USING MULTIPLE, ROLE-RELATED PERSPECTIVES IN THE DESIGN OF ALARM SOUNDS FOR SAFETY CRITICAL CONTEXT

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ABSTRACT

The requirements for alarm sounds for safety critical contexts are many, some of which may be conflicting. This study concerns the design of alarm sounds for a hospital environment, in particular operating room conditions. We describe the process of capturing sound design ideas in a form that could be utilised in practical sound design. The process is an application of the Rich Use-Scenario method, and provides an example of how this method should be tailored in terms of the context of use.

The central finding in this study derives from the contribution of people in three different roles in the design process. These roles were those of contextual practitioner, non-expert (man in the street), and sound designer. The design case illustrates the importance of including all these perspectives in the design process.

1. INTRODUCTION

Studies concerning alarm sounds usually concentrate on qualities like reaction time or perceived urgency. Indeed, these issues are central in the design of alarms – the more we know how different acoustic qualities are related to the interpretation of sound, the better. The studies in this domain have resulted in practical guidelines for alarm sound design (e.g. [1]). They provide designers with valuable support.

However, there are at least three problems in the application of guidelines for practical alarm sound design. First, guidelines never cover all qualities of sound. They may provide details about intensity, frequency or rhythm, for instance, but many decisions about a real sound have been left for the individual designer. For example, timbre is difficult or impossible to define at a level that could ever result in detailed guidelines. Second, the interpretation of sound depends on the intentionality of an observer and it is always bound to the context of use [2, 3]. Therefore, the value of guidelines which do not take the situational context into account is limited. The third problem is that the guidelines for alarm sound design concentrate on interpretation of the sounds. Not enough attention has been paid to the emotional responses to sounds, especially when frequently exposed to them.

In the current study, the challenge was to design alarm sounds for an anaesthesia workstation for operating room (OR) conditions. The assignment had features in common with design challenges for other safety critical systems. However, there were issues which were unique to OR conditions.

2. OPERATING ROOM AS A CONTEXT

The problems in using alarm sounds in an OR context have been widely acknowledged [4, 5, 6, 7], but no simple solution has been found. The intention of the current study was to avoid these problems in one design case – the warning sounds of an anaesthesia workstation – by deriving design from the specific context of use.

For the needs of the current study, we needed to start by familiarising ourselves with the OR conditions, with particular regard to the soundscape. In an OR, there are numerous gadgets which all have their own repertoire of alarm sounds. A mayhem of different alarms is guaranteed when the room is equipped with technology of different manufacturers, which all have their own product in mind alone when designing it. The hard acoustic properties of a typical OR, caused by the interior surfaces which have primarily been chosen for hygiene, do not make the situation any easier.

Beyond the challenge of taking the problematic soundscape into account in sound design, we were challenged to discover in what kind of categories alarms should be distinguished. Most importantly, the alarms should differ in terms of urgency; there is a standard of dividing the alarm sounds into low, medium and high priority sounds. Another optional categorisation of alarms would be the referent of the sound; whether relating to the patient or the device. In addition, the manufacturer was interested in including sound design in their branding policy, but that issue is not dealt with this particular study.

To rise to the above challenges, we needed to capture the reality of an OR and how alarm sounds are related to the anaesthesia procedures. Since we had practically no experience of it, we chose to use the Rich Use Scenario (RUS) method in order to get immersed in an everyday event in an OR.

3. RICH USE SCENARIO AS A MEANS TO UNDERSTAND THE CONTEXT

RUS method has been created to understand the essence of the context of use for the needs of design [8, 9, 10]. The main difference between traditional use scenarios [11] and RUS is the rationale. Traditional use scenarios are typically short descriptions of a user using an application. The aim is to cover as many use situations and as many kinds of plausible users as possible, and therefore several scenarios are recommended to be used. Conversely, in RUS only one scenario is created. Whether it is the most likely scenario or whether the character in the scenario is the most likely user, is not the primary concern. Instead, in RUS, the aim is to provide inspiration for designers. Therefore, RUSs are lively stories, which provide vivid imagery depicting the flow of using the application, and also provide characters with which the listener or reader of the story is able to identify herself.

In the previous cases in which RUS has been used for sound design, the process has been divided into the following stages:

1. The process of creating the RUS, i.e., constructing all the contextual understanding and models of interaction needed

in creating the story manuscript. In writing the manuscript, special attention has been paid to the creation of credible character persona.

2. A radio play format dramatisation has been prepared on the basis of the manuscript. In the radio play, the sounds-to-be-designed appear as points of "missing" sound effects of the play. In other words, the manuscript has been prepared so that the use of the application is a fluent part of the story, and the intended user-interface sounds can thus be imagined in the play.
3. A brainstorming panel with people who are not at all involved in the application design (basically men-in-the-street), is conducted. In this panel, the panellists hear the story without the sound effects. The task of the panellists is to "hear" the missing sounds and thus describe what kind of sound would fit in each part of the story.
4. The designers implement the first set of draft sounds on the basis of ideas collected from the first panel.
5. Another panel is organised, but this time the draft sounds are included in the radio play. The task of the panellists is to elaborate the sounds – in other words, to brainstorm how they could be further developed.
6. The designers implement the next versions of the sounds.
7. A third panel is organised, using the elaborated version of sounds in the radio play. The role of this third panel is to provide still more feedback for possible further development, but mainly to evaluate the more or less completed sound set.

In the method, two policies in the recruiting of panellists have been used: In the first version, different panellists were used in each session. In the second version, the panellists were the same each time.

The RUS method has been found useful as a generator of creative ideas for sound design in different contexts. However, it is not appropriate to follow exactly the same line of procedure in different contexts. We tailored the method to the needs of the current design case in two main respects:

1. We used both 'men-in-the-street' and contextual experts on panels. In practice, we first organised two panel sessions with non-experts and then two panels with experts (each consisting of two nurse anaesthetists and one anaesthetist). The reason for using experts was that the context was so unfamiliar for us, and on the other hand, the application was safety critical; we needed to make sure that the actual users understand the sounds.
2. Unlike in the previous cases of RUS panel work, in which the task of the panellists was mainly to verbally describe their sound ideas, we asked the panellists of the non-expert panels to implement the draft sounds as well. The sessions were organised in a music therapy studio, in which they had some musical instruments for producing sounds. They also had their body and voice available for use, of course. In the later non-expert panel session, the sounds were recorded as overdub to the radio play. The expert panels could then listen to the play and say what they thought of it.

4. THE IMPLEMENTATION AND INITIAL FINDINGS

In this section, we discuss the observations concerning the application of the RUS method in the current case, contextual issues, and their reflections in sound design.

4.1. Application of RUS

The main reason for using the practitioners (nurses and doctors) in panels, was our inadequate knowledge about the reality of OR. This decision proved to be ideally suited. Even if we had been given a lot of information by the manufacturer about the problems in an OR, the view of the practitioners was clearly essential. This is of course true in all design; understanding the users and the context of use is a cornerstone of a successful design process. However, in this case, the inclusion of practitioners in the design process felt particularly appropriate.

The decision to ask the non-expert panellists to produce the draft sounds was found successful. In the previous versions of RUS, the production of draft sounds has been found problematic: Even if in visual design, hand drawn sketches have been found effective stimulators for discussion, in sound design, draft-quality may not convey the underlying sound idea [9]. The draft sounds which we have previously used were produced with a computer, and they always contained some qualities so irritating that they did not provide a basis for constructive elaboration. However, while we this time used human voice and real instruments, the sound idea was much better communicated.

Although the outcome of non-expert panels clearly illustrated the sound ideas of panellists, in some cases we (as sound designers) generalised the ideas of various different draft sounds into a more coherent whole. On the basis of all varying draft alarms, for example, we constructed a single model representing the basic features for alarms of different priorities. By using this model, we re-produced the draft alarm sounds that represented each priority level alarm in the radio-play used in the practitioner panels (see Table 1).

4.2. Contribution to sound design

When starting to design the actual sounds for the application, we have a lot of material in use. We have the sonic outcome and the notes of the panel work of the non-experts, as well as the transcribed discussions of the expert panels. The first, initial findings, which are directly related to the sound design, are summarised below.

The starting point for the work of the amateur panels was that the panellists had no prior experience in sound design nor the OR environment. This was intentional; it was supposed that people who look at the context from outside, have potential to present more creative ideas than practitioners who are accustomed to the existing sounds.

In general, the practitioners found that there are too many and too strong or inappropriate alarms in ORs. The attitudes of the practitioners were extremely negative towards all kind of alarm sounds. On the other hand, they admitted that most of the alarms are necessary. These attitudes could be seen throughout the panel sessions. The nurses and doctors wanted the alarms for non-critical and recurring situations to be non-obtrusive and reasonably quiet. They realised the potential of the use of non-speech sounds in their work, though – it appeared that it was mostly their negative experiences of alarm sounds which had resulted in negative attitudes. Experiences were negative, not only due to their "irritating" qualities as alarm sounds, but also due to their frequent occurrences in non-critical situations which could in many cases be called "false alarms". This indicates the challenge of taking situational context, communicative intention and emotional responses into account in the design of alarms.

As demonstrated in Table 1, practitioners valued qualities of urgency in alarm sounds, when they appear in a high-priority emergency situation. However, when medium and low priority alarms were concerned, obtrusive qualities were rejected al-

Table 1: Example of draft-sounds of each alarm priority and their evaluations in the practitioner panels. Sounds were produced with a metallophone instrument.

Priority	Draft sound	Evaluation
high	repeating rapid three-hit bursts, high register, fast tempo	very good alarm sound for a critical situation that needs immediate care, could be adopted as such
medium	repeating two damped hits, medium register, medium tempo	should be much less obtrusive, more "relaxed" (preferably single-tone structure instead of two tones, and longer pause between repetitions)
low	damped low intensity hit, medium-low register, repeating unhurriedly	pauses between tones should be longer; approx. 5 sec, sound is also "too snappy" and too short – should be softer

most completely. In fact, it was difficult to even differentiate low and medium levels from each other as practitioners wanted even medium priority alarms to be scaled very low in their "alarming" qualities. Practitioners preferred medium and low priority sounds to be more like "soft-sounding" reminders which are noticeable but do not disturb the more pressing work that doctors and nurses have in hand. This observation indicates the possible redundancy between medium and low priority alarms. It may also indicate that in sound design, not all sounds in an OR context should necessarily be conceived as alarms (see [6]). Thus, non-speech sounds should always operate in situationally appropriate functions of communication [3].

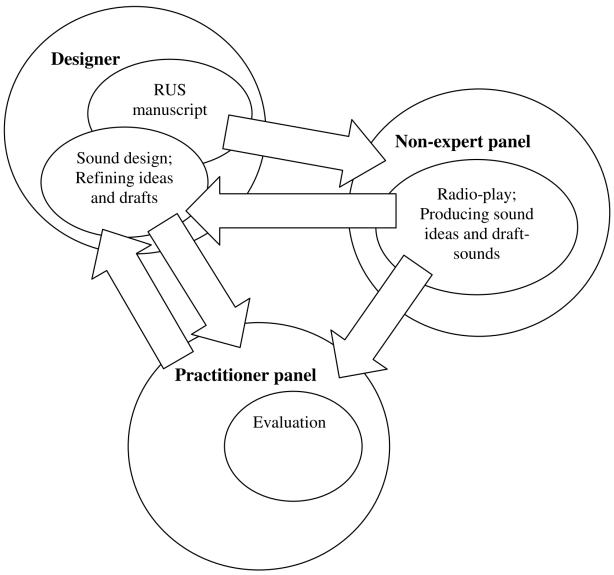

Figure 1: The roles in the utilisation of RUS in the sound design process.

5. CONCLUSIONS AND DISCUSSION

In Figure 1 we illustrate the process and roles of the current design study. The starting point is the RUS manuscript, which works as input for the preparation of the radio-play. The non-expert panel implements the radio play: It plans the sound effects, and completes the whole play. The radio-play, in turn, is the basis for the discussions of the expert panel. All the input from both amateurs and experts provide material for the actual sound design.

The initial analysis of the discussions in the expert panel indicates that the draft sounds, generated by the amateur panel, received surprisingly positive feedback from the practitioners and functioned well in their role as stimulators for discussion. As already mentioned, this was quite the opposite to our previous experiences of the use of draft-quality sounds in the radio-play. We conclude that our previous parallel between draft visual layouts and draft UI-sounds was not appropriate. In visual mock-ups, draft quality has been found to encourage the users to make suggestions. Apparently, the power of draft quality (especially hand drawn) is not in its coarseness per se, but in the "human touch" – the panellist/designer can easily attune to the outcome and imagine having produced the draft by herself. Completely in line with this, the sounds which our non-expert panellists produced, sounded human made. It is easy for a listener to identify with the person who actually produced the sound and thus to be able to empathetically denote the underlying idea. This is, however, just a hypotheses derived from our experiences, but has potential to provide a link to a more general theoretical framework, *embodied cognition*. According to this, the perception of a human-caused sound involves embodied attuning to the sound-producing action by mentally simulating the performance [12]. Therefore, and on the basis of our experience in the design cases, we highly recommend the use of body and simple instruments in the implementation of sound ideas.

We argue, on the basis of this design case, that the proposed version of RUS is appropriate in many safety critical contexts. It utilises unprejudiced creative ideas from non-experts, but also takes into account the perspective of experienced practitioners. The detailed analysis of the panel work and the sound design process is still going on, and a more comprehensive analysis is expected to reveal issues which deserve a closer look in alarm sound design.

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