Creative Surrogates: Supporting Decision-Making in Ubiquitous Musical Activities

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We present results of two studies that address creative decision-making through the usage of local resources. Adopting an opportunistic design approach (Buxton 2007; Botero et al. 2010; Visser 1994), both studies use off-the-shelf infrastructure to identify support strategies that deserve further implementation efforts. Both studies yielded complete creative products, consisting of a mixed-media performance artwork and a multimodal installation. We discuss the procedures employed to assist the decision-making processes with an eye on the development of new creativity support metaphors. The examples serve to frame the discussion on human-computer interaction and musical creativity in the context of ubiquitous music making.

1 Introduction

This paper deals with the convergence of interaction design techniques and artistic practices. Analyzing two design projects – involving multiple iterations - the impact of creative practices on interaction design methods are discussed. On the one hand, the development of technological support for creative practices opens up new opportunities for artistic application. On the other hand, the concepts unveiled through the study of creativity expand the potential for participation in artistic practices. One of the theoretical and methodological perspectives exploring this convergence is ubiquitous music research (Keller et al. 2014a).

Recent advances on creative practices in information technology (Mitchell et al. 2003; Shneiderman 2007; Shneiderman et al. 2005) indicate the need to change the focus from technological product development to support for meaningful experiences (Rogers 2014). Creative computing highlights the non-utilitarian aspects of technology inserted in everyday life (see for example, Bødker 2006; Harrison et al. 2007). More recently, the aesthetics interaction design perspective broadens the range of the application of artistic endeavors to assess the results of human-computer experiences (Keller et al. 2014b; Löwgren 2009).

In this paper, we discuss exploratory strategies in creativity-centered design (Lima et al. 2012) as a way to encompass research methods for the study of creative procedures that yield relevant and original products. We analyze two artistic applications of the graphic-procedural metaphor, focusing on its limitations and its applicability within the realm of artistic creativity. The results show good potential for enhancing audience participation in music making and for expanding the available spaces for creative action beyond collocated activity. The graphic-procedural metaphor allows for the use of visual elements to organize temporal parameters asynchronously. This metaphor is based on close relationships among local material resources and creative decisions, mediated by the action of the participants. This mediation mechanism puts the focus on the active participation of stakeholders in the creative act, emphasizing the human side of creativity support.

2 Ubiquitous Music and Creative Design

A key aspect of the creative process is the choice or development of technological support. This task involves finding out how material, cognitive and social factors influence the strategies applied in decision-making. Our overall proposal is to expand the study of creativity to the context of everyday actions. More specifically, we

want to insert music creation in settings that were not originally designed for music making. A first step has already been taken by experimental studies in ubiquitous music. Ubiquitous music - or ubimus (Keller et al 2014a) - emerges as a theoretical and methodological alternative to the approaches attached to the European instrumental musical tradition of the nineteenth century (Tanaka 2009; Wessel and Wright 2002). Ubiquitous musical activities generally use distributed resources and involve multiple stakeholders with various levels of expertise. While ubiquitous music requires expanding the access to creative activity by laypeople, the acoustic-instrumental paradigm demands a strict separation between novices and musicians-performers.

Most research in musical interaction has focused on the validation of instrumental music tools (Tsandilas et al. 2009) or on simulations and extensions of musical instruments (International Conference for New Instruments for Musical Expression – NIME). By grounding the design choices on instrumental music molds, the researcher reduces the participant's role to a consumer of ready-made procedures predefining the aesthetic perspective to be adopted. Thus, the creative choices are established by the research design, rather than by the subjects-participants. Hence, the results reflect the methodological choices of the experimental design restricting the participation of the creator to a predefined creative path. This caveat has been term *early domain restriction* (Keller et al. 2011b).

The procedures that have emerged for supporting ubiquitous musical activities encompass four inter-related stages: defining strategies, planning, prototyping and assessment (Pimenta et al. 2014). Given the iterative and participatory nature of our design practice, these four stages are not necessarily successive and each stage may be repeated several times during the development cycle. Our practice suggests three emergent methodological trends that may be used as general guidelines to define design strategies: (a) avoid early domain restriction; (b) support rapid prototyping; and (c) foster social interaction. After the initial choice of design strategies, planning activities may be pursued in the form of exploratory studies. The objective of this design phase is to obtain a set of requirements and to gather initial feedback on user expectations. Once the minimal requirements and the overall objectives of the project have been set, simple prototypes can be built to allow for more detailed on-site observations. Prototypes do not need to be complete software solutions. This stage's objective is to gather useful information on specific aspects of the musical experience. Thus, sonic outcomes can be handled by simplified signal-processing tools (Lazzarini et al. 2012; 2014b) or by Wizard of Oz simulations (Gould et al. 1983). Design issues of the

adopted interaction approach can be studied by using software mash-ups, verbal scores, aural scores, graphic scores, storyboards, videos and animations. The focus is fast turnover, not refined implementations.

To be able to orchestrate these activities is a tricky business. So no ready-made recipes are available yet. Furthermore, to guide the choice of technologies and interactivities that support the on-going creative activity some sort of assessment is necessary and this should be as closely tied to the activity as conditions permit. Both objective data – related to the subjects' profile, activity variables, environmental variables and technological infrastructure – and subjective data – the subjects' feedback on various aspects of the experience – should be gathered. Through comparisons among various conditions, it is possible to evaluate the impact of the material and the social resources on the participants' performance. These results feed the previous design phases, pointing to updated strategies and prototype refinements.

2.1 Creativity support metaphors

Creativity support metaphors are at the contact point between musical interaction metaphors (Pimenta et al. 2012) and the proposals laid out in interaction aesthetics applied to creativity (Keller et al. 2014b). The focus is the sustainable support of creative activity, covering on the one hand the activity results - the creative products and the generation of resources - and on the other hand, dealing with the procedures required to achieve creative outputs - the creative or design processes. This latter aspect differentiates the metaphors for creative action from musical interaction metaphors. While musical interaction metaphors provide the necessary support for novices and musicians to be able to achieve musical results, metaphors for creative action target the increase of the participants' creative potentials. This creative potential can impact the intended and the unintended products of the activity. Hence, the main goal of the support is not the creative product itself, but the ability of the agents to take advantage of the resources available at the site of the activity.

Classic examples of support metaphors for musical creative activities are the proportional notation systems. In this case we are talking about *proto-metaphors*, since they don't reach the level of flexibility necessary to enable activities in everyday contexts. In proportional notation, the visual representation is directly correlated to the sound parameters (Cope 1974; Keller and Budasz 2010). For instance, a point represents a sound event with a short duration. A long line indicates a sustained sonic event. One of the limitations of proportional notation is the distance between the

perception of the spatial representation of the event and the perception of time. Approximate interpretations of duration as absolute time are possible for expert musicians (e.g., "play a 20-second event as represented by a line on a track"). This is not the case for novices. As it will become clear in the following sections, graphic-procedural metaphors - exemplified in the *audiovisual trackers* (akin to sequencers with a dynamic temporal display) – may provide a path to overcome this constraint.

2.2 Study 1: Creative surrogates in Tocaflor

An interaction technique involving the use of photographs and video footage, inspired in the tradition of the experimental-music graphic scores was devised: *graphic-procedimental tagging* (Melo and Keller 2013) . A case study was carried out to developed support for the creation and performance of the composition *Tocaflor*, for instrumental duet and a electroacoustic stereo track.

Fig. 1 Local data used in the *Tocaflor* study.

The creative product is a visual score 5:20-minutes long. The performance materials consist of two wind or string instruments (e.g., clarinet, violoncello or viola), a video projector, a projection screen and a stereo playback system. *Tocaflor* was presented during the International Symposium on Music in the Amazon (SIMA 2013, Rio Branco, Brazil). Two audiovisual data-gathering sessions were done with a consumer-level digital camera. An initial screening of the multiple visual materials was done adopting the criteria suggested by Backhouse (2011). Six images presenting patterns of lines or dots that could be easily adapted to parametric musical reference systems were chosen (see figure 1). Applying a second filtering criterion, four images with clear contrasts between different colors were identified. In particular, figures 12 and 13 showed a large generative potential, with patterns close to

those observed in multiple-scale self-similar systems (e.g., chaotic and fractal systems) (Malt 1996).

The selection strategy applied in *Tocaflor* prioritized visual objects that could provide an intuitive dimensioning within a close range to the size of the human body. Picture 16, chosen as a basis for the composition, is simple yet it has enough visual elements that can be used as musical data (see picture 16 in Figure 1). The arrangement of flowers on the horizontal axis suggests an approximate mapping to duration, through matching the spatial position of the flowers to the temporal position of the event (Melo and Keller 2013). The vertical axis can be interpreted as pitch. Colors can be mapped to timbre or sound source. Other sound parameters, such as intensity, can be related to thickness or size of the visual cue. To maintain the material accessible to performers, we decided to adopt pitch as the only parameter displayed on the vertical axis, scaling the frequency values from lower to higher, from the bottom to the top of the figure.

After listening to the local sound material, it was decided that it was sufficiently interesting on its own, so other than simple editing, no sound processing was applied. From the database of collected sound samples, materials recorded during the morning session were chosen. The selected recording has a complex texture featuring bird singing and other biophonic events. Most sounds are concentrated on a frequency band higher than the pitch range of wind instruments. Therefore, the soundtrack works as an independent layer that can be used to inform the way the visual events can be interpreted. This material served as a basis to deal with the visual parameters, highlighting the relationships of complementarity between local sound materials and local visual resources.

Having established the visual and audio materials to be employed during the compositional process, we created a reference system to generate musical data from the collected visual data. Firstly, we eliminated the background colors, yielding a neutral gray-scale base. Subsequently, a selective filter was applied to restore color to the red flowers. A similar procedure was applied to recover the yellow flowers. The resulting pattern featured lines and dots in two colors (figure 2). In order to interpret the graphics as instrumental performance parameters, we applied a reference grid on top of the bi-colored patterns. As a compositional choice, all events were restricted to the instrumental range of the clarinet. Given the continuous distribution of visual elements on the vertical axis, the position of the elements could simply be interpreted as micro tonal changes. Thus we avoided the use of complex symbols to indicate subtle inflexions of tone. Nevertheless, in order to introduce time as a control parameter, it was necessary

to implement a format that supported the projection of time-based frames. Considering that most devices can handle multimedia material, we decided to adopt video as the delivery format. This choice extends Nance's (2007) aural scores to the realm of

Fig. 2 Reference system and tracker in *Tocaflor*.
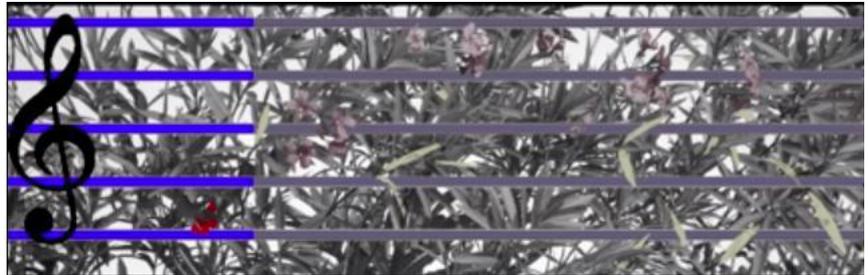
the audiovisual.

First, we cropped the image as a series of rectangles. Each rectangle corresponds to a frame within the visual sequence. To provide a cue of the passage of time, we added a color-changing tracker on top of the reference lines. Duration was mapped as a 1:1 proportion between position and execution. Hence, the positions of the events are shown exactly at the time they have to be performed, avoiding ambiguities in the relation notation-performance. The audiovisual score was rendered as a standard video file and, to allow for distributed performances, it was shared on YouTube (Melo and Keller 2013).

Creative results

The graphic-procedural metaphor supports the use of visual elements to organize temporal parameters synchronously. As a case study, we described the creation and performance of the multimedia work *Tocaflor* for two clarinets and stereo electroacoustic soundtrack. The resulting creative surrogate is a 5:20-minute audiovisual score. Location-specific visual material is anchored (Keller et al. 2010) through a time-based bi-dimensional reference system. The visual anchors are used as performance instructions within the audiovisual score. The piece was presented in November 2013 at the Amazon International Symposium on Music (Melo and Keller 2013).

The application of the graphic-procedural metaphor was described in the previous section as an instance of a general strategy to support collocated, asynchronous creative decision-making. The use of local resources indicated a viable strategy for opportunistic design (Hartmann et al. 2008; Keller et al. 2013; Visser 1994). Creative surrogates - in the form of visual data - were used to assist the compositional procedures. Through the application of a time-based reference system, by means of an

audiovisual tracker, visual features were converted into instructions that yielded sonic events.
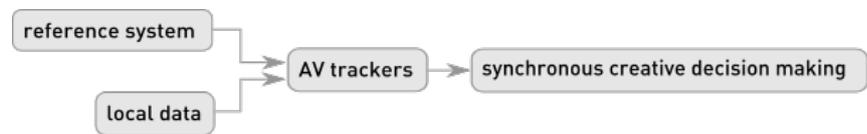
Figure 3 summarizes the flow of information applied during the *Tocaflor* study. The first stage involved gathering visual data on site. This data was externalized as creative surrogates by means of graphic transformations. The adopted reference system provided a mechanism to map visual features of the materials to sonic events. An AV tracker was used to guide the musicians' interpretation of the visual elements, providing support for the collocated, synchronous musical activity.

2.3 Study 2: Creative surrogates in Palafito 1.0

A ten-month design study targeting the observation of creative artistic practice by a video-artist, a sculptor and a composer, yielded the multimedia installation Palafito/Palafita/Home-on-stilts 1.0 (Capasso, Keller and Tinajero 2012). Asynchronous, ubiquitous group activities were carried out by the three subjects through lightweight, off-the-shelf infrastructure. Data was extracted from a virtual forum and a file repository (see next section, procedures, to see the nature of the data collected). The analysis of the creative exchange indicated cycles of activity alternating between reflection, exploratory action and product-oriented action. Technological support was incorporated through cycles of demand-trial-assessment, embracing a parsimonious approach to the adoption of new information technology objects. Through the adoption of an opportunistic design strategy (Keller et al. 2013; Visser 1994), priority was given to repurposing of existing resources as opposed to development from scratch. Creative results included 19:30 minutes of sonic material and video footage, and three 5x8x3-meter raw-wood sculptures.

Settings and materials

This design study avoided the introduction of disruptive environmental factors by adopting the artists' usual working settings. Audiovisual source materials were gathered by the authors through an ecocompositional journey that encompassed several locations in the Ecuadorean and Peruvian Amazon tropical forest (Keller 2004). These raw materials served as anchors (Keller et

al. 2010), for the elaboration of the sculptural, visual, and sonic elements utilized in the piece. The experience of the journey provided the social grounding for the conceptual relationships later developed in the multimodal installation (Keller et al. 2014c).

Procedures

During a ten-month period, the three subjects' creative activities were monitored using two tools: a virtual forum and a file-exchange repository. The creative exchanges were classified into four distinct types of activity (Keller et al. 2014c): argumentation (a form of dialogic activity involving verbal exchanges), reflective activity (when no material resources were exchanged), epistemic activity (exploratory actions targeting increased knowledge to inform decision-making) and enactive activities (actions that impact material resources and products). Although a detailed description of the classifications made and the overall exchange processes are beyond the scope of this present paper we can generically give and overview of nature of the data collected and analyzed. Argumentation was done mostly through asynchronous dialogues among the stakeholders (only two encounters were carried through video-conference). The observed exchange of textual, visual and sonic materials enabled the participants to explore further the ideas under consideration and can also be viewed as a form of dialogue complementary to the process of argumentation referred to before.. Enactive activity involved the exchange of material that was intended to be part of the work. Therefore, only the materials that were approved through an argumentation cycle of proposals and commitments and that were labeled as acceptable creative products by at least one of the artists were considered to be the outcomes of enactive activity.

Fig. 4 Creativity support metaphors for asynchronous decision-making: designing AV sketches.
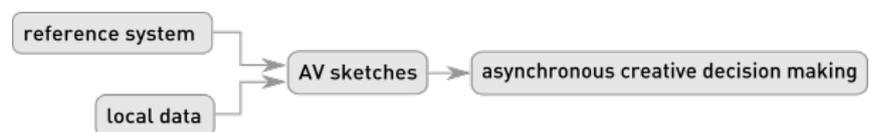
The procedural depiction of the *Palafito* study is structurally similar to study 1. Local data, in this case representations of source sounds and footage, were shared through creative surrogates. The AV sketches provided a temporal reference system for the asynchronous decision-making process. Given the collective character of the endeavor, a common reference system becomes a requirement. Local decisions can only be made if the stakeholders have access to the status of the other participants. This study made use of volatile resources – in the form of AV sketches – to

increase the flexibility of the exchange, reducing its ecological impact.

Creative results

The study yielded the multimedia installation *Palafito/Palafita/ Home-on-stilts*. Its first exhibit was held at the Floor4Art venue in Manhattan, New York. The exhibit took place during the month of November 2012 and ended with a closing gathering on December 1. The second exhibit took place in Denver, CO, USA, at the Museum of the Americas from June to September 2013.

The sculpture featured three 5x8x3-meter metal and wood vertical structures hanging from the ceiling and placed on the floor of the installation space. Three audiovisual tracks, lasting 6:30 minutes each, were played as loops on two stereo and one mono playback modules. The single-track module consisted of a DVD-player and a directional speaker (house 3). The speaker was attached to the ceiling, pointing straight downward, and the sound beam was adjusted to span a radius of approximately one meter, creating an isolated sound field. The video footage was displayed on a 10" LCD screen. The two stereo modules featured video projectors attached to the ceiling, facing opposite walls (houses 1 and 2). Two DVD-players sent audio to two sets of speakers hanging from the walls at a height of 2.5 meters, matching the locations of the projected videos.

The layout of the installation was designed to allow the visitors to walk freely within the gallery space. Consistently with other ecologically grounded creative endeavors (Keller 2000), the actions of the visitors were considered a central component of the artwork experience. Depending on the locations of the participants, different combinations of visual and sonic content were available. The house 1 module defined a sound field constrained to the sound beam area. Thus, the listeners had to be standing in front of the module to access the sounds. The sound fields corresponding to house 2 and 3 were audible throughout the gallery space. But given the different distances from the sources, visitors were free to design their own mixes by exploring the multiple perspectives afforded by the space.

3 Implications for the development of creativity support metaphors

We discussed two exploratory design studies - involving complete creative cycles - which yielded public presentations of artistic products. The first study targeted the use of local visual resources to produce audiovisual trackers for a mixed media performance.

The deployment of the creativity support metaphor *graphic-procedimental tagging* called for the participation of two musicians who employed the visual data – structured as an audiovisual score – as continuous pitch and onset-duration parameters. Execution time was directly correlated to the spatial position of the tracker on the score. The flowers' colors extracted from the original picture – pink and yellow – were repurposed to separate the instrumental sources. The sources were chosen ad libitum by the musicians. Pitch content was indicated by the distribution of the flowers' colored markings on the vertical axis, dynamics being defined by the markings' widths. An unprocessed recording done on site, following the traditional soundscape methods (Truax 2002), was used to define the total duration of the piece.

The second project, a large-scale installation commissioned to the Capasso+Keller+Tinajero Collective by the II Biennial on Latin American Art, was presented at the Denver Museum of Latin American Art and at the Floor4Art Studio Space in Manhattan, New York. The artwork featured three sculptural objects and three video and audio tracks that made use of ecologically grounded techniques to process Western Amazon audio and visual footage. The layout of the installation was designed to foster an active engagement with the multimodal elements of the piece. Visitors were encouraged to walk through the space to experience multiple combinations of sound fields. Following an ecologically grounded creative practice (Burtner 2005; Gomes et al. 2014; Keller 2000), the actions of the visitors were used to support the decision-making processes that shaped the aesthetic experience.

The results yielded by both studies indicate a recurring strategy in ecologically based creativity support metaphors. The projects discussed in this paper employed creative surrogates as material resources to support aesthetic decisions. The comparison of the processes involved in the two studies reported strongly suggest the existence of two distinct modes of usage of creative surrogates for the scaffolding of the different decisions involved in the creative processes. The first model is tied to the synchronous nature of the musical activities under scrutiny. Synchronous musical activities demand a single temporal representation to interpret the visual data. In *Tocaflor*, this visual data was used as a trigger for human performance of musical events by means of an *audiovisual tracker*. Contrastingly, audiovisual sketches serve as material proxies for distributed resources, supporting decision making through a shared symbolic representation of time that can be accessed remotely by all stakeholders. In *Palafito*, asynchronous activities featured *audiovisual sketches* as creative surrogates. While the latter model can handle the participation of non-musicians through unstructured exploratory actions within

the installation space, the former model necessarily targets musicians that have the expertise to use the AV trackers' visual information as a guide for bodily actions.

Given the use of local resources as materials for creative actions, both models abide by the directives of ecologically grounded creative practice (Keller 2012; Keller et al. 2014c). Nevertheless, only the audiovisual-sketch model meets the usability demands of ubiquitous music ecosystems (Lazzarini et al. 2014b) providing support for casual, untrained users. Audiovisual trackers require trained musicians that can synchronize their actions to complex visual cues with little look-ahead time. This type of decision-making activity places high demands on cognitive resources, hence it probably demands automatic mechanisms that are typical of expert performance (Shanteau et al. 2002). AV trackers fit the narrow view on embedded-embodied musical cognition that links musical activity exclusively to bodily actions (Nijs et al. 2009). In order to enhance the range of applications of AV trackers for everyday usage, some adjustments are necessary.

Firstly, both collocated and distributed musical activities need to be supported. By incorporating synthesized sounds through sonification techniques (Serafin et al. 2011), AV trackers do not need to rely on collocated human actions for sound rendering. Remote stakeholders may assess the musical results by making local changes to the AV tracker. A shared consistent representation – akin to a musical prototype (Miletto et al. 2011) – may reflect the stakeholders' proposals. To avoid intensive usage of bandwidth, rather than video formats, the system needs to support local sound rendering. In this scenario, all data exchanges may be done using standard still images.

Secondly, temporal synchronization among remote resources can only be accurate through asynchronous mechanisms (see Barbosa 2010 for a discussion on the limitations of traditional performance approaches to network-based musical activities). Sonic events do not need to be synchronous, they only need to be *perceived* as synchronous. This subjective perception of synchronicity can be attained by aligning the events to the local clock. A fit metaphor is provided by the theory of relativity: there are as many different times as there are space-time reference systems. For example, two stakeholders participating at a local (A) and at a remote location (B) produce two sequences of events. Stakeholder A adopts clock A as her frame of reference to generate a sequence A. Stakeholder B adopts clock B to produce a sequence B. For instance, in order to synchronize the sequences A and B, the remote clock needs to be adjusted to the local clock. Thus, if clock B is slower than clock A, sequence B needs to be accelerated to fit sequence A's temporal frame. Also, sequence B's onset needs

to be aligned to match the onset of sequence A. For AV trackers, this implies a two-stage procedure: (1) the local system calculates the difference between clock A and clock B yielding a time-difference index; (2) this index is used to adjust the speed of the AV tracker. In a hypothetical scenario in which the infrastructure handles the visual information and the meta-data separately, no exchange of audio or video material is necessary. Hence, sonification-based audiovisual trackers can bypass the requirements of computationally demanding audio-event recognition systems.

4 Conclusions

The two exploratory design studies reported in this paper yielded two instances of creative surrogates as viable support mechanisms for creative musical activity. Audiovisual trackers can be used to support synchronous, collocated decision-making activity. Audiovisual sketches are useful for asynchronous activity or when stakeholders and resources are not collocated. AV trackers demand domain-specific skills that may not be attainable by casual users. Contrastingly, AV sketches have good potential for untrained stakeholders. Thus, they enlarge the palette of support techniques for everyday creative practices.

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