Collective Creativity: Utilizing the Potentials of Multimodal Environments

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Abstract. Advances in technology have expanded the methods by which users interact with computer-based systems beyond the screen and into physical space. To design these types of innovative interfaces, new design techniques and practices will be needed to understand how users perceive and interact with such multimodal environments. One area where we can look for such novel approaches is the field of interactive media art and design. An interactive art installation called Art Machine: MindCatcher was built to allow users to create audio-visual sentences (artifacts) by moving through a field of sensors that generate circles and sounds that varied depending upon the amount of time spent on the sensor. This research experiment has intention to contribute to the field of collective creativity and participatory design by representing a test-of-concept regarding the viability of interactive media art and design as a method that contributes to the repertoire of techniques and practices for engaging participants in design activities.

Keywords: Collective creativity · Multimodal environments · Activity Theory · Human-centered design

1 Introduction

Technology now allows us to create many different types of user interfaces to technology, and to computer-based systems in particular. Interfaces are no longer constrained by the use of a keyboard, mouse, or even a touch screen. It is now possible to use human movement and gestures as a means of providing commands and interacting with technology.

Many of the techniques that have been successfully used to facilitate user participation in the design of systems and interfaces such as storyboards, mock-ups, and game boards [1], are not directly applicable to the design of interfaces which use gestures, body movement, location, and other physical characteristics observable by the system itself as input.

It is proposed that interactive art installations can be created with the intention of providing users and designers a fun and functional three-dimensional space in which they to explore a wide variety of physical, visual, and audio stimuli and responses, subject to constraints which can be manipulated in many different ways. Through data collection, including observation, of the interactions between user and the

R. Giaffreda et al. (Eds.): IoT360 2014, Part II, LNICST 151, pp. 27–37, 2015.
DOI: 10.1007/978-3-319-19743-2_5

technological interface as well as between users as co-creators, designers can gain understanding of the impact of constraints on human involvement, interactive experience, incentives which can enrich users' creativity, and cognition, and contribute to sustainable interactive and interface design practices.

This paper will present a brief background section, a description of a specific art installation that could be used in such a way, a discussion of the data collected from the installation, and suggestions for where to go from here.

2 Background

The concept of interactive art, the art which allows viewers to become participants in the co-creation of the art (artefact) itself, has been implemented in many different ways. Frank Oppenheimer, the late director of the Exploratorium in San Francisco, was one of the pioneers who anticipated the necessity of interactive methods of presentation. In 1969 the development of computer-controlled Interactive Art started with American mathematician Myron Krueger and colleagues in GlowFlow, a visual and auditory reactive environment triggered by pressure sensors which start choreography of light and sound. The concepts for designing the interface and the interaction have continued to develop and become more diverse [2]. While interactive art installations may be motivated by different intentions, such as moderating perception by allowing the viewer access to a virtual world by using a handheld virtual eye (Handsight by Agnes Hegedus) or purposely confusing the visitor with the nature and cause of the images generated (Silicon Remembers Carbon by Rokeby), many are supported by computer systems that use feedback from the participants' actions to change the behaviour of the system creating the art. In most cases the participant has to perceive the system rules or constraints as a result of his or her interactions with the installation. Therefore users could quite passively interact without learning, or could actively experiment with the reactions of the installation to determine and then use the underlying constraints to obtain a desired outcome.

We propose that interactive art installations can be used to expand the techniques of participatory design in such a way that its supports collective creativity directed by a conceptual framework. Using interactive art as a tool for understanding user interactions with technology allows us to use a language whose components are not only both visual and verbal [3] but also experiential in the sense that the participant can see and hear (and potentially feel) the response of the art installation to his or her actions. Collaborative creation such as that addresses the aesthetic and emotional sides of the experience, by allowing users to "escape the limitations of existing structures of meaning and expectation within a given practice" as with the Fictional Inquiry technique used by [4], and to experiment with new ways of communicating with technology.

Iversen and Dindler [4] describe the concept of *aesthetic* as "a profoundly meaningful transformation that provides a refreshed attitude towards the practices of everyday life, and as a change in our modes of perceiving and acting in the world". We support this view which opens possibilities of various aesthetical interventions and applications of transcendence in Collective Creativity. The use of imaginative artifacts

may result in better, more creative, collaboration between participants in the process and eventually to more innovative design by providing a means of exploring those desires (deeply-felt preferences regarding the interface) that cannot be articulated on a purely conscious level [5].

Activity Theory has been used as a theoretical foundation in design evaluation and human-computer problem analysis, which serves as a useful framework for understanding MindCatcher in the broader participative design context. In Activity Theory the unit of analysis is motivated activity directed toward a goal [6]. In the case of MindCatcher this activity is the movement through the installation, pressing on certain spots. The activity is mediated by the structure of the MindCatcher installation – the artefact – and constrained by the rules built into the installation. Other theory framework components that can be studied using MindCatcher are the environment, the characteristics of the participants (history and culture), and differences in motivations and the complexity of the interaction.

Activity Theory emphasizes the distinction between internal and external activities. The interactive art installation MindCatcher tries to capture internal processes such as perceptions and emotions and express them through external activities represented by participants' behavioral changes. The theory also highlights the importance of tool development for further mediation between internal and external human activities [7]. This opens the experimental space to artistic forms and aesthetically composed environments. This is where artistic concepts could contribute to the design process especially in the sphere of innovative human-centered interactive and interface design. Further, this should lead to deeper investigation of how people perceive and engage in the world. Having that in mind, we could say that individual and collaborative experience vastly depends on respect of people's choices and lifestyles, personal beliefs and values. Pervasive technologies and the future vision of ubiquitous computing, foresees novel scenarios of highly interactive environments in which communication is taking place between users and devices, between devices and devices, and between users and other users. Such responsive environments enable automation, interactivity, ubiquity [8] while meeting user expectations and allowing interaction at almost a subconscious level [9]. For more than a decade researchers have been working on sustainable concepts for integration of real and virtual space. Followed by technology improvements, cross-reality ideas and technologies started widely to appear in various projects, ranging from interactive art installations to industry and commercial based systems.

In order to explore world around us we use all our senses. Numerous studies have suggested that the greater the number of sensory modalities stimulated at any time, the richer our experiences will be [10–12]. As a consequence, increasing number of modalities of sensory input, presented in a virtual environment, can help increase people's sense of presence and also increase their memory for objects placed within the virtual environment [13–15]. The way we interact with such an environment is through an interface placed between us, and the non-physical, often abstract, world we experience. What we try to investigate is where and how such a human-centred design can be utilized in practice, and what can be the outcomes of such collaborative and communication-oriented multimodal environments. We used aesthetically-based experiment design in a form of interactive installation as a platform for user participation in research, as we assumed that such enriched perceptive surrounding could

provide us with more comprehensive data regarding user emotional reactions, feeling and behaviours to contribute to better future sustainable interactive environments design.

3 The MindCatcher Experiment

In the interactive installation Art Machine: Mind Catcher the goal was to investigate how an interface based on body-movement interaction and sound-visual response could affect visitors' perception during interaction, and how it could deliver a rich and varied multisensory experience. The intention was to explore how this human-computer interaction could make people feel comfortable to collaborate, express their feelings and emotions, on which is based every sustainable environmental but also product or service design.

The installation uses sensory data to output a 3D real-time, open-GL-based rendering of a graphical-based universe. It can be seen on the wall projection situated in front of the user. Those data are collected through participants' interaction with floor interface and are based on offered audio-visual vocabulary which consists of three colours (red, blue, yellow), three tones (C, G, E), three sized circles, and a touch sensitive space for creative dialogue between artwork as a paradigm of complexity system in a phase of creation and participants as co-creators.

The purpose of using different media and technologies is to increase the perceptual manipulation of the participants in order to achieve a higher degree of persuasive experience [16]. The Art Machine: Mind Catcher installation invites visitors to step on the interactive floor interface and visualize their multisensory experience by pressing floor switches. Every switch has its colour and its tone which corresponds to created output and could be modulated depending on pressure duration. This interface allows users to create audio-visual patterns (composed of circles of varying colors and size that corresponded to different tones) based on simple rules. At a deeper level, to provoke emotions and communication in the perceived space we used imaginative abstract artifacts which we named *audio-visual sentences*. The sentences are a paradigm for meaningful communication that can be built and made visible with abstract signs we call *letters*. Based on that we can build our creative vocabulary on any sign, color or form and proclaim it as the letters we are using to build sentences and express ourselves.

In contemporary design methodology it is crucial to allow participants to create. By observing the creative process, users' behavior and analyzing the creative artifact itself, designers are in a position to fulfill user expectations and meet their needs. In the MindCatcher installation, the creative activity occurs when participants interact with the installation to produce the audio-visual sentences that are the creative outcomes.

The interface itself is placed on the floor of the installation. It is a circular arrangement of pressure-sensitive circles of red, blue, and yellow, with one white circle in the middle to serve as the "start" indicator. This interface and the area where the pattern would display are shown in Fig. 1.

After starting the session the participants move around and press the colored circles. The way audio-visual sentences are generated such as in a form, direction or movement

Fig. 1. The MindCatcher installation

depends on rules defined by the author (designer). Having that in mind we were able to affect users' collaboration, involvement, cognition and trigger their emotions based on observed user behavior and thought they shared with interviewers after the sessions. Based on that the installation evolved through three versions named Essentiality, Universality and the last one I, Universe. The last version of the installation will not be part of the research presented in this paper.

In the first version Essentiality, once the first circle is pressed the rest of the circles generated in the audio-visual display go in the same direction as the participant moved to press the first one (left, right, up, down, etc.) In order to change the direction of the "branch", the participant must make a pause. (Physical inactivity is perceived to involve mental contemplation.) As a result the created artifact can increase in richness by showing more complex patterns. Examples of these patterns are shown in Fig. 2.

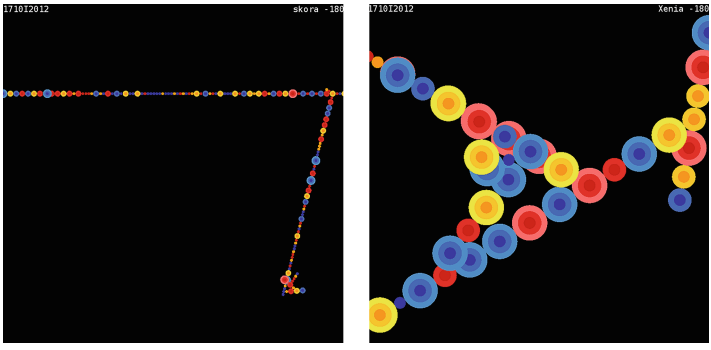

Fig. 2. Simple (left) and more complex (right) patterns produced by MindCatcher participants

Finally, the finished individual creation is joined to the collective audio-visual art piece on a daily and global level. This is illustrated in Fig. 3. Collaboration between users were not in a physical space, it was spread over audio-visual user-generated virtual space projected on the wall and transferred also into web space, where everybody could follow the evolution of their collaborative artifact patterns, over the project's website.

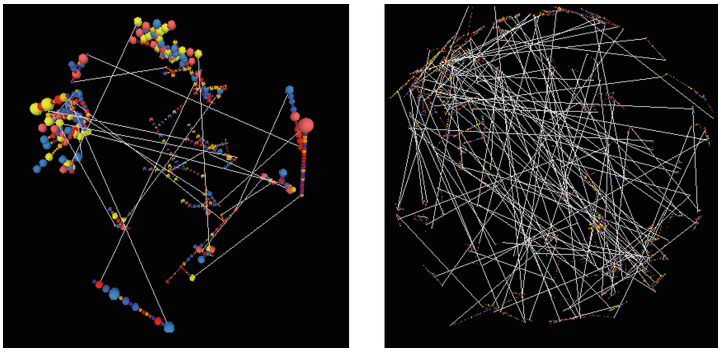

Fig. 3. Daily (left) and global (right) collective patterns.

In the second version Universality collaboration between users in a physical space became very important creative factor and as such deeply affected rules upon which the installation responded on participants' actions, behavior and interpersonal collaborations. The maximum number of participants hosted by the installation was six, as shown in Fig. 4.

Fig. 4. Direct collaboration on the floor interface

The artifacts they created were different then in the first version of the installation, as reflection of a new generative rule applied to leverage users' collaboration and involvement, provoking different meaning and feelings as incentives to participants' involvement and creative contributions. Example of the sessions is shown in Fig. 5.

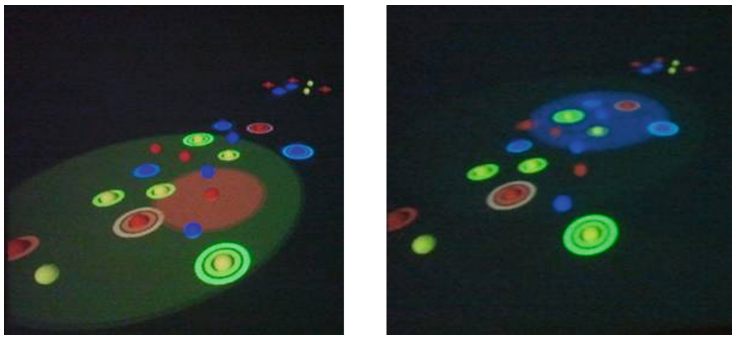

Fig. 5. The audio-visual artifacts generated by one or more participants at the same time.

4 Findings

First version of the installation Art Machine: MindCatcher was exposed in the Museum of Applied Art in Belgrade, Serbia, from 7 to 21 September 2011. A total of 140 interactions were recorded. Every participant was recorded with a video camera and observed directly by the researchers. Metrics collected about each interactive session included the time spent in the installation, the number of repeated visits, gender, date of birth, number of each color, as well as the number of each tone used. In addition, the pattern of behavior on the floor interface was captured. Errors made by the participants were also recorded. Errors would include actions such as pressing the central white circle after the session has started even though it was clear that doing so would not affect the colorful creation, pressing the colored circles without stepping on the white circle to begin, or pressing the switches which are selectively disabled during the duration of the installation even though the participants were told which switches were disabled.

Second version of the installation Art Machine: Mind Catcher has been exposed at the Educational Museum in Belgrade. During the period of 12 days 112 sessions were recorded, with a presence of various numbers of participants in the installation floor interface, with different interpersonal relationships. Example of mother and daughter who interacted together on the floor interface is shown in Fig. 6.

Based on personal observations three mayor types of the user behavior were similar for both versions of the installation:

Type 1: Participants focused only on interaction with the floor interface - they used it as a musical instrument or a stage for their performance. This user type ignored the audio-visual artifact they were producing during the session.

Fig. 6. Mother and daughter in the collective creative session, interacting together on the floor interface.

Type 2: Participants focused only on audio-visual artifact they were producing (by interacting with the floor interface) during the session and how to control raising visual complexity. They used floor interface as some kind of a painting tool. For them, sound generated through interaction with the installation was of a secondary or of none importance. They concentrated on finding out how to synchronize their body movements with the visual creation they were producing.

Type 3: Participants focused on all aspects of available creative and sensory experiences they were immersing, starting from the physical interaction with the floor interface through 2D visual creation and finally observing joint of it to the 3D artificial structure co-created with other users.

Besides these characteristics attached to certain groups of users, what was common for all participants, there were transfers from the phase of surprise and uncertainty in the beginning, through phases of cognitive thinking, intuition problem solving and conclusions and ending with joy, excitement and satisfaction as they became fully embodied with the installation space and certain about how to fulfill their task.

In this experiment it was important to explore how the new installation rules, defined in the Art Machine: Mind Catcher *Universality* together with the opening of a new interactive space for physical collaboration, reflect on collective creativity and the audio-visual sentences, produced by the participants. Based on interviews taken from the users, the first installation version *Essentiality* did not achieve expected collaboration due to participants' lack of understanding regarding:

- the individual contribution to group sessions;
- the group contribution to individual sessions;
- the correlation between generated creative artefacts;
- the possibility to control created collective artefact.

In the second version named *Universality*, by allowing direct physical interaction and simplification of the audio-visual respond on collective users' behavior we delivered more meaningful collaboration between participants. As a result, the percentage of repeated visits and continuing the sessions increased dramatically, from 3.7 % to 27 %. The youngest group of visitors (age 6–10) showed huge interest to repeat their interactive sessions, usually one after another, but sometimes even within a period of several days. Second group of the most active users showed interest to share experience and collaborate with different people, so they were returning to interact with the installation. By changing the way creative artifact are generated they became a more quantitative parameter despite qualitative and quantitative role they had in the first installation data analyses. The relevant data we used to measure user engagement and embodiment was the number of produced audio-visual dots and the created artefact size and complexity.

The mentioned simplifications of the installation functional and conceptual system helped us also to validate with more clarity the immersion, interaction and information intensity with only one interaction complexity evaluation parameter. We derived it from personal observations, answers collected through a questionnaire and measurements of the following metrics:

- number of visits;
- time spent in the installation;
- number of generated audio-visual dots (Fig. 7);
- size of the created audio-visual structure/artefact.

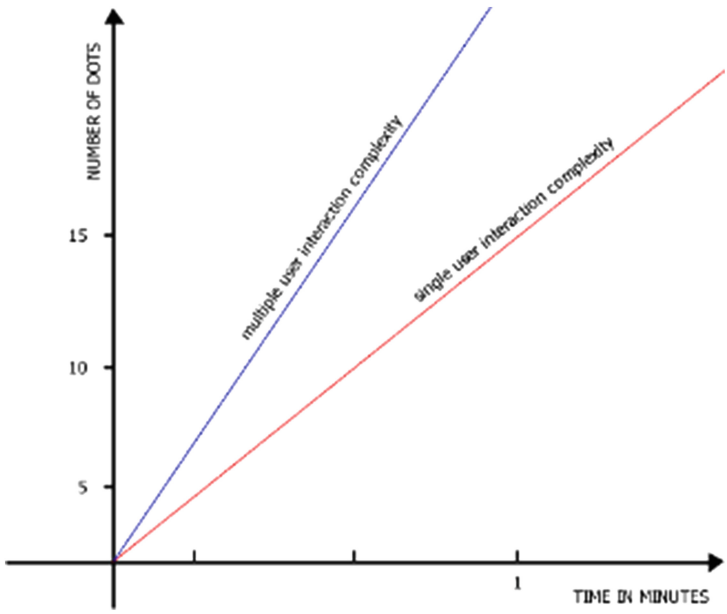

Fig. 7. Graphic of the Art Machine: MindCatcher v2.0 users' involvement and embodiment throughout time.

With the defined metrics and parameters we were also able to evaluate achieved collaboration between participants in a sense of mutual understanding of the tool they use to generate the artifacts and physical and virtual synchronization of the interaction in order to archive desired interactive experience and potential creative results.

5 Conclusions and Future Directions

The results collected from two separate installations: the Art Machine: MindCatcher *Essentiality* and its second version *Universality*, could lead us to the new collective creativity practices in developing designers tools toward innovations in interactive and user experience design.

MindCatcher experiment demonstrated that it is possible to use an interactive computer-based art system to better understand perception, affected emotions and behavior. The level of involvement directly affects the level of creativity generated by the environment. Results can be analyzed not only by using statistical data but also by examining the created artifacts as illustrating the perceptional and emotional states experienced. Hence, based on the final user-generated forms and meanings we believe it is possible to derive certain conclusions on usability and new approaches to interface development particularly in the case of collaborative, creative or educational tools. MindCatcher combines aesthetics with metrics, and visual language with human experience and habits.

Based on our experiment we believe that adoption and introduction of human-computer interaction, through visual, audible and tactile interaction, could be helpful in user-centered design decision making. Furthermore such investigations could help in applying possibilities of the meaningful multisensory art experiences raised on human values in the centre of the process of designing.

Thus, we found the possible applicability of multimodal environments in the sense of helping businesses provide "smart services". For contemporary companies, especially from the fields of communications and information technologies, it is no longer to offer prompt, good service. Providing "smart services", based on real-time data about clients, collected for purpose of effective decision making [17] is a cutting edge source of competitive advantage. Smart service is based on business intelligence, on awareness of clients' needs, on connectivity, and feedback from clients and customers.

Future interactive media art and design experiments such as MindCatcher installations can go further towards achieving a better understanding of the collaborative creative experience, social communication and its relationship to interaction in human actions towards better design. As a result we expect to gain a better understanding of possibilities for new methods and techniques in development approaches for collaborative-multimodal experience design as well as human-centred interactive services and environments. Other types of interactive art installations could be used to illustrate the way technology can open up new forms of participation and to foster a basic understanding about gesture recognition algorithms and how they can be used or adapted to an individual's own needs to contribute to the design of multimodal interfaces, physical interaction and computational models for audiovisual environments, thus expanding the field of collaborative creativity and participatory design into new territories.

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