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Conceptualising sound-driven design: an exploratory discourse analysis

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ABSTRACT

Sound-driven design is an emerging, human-centered design practice informed by technology and listening in the multisensory dimension of interaction. In this paper we present a discourse analysis approach aimed at qualitatively understanding the constituent concepts of such a practice, by means of semi-structured interviews with sound designers, design researchers, engineers and expert users in the context of critical care. Preliminary results show that sound-driven design is inherently embodied, situated, and participatory, that the four categories of interviewees equally contribute to the definition of the design problem, and yet that a clear, shared arena is still missing.

CCS CONCEPTS

• **Human-centered computing** → **Interaction design theory, concepts and paradigms**; *Participatory design*; • **General and reference** → Surveys and overviews.

KEYWORDS

Sound-driven design, discourse analysis, design methods, design research

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1 INTRODUCTION: THE SOUND / SONIC / SOUND-DRIVEN TRANSITION

Machines, and artefacts in general, have been long imagined as conversational agents. At present we can request many services by voice, and yet we largely rely on noises of many kinds to steer our everyday interactions. Either intentionally designed or as by-products of mechanisms and processes, non-speech sounds are an essential presence in our contemporary environments. In the past two decades we have witnessed several paradigm shifts and reframings in the area of sound design and computing, that is from the how to model and generate sound (and music) through computational approaches to its societal commitments [24], its areas of intervention and the role of practitioners [39].

Sound design as a label encompasses wide fields of applications, from films, video games and performative arts, to functional, yet pleasant uses of the auditory channel to support actions and encode information in multisensory interaction [13, 31], essentially in computation-enhanced products and environments such as the home, the car, the hospital, public spaces and so forth. In this paper, we use the sound design label to signify this latter area of intervention. In this context, sounds typically take the shape of notifications and alerts or continuous sonifications for peripheral to focal monitoring [18, 25, 32, 37]. Hence, sound design represents a rich, multidisciplinary area of expertise in which diverse knowledge converge, including psychoacoustics, engineering, computer science, psychology and interaction design [23].

Overall, the problem of designing sound, in contexts which are inherently interactive and multisensory, is to reach a consensus on the meaning of the listening experience [1], and to make sense of the so-called semantic gap between our daily meaningful experiences with sound (i.e., proximal representations, as they appear to our senses and form auditory mental images) and the encoded physical energy of sound (i.e., distal representations, as they exist in the environment). In this respect, it has been advocated the central role of the human body as bridge between the distal (source-related) and the proximal (sensory-related), towards a process of sound creation that has been renamed as embodied sound design [8].

These general considerations reflect an ongoing transition from designing the sound of things, to interactions with sound (i.e., sonic), to embryonic, socio-technological approaches to sound issues as driver for innovative design solutions (i.e., sound-driven): The difference is not subtle and reflects a proper shift from a *design-oriented research* towards a *research-oriented design* [12]. The first aims at producing a corpus of cumulative knowledge and consensus around sonic interaction phenomena. Here, sonic interactive artefacts are sketched and developed as means to understand how sound and action intertwine to shape dynamic relationships between humans and objects [30].

In the second, the perspective is flipped, the main motivation is not the production of knowledge, although it stays implied, rather the emphasis is on the artefact or the intervention, which show a higher degree of completeness and represent the main outcome and goal [4, 29]. In this respect, `Olo Radio`, a music player that supports and sparks reflective and memory-oriented experiences, allows to explore one's own archive of personal listening history data [27]. `Heart Waves` is a heart rate monitoring device, composed of a pulse sensing wristband and a variable speed water system, to reduce anxiety by means of the sound masking effect of the

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increasing water stream [10]. Vita is a pillow-like sound player that exploits everyday sounds to promote conversation, playfulness and connection between people with advanced dementia and their caregivers [20].

Apparently, the health and well-being fields represent a promising arena for sound-driven design, as a design practice that aims at seamlessly being societal in its expression, and yet grounded within a larger network of research disciplines. In the context of critical care, a soundscape design and patient-centered approach has been used to analyse and assess the ecology of noises and actors affecting the sleep quality of critically ill patients in the ICU, and to provide lines of intervention to promote sonic awareness, improve the alarms management, and support the patient's familiarisation with the ICU sonic environment [3]. Similarly, a design framework informed by principles of multisensory integration has been proposed in order to reduce noise fatigue, deliver more meaningful clinical information, and improve the patient outcomes [4].

A sound-driven design process must inevitably face the abovementioned semantic gap problem, which pertains to how people talk about sound, and how they communicate and externalise the sonic experience. This is relevant not only to probe the extent of the sound-driven design inquiry, but also to develop appropriate representational competencies and tools, from sketching to prototyping, that are instrumental to the understanding of the users' experience, making discoveries and creating concepts. This is even more relevant when multi-stakeholders are involved in multidisciplinary, co-design activities [28].

In this paper we present a discourse analysis approach aimed at qualitatively understanding the constituent concepts of sound-driven design, by means of semi-structured interviews with sound designers, design researchers, engineers and expert users in the context of critical care. The rationale of the interview script is to stimulate the participant into self-reflections 1) on the personal experience of sound in their own working environment, 2) on the expression and sharing of sound concerns to others, and 3) on imagining solutions and alternative uses of sound. Hence, the discourse analysis is aimed at shedding light on 1) what people actually mean and refer to when they talk about sound and 2) how they represent it, and 3) locating opportunities for design.

In this contribution, we offer an understanding of the global picture emerged from the analysis of 10 interviews. This work is relevant to probe the method of inquiry, and it is currently ongoing towards a larger collection of interviews. Whereas the discussion is currently focused on the critical care context, we expect that the inclusion of participants from other fields will produce coherent maps of increasingly abstract concepts and themes evoked by sound.

The paper is organised as follows: in Section 2, we reason about the significance of integrating non-verbal, auditory expressions and representations in design cognition studies; in Section 3 we introduce our study and discuss the rationale of the discourse analysis approach; the interview structure and method are reported in Section 4, whereas the interpretive analysis of the results is discussed in Section 5. Finally we draw the conclusions and provide implications for our ongoing research agenda.

2 A CALL FOR SOUND-DRIVEN DESIGN COGNITION STUDIES

Design cognition studies focus on the mental processes and representations involved in designing. This is a wide area of design research, concerned with two main subjects, that is the understanding of designing itself, and the methodologies and analytical means to evaluate cognition [16]. Understanding design thinking is ultimately aimed at improving the outcome of designing, by means of better tools and methods for designers, enhanced design learning processes, and more effective design research methodologies. In this respect, it has been argued that the future generation of CAD tools will be informed by cognition, collaboration, concepts and creativity [15]. Traditionally, the study of the design process has been carried out by means of qualitative approaches, including protocol analysis and controlled experiments, within ontological frameworks of design [17]. Smart environments and tools to support the exploration of protocol data are typically limited to the acquisition of video recordings and verbal transcripts, although designing is inherently multimodal and includes at least talking, writing, drawing and gesturing [9].

More recently, the increasing availability of off-the-shelf technologies for physiological sensing allowed design researchers to measure design reasoning and creativity by looking at eye movement, galvanic response, and heart rate variability. VizScribe is a visual analytics tool that allows designers to produce interactive visualisations of protocol data, such as video, transcripts, sketches, sensor data, and user logs [6]. In addition, neurocognition studies are progressing to investigate links between design cognition and the brain activity [14].

These represent significant advancements, yet they betray an account of designing mostly focused on the visuo-spatial dynamics of the activity. In this respect, we advocate the urgency to integrate the inquiry of non-verbal, yet auditory expressions and representations in design cognition studies. There are tentative and sparse signs in this direction. Studies on sonic sketching are emerging [26], in particular regarding the use of the vocal apparatus as means to draft quick and economical representations of sonic interactive systems [11]. Protocol analyses of vocal sketching sessions investigated the use of voice as embodied tool, in the tension between generating sound and externalising sound-driven ideas and concepts held in the mind: It has been shown how the use of utterances, in combination with verbalisations and gestures, fosters communication and collaboration in multidisciplinary sound design teams [7].

A visual analytics and interpretive approach has been used to code the sound design process, in terms of project types, occurring activities, phases, overall structure, dynamics, and social exchanges: Overall, sound design emerges as a rather engineering-oriented, individual practice kept separate and asynchronous from the global design process. Creativity unfolds linearly to fulfil the expectations of clients and stakeholders, whereas iterations and evaluation take the shape of general approval or judgement on how well a sound work is received [21].

A survey research with crowdsourced questionnaire, sent to more than 100 sound designers in Europe, provided a grounded picture on the profession's identity, including the background knowledge and education, the *modus operandi* and the average projects

timeframe [39]. Finally, sound design tools aimed at covering the semantic gap problem are being explored, especially to empower non-experts to access internal representations of sound and to span vast sound design spaces [8]. A lexicon of 35 verbal descriptors of the salient morphological characteristics of sound (i.e., basic psychoacoustic features, timbre, and temporal descriptions) was validated and conceptualised in a pack of cards as well in a software interface to facilitate the communication between sound designers and non-experts [5]. `Co-Explorer` is a software tool that exploits reinforcement learning algorithms to enable creative human(s)-machine partnerships in the exploration of high-dimensional, parametric sound spaces [34].

These works provide evidence of a fertile and active ground of inquiry, yet they mostly embrace the perspective of the sound designer only, and are positioned on the periphery of research in design cognition and creativity. In our study, we take a step back and equally consider (sound) designers and stakeholders to make sense of designing with sound. We exploit the critical care as starting context to ground our reasoning, understand how far an approach informed by listening can propagate in design projects, and ultimately grasp the inner meaning of a design process driven by sound. To do so, we use a topic modelling approach to explore the textual data in the interviews, by using `Leximancer`[1], software for automatic content analysis and text analytics visualisation. In the next section we briefly discuss the rationale behind the choice of using this software environment, and then we report the study and our findings.

3 FARAWAY, SO CLOSE, LOOKING AT THE UNEXPECTED

Computer-aided Qualitative Data Analysis Software (CAQDAS) have become increasingly popular in social sciences and design [38]. They are used to support the researcher in the understanding of complex phenomena, typically by providing semi-automated coding of video, transcripts, and document data, and by assisting their interpretation by means of interactive visual analytics. Whereas the discussion of existing CAQDAS environments is beyond the scope of this paper, we point out that the choice of the tool is not exempt from ontological and epistemological considerations.

Computer-assisted environments for qualitative data analysis can be broadly split in two main categories, that is tools that emphasise and require the researcher's intervention in handling the data (e.g., `NVivo`[2], `Atlas.ti`[3]), and tools that produce automated analysis based on textual statistical properties, like `Leximancer` does. Compared to the first class of tools, `Leximancer` is potentially more objective, as the automatic creation of concepts lists removes the researcher bias coder reliability and subjectivity, it allows a rather exploratory style, especially when an *a priori* model is not available, and yet it may return unusual or unexpected relationships within data [36]. The system seeds concepts as list of lexical terms that are ranked according to their frequency of occurrence, then a thesaurus is built and concepts are defined as collections of terms that travel together within the text. Finally, highly connected concepts are clustered in higher-level groups, defined as themes [35]. However, the environment allows the researcher to intervene in the various stages, and add or remove seeds, and manipulate concepts. Clearly, the automatic analysis does not replace the role of the researcher, instead the aim is to uncover networks or patterns that may have not emerged in more traditional approaches to qualitative analysis, which is the present case.

In our ongoing study, we aim at systematising and understanding what the concept of sound stands for in current design practices, especially when non-experts are involved, and at stressing implications for future design research directions. Similar approaches based on natural language processing, although across time, have been used to examine how the notion of interaction evolved over 35 years of proceedings from the ACM Conference on Human Factors in Computing [19], and how the concept of interactivity progressively linked to empowerment, as dominant mode of interactivity, across 20 years of print media [2].

[1]https://info.leximancer.com/.
[2]https://www.qsrinternational.com/.
[3]https://atlasti.com/.

Table 1: Left: the bold digit indicates the number of participants per field. Right: the individual expertise of the single participant per field.

Field	Expertise
Sound Design: **3**	[1] Sound art, medical alarms sound [2] Audio branding, music composition [3] Automotive HMI, music composition
Design Research: **3**	[1] Virtual reality, critical care [2] Research policy and management [3] Sound design, interaction design, music education
Engineering: **1**	[1] Medical alarms software and standards
Critical Care: **3**	[1] Critical care nursing [2] Intensive care, neurosurgical nursing, education [3] Intensive care and anaesthesiology, education

4 INTERVIEWS

Our goal is to develop a more grounded understanding of the sound-driven design process, by discovering relevant themes in the analysis of interviews with diverse categories of actors involved in the design process, including (sound) designers, design researchers, engineers, and expert users from different fields. We start by looking at the specific context of the critical care, wherein noise fatigue, alarms compliance, patient's monitoring and hospitalisation represent major relevant design issues.

4.1 Method

We interviewed 10 professionals (mean age = 45.2; SD = 9.0; mean years of experience = 16.5; SD = 5.6), whose fields and individual expertise are reported in Table 1. The candidates were invited via email, and provided in advance with the information sheet and the informed consent form to be signed and sent back before the interview. The interviews were held in English and took place remotely on `Zoom`,[4], to take advantage of the automatic audio transcript functionality. Each interview had a duration of 40 minutes

[4] https://zoom.us/. This option was made necessary to cope with COVID19 restrictions.

Table 2: Interview script: Q1 and Q2 stimulate analytical reasoning on the sonic matter and its communication respectively, whereas Q3 represents the synthesis phase.

Q1:	- Which role does sound play in your working environment? - How does sound affect your daily routine and tasks?
Q2:	- Have you ever been involved in designing with others? How? - How did you manage to express and share your ideas on sound to them?
Q3:	- If you had a magic wand that could fix two things in your experience, which would you choose?

on average. The transcripts data underwent a clean up, including full anonymisation, the editing of transcription errors, basic text processing (e.g., stopwords removal), and were fed to `Leximancer`. In the concept coding settings, we removed the data relative to the interviewer's dialogue.

A few caveats must be acknowledged. First, the population is limited in number and, secondly, the category of engineers is clearly unbalanced. Thirdly, the interviews were held in English, yet only two participants were native speakers. The average English speaking confidence and skills were of good level, nonetheless we observed a reduced vocabulary richness in non-native speakers, which may have hindered their ability to fully express their opinions. Although we cannot draw conclusive results, yet we could test positively our method of inquiry and stress relevant implications for the ongoing collection of interviews and future research in sound-driven design.

The interview is arranged in 3 questions, preceded by a short introduction by the interviewer and a presentation of the interviewee. To keep a neutral distance from the categories of interviewees, we scripted the interview in order to prompt the participants on 3 main aspects of the sonic experience: 1) the long-term experience in the daily working environment (Q1); 2) the ability to describe the perceptual experience of sound and share it to others (Q2); 3) the creative possibilities triggered by sound (Q3). The corresponding 3 open questions are detailed in table 2.

In the next section we discuss the major themes emerged from the analysis of the transcripts. Eventually, understanding the shared and peculiar mindsets of the 4 categories of participants towards sound is instrumental to achieve a more inclusive and effective design process.

5 RESULTS AND DISCUSSION

The software coded 665 text blocks, and found 73 concepts across the 4 categories (i.e., sound designers, design researchers, engineers, medical staff). Figure 1 shows the 2D heated map of themes (i.e., higher-level clusters of most prominent concepts), and concepts arranged as nodes in a network. The connections in the map provide pathways to navigate the concepts. For instance, following the blue line in Figure 1, we can trace the path [knowledge ↔ fatigue], by passing through [design → sound → technology → alarm], back and forth. The position of the four categories tagged in red on the map is a coarse indicator of their connectedness and proximity to the themes.

A synopsis is shown in table 3, with the themes ranked according to their relevance and their main constituent concepts. The themes' name reflects the most ranked concept, that is the theme `sound`, for example, is named after the concept "sound" which is the most ranked among "design", "use", "important", "talk", "improve", "algorithms", "environment", "understand", and "role". The values in the Hits column refer to the number of text blocks in the data, associated with the theme. `Sound`, `alarm` and `people` are the most relevant and rich clusters of concepts, whereas the remaining are formed essentially by the corresponding concept and show a limited occurrence in the data. These themes are peripheral and represent peculiar, focused viewpoints that the 4 categories of participants brought in the interview. In the following, we offer readings and research suggestions that we want to investigate further, as the collection of interviews develops.

Table 3: Themes are ranked according to their relative importance, based on the number of text blocks associated to the theme. For the less relevant themes, the top 4 related concepts are displayed, and the most contributing category. Bold values in brackets indicate the text co-occurrence counts of the most prominent concepts.

Themes	Hits	Concepts clustered		
`sound`	342	sound (**290**), design, use, important, talk, improve, algorithms, environment, understand, role		
`alarm`	201	alarm (**94**), patient, situation, device, problem, monitor, noise, mobile phone, nurse, standards committee, ventilator, system		
`people`	162	people (**55**), ideas, feel, process, experience, describe, ability, visual, play, participatory		
			Top 4 related concepts	**Profiling**
`music`	27	music	*wish, culture, facilitate, education*	sound designers
`information`	12	information	*wish, senses, ethical, participatory*	medical staff, sound designers
`knowledge`	11	knowledge, describe	*intention, vocabulary, communication, describe*	engineers, design researchers
`manufacturers`	7	manufacturers	*understand, standards committee, noise, describe*	engineers
`listener`	5	listener	*visual, improve, algorithms, use*	sound designers
`diagnosis`	3	diagnosis	*situation, monitor, patient, sound*	medical staff
`behaviour`	2	behaviour	*idea, design, people*	design researchers

5.1 Peripheral themes

Trust and meaningfulness in sonic information seem to represent major concerns for both sound designers and medical staff. **Sound**

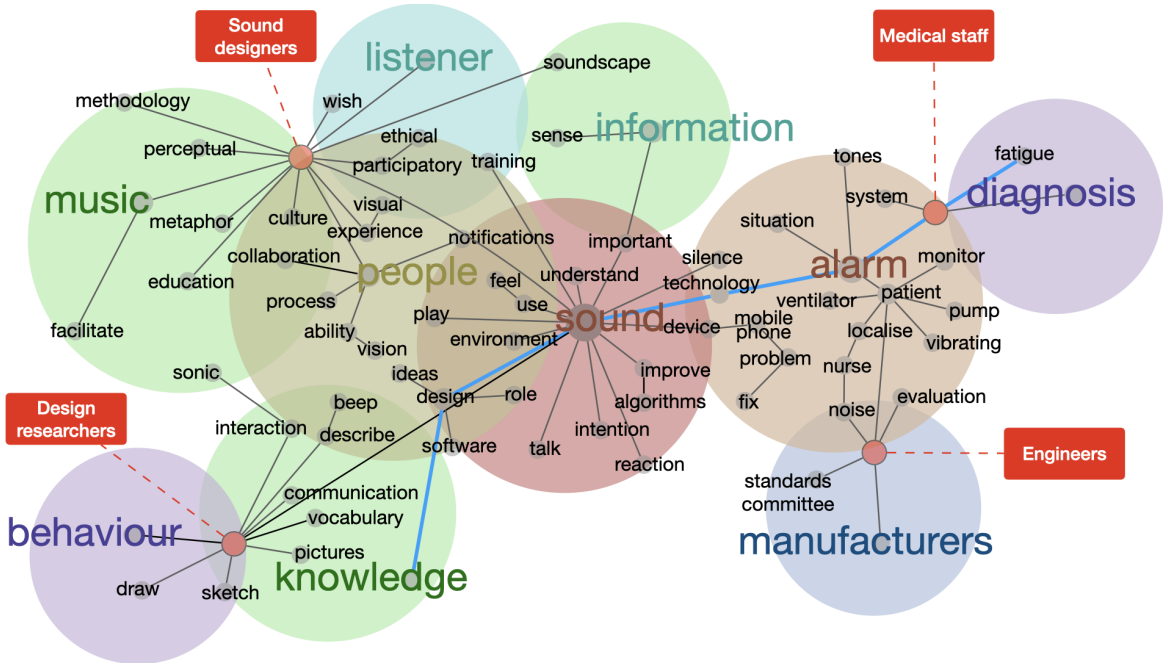

Figure 1: Topical map of discovered concepts. Clusters are displayed as heated circles. The blue line shows an example path to navigate the map.

designers emphasise the relevance of a basic education and training in sound and music, as means to facilitate the collaboration with stakeholders. They are very concerned about the `listening` conditions, how visuals intertwine in the experience, and more in general how it affects the sensory `information`, because "in presenting a sound you're instantaneously changing someone from being a passive reactive listener to an active listener in that moment, and that changes the way we hear a certain sound". In this respect, this concern is shared with the **medical staff**, who makes use of active listening "to assess the situation of a patient, listen to blood vessels and lungs, and use percussion to use the resonance of the abdominal cavity", as part of a `diagnostic` examination. On the contrary, patient's monitoring by means of alarms seems rather perceived passively, whereas false information, that is non-actionable alarms, represents a major cause of `fatigue`. Nonetheless, "the alarm functions for large part reassure you that the patient is being watched, not in person, but by the system".

The **engineers** stress the central role played by `manufacturers` in dealing with the nurses' expectations, including ways to delegate alarms to the correct person, as well as understanding the adequacy of use of identical, standard solutions between competitors. This whole ecosystem of sound-driven issues requires a whole new integrated `knowledge`, that **design researchers** are looking at.

Whereas these topical considerations are quite straightforward, we are more interested in exploring the emerging meanings in the most relevant clusters, that is the themes of `sound`, `alarm` and `people`. We look at the co-occurrence of the most prominent concept (i.e., `sound`, `alarm` and `people`) with the other most ranked concepts forming the theme, and inspect the corresponding blocks of textual data.

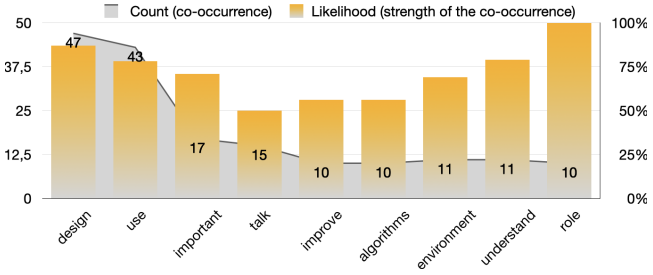

Figure 2: Co-occurrence of the top ranked concepts in the sound theme.

5.2 The sound theme

The red circle in Figure 1 shows the most prominent conceptual connections with "sound", namely "design", "use", "important", "talk", "improve", "algorithms", "environment", "understand", and "role". These are the concepts that mostly travel together when "sound" is discussed in the data (co-occurrence), and that at the same time are very likely to include "sound" when they are individually considered (strength of the co-occurrence), as shown in the chart in Figure 2. For instance, "sound" and "role" co-occurred only 10 times, yet when the "role" concept is discussed, it is very likely that the participants were referring to the "role of sound".

We inspected the text blocks associated to each pair (i.e., sound-design, sound-use, etc.), to interpret meanings that may stand at the intersection of the 4 categories.

The ambiguity of sound – We observe that sound is used by the

participants in a holistic acceptation, as a conceptual placeholder, to mean interchangeably the product itself, the function, the information and its quality, the sound-producing system or device, but also "the presence of things and beings", "the surrounding aspects of how it influences my work", the subjective responses, positive and negative, that it elicits.

Designing sound is not necessarily realising it – There is the belief that sound as a domain can be shaped by design. Designing sound emerges an activity of sensory translation of ideas into audible experiences: "The work is a lot about building languages, systems of sound that help to build narratives or can guide the user", "the most important things we can really put in is empathy or inspiration, [...] to understand the workflow and functionality which lead to certain architectures of sound or design principles".

I use sound to – More interestingly, sound (and silence) emerges as a holistic manifestation of something to use, rather than listen to. Noises and notifications are attractors that may support or hinder the accomplishment of tasks, as well as affect the concentration and the mental state. Sound designers use sound "to probe the people who will be using and hearing them", with the intention of "reducing misunderstandings and enforce directions during a project". Physicians emphasise the hearing sense as means to assess the patient's condition. When coupled with alarms, "the intention of the sound is to say - I have a problem, please come and fix the problem - And it could be both the device asking for assistance or the patient asking for help", yet "these sounds are often associated with redundancy, but they are part of the reassurance that you can turn your back to the patient and go somewhere else".

Sound is inherently systemic – "Providing the use context of sound is important for measuring its impact on people". "We have environments with five, six, or seven equipments nearby the patient, and they all emit their own sound", "when I am in the hospital, my brain switches, and I feel that these sounds are useful, they are there to watch the patient". "I can operate with a much clearer auditory vision, when I'm surrounded by a more peaceful and lower volume environment", "I try to be very mindful of which apps are giving me which sound notifications, [...] but also to have the right level of notification". It is suggested the value of interpersonal communication, not only in terms of methods and appropriate vocabularies to talk about the sound-driven experience, but also in terms of space for communication, social awareness, and well-being. Understanding the context sets the playground for technologies, systems, and better algorithms that sonically cooperate with humans.

Listening to the sound-driven experience – A sound-driven design approach is concerned about the meaning and understanding of the experience driven by listening rather than by sound. " So one way to look at sounds is how functionally people distinguish between those. This is very important, but how they make people feel is a slightly different question that can walk hand in hand. I wish the sound design paradigm could be more inclusive of the human experience as a whole". This requires a more effective collaboration and dialogue between the stakeholders involved at the different levels: "Nurses and physicians are the users, and the manufacturers are the developers. If there had been a cooperation in the past between them, maybe this whole sound problem in the ICUs wasn't there. It is a really conservative industry, bound by regulations, and safety rules. But I think of new designs. I think it should relate where innovation is taking, which is happening in society".

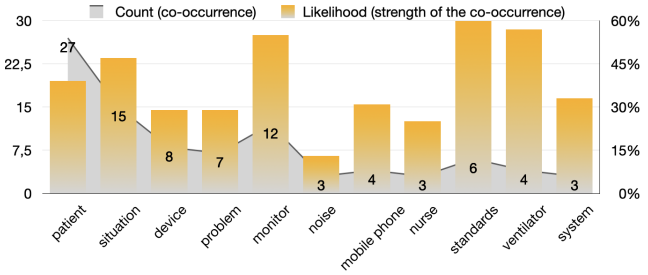

Figure 3: Co-occurrence of the top ranked concepts in the `alarm` theme.

Process-wise, "in the industrial sound design is really more about listening to the other people and trying to understand which is this common idea that is coming out from the brainstorming, so I consider my role to be rather a translator of their vision into sound". "Working with engineers and designers whose expertise is not making sounds, they already have certain vision about their product because that's like their baby for many years. They struggle, but they have a vision".

Sound embodied – Taken together, the sound theme describes a complex space of embodiments of sound, situated activities, and sonic affordances. Yet, there is a whole tacit knowledge that needs to be made apparent and shareable.

5.3 The alarms theme

This theme is more straightforward, highlighting the elements of a sound-driven design scenario, wherein pathways of systemic relationships in the critical care become visible. That was expected, since, as we anticipated, the majority of the participants in this batch of interviews are actively involved in this field. At the same time, this theme provides a clue of how a sound-driven approach can potentially propagate in the design engineering inquiry: One can look at the alarm scenario, in the tan circle in Figure 1, as a whole as well as inspecting the single elements in relationship.

Setting the context, naming the problems – For example, despite the undisputed value of alarms, their real effectiveness depends on the situation in which they occur. "The danger is that you are constantly warned that a situation can be really true. But you'll never know until you check the monitor". Non-actionable alarms represent a major issue in ICU practice. "Alarm sounds are very useful and necessary, yet if the technology is working correctly and the patient is still, but there is a shift of how patients are nursed nowadays compared to years ago. Nowadays we try to wake up and stimulate the patients very early in the ICU. The body movements displace catheters and sensors, thus producing false alarms and that's the challenge in designing alarms or software to cope with those issues". On the other side, "from the standards' perspective, when there is a high priority alarm, it does not matter from which device it comes. The standards would advocate the same sound in such a situation". This apparent conflict is a proper interaction design problem. Strategies and technology-based solutions for alarms

Figure 4: Co-occurrence of the top ranked concepts in the `people` theme.

localisation and delegation represent as well two other relevant design problems in the critical care environment. In this respect, the `alarm` theme provides concrete examples of sound embodiments, as resulting from a sound-driven inquiry.

Sound-driven, human-centered – On a closer inspection of the chart in Figure 3, we notice that patient is the most co-occurring concept, followed by situation and monitor, whereas the nurse concept shows 3 counts only. We infer that the interviewees mostly brought about a patient-centered perspective when problematising on how sound affects their working environment and its communication: "We are trained to recognise alarms, react to them, and place them in the right context. What I would like to see is systems of alarming tailored to the movement of the patients, smart enough to recognise first whether the problems concern the sensors, the movements, the occlusion, etc. and then to produce the alarm", "as a nurse, I have to take care of two or maybe three patients at the same time, but I hear all the alarm sounds from all the patients in the ward. And the patient, especially, does not need to hear all of those sounds".

In the practice, the `sound` theme describes the sound-driven situatedness from the expert users perspective. However, as we plan to extend the future interviews to other application domains, we expect to have more general and abstract concepts that may characterise what a sound-driven design scenario is about.

5.4 The people theme

The `people` theme is more ambiguous and apparently less structured compared to the `sound` and `alarm` themes. As shown in the chart in Figure 4, not only the counts of the top concepts related to "people" are limited, but also their co-occurrence shows a low likelihood. This theme seems rather a collection of individual opinions, particularly displaced towards the sound designers and design researchers categories (see Figure 1).

Participation, ethics, and sonic awareness – These opinions point in different ways to the general need to better integrate users and stakeholders in the sound-driven design process. " I don't consider myself as an author, because it's always a collaboration with many people giving ideas and I try to summarise them". "The bottleneck is to get into testing soon or to trying out stuff soon. I always come back with the experienced prototyping idea that you should, as soon as possible let people hear and interact with it".

The effective inclusion and participation of stakeholders has ethical implications. "Sound, this may be a particularly sensitive area because people are not educated. They will probably not be able to criticise the sound in a sonically educated way, but they will be able to say something about how the sound relates to their actions, if it's meaningful and what it motivates them to do or do not". "Surprisingly a lot of what we end up doing, especially in the healthcare area, is more about helping people to be more aware of sound, rather than actually being able to improve it". "The sense of trust is the most important with people. [...] I wish we can reach more people, and that there was a tool that can make them participate in a way that is really empowering, that they feel they're part of the main chain".

The `people` theme reflects a rather design-centered perspective, particularly focused on the search for methods, practices and tools to empower stakeholders in the active and aware collaboration and communication on embodied sound experiences. In this sense, two main pathways for concrete action emerge from the conceptual map in Figure 1, that is 1) promoting education, sound culture and training, and 2) gaining a better knowledge and understanding about the mechanisms by which humans conceptualise sound-driven experiences.

6 CONCLUSIONS AND IMPLICATIONS FOR DESIGN RESEARCH

We have presented a discourse analysis of a set of interviews with sound designers, design researchers, engineers and expert users, aimed at providing insights on current, emerging design practices informed by sound. We argued for an ongoing paradigm shift from a focus on the *how* to design sound to the *what* to design, wherein formalised designer-client dynamics [39] gives way to participatory and co-creation approaches to designing with sound [33]. We proposed sound-driven design as a label that signifies this wider approach. Yet, the legitimate question is to pinpoint what the *sound-driven* may stand for. Although limited in number, the interviews provide a picture of a design practice which is inherently embodied, situated, and participatory in its aim, and yet not fully resolved. We highlighted a number of emergent topics, in particular we stress the observations regarding the use of the word "sound" as a conceptual placeholder, as a systemic manifestation of something to use, wherein listening occurs as an active behaviour. We aim at expanding the database of interviews and refine the text mining analysis in order to achieve a clearer understanding. At the same time, we consider timely the introduction of the sound matter in design cognition studies.

Two research directions are suggested in the interviews, that is 1) externalising the tacit knowledge of sound experts and making it possibly available and shareable in some kinds of sound sensitising forms, and 2) developing a design-centered understanding of the processing mechanisms of non-verbal sounds and their conceptual representations. In this respect, recent advancements in cognitive sciences have been proposing hybrid models of conceptual representations, grounded in perception and action, and accommodated by hierarchical processing between modality-specific, multimodal and amodal semantic hub regions of the human brain [22]. Put in sound-driven design terms, this implies not only systematising sound categorisation strategies for design purposes, but also mastering how different types of explanations (i.e., representations) can lead to better mutual understanding, communication and learning.

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