be used to effect a characteristic of emergence i.e. creativity as it is understood in another domain. In this artwork emergence as it is understood in complex sciences and, particularly using a fractal theory, has been used to enable audience perception of emergent structures. The outcome is perceptual emergence, consistent with the understanding of emergence held in the Design Research community.

Emergence may also hold potential for designing engaging artistic visualizations. Here the scaled and transformed copies of participant gestures are the ‘parts’ that interrelate to form an emergent, compositional ‘whole’ (as in Figure 6). At the same time, these parts are also the actual data. Similarly, the data is also a means whereby the parts are organized. Following the earlier discussion on engagement in interactive art, it may be that direct visualization can facilitate increased audience engagement in some contexts. In summary, the interactive art system Of me with me shown here illustrates the potential of emergence for both emergent organization of the data, directly, to enhance audience engagement as well as for the creative experiences it can support in that audience’s interaction.

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9. REFERENCES


