Towards a Conceptual Framework to Integrate Designerly and Scientific Sound Design Methods

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ABSTRACT
Sound design for interactive products is rapidly evolving to become a relevant topic in industry. Scientific research from the domains of Auditory Display (AD) and Sonic Interaction Design (SID) can play a central role in this development, but in order to make its way to market oriented applications, several issues still need to be addressed. Building on the sound design process employed at the Sound Perception and Design (SPD) group at IRCAM, and the information gathered from interviews with professional sound designers, this paper focuses on revealing typical issues encountered in the design process of both science and design oriented communities, in particular the development of a valid and revisable, yet innovative, design hypothesis. A second emphasis lies on improving the communication between sound and interaction designers. In order to address these challenges, a conceptual framework, which has been developed using both scientific and designerly methods, was presented and evaluated with expert reviews.

Categories and Subject Descriptors
H.5.2 [**User Interfaces**]: Auditory (non-speech) feedback; H.5.2 [**User Interfaces**]: Evaluation/methodology; H.5.2 [**User Interfaces**]: Prototyping

General Terms
Design, Human Factors

Keywords
Sonic Interaction Design, Sound Design, Interactive Commodities

1. BACKGROUND AND MOTIVATION
Interactive commodities are computationally enhanced artifacts of everyday use [5]. An important characteristics of such artifacts is, that they are not experienced as computational. Instead their interactivity and constant aesthetic shifting and functional transformation become part of their "nature". Examples are smartphones, smart homes, or wearables. The proliferation of interactive commodities will be further increasing with the advent of standardized APIs like Google's Android Open Accessory standard[1].

Sound can play an important role in the design of such interactive commodities, given their small size, or even invisibility, but also because sound is a powerful medium for conveying complex processes and informations, even if they are in the background of our attention. In comparison to the "traditional" use of sound in the - mostly screen-based - applications in Auditory Display (AD), interactive commodities constitute a new type of artifact, as they can be seen as the full realization of the anthropomorphised artifact.This means, that we are also dealing with *expressive* artifacts, agents with a certain amount of autonomy, and sound can fulfill a central role in this process. This also means, that sound designers face a new design challenge, which requires novel methods and conceptual frameworks.

Recently, interest in the industry to leverage the knowledge developed in Auditory Display and Sonic Interaction Design (SID), in particular for the design of interactive commodities, has increased. This is manifested in the interest shown by various companies in the methods developed by the SID community, for instance during the SID Summer School on Product Sound Design[2]. Moreover, Sonic Branding is becoming a powerful driver for the development of sound for everyday applications [1] and requests from companies are directed at how interactive sonic identities could be developed and evaluated in the context of a corporate identity. This is a challenge, as the criteria for designing interactive sounds (e.g. identifiability, metaphors, usability) are different from the criteria that drive the sound branding process (style, representation of values, etc.) and need to be integrated.

2. AIM AND STRUCTURE OF THIS PAPER
This work contributes to the integration of scientific and designerly methods for commercial sound design, in particular for interactive artifacts. First, we will describe a typical sound design process which is strongly based on scientific, experimental methods. As specific case for such a process,

[1]http://www.engadget.com/2011/05/10/google-announces-android-open-accessory-standard-arduino-based/
[2]For documentation on this event, see http://sid.soundobject.org/wiki/SIDTrainingSchoolProductSoundDesign201008

the sound design method at the Sound Perception and Design team (SPD) of the IRCAM in Paris is outlined.

A second view of the sound design process then is developed based on the evaluation of a set of qualitative interviews with professional sound designers. Sound designers describe their work, expertise and role in the production process, in particular regarding the creation and evaluation of early design approaches to a given problem. Another focus lies on interpretational aspects of sound design, how they are conceptualised and framed by professionals and how a common understanding between stakeholders is established. Revealing this knowledge serves to clarify what "sound design" means in the specific context of industry or market oriented work and thus provides essential evaluation criteria for tools and theories aimed at supporting it, such as the conceptual framework presented in this paper.

In the next part, a conceptual framework for the design of sounds of interactive commodities is presented. Its main elements have been developed in previous research, but only now have been integrated into a whole, in order to evaluate it with potential users. The framework aims at integrating several relevant aspects of design to support the decision making process, in particular in an early phase of development and during design evaluations. Its development integrated both scientific and creative methods. The evaluation of the conceptual framework, which was done using expert reviews and the insights into the sound design process provided by the preceding expert interviews, is also presented. Finally, future work is proposed, based on specific insights from the interviews and the evaluation of the conceptual framework.

3. SUPPORTING SOUND DESIGN BY SCIENTIFIC, EXPERIMENTAL METHODS AT IRCAM

A general sound design approach, as it is followed at the IRCAM - SPD, can be decomposed into three successive steps : Analysis, Conception and Validation. The last two (Conception and Validation) are put in an incremental loop in order to converge towards an optimized solution (see [9], [15], [14] for examples of the application of this process in various projects).

A basic synopsis developing these steps can be described as follows :

1. Considering a given issue - for instance, a new sound design for a new interface in a car - the departure point consists in analyzing the state of the art of the problem (Analysis). For this purpose, an inventory of existing similar sounds is prepared in order to gather as much information as possible about what has been done in the domain. Then on the basis of this sound corpus, experimental procedures are conducted in order to analyse and reveal, from a perceptual point of view, auditory features that characterise similarities, differences or specific qualities among all the elements. This procedure leads to the definition of guidelines, rules or specifications which drive the second step of the process.

2. The recommendations following from step one are then integrated in the beginning of the second step (Conception) and give clues for creating sounds that will fit within the formal frame of the study. On the other hand, this part of the work is complemented with the know-how of an associated composer/sound designer who takes care of the aesthetic part of the project and brings his/her artistic intuition and singularity to the resulting solutions.

3. The solutions in the form of specific sounds are then subjected to an evaluation procedure. This third step (Validation) is conducted in the same experimental framework as the first one with regards to recommendations specified at the end of the initial step (Analysis). It leads to validation or partial falsification of the solutions; in the latter case, returning to the previous step (Conception) is needed in order to modify the suggestions, until the evaluation gives a positive conclusion and the loop is ended.

However, this process has several limitations. First, even if it is formalised in a very generic way, it always needs to be adapted to a specific case study, especially when considering the initial step (Analysis), which relies on the constitution of a representative sound corpus. This corpus is made by drawing up an inventory of several other existing versions similar to the considered topic; this collection can be made either by selecting from a pre-recorded database or creating self-recorded sounds that both may need signal processing operations to clean or uniformize the final corpus. In all cases, this preliminary work on the *raw materials* of the study can determine, in a large part, its range and impact in terms of specifications and conclusions. This strategy establishes a preliminary range of possible design solutions, which to a large extend is based on already existing examples. In some cases this may constitute a limitation for sound design, as it prevents to reconsider a design approach from scratch and favours taking over existing design patterns, even if they are problematic.

Second, once the specifications are defined (at the end of the Analysis step), the transmission of this information to the creative part (i.e., the associated composer / sound designer) can also be an issue of importance. Specific attention must be paid to the transformation of scientific data into notions that can be understood by a person who speaks and understands more the musical than technical or scientific language. On another level, this general communication issue can also be encountered during the evaluation of early as well as intermediate or final design proposals.At these moments, experts and non-experts on sound, try to understand each other. Different ad-hoc techniques are used to achieve this goal: depicting sound by graphical means, mimicking, referring to representative objects, describing with words or with regards to other sounds (references) that are commonly known and understood, and so forth. This communication challenge is a key-point which a conceptual framework for sound and sonic interaction design should address.

4. UNDERSTANDING SOUND DESIGN AS PROFESSIONAL PRACTICE

In the previous section, we have reported specific issues associated with the scientifically grounded sound design process conducted at IRCAM - SPD. The following section aims at fleshing out the point of view of professional sound design-

ers, their needs and the possible issues emerging in a sound design process for interactive artifacts.

4.1 Method

In order to achieve the research goals of providing a ground for tools and concepts that can support market-oriented sound designers, a method was required that focuses on the inductive revelation of a discourse and conceptual categories, which are rooted in practical experience of individuals, avoiding hypothetical bias as much as possible. Therefore, semi-structured expert interviews were conducted and analyzed using a adopted version of Grounded Theory (GT) [2]. Therefore the results are based on emergent categories which in part can be new and unexpected, and in part may confirm existing assumptions.

The majority of the interviews were conducted in the participant's office or studio and lasted between one and two hours. All interviews were recorded (audio) and loose transcriptions were produced, which served as orientation for navigating the recordings and for developing the memos and categories for the Grounded Theory. The questionnaire was produced in three versions, targeted at the specific expertise of the participants: professional sound designers, electroacoustic composers and sound tool creators. As several of the participants fulfilled more than one role, some questions were combined across the three versions, and some participants, who represented several target groups, were interviewed twice with the respective focus.

Each interview had two main parts. The first part served to clarify the expert's position on several questions related to the design of sound as both functional and aesthetic contribution to artifacts and how meaning and sound quality was defined and addressed, in particular in client oriented projects, but also in sound design for musical purpose. This also included questions related to the design process and tools, including those used for electroacoustic composition and live-electronic music. The second part of the interview focused on the concept of interactivity as a challenge in the design of sounding artifacts and how it was or could be addressed in the work of the expert. As the interviews were conducted quite freely, these to parts would often overlap.

In the following, we list the experts that participated in the interviews. Those who also participated in the evaluation of the conceptual framework are marked with an asterisk.

- Andrea Cera[3], freelance composer and sound designer, who collaborated with IRCAM for the sound design for electric cars.
- Xavier Collet[4], a sound designer specialized in video games, web and multimedia products who is also a lecturer in various sound design courses.
- Ludovic Germain*, who has done a HCI course in Industrial Design at ENSCI[5], and who is working since about 10 years in his own design and sound design agency LAPS[6].
- Louis Dandrel, a well-known french sound designer, composer and journalist who held several important positions, for instance as head of the french radio France Musique. Dandrel established sound design at IRCAM in 1999. While not being at IRCAM anymore, he is still doing sound design projects in his own agency DIASONIC[7].
- Jean Lochard*, an IRCAM musical assistant working in the pedagogical department[8], who developed a Max/MSP high level environment (NMI, the Najo MAX Interface) for creating sounds. He is involved in the development of the Karlax instrument in collaboration with Dafact[9]. Lochard collaborates with the Sound Perception and Design team for the sound design course taught annually at IRCAM.
- Mathieu Pavageau, a sound engine and sound programming tools developer for video games at Ubisoft France.
- Emmanuel Deruty*[10], an independent sound designer.
- Nicolas Donin, musicologist and head of the IRCAM Analysis of Musical Practices research group[11].

As the interviews were rather open and explorative (a precondition for Grounded Theory, as hypothesis-driven bias should be avoided as much as possible), a multitude of topics emerged. In the following we present those results from the GT analysis of the interviews, which are relevant for the issues addressed in this paper. Major topics are represented in the section titles, and subtopics are marked by bold typesetting.

4.2 Outcomes of the Interviews with Sound Design Practitioners

4.2.1 *Sound Design as it Should Be*

Sonic quality is considered by the participants to be the central concern in sound design. This may sound obvious, but most participants emphasized that in particular "functional" sounds are not designed in this sense. Sonic quality is not understood as production quality in a technical sense alone, but also as a certain level of complexity in the design, and always also refers to the **conceptual backing and refinement** of the individual sonic events. A common statement was, that a sound has to have a character, an identity of its own, which is based on sonic qualities or qualities of sonic processing, rather than sonic references to familiar, "natural" sounds. Familiarity as quality of new sounds may be important but rather "hidden" using various processing strategies. Only then a unique, meaningful relationship can emerge between sound, the sound generating event or object,

[3]http://andrea.cera.free.fr
[4]http://xaviercollet.com
[5]http://www.ensci.com
[6]http://www.laps-design.com
[7]http://www.diasonicdesign.com
[8]http://www.ircam.fr/39.html
[9]http://www.dafact.com
[10]http://www.1-1-1-1.net
[11]http://www.ircam.fr/apm.html?L=1

and listener. In the view of some participants, particularly sounds of novel, interactive products should be conceived as completely new sounds, without too obvious references to a "heritage artifact".

The participants considered **emotional and expressive qualities** not simply an optional embellishment, but a core requirement in sound design, although they could not, or refused to, give a generalizable definition. They emphasized, that even a simple information signal should be designed to be expressive and interesting, to make an everyday task more enjoyable or prevent annoyance. Some participants suggested also, that if the sounds themselves are interesting and well done, a momentary lack of understanding may be more tolerable. As consequence, it was stated that meaning or information cannot be conveyed in a satisfactory way by simply mapping isolated parameters like pitch, volume, speed or arbitrary timbres to data. Also, a simple iconic or indexical relationship between sound and signified, as it is often found in auditory icons, is insufficient. Likewise, a certain process should not be conveyed by the sound of the process itself, or a directly associated dimensional mapping, but rather by second-or third-order relations. While in some cases meaning may emerge from "natural causalities", e.g. that big objects usually produce deeper sounds, in most cases it is exactly the **play with "naturality" or "rationality"** where sound design starts for the participants. Sound design is about **finding a "third quality" in the combination of two (or more) elements**, rather than a straightforward translation from one parameter onto another one or direct links between signifier and signified. This strongly supports the aim of the narrative metatopics proposed (see section 5.3) to provide a link between sonic concepts and concepts of (inter)action and experience.

Defining a sound's properties by empirical, scientific methods and psychoacoustic criteria alone, was also considered problematic and not really "design", in particular if done at an early stage in the process. **Scientific evaluation** can be beneficial, but only *after* first prototypes have been developed in a creative process.

It was considered important by the interviewees to create **systems of sonic relations**, to realize a sonic identity across sonic functions, in particular for interactive commodities. As soon as a systemic sound design is required or interactivity is a key element of the product, compositional aspects become relevant. Also the **situation** where a sound would occur, and how the sound related to the artifact itself, was considered very important. Sounds have to be part of a **holistic design of an artifact and its process**, in order to fulfill the potential role of sound to be "the voice of things". Some participants suggested, that there has to be a new poetics of new interactive artifacts. If they were not poetic, they would not enter our narratives, and remain collateral incidental happenings around us. However, a specific method, or guiding principles, where not mentioned.

All these considerations explain the fact that most participants were critical about applying the term "sound design" to the current practice in industrial or product design. Also "traditional" Auditory Displays (Earcons, Auditory Icons, Sonifications), which are usually developed in the context of academic research, are not considered "real" sound design, for the same reasons. Some participants explicitly mentioned several missed design opportunities of everyday product sounds.

In summary, information is embedded in a more complex sonic construction, which can stand for itself aesthetically and meaning emerges from more complex relational processes and sonic phenomena. The question is, how this complexity can be framed and expressed, and how it can be related to the interaction qualities. Whatever system is devised for this purpose should allow for **expressive, complex and multifaceted design, while still supporting scientific evaluation**. Also, all interviewees agreed that sound designers need to be able to listen to sound for it's own sake, through "reduced listening" [11] and to work on the abstract sonic quality per se, without relying on obvious references only, in order to create novel and unique sounds. This suggests that a **vocabulary that helps express sonic qualities verbally** would be beneficial. In this sense, "musical" competence is important in the sense of knowing how to listen to sonic detail and being able to combine and compose sounds.

4.2.2 The Sound Design Process in Reality

The sound design process, as reported by the participants, usually entails a conceptual phase, often starting on a verbal level, then continuing to sound drafts and moodboards, initially separated from other modalities. In particular, industry-oriented sound design is often **highly concept-driven**. Verbal descriptions and "sonic vocabularies" (e.g. in moodboards or attribute-sound associations) play an important role, and usually there is the need to be able to formulate and convey a design concept and to convince the client. In many cases, the concept and argumentation for a design is even more important to the client than the actual design itself. Representing sonic ideas sonically is crucial but also highly problematic, as clients can not always understand the conceptual nature of moodboard sounds. If the clients can not be convinced, their judgement tends to be rather conservative (e.g. with a preference for common solutions, harmonies etc.), thus opposing innovative approaches. Another problem for the participants is that the client's requirements are often ill-defined. As consequence, despite the ideal of designing rich, novel sounds, in many practical cases that were presented, participants tended to stick to seemingly "save" design strategies, e.g. resorting to simple signals, as they found themselves in a conflict between their design idea and what they believed was acceptable by clients or users. This **"self censorship"** was largely grounded in a lack of conceptual and argumentative tools for formulating design strategies and building convincing concepts around sounds.

Thus, the initial phase seems to be the most challenging one in several respects. In the phase of analysing a design problem, there is the challenge of **balancing both acoustic and psychoacoustic aspects and psychological and socio-cultural dimensions**. A particular challenge seem to be the **multitude of social situations**, in which sounds of everyday artifacts can be encountered. A lot of the issues in the interaction with the client seems to lie in the **arbitrariness of design argumentation**. A holistic conceptual framework, that integrates sonic qualities with qualities

of interactions and the product itself, which also allows to link conceptually to corporate identity, could be beneficial.

Some participants doubt the possibility to achieve a valid and reliable understanding of situational and interpretational aspects, others attempt to reach this understanding in their projects, but can not rely on a solid methodology. In general there is an increasing **need for systematic approaches and structured processes** to cope with the increasingly complex design problems. However, the criteria for evaluation are not always clear, are often defined in an ad-hoc manner, and sometimes strongly influenced by the client. Also there are no specific methods to deal with interactive sounds specifically.

The participants agreed, that all these points could be better addressed, if there was a comprehensive conceptual system available which hints at another area of interest: **The ability to communicate sonic concepts adequately**. The design process needs to offer tools that **facilitate a common understanding** between stakeholders and - in the words of a participant - sometimes even needs to "educate" the client. This requires a **holistic conceptual system for argumentation**.

Discussing common creative practices in the area of electroacoustic music also brought some valuable insights. It was noted, that even popular music today is to a large extend concerned with "sound design", the focus lies on working out the **sonic details, timbres and developments**. Also achieving a certain **effect** - while not appreciated as an explicit goal of musical composition in artistic circles - is a motivation for specific musical sound design decisions. This suggests that the study of musical sound design strategies is in fact valuable also for functional sound design. Moreover, **conveying meaning** of some sort is important, but not in the sense of a specific lexical meaning or information, but rather a certain **sense and sensations**. A common design strategy in musical sound design was to **translate aspects of (simple) phenomena from other modalities** (e.g. colors, shapes, a specific building or objects) into sound, or to use them as conceptual starting point for building a whole composition. The original point of reference may however get entirely lost in the process. This resembles the creative process in sound design, which, as stated by several participants, often starts from real-world phenomena and concepts as sources of sonic inspiration. This is perfectly in-line with the aim of this research to propose narrative metatopics as a common conceptual link between qualities of interactions and sounds.

5. EVALUATION OF THE CONCEPTUAL FRAMEWORK

While the interviews aimed at revealing essential categories and criteria that sound design - also for functional and interactive products - should meet, this part of the research focused on the practice-oriented evaluation of a conceptual framework which has the aim of supporting exactly this integration of sound design, functional and interaction design and scientific evaluation. The focus of the evaluation lied on comprehensibility and applicability, on design strategies that could emerge from its application, and to what extend they were different from the expert designer's "own" approach. This section will describe the framework and its evaluation.

5.1 Summary of Framework

Previous research aimed at developing a better understanding of the types of interactive commodities and resulting design heuristics [4], at leveraging the wealth of knowledge innate in filmic sound design [6], and at exploring the interpretational processes associated with the production and experience of sound in the performance of interactions [7]. For this end, a revisable, design oriented, participatory research process has been devised, which allowed to explore narrative sound designs and their possible application in interactive commodities in a systematic way. The process focused on interpretational aspects and performative prototyping methods and has been applied in several workshops, some of them with industry collaboration. Based on an evaluation of the cases created in the workshops an initial framework of concepts and heuristics has been formulated that helps to inform design decisions. The following sections provide a summary of its main components[12].

5.1.1 *Typology of Interactive Commodities*

This typology [4] has been developed along aspects of morphology and degree of abstraction of sound and object. Sound is closely related to physical, material processes and plays a core role in communicating "hidden" qualities of an object (stability, solidity, etc.). In "schizophonic"[13] interactive commodities this "natural" layer merges with artificial electro-acoustic sounds in many ways. These categories thus are intended to help to orient the sound design strategy used. The categories are:

- **Authentic** commodities: Simple, self-contained. Sound complies with expectations, fits with existing sonic identity
- **Extended** commodities: Simple objects with added functionality. Sound not necessarily related to object's sonic identity, communicates extension quality
- **Placeholders**, e.g. the Wiimote or Tangible User Interfaces: Proxies of a virtual object. Sound defines the virtual object, within gestural and formal constraints
- **Omnivalent** commodities: Defined through software rather than physical configuration. Sound defines the artifact

5.1.2 *Situational Heuristics*

Based on the evaluation of more than 20 experience prototypes developed in Sonic Interaction Design workshops, several trajectories across situational categories that define the relationship between interactive commodities and their use context have been identified [8]:

[12]For detailed explanations please refer to the publications indicated.

[13]Schizophonia is a term coined by R.M.Schafer [12] to denote the separation of sound from its source by means of electroacoustics. While for Schafer this is leading to negative consequences in our soundscape, in our view this condition is a fundamental and unavoidable characteristic of interactive sounding artifacts, leading to new opportunities for design [4].

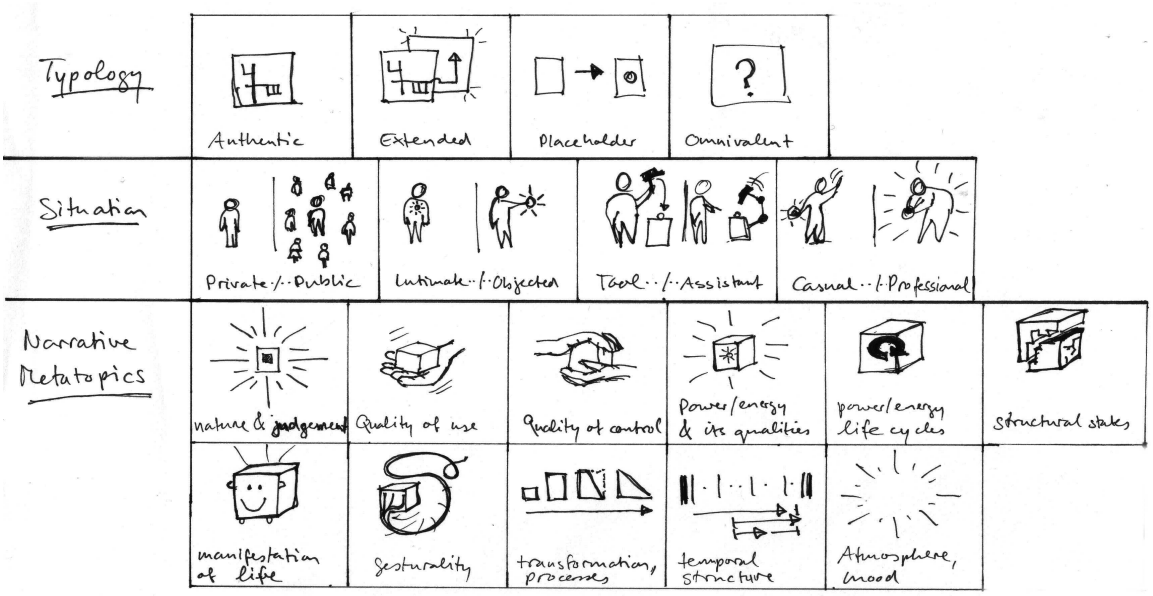

Figure 1: The first version of the iconography, as it was used in the interviews.

- **Social situation**: private - public
- **Level of intimacy**: ob-jectified (meaning: totally detached from human body) - pocketeable - wearable - implant
- **Relationship to user and task**: assistant - tool
- **Type of use**: casual - professional

5.1.3 Narrative Metatopics

Narrative metatopics [6] are abstracted themes and attributes associated with narratively significant artifacts and interactions in fictional media, like film or games. They were established in structured sessions of group discussions, coding and clustering of extracts from over thirty films and games, in which sound played a significant interpretive role. Thus, narrative metatopics provide a means of navigating a complex semantic space, and can be associated with a collection of specific sound design strategies, which serve as material to build grounded sonic interaction design hypotheses as a starting point for design. They also are meant to serve to link qualities of interactive processes with qualities of sonic processes. The narrative metatopics are:

- Nature and judgement of artifact
- Qualities of use
- Qualities of control
- Power / energy and its qualities
- Energy / power life cycles and dramaturgy
- Structural states
- Manifestation of life
- Gesturality
- Transformation processes
- Temporal structure
- Atmosphere, mood

In order to facilitate the understanding of and communication about this conceptual framework, an iconography was drafted, which is presented in Figure 1.

5.2 Evaluation Method: Interviews and Expert Reviews

The conceptual framework was introduced at the end of the interviews, which were reported above, both in order to get a general feedback about it and to prepare the expert review. The experts were asked if and how they could relate the components of the framework to their work, and what sound design strategies they would use for the various aspects. Musicians and composers were also asked if and how they could relate to the terms from the conceptual framework in terms of musical composition.

Five participants agreed to participate in the expert reviews. A structured procedure was followed in order to ensure that the outcomes were comparable. In order to provide the participants with the opportunity to process all the information, the framework was handed out before the actual review session took place. For the entire conceptual framework, the iconography presented in Figure 1 was used to facilitate the discussion. Moreover, a concrete, fictional use case was distributed to all participants beforehand, to provide a common, design-oriented focus for the review session:

Imagine.... A fashionable handbag that can charge your smart phone, which is full of important information and also private stuff. The bag also manages the backup and update of your phone and acts as a firewall, protecting it from hacker

attacks in public space. The phone has to be put inside the bag to use the functions, the connection to the bag is wireless.

At the beginning of the expert review, the conceptual framework was again explained, making sure that all aspects were understood. Then, the participants were asked, which elements from the framework would be relevant in the presented use case, and whether something was missing. Afterwards, the experts were asked, how they would approach the design, using the conceptual framework as support and guideline. They received the instruction to cover one "typological category", all of the "situational categories", and three "narrative metatopics". The resulting design concept was reviewed with its author, to clarify, which decisions correlated with which category. Finally, the process was summarized and evaluated together with the participant. All designers were asked if they would be ready to create a finished design proposal for 2-3 sounds in the described use case. All of them agreed, but at the time of this writing, their work is still in progress.

The use case of the "smart fashionable handbag" was analysed by the researcher before the review session, using the same conceptual framework, in order to provide a reference. This analysis was not shown to the participants initially, and was discussed with the participant after they concluded their own analysis. This helped to shed some light on the interpersonal understandability of the concepts. The following lists the categories of the preliminary reference analysis:

- Typology: Extended artifact
- Situational criteria:
  - private object, with potential to be public under certain circumstances
  - rather intimate, something personal but still it's an object
  - assistant: helps you manage your life with a smartphone
  - casual use: the less you have to focus, the better; the interaction should be "street credible"
- Narrative Metatopics: presence of (positive) energy, quality of control, energy life-cycle, transformation

5.3 Outcome of the Evaluation

All interview participants could immediately understand most terms and arguments of the conceptual framework and apply them in their design thinking. Some stated that for a full integration of the various elements into their everyday practice several iterations in real world design cases would be necessary. The conceptual categories were received with great sympathy and understanding, and appealed to all expert designers, to an extend that they even asked for more information about it. Some notions, such as sound as the "voice" of things, which relates to the narrative of the "manifestation of life" were already quite common among the participants, but not integrated in a holistic framework. About half of the participants could well relate to the notion of interactive objects as agents with sonic expressivity. All participants stated, that the conceptual framework could substantially support their work and help overcome the issues mentioned in the interviews.

In the expert reviews, the framework succeeded as a catalyst and inspiration for design ideas, and was not judged to be restrictive or deterministic, which is a core requirement for heuristics in the creative business. In general, the framework helped all participants to make more informed design decisions and also helped them to create new design ideas that they could not have had without it. All participants emphasized the power of better arguments within design teams and towards clients when using the conceptual framework. Also it was generally appreciated that the framework is systematic and clearly structured.

The narrative metatopics and related filmic cases were considered very interesting and helpful, if the specificity of the medium was taken into consideration. The participants agreed that it was possible for them to relate narrative metatopics to sound qualities and musical notions like dissonance or consonance, tremolo, etc. Some participants stressed the importance of learning from modern and contemporary acoustic and electroacoustic music and confirmed, that in particular the narrative metatopics would be a helpful contribution towards a common language between interaction and sound design.
Some participants even suggested that the conceptual framework could be a contribution towards establishing new codes and thus be a normative contribution to sound design for interactive products. Some terms used in the framework were interpreted differently by different participants (e.g. "gesturality") or led to confusion. While such issues could be solved by providing an explanation, they indicate elements in the framework that need revision.

In order for the framework to fully achieve its potential benefit, it has to be formulated in a even more accessible and practice oriented way. It was suggested, that the conceptual categories should be elaborated around concrete sound examples or to design representative sounds to illustrate them. However, there was no conclusive strategy found to do this, as many design decisions are case dependent. As a general direction, illustrative sounds should be designed to reflect rather abstract qualities that can be easily generalized to other sounds. A few suggestions were made to extend the collection of metatopics by musical notions like counterpoint. Another suggestion for a new category was *"bad imitation"*, which refers to a notion of an "imperfect artifact", a concept that has been successfully applied in sound design of Star Wars (Lucas, 1977) under the moniker "Used Future" (Ben Burtt, in [10]). Also *"dialogic quality"* was suggested, to account for the situations in which a system and a user enter a more tightly interleaved mutual exchange.

6. FUTURE WORK

The amount of data collected using rather open interviews provide rich material for further investigation. Existing themes will be refined and elaborated, and new themes, which were not in the focus of this paper, may still emerge in further GT analysis. Given the importance that sound designers attribute to sonic quality and the detailed refinement of the sonic material itself, and the need for appreciating this in collaborative design tasks, it will be valuable to leverage the knowledge in the field of electroacoustic music and life-electronics (e.g. [3], or [13]).

Another next step is the application of the conceptual framework in design sessions, if possible in real-world industrial situations. From the interviews it turned out, that an important precondition for this is the provision of a useful prototyping environment, which also integrates the designer's familiar tools, and also allows him/her to work alone for a while. The improvisational sound design setup and the method of performing sounds live to a real-time interaction in a Wizard-of-Oz prototype, as described in [7], was new to all participants, but considered very useful and appropriate for this purpose.

This leads to a final topic for future work, the development of suitable design tools. Building on the participant's statements, this tool should support decision making and help to bridge the gap between concept and linguistic expression of attributes, and sounds that embody them or convey them through certain properties. Also some kind of design history management beyond "undo" would be valuable to better cope with the complex mix of techniques involved in sound design. As playful experimentation and improvisation mattered for all interviewees, the tool should offer some real-time sound making possibilities. But it has to be considered, that "real-time" performances are only possible, if the sound material and the real-time controls have been carefully prepared beforehand and the performance has been practiced. Also in sound design for interactive media, careful sculpting and composition of sound, with precise control over frequencies and envelopes, continues to play a central role, and the resources and time required for it must be taken into consideration.

7. CONCLUSION

This research presents a step towards a holistic sound design process specifically aimed at interactive commodities, that can be used in a commercial context. A particular focus of this work lied in revealing the specifics of "design" or "science" oriented approaches to sound design. A conceptual framework was presented, which is based on a combination of both scientific and design methods, with the aim of providing a common system for theory and practice of sound design. Specifically, the results can be used to address problems associated with the beginning and the end of the design process, where the question of managing the design history, prototyping and evaluation cycles, and relationships between tools, methods and aesthetics are dominating. Relevant feedback concerning the conceptual framework for designing sounding interactive commodities was obtained, and future steps of research were proposed, that could further contribute to a better integration of scientific and design methods in the creation of sounds for interactive commodities. Joining these two worlds will result in a comprehensive sound design competence which will enable designer to ground their decision making better and provide convincing arguments, thus helping them to avoid self-censorship and push true innovations in sound design through to their clients, and thus to our everyday experience. We strongly believe that, if the sound design of interactive commodities was executed on a quality standard comparable to film sound, with a holistic consideration of typological, situational and narrative aspects of interaction, more cases of functional everyday sounds would be acceptable or even successful.

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