The Aesthetics of Emergence:
Co-Constructed Interactions

MELANIE BALJKO and NELL TENHAAF
York University

In this article, we describe the *aesthetics of emergence*, which is our theoretical framework for an aesthetics of interaction and the underpinning of *LoFi*, an interactive A-life artwork that we are developing. We provide a survey of relevant concepts from the A-life and new media research communities, and we establish threads of commonalities with the HCI research community and especially the subset of that community that emphasizes aspects of user experience other than those that are characterized by performance-based measures. We describe and discuss several exemplar A-life artworks that are drawn from the last decade of jury selections of the annual Vida Art and Artificial Life Competition, conducted by Fundación Telefonica. We conclude with a discussion of issues that are common to the A-life and HCI research communities.

1. INTRODUCTION

In this article, our goals are to describe our theoretical approach to the aesthetics of interaction, which we are applying in our *A-life sculpture project*; to describe our design methods and approaches in this field of new media, and to provide the results of our evaluations to date. We present an argument that the

frames of reference that are relevant to this A-life (artificial life) sculpture, and interactive new media, more generally, are also relevant to human–computer interaction, especially for design domains in which experience design is at the forefront.

Since the early 1980s, when A-life took shape in the southwestern United States,[1] artists worldwide have adopted its principles as a basis for art production. A-life is a set of computer-based practices that incorporates ideas from complexity theory, chaos theory, artificial intelligence, and theoretical biology—especially evolution and genetics. A-life is concerned with synthesizing lifelike phenomena in artificial media such as computers or robots. Our sculpture is based on A-life principles through its representation of a population of agents that is heterogeneous (i.e., including both artificial and human-representative agents). We have devised a method of display that is an alternative to a typical computer screen: the blunted ends of fiber-optic cables are arranged in grid-like arrays that follow the topology of the undulating surfaces of large, layered sections of brass mesh that are mounted on a large cylindrical structure made of wood. Each fiber-optic cable is coupled to a light-emitting diode (LED) and thus can be illuminated. In our configuration, we bridge to the electronics layer with software. All agent embodiments are in the form of illuminated dynamic clusters of these LEDs and abstract electro-acoustic sound (though the colors and sound differ in order to distinguish human-representative from artificial agents). An overhead camera tracks the motion of interactants around the sculpture, and the behaviors of human-representative agents are yoked to this sensor data. The artificial agents are autonomous but responsive to human interactants. All agent architectures are independent of one another, but instantiated from a common Java-implemented agent framework.

The process whereby this A-life sculpture is designed has a strong connection to the design of other computational media: it is a process of designing for user experience. We feel strongly that interaction with an A-life artwork is simply another kind of human-computer interaction, but also an interesting and unique arena of interaction in that performance-based measures are typically not applied, nor relevant. A primary goal for the user is for he or she to engage in interpretive processes in relation to the artwork's behaviors as well as his/her own behaviors. The synthesis of these processes is emergent relative to the experience of the work.

2. WHAT IS MEANT BY THE *AESTHETICS* OF INTERACTION?

2.1 Background. What is Meant by the Term *Aesthetics*?

In our work, we understand the term aesthetics to refer to the study and analysis of judgements by human experiencers. At its face, this assertion seems merely to shift the definitional burden from the term *aesthetic* to the term

---

[1]Key originators of A-life were Chris Langton, Doyne Farmer, Norman Packard, John Holland, Danny Hillis, and Thomas S. Ray [Levy 1992].

judgement, but the notion of a *judgement* allows us to shift to a frame of reference in which we can distinguish, (1) between percepts and mental states, and (2) among different sorts of mental states, such as affective states (*sensoriemotional values, emotions, feelings*, and so on) and other mentalistic states (e.g., *beliefs*). We are especially interested in those beliefs that involve the attribution of state to others, including artificial others. Although the sensory impact of the built object or artifact can never be discounted as a factor in aesthetic appreciation, the emphasis in our analysis is on the processes that make up the interactant's experience. This includes processes that are judged by the interactant to be initiated by, or wholly generated by, the artifact itself.

The term aesthetic has proven to be notoriously difficult to pin down. For instance, sensory discrimination is touted as part of an aesthetic judgement, but aesthetic judgement is not merely that: the sensory discrimination must be linked to some sort of emotional elicitation (e.g., pleasure, disgust, humor). In the arts, there is a longstanding and ongoing attachment to both sensory pleasure and emotional impact as aesthetic registers. In the visual arts specifically, what has changed is that we no longer equate aesthetics only with beauty in appearance: the conceptual and experiential impact of contemporary works of art, as well as their broader cultural implications, are never entirely separable from their aesthetic effect. In our culture, technological artifacts are pervasive and elicit a range of intuitive and intellectual responses that people bring to interactive new media artworks. These responses underlie any aesthetic judgement we make about new media art, of which A-life art can be considered a subset.

2.2 Purpose of Investigating Aesthetics

The characterization of aesthetics that one constructs depends on the intended use or purpose of the characterization. The desire to sidentify tangible aspects of aesthetics motivates designers, even if only tacitly, and not only for the sake of conducting critiques—these tangible aspects are not only *descriptive*, but also can be *predictive* when they correspond to mechanisms whereby aesthetic judgements are made. But, as Heller [2005, p. 49] points out, when it comes to visual and industrial design, certain tangible aspects have been employed to formalize our critiques of aesthetics (e.g., on the basis of aspects of line, color, weight, type, volume, space, etc.), but these tangible aspects are lacking when it comes to interaction design. Still, designers seek to develop artifacts to exploit these mechanisms of aesthetic judgement, in pursuit of their design goals, and particularly those design goals that relate to desired aesthetic judgements. For example, using Platonian principles, if one wants to create a beautiful object, then one would create an object that incorporates proportion, harmony, and unity among its parts. The golden ratio is another analytical principle that is relevant to the process of design, as it speaks not only to which proportions are visually pleasing (its descriptive role) but also provides a tangible principle for design (its predictive role). Such tangible design principles are highly amenable to an engineering design approach: perform requirements analysis, derive design specification to meet the requirements, and then design a computational artifact, using available and relevant design principles, to meet the

specifications. The field of human–computer interaction, thanks to its computational pedigree, has availed itself of this approach: it often seeks to exploit analytic principles that are known to satisfy the given specifications. Even the call for papers for this special issue espouses this worldview (e.g., "How can we design for aesthetics of interaction?"). The engineering design dimension of aesthetics seeks to turn descriptive models (which can be thought of as the outcome of basic research) into predictive models.

A crucial difference exists, however, between *designing a computational artifact* and *designing an interaction* between a human interactant and a computational artifact. We argue that the notion of designing an interaction is flawed because it incorrectly characterizes the nature of interactions. First, we distinguish between *autonomous* and *joint* activities. The psycholinguist Clark [1996, p. 30] used Levinson's notion of *activity type* to distinguish between two types of contexts within which actions[2] might be performed by an individual: as part of an autonomous activity or as part of a joint activity. A wide range of activities are *joint*—two individuals playing a piano duet, paddling a canoe together, playing catch, conducting a business transaction, negotiating an agreement, gossiping, and so on. An *autonomous* activity (or solo or individual activity) has a single participant, whereas a *joint* activity is carried out by two or more participants who are working collectively. This collectivity is the essential quality of joint activities—joint activities require *coordination*. These two types of activity provide two different contexts in which actions might be performed. An action performed as part of an autonomous activity is an *autonomous* action, whereas an action performed as part of a joint activity is a *participatory* one. Unlike autonomous actions, the performance of a *participatory* action requires coordination among the participants. Clark used this distinction to distinguish a *conversation* (participatory) from other arenas of language use (often autonomous). We use the distinction here to distinguish human–computer interaction (participatory) from other (autonomous) human activities. Second, we assume that the entity (the computational artifact) with which the user interacts has certain abstract characteristics: it has some sort of internal state space, it outwardly manifests information as to its internal state (at least to some level of granularity and possibly in a nonobvious way), and its behavior depends on its state. In sum, the entity affords *interaction* and becomes a de facto participant. Cultural theorist Margaret Morse [2003, p. 20] concurs that "the computer cannot be reduced to a medium of communication between human subjects. Its very capacity to give feedback and the immediacy of its response lends the quality of 'person' to what is a computational tool." Mayer [1998, p. 52] also concludes that "Figures like 'the computer,' 'he/she/it' (the application, or a character avatar within a game world) are experienced as interlocutors . . . based on the immediate nature of the responsiveness experience by the user." In sum, "communicative" processes are afforded not only between "partners or poles that are not just subjects but both subjects and objects" and "each interaction involves a negotiation of the status of the subjects and the meaning

---

[2]Clark [1996, pp. 18–19] used the term "action" to refer *both* to single acts and to sequences of actions (i.e., activities).

of the communication" [Morse 2003, p. 32]. Although these theorists are not explicitly describing principles of A-life research, their ideas are very closely linked to A-life principles in their attribution of lifelike behaviors to artifacts.

The human user's actions in the context of the interaction are *participatory* actions, and the artifact's actions are participatory too (even if only in the sense that its state changes are context-dependent). It follows, therefore, that the interaction is *emergent* to the participatory actions of the engaged actors (in the same sense that the playing of a duet is emergent to the participatory actions of the individual musicians). Thus, to return to our earlier assertion, a designer cannot *design* an interaction, because interactions depend crucially on the human interactants, who cannot be designed a priori.[3] At best, a designer can design interactive media that *affords* certain types of interactions with the goal of eliciting interactions that have certain characteristics, provided that the behaviors of its human interactants fall within a particular scope. The challenging aspect is that, in the realm of outcomes that are not performance based (e.g., in the realm of aesthetics), these behaviors encompass mental and cognitive behaviors that are not yet well understood. In many cases, the desired characteristics relate to the affective states to hopefully arise in interactants and to aesthetic judgements to hopefully be made by interactants.

In designing and making an interactive artwork, the requirements for the object, the interface, and the interaction are generally understood to go well beyond allowing a user to accomplish a goal. We propose that the interactive A-life artworks we discuss here are exemplary of emergent, co-constructed experience. We are interested in how an emergent aesthetic experience can be afforded for an interactant that is unique to that individual, because each individual's behaviors and responses are unique, yet the experience can be aesthetically judged, and therefore analyzed and discussed, through specific commonalities.

2.3 Use of the Term *Aesthetics* in the HCI Community

In the HCI research community, the term aesthetics has been used, synonymously with the terms appearance, visual appearance, or even beautiful in appearance. For instance, " … aesthetics are usually applied to making products desirable in appearance" [Djajadiningrat et al. 2000a, p. 66]. It has also been used as an adjective relating to the appearance, for example, the aesthetic qualities of a document. For instance, Fitzmaurice [2006, p. 46] referred to "ugly aesthetics," as in a future trend is to "move from ugly aesthetics towards cinematic visual experience." Aesthetics has been characterized as a "design feature" that "relate[s] to the system's external appearance" [Ben-Bassat et al. 2006, p. 211], primarily in terms of certain elements of graphical design (e.g., use of shadow and fluidity of line) [Ben-Bassat et al. 2006, p. 220]. Moreover, this external appearance can be measured in such a way as to afford comparison: "more aesthetic" versus "less aesthetic" or "low aesthetic" versus "high aesthetic [pp. 212, 219, 231] (ordinal measurement) or even numerically quantified [p. 220] (interval measurement). In contrast, Hassenzahl [2004,

---

[3]Although interactants cannot be designed a priori, they are also not immune to influences and experiences that serve to shape his or her behaviors (i.e., diachronic change).

p. 345] does not equate aesthetics with beauty. Rather, he characterizes aesthetics as having something to say about beauty: "research in aesthetics . . . explores how objective, perceptual features of objects cause beauty."

Hallnäs and Redström [2002, p. 116] refer to an "inner logic" or "consistent appearance" of a thing that generates "depth in its expression." Aesthetics is then based on a "logic of expressionals" that connects the material qualities of an artifact with its expressiveness. They go on to say that we can analyze such "expressiveness" of an interface structure, and that it is "comparable to analyzing the logical form of an argument and evaluating its logical correctness." This idea of aesthetic is very much in the tradition of the Platonic Ideal that we referred to previously. Petersen et al. [2004] present an overview of the concepts of aesthetics in HCI so as to situate their proposal for "aesthetic interaction" that is based in a pragmatist aesthetics, drawing on Shusterman [1992]. We will discuss this work further in Section 3.

If one grants that aesthetics concerns affective state, subjective judgements, and attributions, then Hassenzahl's [2004] model can be viewed as another model of aesthetics in the HCI research community. The model not only speaks to the notions of affective state and beliefs, but also proposes their theoretical substrate: *product attributes* are constructed by users, combining percepts of features and the user's own personal expectations and standards. Such attributes are then hypothesized to be bundled into a *product character*, and these cognitive structures are not merely aggregates of attributes, but also contain contextualizing information (such as the user's beliefs about the space of possible attribute values and their inter-relationships: covariation between attributes). The model further distinguishes between attributes that are *pragmatic* (relating to the need to achieve goals) and *hedonic* (relating to the user's self-stimulation and self-identification/self-presentation). "Using a product with a particular *product character* in a particular situation will lead to consequences, such as emotions (e.g., satisfaction, pleasure), explicit evaluations (i.e., judgements of appeal, beauty, goodness), or overt behavior (i.e., approach, avoidance). The separation of the perception of attributes from their evaluation allows for the fact that individuals may find a product novel (an attribute) but not necessarily like it (an evaluation)." [Hassenzahl, 2004, p. 322, emphasis added].

3. WHAT IS MEANT BY THE TERM *AESTHETICS OF INTERACTION*?

3.1 Aesthetics of Interaction as Beauty/Pleasure/Enjoyment in Interaction

The term aesthetics of interaction has been used in the sense of eliciting enjoyment, beauty, or pleasure in interaction: products that are "beautiful in use" [Djajadiningrat et al. 2004, p. 296]. For instance: "we think the emphasis [in product design] should shift from a beautiful appearance to beautiful interaction, of which beautiful appearance is a part." [Djajadiningrat et al. 2000b, p. 132]. "This [coupling between a rotary dial and a circular flow of characters] makes for a beautiful aesthetic of interaction, a pleasurable act in itself" [Djajadiningrat et al. 2000b, p. 133].

The notion of beauty/pleasure/enjoyment has also been used in a somewhat expanded sense, in that affective states have been given a role in mediating sensory experiences and have a relation to *usability*: Djajadiningrat et al. [2000, p. 66] asserted that aesthetics of interaction has a focus on "enjoyment of experience," as opposed to usability or ease of use, and argued that the goal should be to strive "for making the *unlocking of the functionality* [i.e., the use of a product by someone] contribute to the overall experience," an experience that may be "challenging, seductive, playful, surprising, memorable, or rewarding," all of which "[result] in enjoyment of experience." All of these facets play a role in usability, which is more than mere ease of use [Djajadiningrat et al. 2000b, p. 132].

An example of enjoyment of experience would be an enlightening interaction that would be afforded by a so-called "attentive object": an object that "can convey interesting information to people that would never have bothered to look up in the first place, thereby turning every moment into a learning opportunity. For example, objects could tell you about their history, how they are made or what others have said about them." [Maes 2005, p. 46], for example, to reveal to an object's interactant what others have experienced about the object previously. This idea was the basis for the *handheld museum tour guide*: "we raised the profile of information about other visitors to the level of information about the art." [Sengers et al. 2005, p. 54].

A tangible design principle can be deduced from the research literature: "a requirement for an aesthetics of interaction is attention to the richness of a system's appearance, interaction, and potential roles" [Djajadiningrat et al. 2000a, p. 66]; this means that, in order to elicit enjoyable/pleasurable interactions, attention must be paid to these facets of system (or interactive object) design.

3.2 Interactive Media: Interactivity as an Arena for Social Experience

3.2.1 *New Media Art.*   The history of new media art (also known as electronic media art) is, in one sense, a history of *interactivity* in the arts. Interactive art is only one subset of new media art, but it is an area that very much foregrounds the role of computing: just like any interactive product (in the HCI domain), interactive art, (1) must have an interface at which the public meets and engages with the artwork, and (2) relies on digital manipulation so as to handle what can be seen at a fundamental level as data flow to and from the interactant.

Interactivity may be one of the defining characteristics of new media art. But there has been some objection to using this term without further theorizing what it means and implies for art. For example, new media theorist Lev Manovich [2001] has called interactivity a "myth" in its claim to turn the viewer into a coauthor of an interactive artwork. Manovich also makes a distinction between "closed interactivity," or selection from a set of predefined choices, and "open interactivity," in which the content is not entirely predetermined but is generated in real time as a response to an interactant. Theorizing or defining interactive new media art is a work in progress; Manovich stated: "I still think that interactivity remains the most difficult among the new cultural dimensions brought about by computerization" [Quaranta 2004, p. 31].

Computer technology that was newly available in the 1970s brought about the technical possibility for the first interactive artworks. Morse [2003] has aligned the advent of this technology with the then emerging spirit of participation and reciprocity in art, which stood in contrast with the historically prevalent, one-way presentation of most artforms to an audience. The social implications of the appearance of interactive work in the art world have been analyzed in the following way: the new communication media began to offer an "object-to-think-with" [Mayer 1998, p. 51], that is, an object that not only could be communicated with but that also afforded contemplation of the meaning of such communication and the status of the subject-participants [Morse 2003]. Mediated interactions began to enable the user to enter into the "change and development of social structures" and interactivity could involve the user in forms of social reflexivity (Mayer [1998], as pointed out in Morse [2003]).

Morse differentiates between *interactive works*, which involve the receiver or user in a process that entails "purposiveness, conclusiveness and agency," and *traditional cultural forms*, which have "passive readers and viewers" and which "espouse a one-sided notion of authorship" [Morse 2003, p. 20]. Thus, and in sum, if a designer or artist sets out to design rather than to guide the interaction, then most likely this will result in a *closed interactivity* or *one-side authorship*, in Manovich's or Morse's terms, respectively.

The stage was set for these developments in art many decades earlier (e.g., see Tenhaaf [1998] for a more detailed discussion). Throughout the twentieth century, art has been expanded by important moments of formal and philosophical reinvention of its relation to the real, quotidian world—moments when the revered status of the art object has been diminished and process has been valued over product. *Anti-art* is a concept derived from these reformulations of the relationship between art and everyday life. Its precedents include the Russian Constructivists' and the Futurists' merging of art and revolutionary politics. *Anti-art* was adopted by the dadaists in post-WWI Western Europe, to express an inseparability between social and political concerns and art manifestations. Marcel Duchamp's *readymades* are considered anti-art, of which the most famous example is the urinal that he brought into Alfred Stieglitz's gallery in New York in 1917, signed as *R. Mutt* and named *Fountain*. Duchamp's idea was both to put forward industrial objects as beautiful in their own right, and to pull the "real world" of industry into the rarified sphere of art. The *Happenings* of the 1960s and 70s, and novel media such as video and performance, were also imbued from the outset with a spirit of reconnecting art to ordinary people and to the issues of the moment. These practices are open to, and even embrace, social causes, but it is in their expression of dissatisfaction with the ability of established art practices to connect with lived reality that they become anti-art.

Developments of interactive artwork in the intervening years have been hugely multiple and diverse, but in essence this concept of reflexivity still has strong currency, in that the meaning of interactive works tends to extend outward from the immediate experience of an interactant (which very often is geared to her/his pleasure and enjoyment, or the "wow" factor) towards the broader implications of new technologies in society—especially reflecting on the desires and expectations that surround them. In her brief history of interactive

art, Söke Dinkla [1994] highlights artists who in the 1980s began to develop novel "friendly" interfaces that could elicit both familiar behaviors and familiar physical activities for the interactant. For example, Australian artist Jeffrey Shaw, working in Amsterdam, began a project in 1988 that invited viewers to get onto a bicycle and, by pedaling and steering, navigate through a "projected city of letters." The wish to have digital technology readily deliver information in a contextualized, relevant format is overtly responded to in this work. Because Petersen et al. [2004, p. 271] draw upon art as well as HCI theory, their emphasis on this notion of the integration of the everyday is very relevant to our ideas: "In a pragmatist perspective aesthetics is a part of everyday life. It stems from a use-relationship. Aesthetic Interaction comprises the views that aesthetics are instrumental and that artifacts are appropriated in use."

Particular modes and uses of interactivity arise in A-life art. We will discuss below how the attribution of agency to virtual A-life agents occurs through interactive processes. Given these particulars, it is interesting to consider A-life research in parallel to anti-art, as the emergence of an alternative, para-scientific practice, an anti-science: it doesn't seek to negate its terms of reference or their knowledge base, rather it depends on them so as to propose reinventing them. Anti-science does not at all mean "not science," but rather serves to expand our thinking about science in a way that parallels how anti-art reorders the symbolic systems we use to interpret and constantly reinvent everyday life. Anti-art shows that once art and life are perceived as enmeshed, the transformative potential of art increases exponentially. Similarly, awareness of how we construct nature through science and technology on a daily basis could deliver a comparable empowerment. It is a way to explore the premises of research, to reveal, unpack and go beyond what has been naturalized in the practices of a given field.

3.2.2 *Parallels in New Media Art and HCI.*   Interactive media artists have made an impressive contribution to the development of interfaces that refuse to be bound by an established worldview and that don't take for granted inherited values or working methods. In parallel, there is a body of HCI development that is concerned with "unconscious assumptions" in the field (e.g., see Sengers et al. [2005]). This research is tuned to the "recognition of critical blind spots," for example the often tacit assumption that the workplace offers the obvious model for interface design, which in turn "risk[s] making all of life work" [Sengers et al. 2005, p. 49]. Reiterating the ideas of Mayer and Morse, the research of Sengers et al. proposes that interactivity and the interface are not only technological apparatuses, but are also bound up with our social and cultural values. Further encapsulating this idea, Allucquère Rosanne Stone [1995, p. 15] identified that computers provide an "arena for social experience," and delineated this conception of technology as follows [p. 89]:

(1) selves and relationships between selves constituted and mediated by technologies of communication: *an apparatus for the production of community;*
(2) technologies that mediate cultural legibility for the biological substrates to selves, substrates that legally authenticate political action: *an apparatus for the production of body;*

(3) technologies mediating between bodies and selves that may or may not be within physical proximity: *interfaces*.

In sum, interactive media artists and theorists, in parallel to HCI researchers, have also articulated that " . . . aesthetics has a purposeful role in the use of interactive systems. . . . Emerging in use; it is an integral part of the understanding of an interactive system, and its potential use" [Petersen et al. 2004, p. 271].

3.3 Aesthetics of Interaction as Eliciting Embodied Subjectivity

Cognitive technology—in which the notion of embodiment is strongly rooted—shares many commonalities with certain notions of the aesthetics of interaction. Just as aesthetics has the dimensions both of product design and of a basic research agenda, so too does the so-called cognitive technology approach:

> "[Cognitive technology] is the study of the integrative processes which condition interactions between people and the objects they manipulate. It is concerned with how technologically constructed tools (A) bear on dynamic changes in *human perception*, (B) affect natural *human communication*, and (C) act to control human cognitive adaptation." (Marsh et al. [1997]; as cited by Dautenhahn [1998, p. 575] boldface added.)

Dautenhahn is particularly interested in the design of socially intelligent agents and the use of cognitive technology to do so, a pursuit that is relevant to "experience design," and shares a commonality with the pursuit of an aesthetics of interaction.

Embodiment is a key notion in Dautenhahn's stance with respect to designing for interactions that are informed by social intelligence. Embodiment both affords one's *coupling* to his or her environment and affords a *state of being* in the world. Dautenhahn identifies two types of dynamics that arise from one's embodiment: the internal dynamics of experiencing of self and others (phenomenological dimension) and the external dynamics of having a physical body embedded in the world. The phenomenological dimension can readily be seen as one of the seats of aesthetic judgement about an interaction. However, these are interconnected and, as will be further elaborated, one's bodily presence and response in an interaction plays a role in the aesthetic response. Petersen et al. [2004, p. 271] situate this point of view within pragmatist aesthetics' concern with "designing for mind and body": "Where as (sic) analytical aesthetics is preoccupied with separating humans into mind and body, a part for thinking and a part for sensing, pragmatist aesthetics insists on their interdependencies in the aesthetic experience."

Dautenhahn [1998, p. 586] further hypothesized that *empathy* is one of the most important mechanisms at work in the phenomenological, internal dynamic: "I consider the internal dynamics of empathic resonance a basic mechanism of bodily, experimental grounding of communication and understanding. A state of willingness and 'openness' toward another embodied, dynamic system is a direct, immediate way of relating to another."

That embodiment, in its more physical sense, plays a role in interaction suggests, to some thinkers, a new paradigm of representation. Media artist Simon Penny [2004] proposes that, "In interactive media a user is not simply

exposed to images which may contain representation of things and actions. The user is trained in the enaction of behaviors in response to images, and images appear in response to behaviors, in the same way that a pilot is trained in a flight simulator." Djajadiningrat et al. [2004] distinguished between the "data-centered" view (the view centered on the data that is being transmitted during the interaction) and the "perceptual-motor-centered view" (the view centered on the perceptions and motor actions that are being formed/performed during the interaction). A recognition of the role of embodiment serves to unify these two views as simply different facets of a common phenomenon.

The environmental context of an individual also plays a role in subjective attribution (and not only his or her embodiment). The projects of Benford and colleagues [Benford et al. 2004; Flintham et al. 2003] seek to blend mobile technologies, digital content, and artistic performances, to create interactive experiences for participants, including both performers and spectator-bystanders. A central observation is that there exists, for performances in conventional theatre and other "traditional" performances, a series of well-established rituals and that spectators who follow them are able to willingly suspend disbelief and engage with the fictional world of performance. The projects explicitly seek to blur "the boundary between the fictional world of a performance and the real world of everyday events" [Benford 2005, p. 57]. Indeed, Benford and colleagues found that spectators did engage in the performances—and therefore entered the albeit-blurred fictional world of the performance—despite the absence of the well-established rituals that would otherwise be offered if the performance were in a traditional venue. This observation is relevant for aesthetics: the process whereby participants make subjective attributions is influenced by the degree, if any, to which the participant has become engaged in the fictional world of a performance. In interacting with a fictional world, participants cannot solely remain grounded in the real world of everyday events, although the fictional world can be coupled with the everyday world. An understanding of the integrated mind-body mechanisms whereby a participant becomes engaged in fictional worlds, or in altered realities, is important to our understanding of the mechanisms of aesthetic response themselves.

3.4 Aesthetics of Interaction as Eliciting Contemplation During Interaction

Sengers et al. [2005] advocated incorporating the use of critical reflection into practices of technology design. The term *critical reflection* means "bringing unconscious aspects of experience to conscious awareness, thereby making them available for conscious choice" (i.e., "conscious value choices in their attitudes and practices") [Sengers et al. 2005, p. 50]. The purpose for such reflection is to be able to understand the world in a more complete way, a way that "alters our perception and interpretation of what is going on around us and the implications of our actions" [Sengers et al. 2005, p. 50]. Initially, Sengers et al. [2005] were referring to the *practitioners* of technology design (it is the practitioners who must examine their own perceptions and interpretation), but they address *users* as well: they argue that "[critical] reflection [by users] itself should be a core . . . outcome" of HCI technology design, and that "design practices should

support *both* designers *and* users in [being able to engage in] ongoing critical reflection about technology and its relationship to human life." This is closely related to the conception of Petersen et al. [2004, p. 271] of the socio-cultural dimension of a pragmatist aesthetics: "According to the thinking in pragmatist aesthetics, aesthetic is not something a priori in the world, but a potential that is released in dialogue as we experience the world; it is based on valuable use relations influencing the construction of our everyday life."

In a similar vein, Morse [2003, p. 18] identifies the *metainteractive aesthetic strategy* in artistic production, which is to "[foreground] the contradictions and mystifications of interactivity itself." In Ken Rinaldo's interactive A-life artwork *Autopoiesis* (see Section 4.5), a very strong part of its impact lies in the "mystification" resulting from the feeling that the piece is alive and watching. The sense of aliveness in the system is elicited through what Dautenhahn [1998, p. 574] characterizes as "believability," a mechanism of social understanding (how one understands others mediated by social processes), which relies on "storytelling" (the narrative construction of social reality), empathy (see Section 3.3), ecological grounding (interpretation of the ecological situatedness of the interactant and his/her embodiment) and autobiographical memory (that which is used to define/construct and to historically ground the self). For interactants engaged with Rinaldo's work, ecological grounding is particularly operative. The contradiction in the work arises from two features: one is that interactants know rationally that they are anthropomorphizing the artwork, the other is that this knowledge is completely overpowered by their sense of the piece as being completely autonomous. Although a large proportion of the public is not able to articulate how these two features are elicited, they are nonetheless readily enticed to find out more because the interaction is so fascinating and so aesthetically powerful. In the context of this work, in which beauty is so strong, it is apropos to declare that "the prospect of beauty of interaction may not only tempt users to engage in interaction, but also tempt them to persevere in interacting" [Djajadiningrat et al. 2004, p. 296]. We would further note that the aesthetic judgement of beauty in this context includes the aspect of believable aliveness, and that it encourages users to engage, to persevere, and then to reflect on their experience through recourse to whatever supplementary information is available to them.

3.5 Aesthetics of Interaction as Eliciting Percepts of Agency During Interaction[4]

3.5.1 *Anthropomorphism.* Not only smartness but also various kinds of other behaviors have been, and still are, increasingly associated with computers and digital systems by their interactants; because of this association, such connotations are more and more, reliably and robustly, elicited. It follows then that we can never reduce the computer merely to a medium of communication between human subjects [Morse 2003 p. 20]. It is wrongly simplistic for a designer to attempt to do so.

---

[4]This section builds on work previously described in Baljko and Tenhaaf [2006].

Concerning the aliveness factor we raised, aesthetic response in interaction can be elicited by shallow approaches to believability that merely take advantage of the anthropomorphizing tendency in humans [Dautenhahn 1998]. Such anthropomorphic connotations are not always embedded in the term *interactivity*. And within A-life art, connotations of anthropomorphization are members of a larger sphere of biological metaphors that are acknowledged and understood to structure our relations with machines (and especially the computer). For instance, this realm of metaphor also makes recourse to the phenomena of evolution and of adaptation as a computational capacity.

The tendency to anthropomorphize remains a primary response toward A-life art works. Thus, for these art works, designing to elicit or to afford a certain interaction can be couched as an investigation into the anthropomorphic urge, an endeavour to understand it and to use its components. To adopt it in an unquestioning way is to assume that everyone's anthropomorphic gesture is equal; it also entails the assumption that the resulting set of relations among humans and virtual entities is also the same for all interactants. We take apart the anthropomorphic gesture and consider two important, linked components in a human interaction with virtual agents (in which the latter seem life-like: anthropmorphized in a first–order response): (1) the attribution of agency by interactants to virtual agents; and (2) participation in a mixed society and its mixed relations composed of human and nonhuman agents. These two components allow for each interactant's experiences to be unique because they are instantiated in the phenomenological dimension, the interactant's subjective internal dynamics. But they also serve to establish a common ground among all interactants because they are foundational mechanisms of social understanding. The agent architecture taps into these mechanisms, such that interactants converge around their understanding of the A-life artifact.

The affordance of interactivity in A-life art, and in new media more broadly, can be used effectively to elicit attributions of agency. In the state of being engaged in an interaction, the user *acts*—and this is readily and willingly linked to the sense of agency for the user. There is a distinction between the user's recognition and acknowledgement of his or her own agency in the interaction and the user's construction of agency for the media, although we believe that these are strongly linked. Depending on the life-experiences that the interactant brings to the interaction, which can be hugely varied, these two types of constructions arise from some combination of preconception (present at the outset of the interaction), or from dynamic processes of construction or elicitation during the interaction. Moreover, the interactive system may build a representation of the interactant that is incorporated into the workings of the system as an agent—or it may not.

3.5.2 *Current Work: The LoFi System.   Low-Fidelity Embodiments*. An approach for designing interaction of particular interest in our interactive A-life sculpture work is the technique of using *low-fidelity embodiments*. Our current instantiation of this technique, which we developed from our common interest in abstract computational representations [Baljko and Tenhaaf 2006], embodies agents as compositions of electronic components (clusters of LEDs
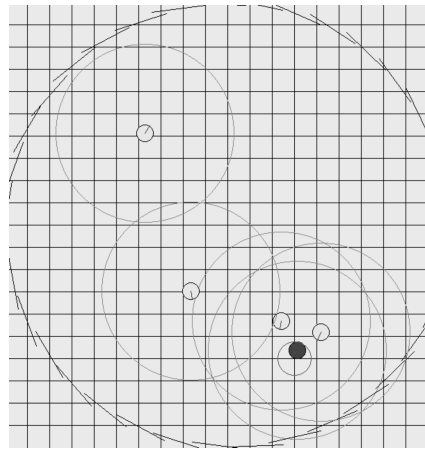
Fig. 1.   Swarm algorithm-based software prototype for collaborative herding task.

and two-channel audio displays—stereo speakers). Such embodiments provide multiple degrees of freedom with which the agent can articulate behaviors that correspond to the agent's modes of articulation. These embodiments also provide the physical infrastructure for the mounting of sensors in a nonobvious manner. These provide the agent's modes of sensory-perception. Such embodiments afford interaction that is multimodal in the sense of having and making use of multiple modes of articulation and/or modes of sensory-perception. Such embodiments also provide the physical infrastructure for the mounting of sensors in a nonobvious manner. Such low-fidelity embodiments stand in stark contrast to high-fidelity ones, such as humanoid-like, digitally rendered characters, and are preferable to use because they circumvent the clichés and expectations attached to humanoid characters, avatars, or (even worse) cartoons. Low-fidelity embodiments also have the advantage of making use of a high level of abstraction. This allows either a single agent or a population of such agents to be embodied in a particular physical infrastructure. The human interactant distinguishes between the two cases on the basis of the behavior of the articulators—whether the pixellated lights and audio displays cohere into perceivable subunits.

Shared Task. Another goal of this work is for the public interactive scenario to afford to its interactants, both human and artificial, the role of task performer. Of particular interest to us are tasks that require collaboration and must be shared among the agent population (to which the human interactant belongs via their representative agent). It is expected that the particular task embedded in the artwork may be modified in subsequent design iterations, but for the current version, a herding task has been implemented. A software prototype has been developed in which the agents are represented simply as two-dimensional circles. In the next design iteration, the agent population will be given low-fidelity embodiments.

The software prototype is shown in Figure 1. In this task, the agents in the population must direct the target entity into what we term *the nest*. In the

Initial Phase: multiple human agents engage with overhead tracking camera

Phase II: a particular interactant is chosen to be a member of the agent population

Phase III: the abstract agent population visualization is overlaid and replaces the video-realistic one

Phase IV: the agent population successfully completes the collaborative task
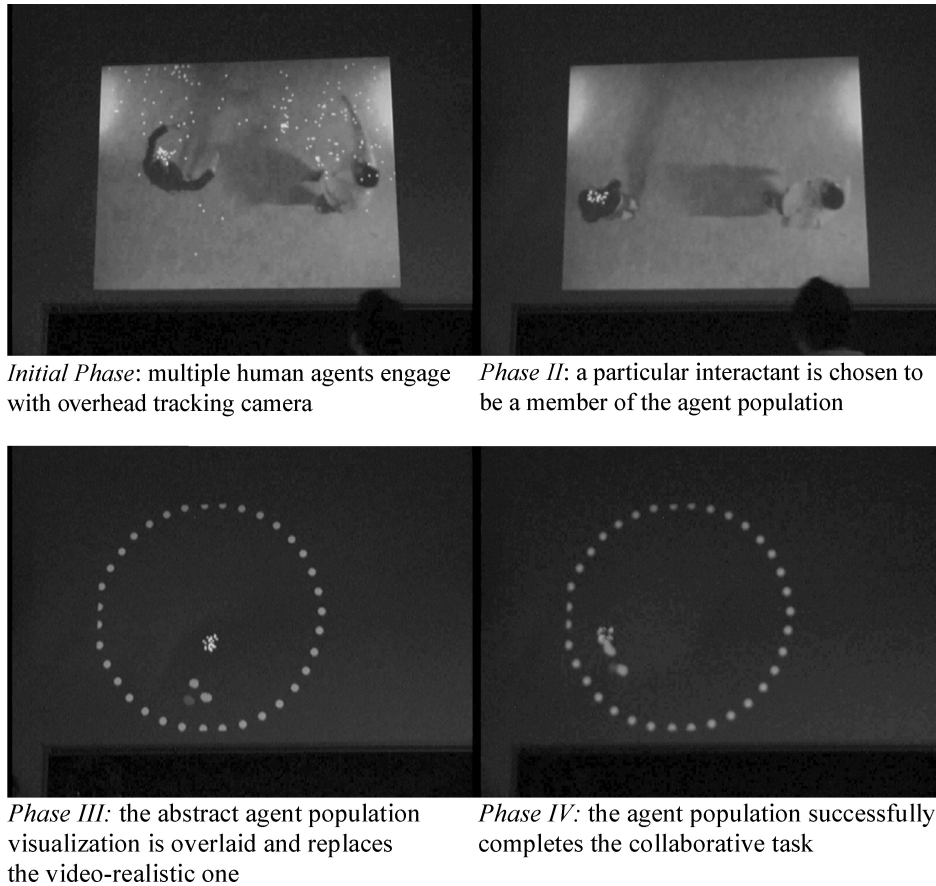
Fig. 2.   Snapshots of interactants engaged with the LoFi installation (snapshots in a temporal sequence, shown clockwise starting at the top lefthand corner).

figure, the nest is shown as a red circle, the target is shown as a blue circle and the agents in the population are shown as cyan circles. The larger circles around each agent indicate each agent's perceptual range.

The behavior of the target entity is implemented by the simple rule to evade the agents. The behavior of the artificial agents is governed by a set of simple rules that express attraction and repulsion among other entities in the arena (e.g., attraction to the target and the nest, repulsion from close proximity to other agents and the arena walls). A single agent cannot perform this task in isolation (except in special cases), since the target robot simply evades the agent. However, when multiple agents are placed in the arena, they are able to collectively herd the target entity to the nest.

The behavior of the human-representative agent will be under the control of the interactant. This mechanism involves some degree of mimesis and a phase during which the representative agent will entrain itself to the interactant. Figure 2 illustrates the sequence of phases that unfold when the interactant engages in the shared task.

Another task we are also presently implementing is one that requires the population of agents to achieve a particular pattern of communication. The inspiration for this task is the observation that complex systems of turn-taking emerge from relatively simple sets of rules (such as those identified by Sacks et al. [1974]). The task is of particular interest as it will allow us to implement an agent architecture that affords the generation and perception of multimodal "communicative acts," and to explore the ideas of multimodal synergies in the low-fidelity embodiments.

3.6 Aesthetics of Interaction as Emergence

Petersen [2005, p. 45] described her research group's "focus on designing *aesthetics of interaction*, which implies a focus on how the means of interaction can be surprising, engaging, and serve to establish a new relationship to the materials that people interact with." [italics added] We are basically in agreement with this characterization of the aesthetics of interaction (i.e., as the study of how affective states arise in interactants and how subjective attributions get made by interactants, as the result of or arising from an interaction). In A-life interactive artwork, though, the work engages an interactant, and subsequently that interactant has a unique impact on how the system behaves and/or how it evolves in the real time of her/his involvement with it. And similarly, the concept of "appearance as constituting the essence of things" [Hallnäs and Redström 2002, p. 116] resonates with any artist designing and building an art object. However an interactive A-life work is process-oriented and based on "behaviors" more than "expressions."

For each particular interactant, the A-life artwork itself evokes a certain domain of responses through its behaviors. Cariani [1992] identifies the notion of an "observational frame" in order to describe how emergence is always relative to the observer's model of the system. Here, two such models can be identified: (i) that of the interactant, and (ii) that of the outside observer/designer, for whom the model consists of the A-life artwork and the interactant(s) engaged with it [Baljko and Tenhaaf 2006]. The concept of emergence is much debated in both science and art [Whitelaw 1998]. Some adhere to the definition that inherent properties in the components of the system, whether physical or computational, give rise to unexpected phenomena of the whole system that are objectively observable (relatively simple interactions or behaviors give rise to complex patterns). Conversely, others argue that the concept of emergence is invoked by an observer when she or he is unable to describe a model of a whole system beyond its component parts (frequently referred to as "synergy"). In terms of emergence in relation to aesthetics, what matters is what is subjectively perceived about the behaviors of the artifact in relation to the behaviors of the interactant(s). In A-life artworks—and more generally, for digital artifacts—synergistic patterns of interactional behaviors are emergent with respect to both observational frames (i) and (ii).

We propose that the art public's experience of interactive A-life artworks can generate a *reification of context*—a common understanding for all participants of how to interpret the artifact and the phenomena the artifact manifests

through discourse about such works. This reified context is based on key features that can be identified in many A-life artworks. First, these works elicit the belief that their behaviors contribute to the user's experience, and second, A-life artworks create a participatory mode for the user's experience in which the artifact and the user have unique but interdependent roles. This common understanding is complementary to the individualized process of interaction for each interactant, and it is what we mean by an "aesthetic of emergence."

4. THE AESTHETICS OF EMERGENCE WITH SAMPLE INTERACTIVE A-LIFE ARTWORKS

4.1 Background

In this section, we consider human–computer interaction in the art domain, in which there has been an increasing production of interactive artworks since the genre's beginnings in the early 1980s. There are always many kinds of users among the large art public, from novice to expert. It is impossible to characterize the experience or understanding of interactive artworks across these many different users because no such data exists. The evaluation or assessment of artworks has generally been considered extraneous to the experience of the work itself, and instead has been seen as the task of critics and curators or for the domain of anecdotal exchanges among members of the art public. Although in A-life art, there is a layer both of content and of method that is taken from the research domain, the broader parameters for our investigation characterize interactive artworks and their interfaces within a framework that is not primarily functional. Rather, it is geared to the individual interactant's performance as unique, with varied levels of comfort, satisfaction, awareness, reflection, and so on. Within such a framework, and with the objective of substantiating the notion of an aesthetic of emergence, we are looking at five projects that have been awarded prizes or distinctions in the annual *Vida* art and artificial life competition held in Madrid since 1999 [Fundación Telefonica 2007] (for a discussion of all of the prize winning entries, see Tenhaaf [2008]).

In these works, convergence of understanding for the public, and more specifically for the interactant, comes about through two conjoined steps that we believe are intrinsic and necessary to the experience of the work. The steps are: attribution of agency to one or more virtual agents by the interactant; and a subsequent sense of shared agency that allows for co-construction of the ensuing experience between the human and virtual agent(s). This co-constructed experience, as well as the set of relationships that takes shape among a mixed population of human and nonhuman agents come about through features that are built into the architecture of the artwork, yet are unique to each interactant. The architecture is a set of rules that are predicated on anticipated behaviour, but each interactant's participatory behaviour and perceptions complete the work uniquely for them. In interactive A-life artworks, the attribution

---

[5]This type of reification differs from the reification that is often incorporated into interfaces, in which task-specific concepts are turned into objects (see Beaudouin-Lafon and Mackay [2000] for a discussion).

Fig. 3.   Tickle [1999], VIDA 2.0; Driessens and Verstappen, Netherlands.

of agency is itself artistically induced through the inventive use of materials as well as visual and audio media. Further, modes of contact between the programmed behaviours of the agent and the physical presence of the interactant are given great attention: we could say that bridging the "affective context" of the interactant with the agent and its environment is a primary concern [Achter et al. 2006]. It is the interactant's direct experience of the virtual entity's behaviour that constitutes an understanding and allows for attribution of agency; interpretation at a semiotic or conceptual level isn't necessary.

4.2 *Tickle* [1999], VIDA 2.0; *Tickle Salon* [2002], VIDA 5.0, Driessens and Verstappen, Netherlands

Tickle by Dutch artists Erwin Driessens and María Verstappen, shown in Figure 3, is a small autonomous robot that walks on the human body to generate a pleasing tickling sensation. *Tickle* is equipped with four sensors that can detect its inclination relative to a horizontal plane. Left and right track motors enable it to steer left/right and reverse direction. When it encounters a slope that is too steep, it will steer until a safe level is found and then continue on its way. This behaviour is implemented using a hardware instantiated finite state machine. *Tickle Salon* by the same artists is an installation that consists of a robot attached to the ceiling, and a bed standing on the floor; the interactant lies down on the bed. In between the bed and the ceiling, a suspended feeler made of silky thread and a metal ball is attached to four threads. The feeler can be moved around freely by varying the length of the four threads. This is achieved by computer-controlled stepper motors that wind and unwind the threads. When the feeler touches the skin surface, the collision causes a tension loss in one or more threads, which is detected by sensors. As the robot explores, it gently strokes the surface of the body while at the same time creating and updating the shape of that body in its *imagination*.

In each of the two *Tickle* works, "two-way feedback gives a convincing sense to the interactant that the machine feels the person while the person feels the machine." [Driessens and Verstappen 2002]. This understanding is shared by
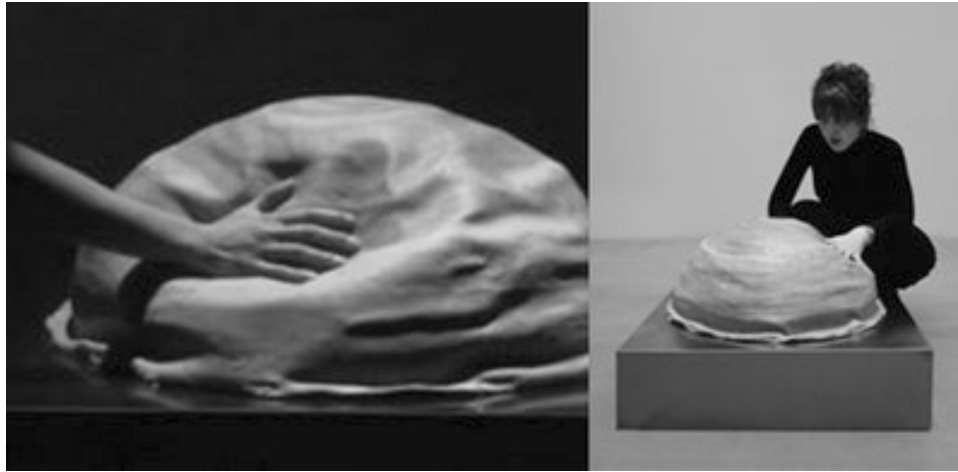
Fig. 4.   Alexitimia [2006], VIDA 9.0, Gaetano Adi, Argentina.

all interactants, and is even extended to viewers who are watching the interaction. Over a brief interlude of interaction, the robot and the feeler are both experienced as agents that are not only responsive but considerate of the interactant's pleasure, and not only assessing their respective environments but *imaginatively* executing sensitive movements over the interactant's skin. Although we could attribute these phenomena of the interaction to a suspension of disbelief on the part of the interactant, we propose that they arise from a much stronger impulse of attribution and coconstruction, and that they are attributable to an aesthetic of emergence.

4.3 *Alexitimia* [2006], VIDA 9.0, Gaetano Adi, Argentina

Paula Gaetano Adi is a young Argentinian artist who explores the concepts of embodiment and autonomy, two concepts that are hallmarks of A-life research, by reducing their overt features to bare essentials. She has made a robot called *Alexitimia*, shown in Figure 4, which is a term that means the incapacity to verbalize emotions. This robot doesn't look anything like a robot though, because its embodiment is perversely minimal (a soft rubbery blob mounted on a low pedestal). Nor does it have mobility or any apparent articulators, such as limb-like parts, sounds, or lights, which are the usual modes of autonomy that interactants can recognize immediately as those that an A-life robot uses for responding to its environment, including the presence of the interactant. Here, interactants have no explicit information about how to interact. But curiosity about what the object could be makes them resort to touching it, so as to find out. When they do, *Alexitimia* "sweats": there are touch sensors embedded in its surface, and there is water in a tank hidden in the base of the work that runs up into hoses and out through small punctures in the latex skin.

The strongest facet of this experience is a sense among the participants of shared participation in a vexing problem, which is that the "wet" domain of nature and the "dry" domain of electronics are currently at odds, if not

Fig. 5.   Universal Whistling Machine [2003–05], VIDA 7.0, Böhlen and Rinker, Canada.

irreconcilable. The minimalism in this work, or what we call low-fidelity embodiment in the context of our own work, permits the interactant to recognize the instant that the sculpture responds, which is the instant of attributing agency to it—coupled with a strong sense of empathy for such an abject, helpless object. Co-construction of the experience by the human and virtual agent then shapes and defines the aesthetic response.

4.4 *Universal Whistling Machine* [2003–05], VIDA 7.0, Böhlen and Rinker, Canada

The *Universal Whistling Machine* (UWM) (2003–05), shown in Figure 5, is a wall-mounted interface that consists of a speaker, camera, and microphone embedded in a neutral white surface. The *UWM* senses the presence of living creatures in its vicinity and attracts them with a signature whistle. Given a response whistle, *UWM* counters with its own composition, based on a time-frequency analysis of the user's. The artists, Marc Böhlen and J. T. Rinker, prefer to install their devices in quiet, low-traffic spaces of exchange and transition: restrooms, corridors, and elevator halls, so that people are caught by surprise:

> "Imagine walking down a corridor lost in thought. You hear a whistle. You stop and search in curiosity or disdain for the person seeking your attention. You notice an intercom-like device embedded in the wall. Again you hear a whistle. You walk towards the device, stare at it. Another whistle. You whistle back. The device whistles again, in a different fashion. You respond, and realize now that you have engaged in a whistle exchange with a machine" [Böhlen and Rinker 2005].

Böhlen and Rinker describe their device as an "anti-interface" because there is no explicit instruction as to how interaction should proceed. But almost invariably, a whistle from the machine will elicit an exchange of whistles from the interactant. In the context of ideas about the primacy of whistling as a

Fig. 6. Autopoiesis [2000], VIDA 3.0, Rinaldo, U.S.A.

pre-verbal communicative language, the artists are interested in how the transcultural and transtemporal character of whistling extends quite naturally to embrace the machine world. It is as if we assume the need for, and desirability of, communicating with machines; since the difficulties in implementing computational discourse systems are amply documented (e.g., see Jurafsky and Martin [2008]), a discourse based on whistling provided a satisfying alternative. So the agency of the machine and its role in eliciting this satisfaction are immediate in this work, through an interface that insinuates itself into the fabric of everyday life.

4.5 *Autopoiesis* [2000], VIDA 3.0, Rinaldo, U.S.A.

In Ken Rinaldo's *Autopoiesis* (Figure 6), interactants walk among a group of fifteen robotic sound sculptures whose behavior collectively changes over time. Each arm-like sculpture, suspended from the ceiling, can individually detect and respond to an interactant through smart sensor organization, moving its tip toward the person but never touching them. The four passive infrared sensors at the top of an arm tell it to move in the direction of the viewer, while one located at the tip of the arm stops its movement within inches of touching the interactant. The sculpture thereby displays both attraction and repulsion behaviors. At the same time, the entire group sends its data to a central state controller for coordination of group behavior. The sculptures are arm-like appendages that have a mixed look of the natural (derived from grapevines) and the artificial (articulators, wires, electronic components). At the tip of two of

the arms, lipstick cameras project what they see onto the walls of the space, giving the interactant a sense of being observed by the sculptures.

The attribution of agency here is of group agency. Although the local control of any one arm, with its own on-board computer control, always supersedes group control if there is a person present, the individual arms behave with elegant coordination, which is reinforced by the telephone tones that emanate from each arm and establish a collective emotional state for all of them. The fascinating shift in understanding that occurs for an interactant is from defensiveness at the initial probing of a sculpture toward them, to feeling part of the overall gorgeous balletic movement of the group. The interactant intuitively grasps that the behavior of the sculptures is more agitated and complex when a person is present, while it is more serene and in a state of waiting when being observed from the outside. This work allows for a direct, intuitive experience of an aesthetic of emergence.

5. DISCUSSION OF CROSSOVER ISSUES

The descriptions of the interactive artworks in Section 4 are notable because, first, the interaction outcomes were not solely functional. Second, the features of the interactions that were highlighted are those other than the traditional ones based on user performance. We believe that these interaction features and outcomes are also relevant to HCI and that they serve to establish a commonality between the HCI and interactive art research communities, specifically where they are involved with digital media. This idea is reinforced by Löwgren and Stolterman's [2004, pp. 122–123] discussion of use qualities that are common to all digital artifacts, such as the control/autonomy tension and the introduction and manipulation of social action spaces by digital artifacts: "Control/autonomy has a significant impact on how people can and will use the digital artifact in question, and how the digital artifact will behave as an actor in a network of actors."

—*Convergence of understanding of the artifact.* A commonality across the Vida competition winners described in Section 4 is the phenomenon of people converging around their understanding of the artifact. For instance, in the *Tickle* work(s), the understanding that the machine *feels* (haptically) the interaction, was shared by all interactants and was even extended to viewers of the interaction. This phenomenon of convergence is important not only in relation to art objects, but also to digital artifacts more generally. In Section 3.5, we advanced an argument about the importance of this phenomenon in interactions with digital artifacts more generally, and, in Section 3.6, we described how it is indeed an emergent phenomenon, which gave rise to our *aesthetics of emergence* approach.

—*The "seat" of assessment/evaluation.* As described in Section 4, the assessment of artworks has generally been considered to be extraneous to the experience of the work itself. Instead, assessment and evaluation are considered to be the tasks of critics and curators, as well as being in the domain of anecdotal exchanges among members of the art public. (The former aligns

with HCI practitioners, who conduct formal evaluations, whereas the latter represents *grassroots* opinion; the latter is what HCI evaluations try to reveal in field studies and other ecologically-valid evaluations).

—*The elicitation of attributions of agency.* In interactive A-life artworks, the attribution of agency is itself artistically induced through the inventive use of materials, as well as visual and audio media. The discussions of the Vida competition winners show that it is the interactant's direct experience of the virtual entity's behavior that constitutes an understanding of, and that allows for, the attribution of agency. The phenomenon of human interactants attributing to the Tickle machine the agency of it imaginatively executing sensitive haptic explorations arose from the interactants making aesthetic judgements about emergent phenomena (as opposed to the suspension of disbelief). Moreover, the attribution of agency also imbues the artifact with the potentiality of being a cointerlocutor. This need to communicate is what the *UWM* work plays on, and ultimately provides. It is these same impulses that Reeves and Nass [1996] identify in interactants with digital media more generally.

—*Curiosity and exploration.* Interactants become motivated to engage with *Alexitimia*, a minimal soft rubbery blob, due to curiousity and a desire to find out what it does. Djajadiningrat et al., [2000a, p. 66], identified curiosity as well as exploration as aspects of interaction that need to be incorporated into the HCI worldview of usability, to combat what would otherwise be a view that is narrow, that overly emphasizes efficiency and productivity, and that brings about interactions that will tend to be self-similar, mundane, and ultimately boring. The promotion of curiosity, engagement, and imagination are motivating goals for adopting the perspective of aesthetic interaction in designing interactive systems [Petersen et al. 2004, p. 275]. "Ludic design promotes engagement in the exploration and production of meaning, providing for curiosity, exploration and reflection as key values" [Sengers et al. 2005, p. 51].

—*The notion of an anti-interface*. The artists Böhlen and Rinker [p. 20, 2004] use the term "anti-interface" in referring to their *UWM* device because there is no explicit instruction as to how interaction should proceed. Similarly, the artwork *Alexitimia* offers no cues to potential interactants. Such designs apparently contravene the most foundational principles of design. Yet, they exist due to artistic inquiry and its reliance on intuition. As these artists show, digital artifacts are not exclusively intended for use in the pursuit of functional goals (and correspondingly, are not to be evaluated exclusively using performance-based criteria). At its core, this repurposing of digital artifacts serves to question their roles in, and relationships to, our everyday lives. In its more general manifestation, the anti-art concept, discussed in Section 3.2, arose from the reformulation of the relationship between art and everyday life and, among other things, expresses an inseparability between social and political concerns, and art manifestations. This has its parallel in the inseparability of socio-political concerns and interface technology: for instance, the politics of search engines [Goggin and Newell, 2003, p. 132],

and the notion of digital apartheid [Cooper 1999] (also see Sengers et al.
[2005]). The London-based team, Dunne and Raby [1996] design "speculative
products and services" that are meant to engage people in debate about the
social and ethical ramifications of electronic objects, for example in their
project Hertzian Tales. Art practices' expression of dissatisfaction with the
ability of established art practices to connect with lived reality gave rise to
anti-art; is it only a matter of time before a collective of practitioners of HCI
interface design become dissatisfied to the point where they subversively
promulgate anti-interfaces?

—*Everydayness.* Despite the "art" context of several of the interactive art ex-
amples, some interactive artworks are intended to be situated in everyday
places. For example, the *UWM* piece was intended to be installed in re-
strooms, corridors, and elevator halls, so that potential interactants would
be caught by surprise. The work by Benford et al. [2004, 2005], discussed
in Section 3.3, we believe is notable for its role in identifying the issue that
the process whereby interactants make their subjective attributions is in-
fluenced by their context: whether he or she remains grounded in the world
of everyday events or has become engaged in the fictional world of a perfor-
mance. Analogously, in the art world, *readymades* (see Section 3.2) serve to
highlight the difference between an everyday object in a rarified context as
opposed to an everyday context.

—*Eliciting desire and providing satisfaction of that desire. Alexitimia* elicits
a desire to figure it out; the machine provides an outward manifestation of
its two states that satisfies that desire. *UWM* elicits a desire to communi-
cate, and it affords the mode of whistling to satisfy that desire, where other
modes, such as natural language, would not. *Autopoiesis* elicits a desire in
the interactant to understand how the individual elements cohere into a
group; the piece satisfies this desire by its balancing of attractive and repul-
sive behaviors, which affords feedback to the interactant that is stabilized
and interpretable to them. A user may be repulsed by an interaction while
at the same time attracted to it. These two conflict, and must be resolved;
if resolved in favor of the repulsion, then the interactant will break away.
But this doesn't happen, because the forces of attraction are stronger. With
Autopoiesis, *interactants* are repulsed by the probing by the sculpture toward
them, but a shift in their understanding motivates them to overcome this and
instead they desire to become part of the group movement.

6. CONCLUSION

In this article, we have described our theoretical approach to the aesthet-
ics of interaction, which we have termed *aesthetics of emergence*. An aes-
thetics of emergence relies on embodied, situated participatory actions of
both human and virtual agents (co-construction of experience) and conver-
gence of understanding for interactants (commonality of meaning) both of
which follow from attribution of agency to virtual agents by the interactant
along with a sense of shared agency and shared relations (all mechanisms of
social understanding). Based on the concept of aesthetics of emergence, we have

situated A-life artworks within a new world of HCI, and also bring to the HCI worldview some exemplar A-life artworks and theoretical frameworks. We have shown how different aspects of social understanding provide both a psychological basis for believability, as well as a theoretical and analytical framework for examining user experience. We have described our design theory, as applied to our A-life sculpture in progress, in particular the use of low-fidelity embodiments and collaborative tasks. We have situated our theoretical framework among the theoretical constructs in the field of new media design and human–computer interface design practices. We have argued that the frames of reference that are relevant to this A-life sculpture, and interactive new media, more generally, are also relevant to design domains in human–computer interaction for which experience design and user experience are at the forefront.

REFERENCES

BALJKO, M. AND TENHAAF, N. 2006. Different experiences, different types of emergence: A-life sculpture designers, interactant, observer. In *Proceedings of AAAI Fall 2006 Symposium on Interaction and Emergent Phenomenon in Societies of Agents*. Arlington, VA, 104–110.

BEAUDOUIN-LAFON, M. W. AND MACKAY, E. 2000. Refication, polymorphism and reuse: three principles for designing visual interfaces. In *Proceedings of Advanced Visual Interfaces (AVI)*. Palermo. Italy, ACM Press, 102–109

BEN-BASSAT, T., MEYER, J., AND TRACTINSKY, N. 2006. Economic and subjective measures of the perceived value of aesthetics and usability. *ACM Trans. Comput.-Hum. Inter. 13*, 2, 210–234.

BENFORD, S., FLINTHAM, M., DROZD, A., ANASTASI, R., ROWLAND, D., TANDAVANITJ, N. ADAMS, A., ROW FARR, J., OLDROYD, A., AND SUTTON, J. 2004. Uncle Roy all around you: implicating the city in a location-based performance. In *Proceedings of Advanced Computer Entertainment* (ACE). Singapore, June.

BENFORD, S. 2005. Pushing the boundaries of interaction in public. *Interactions 12*, 4, 57–58.

BÖHLEN, M. AND RINKER, J. T. 2004. Unexpected, unremarkable, and ambivalent or how the universal whistling machine activates language remainders. In *Proceedings of Fourth International Conference on Computational Semiotics for Games and New Media (COSIGN)*. Split, Croatia, 19–24.

BÖHLEN, M. AND RINKER, J. T. 2005. Experiments with whistling machines. *Leonardo Music J. 15* (Dec.), 45–52.

CARIANI, P. 1992. Emergence and Artificial Life. In C. Langton, C. Taylor, J. Doyne Farmer, and S. Rasmussen (Eds.), *Artificial Life II*. Addison-Wesley, Redwood City, CA, 775–797.

CLARK, H. H. 1996. *Using Language*. Cambridge University Press.

COOPER, A. 1999. *The Inmates are Running the Asylum: Why High Tech Products Drive us Crazy and How to Restore the Sanity*. Sams, Indianapolis, Indiana.

DAUTENHAHN, K. 1998. The art of designing socially intelligent agents: science, fiction, and the human in the loop. In *Appl. Artif. Intell. 12*, 5, 573–617.

DINKLA, S. 1994. The history of the interface in interactive art. In *Proceedings of the Fifth International Symposium on Electronic Art (ISEA)*. Helsinki, Finland.

DJAJADININGRAT, J. P., GAVER, W. W., AND FRENS, J. W. 2000a. Interaction relabelling and extreme characters: methods for exploring aesthetic interactions. In *Proceedings of the Conference on*

Designing Interactive Systems: Processes, Practices, Methods, and Techniques (DIS), Brooklyn, NY, (Aug. 17–19), 66–71.

DJAJADININGRAT, J. P., OVERBEEKE, C. J., AND WENSVEEN, S. A. G.   2000b.   Augmenting fun and beauty: a pamphlet. In *Proceedings of Designing Augmented Reality Environments (DARE)*, Elsinore, Denmark, 131–134.

DJAJADININGRAT, T., WENSVEEN, S., AND OVERBEEKE, K.   2004.   Tangible products: redressing the balance between appearance and action. *Personal Ubiq. Comput. 8*, 5, 294–309.

DRIESSENS, E. AND VERSTAPPEN, M. 2002.   Tickle Salon. Retrieved, from *Fundación Telefonica, Art and Artificial Life International Competition*. WWW: http://www.fundacion. telefonica.com/at/vida/paginas/ev5.html.

DUNNE, A. AND RABY, F.   1996–1999.   *Hertzian Tales*. WWW:http://www.dunneandraby.co.uk/.

FITZMAURICE, G.   2006.   What is the Next Generation of Human–Computer Interaction? In *Proceedings of the Workshop on What is the Next Generation of Human-Computer Interaction (CHI)*? Montreal, PQ, 23, 45–49.

FLINTHAM, M., ANASTASI, R., BENFORD, S., HEMMINGS, T., GREENHALGH, C., RODDEN, R., TANDAVNITJ, N., ADAMS, M., AND ROW-FARR, J.   2003.   Where on-line meets on-the-streets: experiences with mobile mixed reality games, In *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI)*. Fort Lauderdale, Florida.

FUNDACIÓN TELEFONICA. 2007.   *Art and Artificial Life Competition*. http://www.fundacion. telefonica.com/at/vida/paginas/ebases9.html.

GOGGIN, G. AND NEWELL, C.   2003.   *Digital Disability: The Social Construction of Disability in New Media*. Rowman & Littlefield, Lanham, MD.

GREENHALGH, C., RODDEN, R., TANDAVNITJ, N., ADAMS, M., AND ROW-FARR, J.   2003.   Where on-line meets on-the-streets: experiences with mobile mixed reality games. In *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI)*, Fort Lauderdale, Florida.

HALLNÄS, L. AND REDSTRÖM, J.   2002.   From use to presence: on the expressions and aesthetics of everyday computational things. In *ACM Trans. Comput.-Hum. Inter. 9*, 2, 106–124.

HASSENZAHL, M.   2004.   The interplay of beauty, goodness, and usability in interactive products. *Hum. Comput. Inter. 19*, 4, 319–349.

HELLER, D.   2005.   Aesthetics and interaction design—some preliminary thoughts. *Interactions 12*, 5, 48–50.

JURAFSKY, D. AND MARTIN, J.   2008.   *Speech and Language Processing*. Second Edition. Prentice Hall.

LEVY, S.   1992.   Artificial life: the quest for a new creation. *Whole Earth Rev. 76*, 22, Fall.

LÖWGREN, J. AND STOTLERMAN, E.   2004.   *Thoughtful Interaction Design: A Design Perspective on Information Technology*. MIT Press, Cambridge, Mass./London, England.

MAES, P.   2005.   Attentive Objects: Enriching people's natural interaction with everyday objects. *Interactions 12*, 4, 45–48.

MANOVICH, L.   2001.   *The Language of New Media*. The MIT Press, Cambridge, Mass./London, England.

MARSH, J. P., NEHANIV, C. L., AND GORAYSKA, B.   1997.   In *Proceedings of the 2nd International Conference on Cognitive Technology 'Humanizing the Information Age'*. Aizu-Wakamatsu City, Japan.

MAYER, P. A.   1998.   Computer-mediated interactivity: a social semiotic perspective. *Convergence: Inter. J. Res. New Media Tech. 4*, 3, 40–58.

MORSE, M.   2003.   The Poetics of Interactivity. In *Women, Art, and Technology*, J. Malloy (Ed.). The MIT Press, London, England, 16–33.

PENNY, S.   2004.   Representation, enaction and the ethics of simulation. In *First Person: New Media as Story, Performance, and Game,* P. Harrigan and N. Wardrip-Fruin (Eds.). The MIT Press, Cambridge, Mass/London, England.

PETERSEN, M., GRAVES, IVERSEN, O. S., KROUGH, P. G., AND LUDVIGSEN, M. 2004.   Aesthetic interaction—a pragmatist's aesthetics of interactive systems. In *Proceedings of the Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques (DIS)*. Cambridge, MA.

PETERSEN, M. GRAVES.   2005.   Interaction spaces: towards a better everyday? *Interactions 12*, 4, 44–45.

QUARANTA, D. 2004. Quale Interazione? Intervista a Lev Manovich/What kind of interaction? *Cluster. On Innov. 3* (Special Issue on Interaction Design), 30–33.

REEVES, B. AND NASS, C. 1996. *The Media Equation: How People Treat Computers, Television and New Media Like Real People and Places*. Cambridge University Press.

RICHTER, H. 1965. *Dada: Art and Anti-Art*. Thames and Hudson, New York.

SACKS, H., SCHEGLOFF, E. A., AND JEFFERSON G. A. 1974. A simplest systematics for the organization of turn-taking in conversation. In *Language*, 50, 696–735.

SENGERS, P., BOEHNER, K., SHAY, D., AND KAYE, J. 2005. Reflective Design. In *Proceedings of the 4th Decennial Conference on Critical Computing: Between Sense and Sensibility (CC)*. Arhus, Denmark, 49–58.

SHAW, J. 1997. *Jeffrey Shaw: A User's Manual: From Expanded Cinema to Virtual Reality*. Hatje Cantz, Ostfildern, Germany.

SHUSTERMAN, R. 1992. *Pragmatist Aesthetics: Living Beauty, Rethinking Art*. Blackwell, Cambridge, MA.

STONE, A. R. 1995. *The War of Desire and Technology at the Close of the Mechanical Age*. The MIT Press, Cambridge, Mass/London, England.

TENHAAF, N. 1998. As Art is Lifelike: Evolution, Art, and The Readymade. *Leonardo*, *31*, 5, 397–404.

TENHAAF, N. 2008. Art embodies A-Life: the VIDA competition. *Leonardo*, *41*, 1, 6–15.

WHITELAW, M. 1998. Tom Ray's Hammer: Emergence and Excess in A-life Art. *Leonardo*, *31*, 5, 377–381.