Collaborative Design
Methods towards
the Evaluation of
a Tangible Interface

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Abstract
This paper is a reflection on our experience of design of an interactive instrument and its evaluation and redesign using a collaborative creativity process. This paper examines the interface from three different perspectives; designer, performer, and expert audience. The designer describes and evaluates the chain of decisions taken to release an experimental tangible interface for professional use by a duo of electronic musicians. The performers examine the usability aspects, and a group of composers participate in a creative workshop to explore different aspects of the interface in a collaborative creativity process.

Keywords
Participatory Design
Collaborative Creativity
Evaluation Methods
Tangible Interfaces
Sonic Interaction Design

Introduction

Creativity and arts are deeply interrelated and creativity stems from a collaborative context, rather than from the reasoning of an isolated individual. Collaborative artwork has been investigated to explore the improvisational nature of it in both art and human- computer interaction. Other artistic research practice methods such as performance-based and collective making have extended the vocabulary of interdisciplinary and experimental approaches in HCI. We explore such methods and demonstrate how we expand them to an open-ended learning and design process. Art-based creative processes and outcomes can help designers to see and imagine opportunities and dimensions of technology and design that they wouldn't have seen otherwise. Design of musical instruments and composing electronic music are very isolated tasks. By asking such composers and designers to work together in a collaborative process, we aim to expand their vocabulary in design and ours in collaborative compositional ideation as a valid generative research activity. HCI researchers state that collaborative sound creation in form of improvisation is a form of active learning that enables emerging creativity through tension between structure and freedom. Contemporary experimental musicians and composers such as John Cage also had the same idea. They explored the "situational" nature of aesthetics and creativity through a range of novel exploratory works. E.g. Cage's idea of the "indeterminate score" (Feisst 2009) emphasized the interaction of musical creativity with uncertain situations. Driven by the desire to "let things be themselves", the role of the composer in this type of music is no longer to determine the musical outcome through a traditional notation system with a precise relation between notation and sound; instead, the composer determines a set of rules which performers and audience members interpret to regulate and produce situated sound experiences.

Similarly in HCI, human activities are not perceived as goal-directed and linear as in the first wave HCI (Harrison et al. 2007) anymore. A generative and inductive research approach necessitates open-endedness which is actively employed as a resource for discovery and surprise. Furthermore, digital ensembles, collaborative instruments (Hattwick and Wanderley 2012), and other frameworks (Weinberg 2005) (Blaine and Fels 2003) have evolved the notion of collaborative creativity in electronic music creation. Nevertheless, the design and idea creation process of the interactive instruments are left to isolated design processes by the designer or composer. We propose an array of collaborative work in form of designer-designer, designer-performer, designer-composer collaboration (Goudarzi and Gioti 2016). How this open-ended collaborative process continues and evolves is still unknown. The goal is to use these collaborative interactions as stepping stones towards idea creation in design practice and composition.

1.Case Study: A Tangible Interfaces Concert

A collaborative design workshop requires detailed briefing of at least one real case study. This is usually the topic provoking collaborative observation, ideation and prototyping. Instead of providing recorded documentation, we invited the participants of our workshop to attend a concert given by the electronic duo *Intra-sonic*, consisting of Visda Goudarzi and Artemi-Maria Gioti. The duo performed three different sound works at a concert at IEM (Graz) in May 2017. The first sound piece would be used as the case study for the collaborative design workshop. It was "Tangible Scores", an improvisation for two performers with four tangible interfaces. We found this work interesting because we could maintain direct communication with the builder and because it is a critical tangible interface affording discussion about musical intention. A tangible user interface (TUI) is a device for human-computer interaction in which a person interacts with digital information through the physical environment. In other words, a tangible

interface is an electronic artifact whose physical form embeds digital information (Ullmer and Ishii 2010). These interfaces take advantage of tacit human abilities to grasp and manipulate physical objects and materials to suggest interaction. TUIs were envisioned as an alternative to graphical user interfaces that would bring the richness of interaction with physical artifacts back into human computer interaction. As Hornecker and Buur have described (2006), tangible interaction "tends to emphasize materiality, physical embodiment of data, bodily interaction and embeddedness in real spaces and contexts".

More into detail, "Tangible Scores" consists of a musical improvisation following the tactile and sonic affordances of a tangible interface. The author (Tomás and Kaltenbrunner 2014) defines the tangible score of an interface as the physical layer that is incorporated into the configuration of a digital instrument with the intention of conducting the tactile gestures and movements (Figure 1). The physical profile of these artifacts suggests specific gestural behaviors to their performers while they are also the medium to control the sound produced. For this reason the tangible part of the interface is also called a score. The materials used for composing tangible scores can be various: wood, paper, silicones, clay, etc. Technically, each "Tangible Score" interface can incorporate different sensor technologies for detecting tactile activity. For the concert studied, the interfaces featured contact microphones. The physical contact of a performer's hands with the interface produces sounds which are used to drive a polyphonic concatenative synthesizer (Schwarz 2006) based on a real-time analysis and classification of input signal spectra. Each of these interfaces was composed defining the physical profile and the specific sound corpus which defines its sonic identity.

The four "Tangible Scores" interfaces performed by the duo of performers (figure 1) were built from casted paper and laser-engraved wooden panels. The graphic patterns were designed using the library *Generative Gestaltung* for Processing. The profiles on wood were engraved using a standard laser cutter. The molds for casting paper where created with an automatic milling machine.

The duo's first proposal for performing "Tangible Scores" was received two months before the concert. At that moment, the instruments were highly dependant on their builder who had carried the project in a continuous state of development during his artistic PhD. This concert would suppose the first appearance of "Tangible Scores" without their builder. This is a crucial fact for evaluating the concert.

Figure 1. Tangible Scores used at the concert
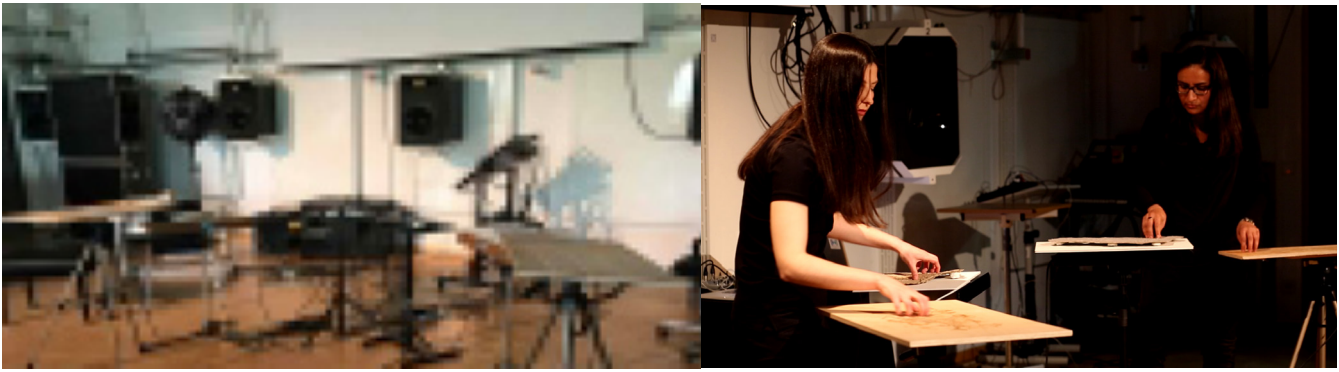
Figure 2. Arrangement of the interfaces for the improvisation and capture of the performance

Preparation Phase and Performance

The performers duo and the instruments builder arranged a first meeting thirteen days before the concert. It served as an introductory session for setting up the instruments and running the computer systems. This session can be resumed as follows:

- Performers were introduced to the instruments, the routines to start and stop the computer system and the temporal structure of the piece.
- The builder took the decision of not giving many conceptual and organological details of the instruments. The intention was affording personal exploration of the instruments.

The first tryouts with the interfaces resulted into interesting findings and discussions. After this first meeting, the duo established a schedule of rehearsals were they could prepare the concert without the support of the builder. For the concert, the interfaces were arranged in the concert space as it can be observed at figure 2. The concert hall (CUBE, IEM) is a mixed space for concerts and acoustics research featuring 120 square meters. The audience, including the workshop participants and the designer of Tangible Scores, were seated in front of the performers. The sound work was played through two main speakers in the corners of the hall. The improvisation had a duration of ten minutes approximately.

2.Evaluation of the Concert from the Designer's Perspective

After the concert, the builder of the instruments provided the performers with the following feedback:

- Technical Release: the duo was able to prepare the performance without the supervision of the builder. Some technical issues appeared but they were solved through online communication with the builder. However, further work has to be done for a real final release (i.e documentation, friendly configuration menus, examples of use, etc).
- Engagement with the interfaces: performers understood how to play and control Tangible Scores. They invested great effort and interest in exploring the instruments during the learning phase. However they couldn't develop an idiosyncratic or personal way to play them. As the performers were not especially trained on techniques to control Tangible Interfaces, a certain lack of mastery was noticeable. We can conclude that the period of time employed for preparing the concert was too short.

- Development of the performance: the improvisation was divided into four sections of around two and a half minutes. These sections were programmed in the system by the instruments builder. From a designer's view that was a strategy to conduct the improvisation but it resulted in a bad idea. Performers had to change sound material too often. As a consequence the musical improvisation lacked of sound exploration. A better strategy would have enhanced a more minimal performer´s connection with the tangible nuances of the surfaces and their sonic outcome.

3.Evaluation Process throughout a Collaborative Design Workshop

Collaborative creativity approach

For the evaluation process, we adopted a User-Centered Design (UCD) approach consisting of two steps. We first asked the volunteers to attend the concert, listen and observe. We then conducted a one day workshop for brainstorming, creating imaginary scenarios, and sketching possible future tools for performance inspired by Tangible Scores. This study follows a UCD approach. UCD is "a broad term to describe design processes in which end-users influence how a design takes shape" (Abras et al., 2004). In this case, the end-users are electronic and computer music composers and performers. We adopted a UCD approach to better understand current practices of the composers/performers and to conceptualize a tool that addresses their needs. Collaborative workshops are defined as "collaborative design events providing a participatory and equal arena for sharing perspectives, forming visions and creating new solutions" (Soini et al. 2005). Due to the collaborative and participatory nature of workshops, they were chosen as a key element of the adopted methodology. A one-day, 6-hour workshop was conducted, aiming to produce sketches of novel ideas for Tangible Scores. The first part of the workshop focused

on the analysis and brainstorming about the Tangible Score interface and performance at the concert. The second half of the workshop was focused on creative ideation and generating new interaction ideas for Tangible Scores. During the workshop, participants went through a cycle of design process: analysis, prototype development and evaluation. Tangible Scores were analysed in terms of: ergonomics, interaction, expressiveness, mapping, and aesthetics.

During the workshop sessions, participants shared experiences through practical exercises. Several practical exercises were conducted such as "speed dating" (Davidoff et al. 2007), generating ideas in pairs in a very short time, regularly changing partners to stimulate ideas. During this exercise, the participants were given two minutes each to answer the following questions:

- Rate the interface in terms of ergonomics, interaction, expressiveness, mapping, and aesthetics (rating from 0:negative ... 7:excellent
- Imagine new scenarios using tangible scores and act as if you are using them. Which types of movements and gestures would you prefer to use?

first by talking in speed dating (two by two and then switching discussion partners as soon as the timer rang). Then they were given some quiet time to think and write down their answers and sketch their ideas.

Furthermore, we used "bodystorming" (Oulasvirta et al. 2003), i.e. play active situations with objects to test scenarios, or "sound drama" (Hug 2010), i.e. the scenarios are staged with objects using audio post production. During bodystorming, one in each pair acted and the other observed and took notes. The notes and sketches were later shared during a short discussion by all workshop participants. These exercises were complemented by sonic prototyping using sound processing in SuperCol-
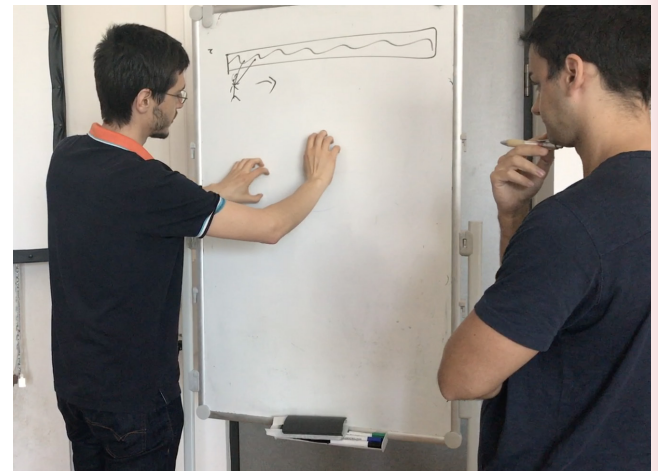
Figure 2. Collaborative creativity workshop session: a group came up with moving the tangible interface (left) and another group suggested a transparent and standing tangible interface to make it more visible to the audience (right)

lider. The workshop participants created sound textures using granular synthesis to emulate the sounds created by the composer, but having their own control structures over the modulations in the synthesis.

Participants and Reflections

The intention of the workshop was to engage in the details of compositional and design process, therefore, an expert group of participants was preferred over a random group of volunteers. Six composers/music technologists were asked to participate in the concert and the follow up workshop.

Gathering the qualitative data from the questionnaires, interviews, workshop discussions, and videos; the participants rated the ergonomics and aesthetics of the interface as very high, but the mapping and expressiveness got the lowest ratings. We can not conclude a statistically significant result because of the small number of participants but we would like to discuss their viewpoints. By clustering the information gathered from the workshop, we could summarize the suggestions of the participants into three categories:

Interaction: The participants found the interface physically very appealing and easy to use and interact with. The hand movement on the scores seemed very intuitive and scratching the scores very organic. Additionally they suggested to use the hands in more ways than just scratching. E.g. by using the whole surface of flat hands, or by using the bones of the hand's fist. Another suggestion by multiple groups was to use physical objects, in addition to the hands, in order to add a variety of frictions between the surface of the scores and different objects. Furthermore, one group suggested to have destructive objects to reshape the score during the performance.

Visibility: All participants had difficulty seeing the performance during the concert. After the concert they all came closer to the tangible interfaces to thoroughly observe and inspect. They suggested variations of the interfaces in order to make them more visible and engaging for the audience. E.g. one group suggested a transparent interface made of glass that is vertically on the wall so that the performer faces the audience while the score is visible to the audience. Another group suggested the performers to be on a stage located lower than the audience, or a video projection of the interface that the audience manage to observe the score and the interactions with it. The third sugges-

tion was a tangible interface that is moving instead of the hand of the performer moving. This allows the interaction of an object with a hanging tangible score that is visible to the audience and very engaging. (Fig.3)

Controllability of sound: Participants found the aesthetics of the objects very intriguing but not the aesthetics of the sounds. All participants of the workshop found the controllability of sound very low. They found that only changes in dynamics were perceivable and suggested more variability of sound parameters with a richer vocabulary of gestures. They found such a small variation of sound makes the purpose of the score ambivalent. One group stated that for such a variation of sound they would just rather use a pair of microphones without any score. They couldn't find an evolving mapping structure in the sound or any fades between the microphones. One group suggested using granular synthesis on real time recorded sound which creates a lot more variability in the sound.

4.Evaluation of the Interface from a Performer's Perspective

For the evaluation of the interfaces from a performer's perspective we examined different parameters than the ones used in the workshop, focusing primarily on usability. In particular, we examined four features: *learnability, explorability, feature controllability* and *timing controllability* (Wanderley and Orio 2002). The communication of compositional instructions to the performer was also evaluated, an addition that was considered necessary due to the premise of the composition (i.e. the integration of score and musical interface).

Learnability. The design of the interfaces was rather straightforward, allowing for a high degree of learnability. While mastering the instruments might take some time, interaction with them is intuitive and effortless already in the first session.

Explorability. Due to the combination of tactile interaction with a variety of engraved graphical designs, the interfaces also demonstrated a high degree of explorability. Each interface showcased a different graphical design, consisting of several engraved areas that enabled a plethora of gestural and sonic interactions.

Feature controllability. In contrast to learnability and explorability, the degree of feature controllability – or, more accurately, *perceived* controllability – was evaluated as rather low. The intention of imitating the input signal through the use of Corpus Based Concatenative Synthesis (CBCS) (Tomás and Kaltenbrunner 2014) was not directly observable from a performer's perspective. This may be attributed to the fact that the composition in hand was based on a fixed time structure, each section of which used different sound samples as an input to the synthesis engine. As a result, no direct relationship could be established between the performative gestures and the sound samples chosen by the algorithm. The sound synthesis parameter with the highest degree of observable controllability was that of amplitude, which was in a direct – yet non-linear – relation to the amplitude of the input signal.

Timing controllability. Due to the absence of a score that requires strict timing this parameter was omitted from our evaluation.

Communication of compositional instructions. It is important to note that the performance that this evaluation is based on was the first performance of *Tangible Scores* by someone other than the composer himself. Because of this, and due to the lack of a score, the first rehearsals were both challenging and engaging. After a short demonstration of the instruments by the composer and a discussion on technical and design aspects, the performers participated in a "naïve rehearsal" (Hsu and Sosnick 2009), without receiving any prior information on either the sounds or the mapping strategies employed in the piece. This had the purpose of allowing the performers to explore and experiment with the instruments without feeling restricted by com-

positional instructions. However, after several "naïve rehearsals" it became clear that a performance/demonstration by the composer would be necessary in order for the performers to gain a better understanding of the expressive capacities of the instruments. During this demonstration, the performers were able to identify a "vocabulary" of gestures developed by the composer over his long-term engagement with the instruments, and subsequently integrate these gestures in their own performance. While this form of communication proved to be quite efficient, the existence of some form of documentation – verbal, graphical or otherwise – of these gestures could have made the composition more accessible to the performers, while providing an alternative for the composer's physical presence at the rehearsals.

5. Discussion and Reflections

In this paper, we explored the design of a tangible musical interface by assessing it from three different perspectives. First, the designer and developer of the interface discussed his design decisions and compositional goals. Subsequently, performers of an electronic music duo, who performed with the interface, described their experience with it, examining the interface from a usability standpoint. Finally, in a collaborative creativity process, a group of composers gathered ideas on how to evolve such an interface physically and aesthetically. The use of different parameters for the evaluation by each group/stakeholder (performers, expert audience, designer-composer) was necessitated by the different roles that these stakeholders undertake in the creative process and served the purpose of integrating different perspectives in the evaluation process. The parameters examined by performers were essential in the process of interaction with the instrument to deliver the performative and sonic ideas that were designed by the composer/developer of the interface whereas the parameters established by the workshop participants were rather developed iteratively based on the creative perspective of the workshop participants.

The design of musical interfaces is a highly idiosyncratic task. Designers always have their favourite understanding about musical interaction and composition. Collaborative and participative approaches can help designers to examine the validity of many aesthetic and conceptual assumptions which usually cannot be evaluated through other methods (e.g., a usability test).

A collaboration with performers other than the designer/composer themselves can also be beneficial for the design process. The composer-designer-performer paradigm has established a bidirectional and dynamic relationship between the traditionally separated tasks of instrument-building, composing and performing. However, the lack of a thorough documentation of technical and aesthetic components of compositions/performances created through this process often limits their reproducibility. Working in collaboration with other performers could help assess design practices and communicate musical ideas, enabling their reproducibility.

From the collaborative workshop, we learned that the process of creating musical interactions could be an iterative process with different stakeholders who communicate their results in further iterations. The way other composers work and interact with one's interactive instrument, could generate a lot of ideas for the designer to explore. A deeper assessment of such ideas could be challenging due to the short length of the collaboration. The workshop participants created a great collection of ideas for further assessments. Their contributions could be more valuable if there was more time for prototyping the ideas physically as well. Our participants' background is in electronic music composition. For future research directions, we would like to recommend adding multidisciplinarity to the creativity workshop by combining a group of composers with technologists or interaction designers to compare and establish the relationship between the three different sets of parameters and perspectives.

Acknowledgment

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