Methods in Creativity-Centered Design for Ubiquitous Musical Activities

Luciano V. Flores[1], Maria Helena de Lima[1], Marcelo S. Pimenta[1], Victor Lazzarini[2], Damián Keller[3]

[1]Federal University of Rio Grande do Sul (UFRGS)
Caixa Postal 15.064 – 91.501-970 – Porto Alegre, RS – Brazil

[2]National University of Ireland, Maynooth (NUIM)
Maynooth, Co. Kildare – Ireland

[3]Federal University of Acre (UFAC)
Caixa Postal 500 – 69.915-900 – Rio Branco, AC – Brazil

{lvflores, mpimenta}@inf.ufrgs.br, helena.lima@ufrgs.br, victor.lazzarini@nuim.ie, dkeller@ccrma.stanford.edu

Abstract. *In this paper we describe a set of creativity-centered design methods, including strategies for interaction, signal processing, planning, prototyping and assessment. These were applied in the development of a prototype for mixing in mobile devices, which was assessed in an exploratory field study. We briefly discuss the implications of this experience for future experiments targeting aspects of creative performance in everyday settings.*

1. Introduction

Since 2007, our group has been engaged in a multidisciplinary effort to investigate the creative potential of converging forms of social interaction, mobile and distributed technologies, and materially grounded artistic practices. We have proposed the adoption of the term *"ubiquitous music"* (or ubimus) to define practices that empower participants of musical experiences through socially oriented, creativity-enhancing tools [Keller et al. 2011a]. The various methods that we have applied to the development and assessment of technological, educational and artistic outcomes can be grouped under the common denominator of *creativity-centered design techniques*. Recent results point to a particularly promising area of application of creativity-centered design, targeting forms of creativity accessible to non-specialized users performing musical activities outside of domain-specific venues. Ubiquitous musical activities open opportunities for musical creation by musicians and untrained participants outside studio settings.

This paper highlights the close relationships between ubiquitous music research and *everyday creativity* [Richards et al. 1988; Richards 2007]. First, we discuss recent advances in general creativity research, defining the domain of application of everyday creativity in the context of ubiquitous music research.

Creativity-centered design of ubiquitous musical systems involves at least four developmental stages, which are presented in the second part of the paper: *defining strategies*, *planning*, *prototyping* and *assessment*. Given the demands of experimental work on musical creativity, strategies that enable data collection without disrupting the creative experience become a requirement. Our previous work pointed toward three possible solutions for this methodological conundrum: 1. *avoiding early commitment* to specific tools [Flores et al. 2010; Keller et al. 2011b]; 2. supporting iterative development through *rapid prototyping* [Keller et al. 2011c]; and 3. fostering *collaboration* by building communities of practice [Miletto et al. 2011; Lima et al. 2012].

Ubiquitous-music planning studies involve early assessment of target population expectations and identification of opportunities for creativity support. Through a ubimus planning study, Lima and coauthors [2012] found sharply differing expectations on technological usage by musicians and musically naive subjects in educational contexts. Based on these results, they proposed a simple rule of thumb: "users like what comes closer to reenacting their *previous musical experience*". Non-technical approaches, such as those proposed by traditional Soundscape activities [Schafer 1977], may not be suited for introducing non-musicians to sonic composition. Naive subjects may respond better to technologically oriented approaches, such as those employed in Ecocomposition [Keller 2000; Lima et al. 2012]. If the rule of thumb previously stated holds true, musically untrained participants would welcome *easiness of use* and *naturality* while musicians would tend to prefer interfaces that reproduce behaviors based on *acoustic-instrumental metaphors* and common-practice *music notation*. Therefore, design of creatively oriented technologies would need to fulfill different demands depending on the intended user base.

Technological support for pervasive musical activities increases the difficulty of the design task on two fronts. Ubimus systems may enhance the users' creative potential by providing access to material and social resources. But a wider accessibility to resources could bring up unintended issues that limit the systems' adoptability to a small user base. Thus, the challenge of ubimus design to provide *intuitive tools for complex creative tasks* does not guarantee wide accessibility. Custom-made, special purpose hardware interfaces may fill the requirements of transparency and naturalness reducing the cognitive load of complex tasks [Fitzmaurice et al. 1995]. But these systems are difficult to distribute and maintain. So, the user base is narrowed by the increased costs of the hardware. Two techniques that we have been applying may provide viable solutions to the problem of sustainability without negative impacts on usability: *hardware repurposing* [Huang and Truong 2008] and *rapid prototyping*. We have reutilized consumer-class mobile devices – such as cellphones and tablets – as creative musical tools [Flores et al. 2010; Keller et al. 2010; Lazzarini et al. 2012]. Within an iterative approach to design, involving creative musical activities and usability assessments, we have developed rapid prototyping techniques tailored for ubiquitous contexts. Since our research targets interaction and signal processing, flaws that arise from coordination among these two processes can be identified early within the design cycle.

Prototyping encompasses two areas of expertise: interaction and signal processing. Our group has been investigating the musical applications of methods based on human-computer interaction and ubiquitous computing techniques. *Metaphors* for interaction provide abstractions that encapsulate solutions applicable to a variety of activities without enforcing unnecessary technical restrictions [Pimenta et al. 2009]. Thus, interaction metaphors can be built from general ergonomic principles that take into account both human and technological aspects of the activity. On a similar vein, recurring technological solutions can be grouped as *interaction patterns* [Flores et al. 2014]. These patterns are particularly useful when developers face the task of finding suitable techniques to deal with specific interface implementation issues. Furthermore, technologically based musical environments also demand tailoring support for sound rendering. *Signal processing* techniques have to be chosen according to the characteristics of the task, the computational resources of the infrastructure, and the profile of the target users. Ubiquitous musical activities may involve mobility, connectivity and coordination among heterogeneous devices with scarce computational resources. Thus, carefully chosen software design strategies are a prerequisite to tackle signal processing in ubiquitous contexts [Lazzarini et al. 2012].

Although creativity assessment is an expanding area of research within psychology [Amabile 1996; Mumford et al. 2011; Plucker and Makel 2010], assessment of creative outcomes is still a taboo topic among music practitioners. From a universalist perspective, creativity assessment would be equivalent to measurement of musical value. Standards are defined by the adopted compositional technique. Given an adopted metric, deviations from the standard are seen as spurious, less valuable manifestations. This approach makes two assumptions. First, the objective of musical activity is to obtain a product that can be labeled as an expression of eminent creativity. Second, the value of the musical product lies in its material constituents (the sounds or their symbolic representation, i.e., scores or recordings), not on the extra-musical aspects of music making. A second limitation of creativity assessments is the overrated reliance on expert judgment within the musical domain. When asked to evaluate musical products – as it is done using Amabile's [1996] Consensual Assessment Technique – experts apply their views on creativity. These views are the result of several years of musical training and experience with eminent forms of creativity. Therefore, unless they re-educate themselves to disregard their background, expert evaluators will tend to assess musical products by eminent-creativity standards. This bias renders their evaluations less useful to everyday-creativity manifestations. To avoid these pitfalls, we rely on a mix of assessment techniques – or a *"triangulation"*, within the behavioral research literature – engaging a small number of expert and untrained subjects in different musical activities under a variety of environmental conditions. This approach does not make assumptions regarding the compositional techniques, and assigns the same weight to musicians' and lay-people's feedback. Given a support infrastructure under study, what we look for are the relationships among user profiles, types of activity and environmental conditions.

The contribution of this paper to the field of new media technologies is three-fold. On one hand, we define a clear target for ubiquitous music research endeavors: to *enhance everyday creativity*. On the other, we bring together a scattered body of methodological knowledge to coalesce into a coherent set of procedures: *creativity-centered design for musical activities*. And as an example of the proposed approach, we describe the exploratory creativity assessment of a ubiquitous-music interaction metaphor: time tagging.

2. Ubiquitous Music and Everyday Creativity

Runco's [2007] two-level hierarchy divides creativity theories into two broad groups: 1. those that deal with creative potential; and 2. those that focus on creative performance. Studies that take the former approach strive to identify factors that foster or suppress creativity in individuals and human groups. Thus, the focus is on unfulfilled possibilities rather than on actual creative results. Within this class of theories, some approaches deal with factors related to personality and to places. Theories of creative performance focus on unambiguously creative behavior. Hence, they try to link creativity factors to creative processes and products by studying the outcome of creative activity. Theories that focus on potentials open opportunities for research on predictors, i.e., variables that influence creative outcomes.

Kozbelt et al. [2010, p.24] suggest that creativity can be studied in terms of products, processes, personality, places, persuasion and potential – the six Ps. Product-based studies are particularly suited for quantitative methods. By observing relationships between external and internal predictors within experimental settings, specific creative outcomes can be assessed quantitatively. Thus, aspects of creative activity that are not directly observable can be studied through their imprint on material products.

The magnitude or scope of creativity is an aspect that has to be established before experimental design. Four levels of creative achievement have been proposed: Big-c, Pro-c, little-c and mini-c [Kozbelt et al. 2010, p.23]. Big-c (or eminent) creativity encompasses manifestations that are socially established as paradigmatic examples of creative results (such as published works of art, scientific theories, etc.). They necessarily target creative products, thus they exclude experiences that are subjectively labeled as creative but that do not involve wide social exposure. The latter are treated within the context of everyday (or little-c) creativity studies [Richards 1988]. Between little-c and Big-c phenomena, Kaufman and Beghetto [2009] suggest a third type of creative behavior: professional creativity – Pro-c. Pro-c studies focus on professional creative achievements that do not attain a level of eminence. The same authors introduced the mini-c category as a concept encompassing subjective little-c manifestations. Mini-c creativity involves internal, subjective and emotional aspects that are hard to assess if only objective little-c factors are considered.

Our research on ubiquitous music practices has uncovered two areas of intersection with little-c studies. Ubiquitous music engages participants in creative activities that do not demand professional-level musical training or long-term learning of technological tools. Although some forms of ubiquitous music making may attain Pro-c level, the greatest potential of novice-oriented technological support lies in everyday manifestations of creativity. Furthermore, musical activities that take place outside the regular specialized venues – such as ecocomposing – until recently demanded special-purpose, usually expensive portable infrastructure (see Keller 2004). By providing accessibility to outside locations, ubimus practice highlights the importance of the place c-factor within everyday creative endeavors.

By incorporating previously unreachable resources, ubiquitous computing systems provide two features that in conjunction expand the potential of creative activities: mobility and connectivity [Weiser 1991]. Mobile devices are carried by users to multiple places and are routinely incorporated into everyday activities. Within urban settings, these devices can make use of pervasive resources [Costa et al. 2008].

Bringing together the concepts discussed in this section, we can state that *ubiquitous music is a research field that deals with systems of human agents and material resources that afford musical activities through sustainable creativity support tools*. Mobility and connectivity are two aspects of the technological infrastructure that impact how resources are handled during the creative activities. These are basic but not sufficient conditions for artistic creation in pervasive contexts. In order to enable manifestations of everyday creativity in music, it is necessary to design support for creative musical activities in everyday settings.

3. Creativity-Centered Design

The procedures that have emerged for supporting ubiquitous musical activities encompass four inter-related stages: defining strategies, planning, prototyping and assessment. 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] 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 turn-over, not refined implementations. Field trials come at a late phase of the design process and preferably involve small groups of subjects doing multiple activities in various realistic contexts. The main objective is to gather data on the impact of the environmental context on the musical experience. This is tricky, and no ready-made recipes are available yet. Assessment 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.

4. Phase 1: Defining Strategies for Ubimus Design

4.1. Avoid Early Domain Restriction

Music creativity models that emphasize the material dimension provide the most direct window to experimental observation. We define the material dimension as the collection of resources available to the participants of a creative activity. In this case, we are dealing with sound sources or tools used to generate creative musical products. Thus the connection to material resources is direct. Two of the three interrelated stages suggested by Dingwall [2008] – the generation stage and the development stage – can easily be assessed by measuring the quantity of the material produced. The stage "putting the pieces together" may involve selection, grouping and disposal of material resources; therefore both objective and subjective assessments may be necessary. Subjective assessment of creative products can be done through Amabile's [1996] Consensual Assessment Technique – CAT. Objective assessment demands measurements of the resource yield and the resource consumption as a function of time [Ferraz and Keller 2014]. Regarding material resources, Bennett's [1976] model suggests that compositional processes start from a single germinal idea. Collins [2005] also adopts this view but allows for several musical ideas (he calls them themes or motifs) at the initial stage. Contrastingly, Hickey [2003], Burnard and Younker [2004], Chen [2006] and Dingwall [2008] models suggest that exploratory activities precede the selection of materials.

The methodological difficulty resides in the task choice for creativity assessment experiments. The underlying hypothesis is – as suggested by Hickey, Burnard and Younker, Chen and Dingwall models – that both restricting and providing access to materials are part of the compositional process. Therefore, by selecting materials or tools the experimenter is taking the place of the composer and the resulting data cannot be used to determine whether the creative musical activity begins by exploratory actions or by a given set of materials. If the musical materials are given by the experimenter, it will not be possible to draw any conclusions regarding the initial handling of material resources. We label this problem as *"Early Domain Restriction"*.

The most important message to be drawn from previous studies is that the experimental settings do interfere with the creative experience. Laboratory-based studies, early choice of tools and design driven by compositional techniques – if not explicitly treated as experimental variables – may limit the applicability of the results on the material dimension.

4.2. Support Rapid Prototyping

A difficulty faced by the designers of musical tools is the slowness of the validation cycle. Because complete integrated systems are hard to design and test, tools usually deal with isolated aspects of musical activity. Musicians usage of the tools may not correspond to the intended design and integration of multiple elements may give rise to unforeseen problems. As a partial solution to these hurdles, we have suggested the adoption of *rapid prototyping*, and the *inclusion of music making* within its development cycles. This integration of music making and software development is based on a broad approach to usability [Bevan 1995; Hornbaek 2006]. Fine-grained technical decisions are done after the usability requirements of the system have been well established through actual usage. So rapid deployment is prioritized over testing on a wide user base.

Prototyping Creative Interaction

If we see music creation as a design activity, it seems natural and straightforward to adopt a prototypical approach to the study of factors that shape this creative process. "Draft" is a term commonly applied to an unfinished musical product, but since our methodological emphasis is on the cyclical creation process rather than on the product, our group has proposed the term "musical prototype" for the creative output produced in musical activities [Miletto et al. 2011]. A prototypical music creation process means that novices can draft initial musical ideas (a musical prototype) which can be tested, modified through a cyclical refinement process until a consensus is reached. This process resembles the prototyping cycles adopted in industry and in incremental software development. Instead of dealing with goals set from the start of the activity, creative prototyping involves exploration of material resources to help define partial targets and to constrain the range of creative choices.

Hence, in creativity-centered design of ubiquitous musical systems we simultaneously deal with *tool prototypes* and *musical prototypes*. The former serve to test hypothesis on musical interaction processes, formulated as metaphors for interaction and interaction patterns [Flores et al. 2010; Keller et al. 2011c; Pimenta et al. 2009]. The latter are used to assess the impact of the proposed technologies on the creative outcomes.

We can think of interaction metaphors and patterns as results of opposite design trends. While metaphors provide recognizable instantiations of general interaction mechanisms, patterns are reusable generalizations of specific solutions. This means that solutions encountered by inductive or bottom-up processes (patterns) could eventually match solutions reached top-down – through deduction of general principles (metaphors). These specific cases are the strongest candidates for useful applications in multiple design contexts. Thus, a possible contribution of ubiquitous music results to the area of design is to help to identify these cases.

Prototyping Signal Processing

Interaction is a key aspect of effective support for creative music making. But given their reliance on computer-based sound, ubiquitous musical systems also need to address design issues related to sound synthesis and processing techniques. Lazzarini and coauthors [2012] report the development of the Mobile Csound Platform to bring the Csound language to popular mobile device operating systems. Work was done to build an idiomatic, object-oriented API for both iOS and Android operating systems, implemented using their native languages (Objective-C and Java respectively). Work was also done to enable Csound-based applications to be deployed over the internet via Java Web Start. By porting Csound to these platforms, Csound as a whole moved from embracing usage on the desktop to becoming pervasively available.

Csound has recently been present as the sound engine for one of the pioneer portable systems, the XO-based computer used in the One Laptop per Child (OLPC) project [Lazzarini 2008]. The possibilities allowed by a reengineered version of Csound were partially exploited in this system. Its development sparked the ideas for its ubiquitous usage, which is now steadily coming to fruition with a number of parallel projects, collectively named the Mobile Csound Platform (MCP). This flexible approach to audio synthesis and processing opens the door to concurrent design of sound synthesis and interaction support. Prototypes can be created on a stationary device, tested through web deployment and eventually compiled for mobile platforms. Thus, issues arising on devices with scarce computational resources can be detected and considered within a single design cycle. In particular, limitations on synchronous sound rendering may impact the quality of the musical interaction experience. This unified and iterative procedure provides a much more detailed feedback on the coordination requirements among interaction and synthesis processes.

4.3. Foster Social Interaction

One of the aspects of everyday creativity that sets it apart from Big-c approaches to music making is the distributed nature of its resources. Creativity in everyday settings demands the usage of local material resources, social interaction with unforeseen participants and quick adaptation to volatile conditions. While Big-c relies on the composer, little-c demands the engagement of multiple (sometimes anonymous) actors for creative action. This is one of the reasons why ubiquitous music research is so closely related to everyday-creativity investigations. Community-based methods are at the center of ubiquitous music practice.

The free access to know-how and the fast circulation of resources within social groups with common objectives foster the emergence of a phenomenon quite relevant to ubiquitous music research: the communities of practice [Lave and Wenger 1991]. A community of practice is a simple social system that arises out of learning and exchange processes. A key aspect of this type of community is that it unfolds through practice, not prescription [Wenger 2010:192], so it can be seen as an extension of the dialogical perspective [Lima et al. 2012]. For example, open-source communities that are agile and flexible foster engagement, imagination and alignment. We believe these characteristics may provide a fertile ground for creativity-centered design. During the last five years, a small community of practice focused on ubiquitous music making has emerged. The Ubiquitous Music Group [g-ubimus 2012] encompasses musicians, computer scientists and educators from half a dozen Brazilian universities and features several international members. Know-how exchange is supported by three channels: one virtual discussion group involving students and researchers (exchanges are done in Portuguese); another virtual group reserved for researchers and international collaborators (the common language is English); and an annual artistic-scientific meeting – the Ubiquitous Music Workshop. Activities have been funded by three major Brazilian agencies (CNPq, CAPES and FAPESP) and by Irish agencies.

Summing up, social interaction happens at three levels of the creativity-centered ubiquitous music design cycle: (a) as a resource for effective musical experiences; (b) as a tool for design assessment and critical evaluation; (c) as a factor for growth and consolidation of a community of practice engaged in ubiquitous music research. The lower level – studied within the context of musical creative activities – is materialized in the musical prototyping process, fostering social exchange among music practitioners. The middle level – involving design activities that serve to adjust the objectives and the research methods – is an arena of negotiation among artistic, computational and educational perspectives. The higher level – the community of practice – encompasses both novice practitioners and designers, providing circulation of material and social resources that foster the community's growth.

5. Phase 2: Planning

The Ubimus Planning Protocol's objective is to obtain a set of social, procedural and material requirements to be applied in the design of creativity-centered systems. Social aspects of creative activities are related to the interactions among agents and to the factors that influence the dynamic of this process. Technological systems may facilitate the access to informational resources and provide support mechanisms for social interaction. But in educational contexts, these same mechanisms may hinder creativity by limiting the type of relationships that agents establish among each other and the access to the available material resources. The purpose of our experimental studies is to identify the minimal requirements that would foster creativity, avoiding the introduction of unnecessary restrictions on the subjects' creative approaches.

We conducted two workshops during July 2011, which focused on aspects of sonic creation and compositional processes and the possibilities afforded by the use of everyday technologies for educational music making, emphasizing the assessment of the complete creative experience as opposed to usage of isolated tools. In addition to enhancing the perception of our everyday listening environment, the workshops had two objectives: (1) to propose that teachers carry out their own interventions and creative experiences taking a stand point of active engagement in authoring their our own sound environments (Soundscape approach); (2) to encourage teachers to appropriate new technologies to explore the possibilities of sonic interventions, carrying out their own musical creations inspired by their daily activities (Ecocompositional approach).

The meetings were divided into two stages: 1. Low-tech (i.e., the use of technological resources was optional) featuring activities such as “ear cleaning” and “soundscape walks” [Schafer 1977; Truax 2002]; 2. High-tech activities (with focus on the use of technological resources) based on ecocomposition [Keller 2000; Keller and Capasso 2006] and ubiquitous music [Keller et al. 2011a; Miletto et al. 2011]. Both meetings involved participants of mixed profiles, encompassing high school teachers with no musical training and music teachers from the M&C NGO who had formal training or previous ad hoc musical experience.

As a whole, we could classify the results as a two by two matrix. Subjects with formal music training and subjects with unstructured musical experience had very different reactions to ecocompositional techniques. The first group did little exploration and had difficulties in realizing ecocompositional activities. The second group labeled these activities as being easy, enjoyed the process and attained a high level of engagement. Naive subjects were less receptive than musicians to soundscape proposals. Despite the fact that these activities were not very demanding, they generated anxiety and strangement among non-musicians.

6. Phase 3: Prototyping

As an interaction metaphor, time tagging defines a process by which a set of unordered virtual elements or processes is layered onto an abstract one-dimensional structure – a tagged timeline. In order to test the applicability of time tagging in the context of a ubiquitous musical activity, we focused on one of the most basic uses of technology for sonic work: mixing.

The study involved the implementation of a prototype that supported a stripped-down definition of the activity at hand – MixDroid 1.0 – as a testbed for the application of the time-tagging metaphor to mixing. The variables controlled in this interaction metaphor are time tags and sound samples. This simplified definition fulfilled two requirements. On one side, it was simple enough to provide the basis for an easily scalable interaction technique. On the other, it preserved the musical complexity of the process. In mixDroid, time tagging proceeds by synchronous sequential access of each of the sampled sounds stored in memory. Sounds are tagged when the user presses its key.

Keller and coworkers’ initial studies with an expert musician [Keller et al. 2010] and novice users [Radanovitsck et al. 2011] showed that time tagging can be used as an interaction metaphor for mixing, and evaluations yielded consistent high ratings for usability support both by musically experienced and untrained users.

7. Phase 4: Creativity Assessment of Time Tagging

To assess the impact of the location on pervasive musical activities, we designed an exploratory field study of the time-tagging metaphor encompassing four variables: musical training, activity type, location, and type of sonic materials. This study provides an example of creativity assessment in everyday settings, complementing the results discussed in phase 2 (planning).

Six subjects – musicians and non-musicians – performed two types of creative musical activities using mixDroid: creation and imitation. The objective of the activity labeled "creation" was to produce a sonic mix lasting approximately 30 seconds. "Imitation" engaged the users in listening and reproducing an already existing mix through a single trial. Two types of sound samples were employed: animal sounds (prominently frogs sounds) and urban sounds (traffic sounds recorded at a busy road). A total of 47 iterations were done involving multiple locations: inside an isolated environment (studio) and at the sites where the sound samples had been gathered (street and pond).

Creativity ratings were obtained after each trial by applying the CSI-NAP protocol [Keller et al. 2011c] – an adapted version of the Creative Support Index proposed by Carroll et al. [2009]. We translated the factors to simple direct questions in Portuguese. Qualitative descriptors were added to clarify the meanings of the evaluations. All questions were answered using a zero to ten likert-type scale. A field for comments was also made available.

Overall results yielded high scores, particularly for the factors enjoyment and collaboration. No differences were found on the subjects' assessments of the activity type (creation vs. imitation). Both sound-sample classes yielded similar results. Activities carried out by musicians inside the studio got the lowest scores, but initially we could not determine whether this effect was correlated to the subject profile or to the location. A more refined analysis unveiled compound effects due to the type of sample and the location of the activity on the explorability factor (for animal sounds) and on explorability, productivity and concentration (for urban sounds).

The subjects' higher scores on the productivity factor for activities realized in external settings are baffling. From an eminent-creativity perspective, we would expect focused studio work to be more rewarding to musicians than other settings that are highly noise (street) or unfamiliar (pond). On a similar vein, novice participants should have yielded more consistent results when mixing inside the studio than at the outdoor environments. The tendency observed was the opposite. Ratings of the productivity factor were less consistent and lower for the studio condition.

Explorability was also consistently rated higher outside than inside the studio. This result supports the hypothesis that subjects are actually using environmental cues as proxies for the mixing activity. One factor that could undermine this conclusion would be high ratings for the concentration factor indicating that increased cognitive effort was necessary to execute the activity. This increase was apparent only for the street condition. But given the higher evaluation of productivity, more concentrated effort could also mean more engagement in the activity. Future experiments assessing engagement vs. attention level are necessary to settle this aspect of the analysis. In any case, the combination of higher productivity and explorability in outdoor settings points to a preliminary conclusion that time tagging provides support for enhanced creative on-site mixing experiences.

8. Concluding Remarks

We described four approaches to creativity-centered design and provided examples of their application within the context of ubiquitous music practice. Defining design strategies involves methodological decisions that impact the experimental results and their interpretation. Planning involves experiments that provide initial data to determine basic requirements and unforeseen aspects of the creative experience. Prototyping entails materialization of methodological proposals by technological means. Finally, creativity assessment techniques provide qualitative and quantitative results that can be used to re-evaluate the proposals put forth in the other stages.

Future experiments targeting the influence of mobility on everyday creativity will need to unravel the relationship between cognitive effort and engagement during in-situ creative activities. In any case, the results of the time-tagging study supported previous findings on the effectiveness of this metaphor for on-site creative mixing. This is the first application of creativity-centered design within the realm of everyday creativity studies.

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