Safe and Sound:

A plea for considering context related factors for the intended urgency of alarms

Author 128

Track 10: The machine that goes 'ping'!

ABSTRACT

This report contains the setup, execution and results of a research toward the influence of context on perceived urgency in auditory alarms. It utilizes a user-centered approach to determine appropriate levels for four acoustical properties (pitch, pitch range, between signal interval and between pulse interval) in several working and living situations. The research is meant to inform alarm designers on the importance of context in their work and to provide them with a suggestion of values for the four acoustical properties named above.

Keywords

Perceived urgency, alarm design, sound design, context

INTRODUCTION

Alarm design as a topic that is noticeably often subject to research in the academic world. This academic attention can be explained by the amount of importance and influence researchers and commissions attribute to alarms and their shortcomings within each of their respective fields of expertise. Within clinical context The Joint Commission (TJC) reported 80 deaths attributed to alarm hazard in a 42-month period [1] and the American Food and Drug Administration's (FDA) database contains more than 560 alarm-related deaths between 2005 and 2008 [2]. Tyler concluded that in the years between 1984 and 1994 5 percent of the 28.762 aviation hazard and mishap reports submitted to the U.S. Navy involved false or erratic indications by alarm systems [3]. In other, less specific workspaces alarms contribute to noise, which is named as a contributing factor in approximately 2.2% of all fatal incident reports [4].

The most frequent occurring explanation for these alarm-related incidents is alarm fatigue [1]. Alarm fatigue is a mental state caused by an overexposure to frequent alarms desensitizing the user and leading them to not adequately respond in case of a critical event [5].

According to Özcan & Edworthy criticality is attributed to alarm design before urgency is perceived by the alarm user [6]. For the sake of unambiguous communication we will speak of intended urgency as the level of urgency the alarm designer intended to evoke and perceived urgency as the actual urgency experienced by the alarm user.

Numerous researches have been done toward the influence of specific acoustical properties of alarm design on the perceived urgency [7] [8]. Audio designers may be tempted to utilize a 'rather safe than sorry' rhetoric when inducing urgency in their sound design [9] [10]. This leads directly to environments in which alarms demand a cognitive load from their users that is larger than strictly necessary [11].

For this reason multiple writers call for greater consideration of context in alarm design [6] [12]. the statement can be made that the acoustic properties of alarm designs should be tailored toward an appropriate amount of intended urgency for their respective context. In order to show the influence of context on appropriate ranges of urgency a research is executed in which participants create alarm designs that they find appropriate for given situations. Afterward the design signals will be compared to see if the result contains differences between the selected contexts.

This research is not meant to uncover significant statistical relations but is rather meant as an eye-opener for alarm designers and is to provide them with starting points for designing more appropriate urgent alarms.

METHOD

Participants

A total of 10 participants partook in the study. Their ages ranged from 20 to 30 years. None of the participants had previous experience with auditory acoustic experiments.

Stimuli

First, acoustic parameters that are proven to influence perceived urgency are selected. The following parameters were selected: pitch, pitch range, between pulse interval (also known as Inter Onset Interval) and between signal interval [7] [8] [10] [13] [14]. It is assumed that alarms that contain a higher pitch and pitch range will be perceived with higher urgency and that alarms with a higher between pulse interval and between signal interval will be perceived with lower urgency.

A soundboard is designed that makes it possible to manipulate these acoustic parameters manually while keeping other properties in the form of a typical alarm. A typical alarm is defined as a repetitive signal where the signal consists of four consecutive pulses with a heightened pitch in pulse two and four. Alarm rich contexts are selected that differ greatly in the criticality rate of the contained alarms. The selected contexts are: Intensive care department of a hospital, IT department and a household. For each context, 3 situations are defined that are assumed to range from low to high criticality. The selected contexts and situations can be reviewed in figure 1.

1.	**Intensive care**	**Criticality**
1.1.	Backup-battery needs to be replaced soon	**Low**
1.2.	Patients' blood pressure is above normal standards, needs to be checked	**Medium**
1.3.	Heart has stopped, reanimation is needed immediately	**High**
2.	**IT department**	
2.1	Incoming email	**Low**
2.2.	Incoming call	**Medium**
2.3.	Server is overheating, immediate action needed	**High**
3.	**Household**	
3.1.	Washing machine is ready	**Low**
3.2.	Oven is ready, needs to be turned off soon	**Medium**
3.3.	Dish is burned, immediate action needed	**High**

Figure 1. The selected contexts and situations.

Apparatus and setup

For operational convenience, the testing took place in the work and home locations of the participants. They were seated in front of a laptop and used the soundboard with a Gerrard Street headphone (Model Bird) on a volume level of approximately 75 dB (see figure 3). The ambient noise in all rooms was reduced to acceptable levels. The soundboard was designed in Max MSP 7 (see figure 2).

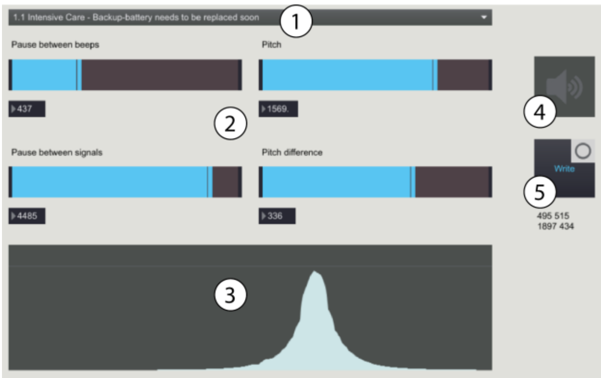

Figure 2. The soundboard contains 4 sliders to manipulate the acoustical parameters (2), a spectroscope as visual feedback of the heard sound (3) and buttons for selecting tasks (1), toggling the sound (4) and writing the data to the logbook (5).

Procedure

Participants were individually tested. At the start the participants are explained what is expected of them and how they can manipulate the alarm using the soundboard. The participants are then given control of the soundboard and are asked to create an auditory alarm that they would find appropriate for the given context and situation. When a participant is satisfied with the design they push the 'write' button to register their data to the logbook and then select the next task. This process is repeated until an alarm design is made for all context situations. Since participants were free to spend as much time as they wanted per task the length of each individual test was depended on the speed of the participant but had an average of 11 minutes.

Figure 3. A participant during the study

RESULTS

Difference between the contexts can be observed in figures 4 to 7. The acoustical parameters pitch and between signal interval show the biggest differences between the contexts.

The resulted urgency from pitch difference does not seem to have a very clear relation. Multiple participants noted that they related pitch difference to the meaning of the alarm rather than the urgency. Perhaps this parameter can be reserved for that purpose.

Considering all parameters we can conclude that the context of the intensive care requires the most urgent sounding alarms according to our participants.

The parameters between pulse interval and between signals interval have the most consistent pattern. This confirms the expectations that these parameters are the most influential on urgency. The urgency of the alarm becomes less as these intervals become greater.

Alarms that are meant for a household situations do not necessarily seem to call for lower urgency alarms than the other two contexts. This is against the expectations of the author.

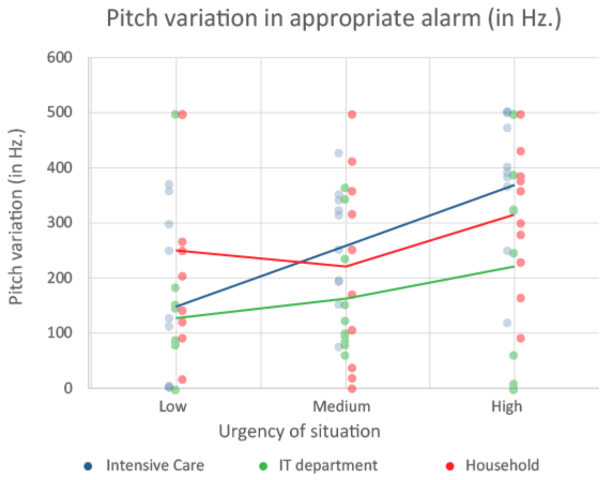

Figure 4

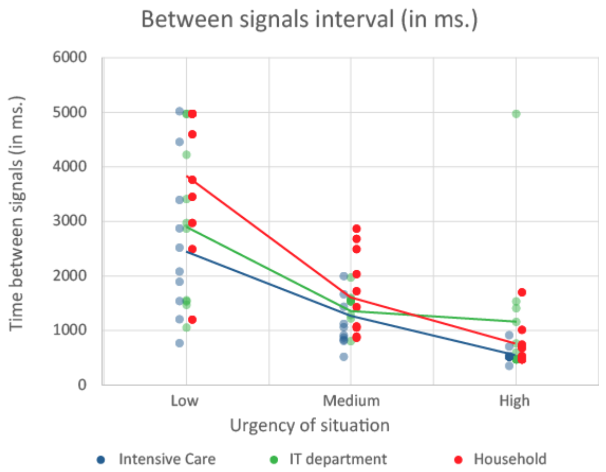

Figure 5

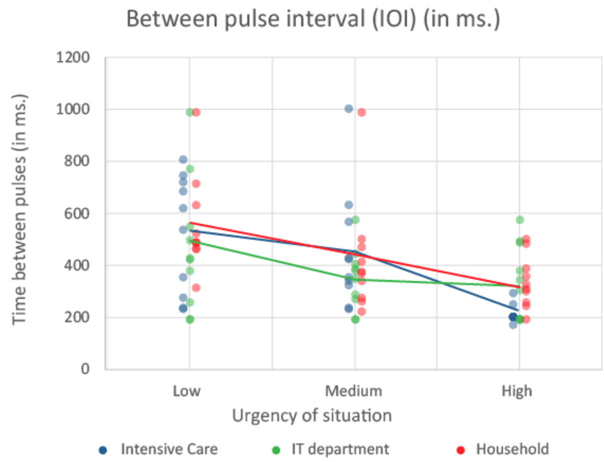

Figure 6

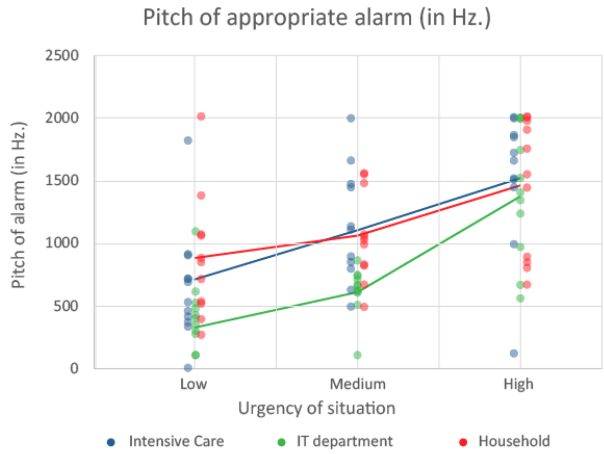

Figure 7

DISCUSSION

Although the results of this research may be useful for alarm designers and researchers there are a multitude of ways in which this research could be redesigned to result in more accurate results or be supplemented to create a more complete image of the influence of context to the perceived urgency.

The volume of sound is a substantial factor in perceived urgency and was excluded from the research design because no practical way could be devised to guarantee exact volume measurements. If volume is to be as a part of the research the volume of background noise in the test environment should be added to compensate. In this research volume was kept constant over all tasks and participants.

Situational awareness has been shown to influence perceived urgency. This could lead to alarms requiring even lower amounts urgency to serve their purpose. [14]

Participants are asked to imagine being in a context that they are not familiar with. It could be argued they are not capable of assigning the right urgency to the criticality of the situation. However, the implications of not adequately responding to the alarm are communicated to the participant which gives a fair indication of the situational criticality. Furthermore, the perceived urgency has been shown to be mostly universal both cross-cultural and across different occupations [12].

Considering that hearing is lost with age it might yield interesting results to compare different age groups in future research.

Participants seem to create alarms that tend to be acoustically close to the last design they created. For future research, it might be advisable to randomize all parameter values between each task because it is suspected that participants are subject to ‘anchoring’ or more specifically: starting point bias [15]. The order of the tasks can be randomized to minimize a possible learning curve.

CONCLUSION

To achieve better living and working environments alarm designers should inform themselves about the desired range of urgency that is appropriate for the alarm users in that context. Acoustical properties can be the primary way in which these designers can stir their auditory designs toward a more appropriate urgency level. The values that were derived were derived from the research can serve as a starting point for achieving this goal.

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