Listening Types in Operation Theatres

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Listener sonic needs in operating theaters

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ABSTRACT

Some operation theaters entail excessive noise, which poses physiological as well as psychological risks to the medical staff. This can also affect the patient's wellbeing, as sound affects the medical staffs' work performance during surgery. This observational study investigated medical staffs' sonic needs in operation theatres to understand how professionals listen and interact with sound in complex sonic environments by virtue of their listening role and individual workflow. We adapted the framework of Truax's [1] three listening attentions to the context of operating theater soundscapes and augmented the framework by two additional "listening interactions" by considering the sedated patient (the exposed with "no-listening-attention") and the primary sound producer (main focus of listening). Two streams of listener hierarchies were analyzed: From the perspective of performing the surgery (e.g. surgeon) and the perspective of monitoring the patient (e.g. anesthesiologist). These two perspectives also determine the listening roles of other medical staff, as teams are subdivided to assist the two sound users (e.g. scrub nurses assisting primarily the surgeon, while the circulating nurse also assists the anesthesiologist). Depending on the procedure steps during the surgery, listeners can move in-between those listening types, but mainly they stay in their role. Identifying the different listening types supports the understanding of individual concerns and needs on sound and soundscape management depending on the profession.

1. INTRODUCTION

While operating theaters often contain numerous advanced technologies, they are also a place where high levels of noise can be found. Almost 50 years ago, noise in operating theaters was already described as the "third pollution" while the problems of air and water pollution were already solved [2]. It is still existent in present-day operating theaters. Trends and technological developments have even contributed to an increase in noise [3]. Being exposed to loud sounds entails not only physiological risks (e.g. hearing loss, tinnitus) but also risks of psychological discomfort (e.g. stress, fatigue, distraction) [4]. As operating theaters are of utmost importance to assure public health, a holistic investigation of this complex sound environment is essential. In this research, we followed a soundscape approach.

According to ISO 12913-1 [5], a soundscape is "an environment of sound (or sonic environment) with emphasis on the way it is perceived and understood by the individual, or by a society". There are two approaches that go hand-in hand to assess sound perception: Analyze the acoustic situation through various sound parameters (e.g. sound measurements) and assess peoples' sound interactions and their sound experiences (e.g. through observations and interviews). Already performed sound measurements show that some orthopedic operating theaters bear particularly high sound levels [3], [6]. But there is a lack of evidence in current literature on how the medical staff uses sound and "listen" in operating theaters.

Hearing is an involuntary, physical process that happens naturally, even when someone is asleep. Listening in contrast (i.e. sound perception) is an active mental state, where acoustic signals are analyzed, acoustic patterns are recognized and the information contained is processed in order to recognize the meaning and consecutively interact with the environment [7]. Thereby, sound perception is especially important for orientation as well as for communication with other individuals. According to Truax [1], there are general distinctive layers of listening or acoustic attention. He has defined three in the context of everyday environments: listening-in-search, listening-in-readiness, and background listening.

The highest level of attention is called "listening-in-search". It is a "fundamental process by which meaning is applied to sensory experience" [8]. It means that individuals are intentionally scanning the soundscapes for a sound that is important to them to perform their tasks. By recognizing and classifying noise patterns and comparing similarities in patterns, people can interpret sound sources to understand their surroundings.

"Listening-in-readiness" is the state in which the attention of listeners' is "ready" to receive important information. Since the sense of hearing allows multitasking through pattern recognition and interpretation, listening can be performed while a person is concentrated on something else, for example on a visual task [9]. While recurrent, regular sounds can be masked out easily requiring little cognitive attention, a considerable change in the sound situation will alert the individual and will almost immediately receive their attention [9].

The lowest level is "background listening". It means that people are not at all actively paying attention to what is happening sound-wise. They are not directing their attention to a sound to "achieve any practical purpose" [10]. But still, since they are part of the situation, they might be able to recall the sound later on [7].

But how listening is performed in orthopedic operating theaters has not yet been studied, which is why this observational study is focused on assessing medical staffs' sound interactions.

2. METHOD

The observations for this study were performed as part of a larger research project of the Critical Alarms Lab, TU Delft. This observational study is focused on assessing medical staffs' sound interactions. The observations were used to understand the listening roles of medical staff in orthopedic operating theaters. The above-presented listening attention types were applied as a primary guideline for the observations. To understand and categorize medical staff members according to their listening attentions, we captured common sound sources in orthopedic operating theaters (see Figure 1). The observations took place in three different hospital facilities and operating theaters in the Netherlands, all featuring orthopedic surgeries. The design researcher attended a total number of 12 orthopedic surgeries (e.g. total hip replacements, knee arthroscopies, osteotomy of the lower leg) spread out over multiple days. The surgeries lasted on average 1,5 hours. Due to privacy concerns for the patients and the medical staff, no pictures were taken. Instead the situations during the surgeries were captured through sketches and notes.

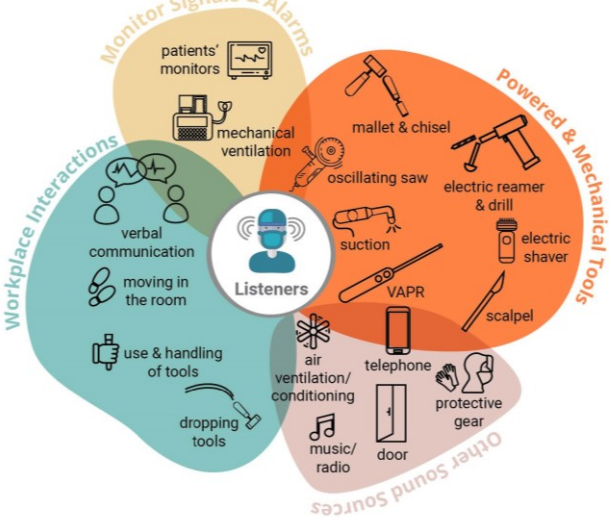

Figure 1. Sound sources in orthopedic operating theaters

3. RESULTS

The various sound sources contributed to the soundscape at different points of time, duration, repetition and intensity. Sometimes, multiple sounds from sound interactions also occurred simultaneously. Nevertheless, individual listeners only reacted to or interacted with one the sound sources, dependent on their professional role (e.g. anesthesiologist reacts on monitor signals while the hammer is used by surgeon). Taking into account that sounds occur simultaneously, two streams of listener hierarchies were observed within orthopedic surgeries (see Figures 2 and 3), the perspective of performing the surgery (e.g. surgeon) and the perspective of monitoring the patient (e.g. anesthesiologist).

As a consequence, the listening roles of the medical staff differ. The individuals focus their attention to sound events that are relevant to them. The anesthesiologist primarily listens to the patient's monitor, while the surgeon primarily listens to the sound situation at the operating table (e.g. feedback from tools). However, these two listening-attention types sometimes interrupt each other, for instance, if there is a lot of noise at the operating table (e.g. through tool use), overlaying the signals from the patient's monitors.

During all observed surgeries the patients were sedated. But as the patients ears are still exposed and at possible risk to sound damage through the sound situation, they are referred to as "the exposed" in the presented frameworks. Nevertheless, the role of the patient was not further elaborated in this study.

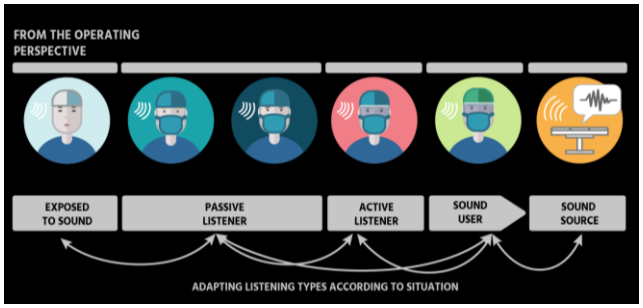

Figure 2. Listener types from the operating perspective

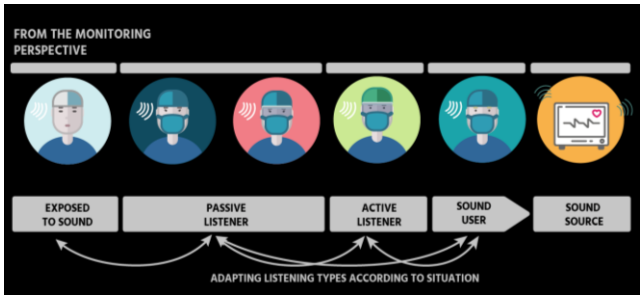

Figure 3. Listening types from the monitoring perspective

Consider an example from a medical staffs' perspective for "listening-in-search" or sound user (see Figure 4): A surgeon listening for the specific sound of a medical device (e.g. drill) to verify that it is performing the desired action. The surgeon requires this acoustic information, whereas the anesthesiologist requires auditory signals from the patient's monitoring systems and derives no use from the sound of the drill, meaning that it is rather obstructive for him or her. Therefore, the

anesthesiologist is a passive listener for the drill. But the anesthesiologist is "listening-in-search" for the patient's monitor signals, whereas the surgeon is a passive listener for those signals during the use of the drill.

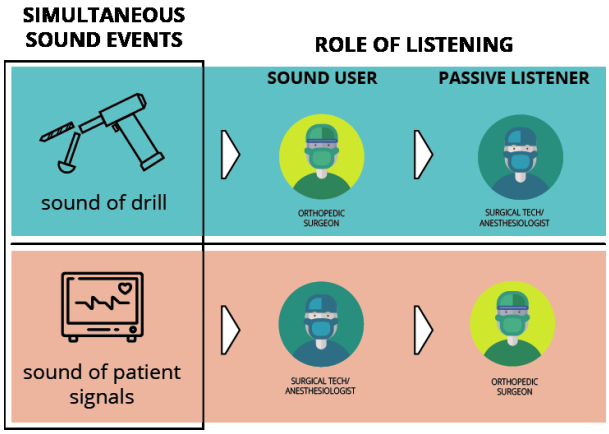

Figure 4. Differing listening roles in one sound situation

Another finding is that the sound producer has the benefit of knowing when to expect the occurrence of sounds (e.g. starting to cut a bone), while the anesthesiologist is not aware that this sound event is about to happen.

Although a general distinction between the listeners can be made, listening types may fluctuate according to the situation within the surgery (indicated in Figure 2 & 3 as arrows). For example, when scrub nurses are performing a step in the procedure (e.g. use of the suction device), they will become sound users themselves, but will most likely switch back into active listening mode after the step has been completed. The only listener types not fluctuating are the sedated patients. If not sedated, they may become passive listeners.

4. DISCUSSION AND CONCLUSION

This study aimed to observe and provide an overview of sound-related aspects that need to be considered in the complex sound environment of orthopedic operating theaters. Previous literature showed that some operating theaters produce high noise levels [3],[6]. With this study, we do not aim to propose solutions to the noise levels, but to take a step back, understand the overall sound situation and start a conversation to increase awareness of the existence of this complex soundscape.

In orthopedic operating theaters, several different professions work side by side. As tasks differ, listeners are prioritizing individually to which degree they pay attention to the varying auditory information arriving from the soundscape. In virtue to their role, listeners selectively use acoustic information by focusing their attention to specific, desired sound sources. Amending and adapting Truax's [1] listening attentions to operating theaters, five listening types were identified: "No-listening" by exposed listeners, "background listening" by passive listeners, "listening-in-readiness" by active listeners, "listening-in-search" by sound users and "listening-and-acting" by sound producers.

As the focus of listening to the same sound situation differs, we conclude that the sonic needs of the listeners also differ, leading to different sound perceptions of the overall sound situation. Listeners pursues different listener goals (e.g. focus monitoring the patient, performing the surgery) and by that also has different sound sources that they aim to hear best. Given this, we conclude that sonic needs differ between the listeners. Sound events arriving from the different streams can interrupt individual workflows, possibly leading to distraction for some listener types. But to assure that all listeners receive the acoustic information or the auditory signals they depend upon, further research with medical staff is required. With these frameworks we provide a first guideline that can be used to categorize and examine the impact of individual sound sources on the medical staffs' listeners.

5. REFERENCES

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