DESIGNING FOR SOUND AS A COMPONENT OF PRODUCT EXPERIENCE: DEVELOPMENT OF A NOVEL CONCEPTUAL TOOL

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ABSTRACT

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As a medium of interaction between users and products, the sound emitted by a product plays an important role in people's product experiences. However, in order to enhance user-product interaction, the design of auditory features of products is generally overlooked in the course of design process. This is in comparison with the significant effort spent by designers for the visual features of products. In this context, the purpose of this thesis is to explore the current and future practice of product sound design and to conceptualize a set of suggestions from a 'design for interaction' perspective that respond to auditory interaction opportunities within product design.

The foundational literature review focuses on crossovers between user experience and auditory interaction, whilst also uncovering present thinking and research in relation to the anatomy and classification of sounds, and proposed methods for product sound design. A 'research through design' approach is adopted for the thesis fieldwork, combining the iterative design of a conceptual tool (SoundsGood V1, V2, V3) with feedback and design suggestions generated through interviews and focus group sessions conducted with industrial designers. SoundsGood V3 is proposed as a suitably specified solution to stimulate designers to develop auditory user-product interaction ideas within their wider product design processes.

The thesis concludes with suggestions for the consideration, generation and communication of auditory interaction ideas by industrial designers, in addition to a presentation of the features of SoundsGood V3.

Keywords: product sound design, auditory interaction, conceptual tool design

ÖZ

ÜRÜN DENEYİMİNİN BİLEŞENİ OLAN SES İÇİN TASARLAMAK: YENİ BİR KAVRAMSAL ARACIN GELİŞTİRİLMESİ

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Ses, kullanıcılar ve ürünler arasındaki etkileşimin bir bileşeni olarak, insanların ürün deneyimlerinin şekillenmesinde önemli bir rol üstlenmektedir. Fakat, ürün-kullanıcı etkileşiminin zenginleştirilmesi amacıyla, ürünlerin işitsel özelliklerinin tasarımı görsel ögelerin tasarımına harcanan çabaya kıyasla ağırlıklı olarak göz ardı edilmektedir. Bu bağlamda, bu çalışmanın amacı; ürünlerin işitsel özelliklerinin tasarlanmasına yönelik güncel ve ileriye dönük pratiklerin araştırılması ve 'etkileşim için tasarım' perspektifiyle ürün tasarım sürecinde işitsel etkileşim fikirlerinin değerlendirilmesi için bir takım öneriler sunulmasıdır.

Literatür çalışmasında işitsel etkileşimin kullanıcı deneyimi boyutu, seslerin anatomisi ve sınıflandırılmasına dair yapılan çalışmalar ile ürünlerin ses tasarım süreci için önerilen yöntemler üzerine odaklanılmıştır. Bununla birlikte, saha araştırması kapsamında 'tasarım odaklı araştırma' geleneği benimsenerek, tasarımcıların ürünler için işitsel etkileşim fikirleri geliştirmelerini teşvik etmeyi amaçlayan kavramsal araç tasarımı (SoundsGood V1, V2, V3) ile derinlemesine görüşmeler ve odak grup çalışmaları eş zamanlı olarak yürütülmüştür.

Sonuç olarak, revize edilmiş kavramsal araç tasarımının (SoundsGood V3) özelliklerinin sunulmasının yanı sıra, ürün tasarım sürecinde tasarımcılar tarafından işitsel etkileşim fikirlerinin ele alınması, geliştirilmesi ve diğer paydaşlara iletilmesi üzerine öneriler getirilmektedir.

Anahtar keilmeler: ürün ses tasarımı, işitsel etkileşim, kavramsal araç tasarımı

to Mom, Dad and Deniz

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CHAPTER 1

INTRODUCTION

Almost every morning, we wake up with the sounds generated by our alarm clocks. After taking a shower, we experience the powerful sound of our hairdryer while drying our hair. Before drinking tea or coffee, we listen out for the click sound of the kettle's button along with the increasing bubbling sound of water, in order to understand if the water has boiled. When we go out, it is more likely that we will be exposed to annoying car horns, exhaust noises and the sounds of other products instead of bird chirpings. While crossing the road on a crosswalk, according to *Architectural and Transportational Barriers Compliance Board* (1998), we arrange the initiation of our first step according to the changing tone of the sound emitted by the stoplight.

Just like the aforementioned examples, in our daily lives, there are numerous objects that communicate with us through the medium of sound. As an integral element of user-product interaction, the sound emitted by a product plays an important role in people's product experiences.

Özcan (2008) stated in her doctoral dissertation on product sounds that sound is an indicator of product performance as well as a trigger for product appraisals, being implicated in end users' reasoning, emotional state, decisions on purchasing, preferences, and product expectations.

To be more specific about the crossovers between industrial design and product sounds, Özcan (2008) categorized various ways in which sound can be implicated in products, such as auditory ergonomics, well being, user satisfaction, product identity and brand differentiation. Although product sounds have a clear role in augmenting user-product interaction and affecting user experience, within design processes auditory properties of products are relatively overlooked. This is especially the case when compared with the visual attributes of products. In this respect, Robare (2009) state that in reference to designing product sounds, there is a lack of resources that industrial designers can turn to and benefit within their design processes. In line with this view, according to Özcan (2008), "…it is surprising to see that not much is known about product sounds and yet alone about how people respond to them. Available knowledge concerning experiential aspects of product sounds is limited" (p.14).

1.1. Background to the Problem

In the course of daily life, people interact with countless products in various ways. These interactions between users and products occur within the sensorial boundaries spanning visual, tactile, acoustic, olfactory, gustatory and kinaesthetic attributes. However, despite the richness provided through these different sensory modalities, product design generally focuses on the visual side of user-product interaction.

As Hollins and Pugh (1990) have mentioned, industrial designers have traditionally given dominance to the visual definition of a product over other sensory elements. Similarly, as uncovered through the thesis of Verviers (2010), the 'expression' or 'personality' of a product has been greatly explored in the past through visual features (Govers, Hekkert & Schoormans, 2002), while auditory features, which are the focus of this present study, have been ignored for a long time. In parallel with these, Robare (2009) claims that in order to offer engaging experiences, designers always expend major effort on visual product properties. He continues that as a component of the total product experience, designers would be well advised to include sound within their design processes.

The theme of visual property dominance can be found in many other references. The result is that in the context of user-product interaction, other modalities are repeatedly overshadowed or overlooked. In order to enrich users' product interaction and experiences, industrial designers, who are quite saturated on the visual domain, may be provided with new design support tools or methods to help develop concentration on the auditory attributes of products. In other words, considering the attention paid by industrial designers to the user-product interaction cycle, it can be observed that designers' ways of handling sound and taking design decisions about the auditory realm remain immature, due to a lack of available methods and tools to help design auditory elements of user-product interaction.

Apart from the dearth of sound-specific advice, methods and tools, the multidisciplinary nature of sound design and creation is another factor that complicates the consideration of product sounds. Knowledge from distinct disciplines such as engineering, acoustics, psychology, musicology and psychoacoustics can all be relevant to creating a high-quality auditory experience. For industrial designers, it is an option to attempt sound design for interaction but currently the lack of advice and tools makes this difficult. Additionally, involving the related professional disciplines just mentioned can undoubtedly increase the quality of the sound design process, but again the ability for industrial designers to collaborate on these issues and exchange sound design ideas is not well established or developed.

1.2. Aim and Objectives of the Study

Considering the potential of the auditory modality to enhance users' product experiences, (raising the question in the field of industrial design on the role of auditory user-product interaction), the aim of the current study is to (i) investigate the act of sound design throughout the (industrial) product design process and (ii) to provide a set of suggestions, as well as an embodied example, that can help designers and design students to improve their consideration of sound within the formulation and creative idea generation of user-product interaction scenarios.

Therefore, the study sets out to explore the current condition of product sound design practice both in professional and educational contexts, and to foresee future possibilities for the design process of auditory interaction between users and products from an industrial designer's perspective.

The work has been carried out through literature reviews; user needs elicitation; and practical design activity. The user needs elicitation and practical design activity were conjoined into a series of 'research through design' steps. User needs elicitation was approached qualitatively, through the use of (i) semi-structured interviews with professional industrial designers from a variety of industries, and (ii) focus group studies with expert graduate students (also employed as Research Assistants) at the Department of Industrial Design, Middle East Technical University. The practical design activity centred on the design and visualization of a conceptual sound design tool, named 'SoundsGood'. Several versions of the tool were developed based on the insights gained through consecutive periods of user needs elicitation and user evaluations.

The overall aim of this study was therefore to suggest effective ways in which professional designers and design students can consider sound as a part of their product design projects and offer creative and rationalized ideas within the realm of 'design for sound- based interaction'. In this respect, the SoundsGood tool, allied to the rationale behind its conception and development, form the major subject coverage of the thesis.

1.3. Research Questions

The main research question is:

- How can an intended audible user experience be communicated and manipulated by industrial designers, within the context of 'design for interaction'?

The secondary research questions are:

- What are the challenges that industrial designers may encounter during the incorporation of sound design into industrial design processes?
- What kinds of considerations should be taken when designing for product sound?

1.4. Structure of the Thesis

As shown in Figure 1.1, the thesis has been written across five chapters, which also reflect the general progression of the study.

Chapter 1, *Introductio*n, comprises the background to the research problem, the aim and objectives of the study, and sets out the research questions.

Chapter 2, *Literature Research,* includes a review starting with the presentation of current frameworks of product experience, with special focus on product sound experience phenomena. It continues with a brief description of physical sound events, followed by the classification of different sound types in reasonable detail. In the final section, the chapter investigates the practice of product sound design as a component of the wider task of new product development.

Chapter 3, *Methodology,* explains the underlying reasons for adopting the 'research through design' approach and presents the design of the user needs elicitation and concept evaluation studies, which comprise two sets of semi-structured interviews and focus group sessions. The chapter also gives information about the participants involved in the sessions and methods of analysing the gathered data.

Chapter 4, 5 and 6, *Research Through Design*, presents the process through which the design of a conceptual tool (SoundsGood V1, V2 and V3) is documented and argued. These chapters contain the outcomes of the user needs elicitation and concept evaluation studies, which feed into detailed accounts of the iterative design improvements of the SoundsGood conceptual tool.

Chapter 7, *Conclusions*, reflects on the achievements of the research with regard to the literature review and research through design steps. Answers to the research questions are constructed. In the final part of the chapter, the limitations of the study are presented and some opportunities and implications for follow-on studies are discussed.

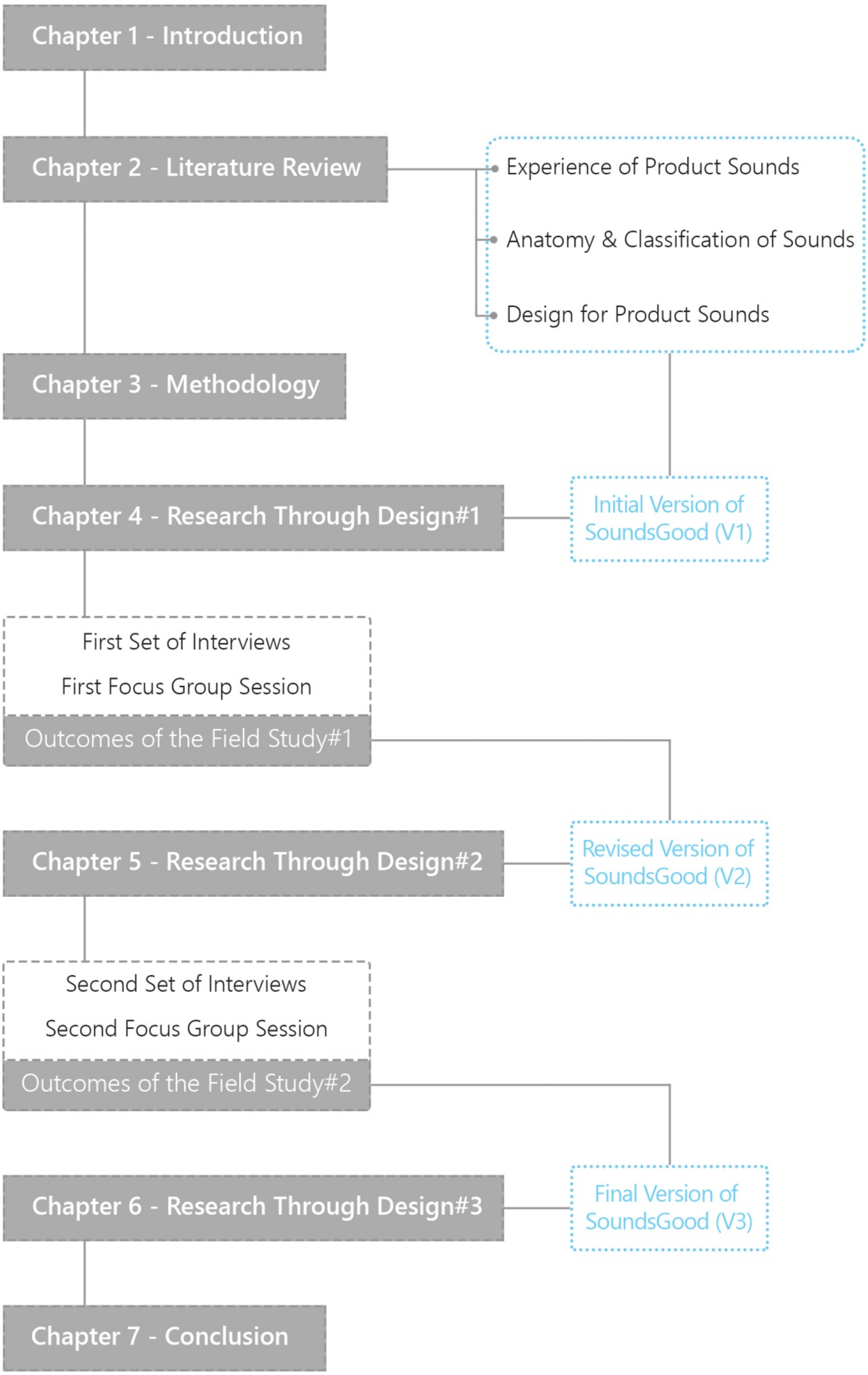


Figure 1.1. Structure of the study and thesis

CHAPTER 2

LITERATURE REVIEW

2.1. Experiences Of Product Sounds

Interaction between users and products has gained more importance in the past decade. Because of the ubiquity and variety of products in daily life, the diversity of user - product interactions is extensive as well. These interactions can occur within the realm of different sensory modalities of users; for example, one can understand that fuel is running out by looking at the indicators located on the dashboard of a car, the concept of freshness can be conveyed to the user with the opening sound of an air conditioner, leather texture of an armchair can make one sweat and affects his or her overall seating experience, the smell of eva foam emitted from a children mat can change the purchasing decision of a mother, or the taste of a cup of tea can be unsatisfying because of the softening plastic stirrer in hot water.

These separate sensorial events can be experienced simultaneously by users with the usage of different senses because of the multi-modal nature of products and intended product interactions (Hekkert, 2006). For example, while the user is pressing down on a textured and relatively small sized button in order to increase the volume of a movie on his/her laptop, he/she also sees the graphical representation of this action on the screen in addition to the simultaneous beeps as auditory feedback of the event. Schifferstein and Desmet (2008) explain the relationship between sensorial information and the process of product experience as following:

> All the sensory information people receive when they interact with products – independent of whether the designer created it intentionally or accidentally, and independent of whether the user perceived it consciously or

> unconsciously – can have an effect on product perception, cognition, experience and behaviour (p.139).

At this point, it can be argued that sounds emitted by products, as one of the elements of user-product interaction, are effective on users' product experiences just as with other sensory modalities. Indeed, as industrial products have become increasingly ubiquitous through the passing of time, so their associated or referential sounds have become more and more familiar (Özcan, 2008).

In this chapter, in order to understand the experience of product sounds, different frameworks of product user experiences will be investigated first. After briefly covering the product experience frameworks, different perspectives on product sound experience will be discussed.

2.1.1. Frameworks of Product Experience

It is helpful to begin with a definition of the word 'experience'. According to the dictionary of Merriam-Webster, experience is "the process of doing and seeing things and of having things happen to you" (2014). In other words, experience may be explained as the process of interacting with things, acquiring information as an outcome of these interactions and continuous sense-making. In parallel, the term ‘product experience’ is defined by Schifferstein and Cleiren (2005) as "the entire set of effects a product has on a user" (p.294). They added that product experience as a process contains the perception of product properties, the identification and cognitive processes triggered after perception, as well as emotional and evaluative judgements as consequences. In addition to this, Hekkert and Schifferstein (2008) define product experience as "the research area that develops an understanding of people's subjective experiences that result from interacting with products" (p.1). Within the process of experiencing an event, Hekkert and Schifferstein (2008) explain the capabilities of human beings with the following statement:

> Independent from their surroundings and social context, humans are biologically equipped with a number of systems that make it possible for

them to interact with their environment: a motor system to act upon the environment; sensory systems to perceive changes in the environment; and a cognitive system to make sense of the environment and to plan actions (p.2).

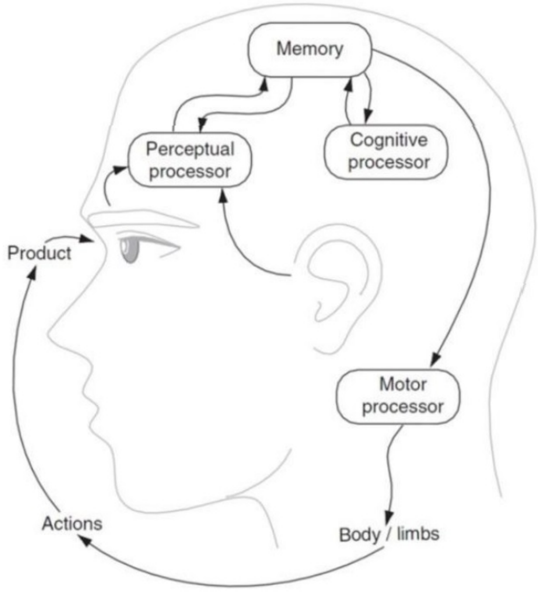


Figure 2.1. The interaction between sensory, cognitive and motor capabilities (Clarkson, 2008, pg.169)

As shown in Figure 2.1, sensory systems make the user able to gather information about the properties of a product with regard to visual, auditory, tactual, olfactory and gustatory modalities. After these acquired data are compared with previously experienced product information stored in memory, a cognitive process is triggered in which the user establishes what kind of product he/she is faced with and what the interaction possibilities are. With the help of motor capabilities, the user can then carry out an intended action on or through the product. As a result of the interaction, the user receives an updated set of sensorial information as feedback. This interaction process repeats and iteratively contributes to shaping product experience (Hekkert, Schifferstein, 2008).

In a similar approach, Hassenzahl (2005) explains the product experience is a process triggered by users' encounters with products. After receiving the 'features' of a product via sensorial capabilities, the user creates 'the apparent product character' in their mind, which essentially is a personal version (or interpretation) of the product designer's 'intended product character'. The combination of pragmatic and hedonic values contained within the apparent product character paves the way for users to create judgmental, emotional and behavioural consequences.

In line with this, Thüring and Mahlke's (2007) approach to the broader term ‘user experience’ shows similarities with the aforementioned definitions of product experience. They state that interaction, which is taking place between a user and a technical device in a specific context within a certain period of time, creates the user experience.

Additionally, Kort, Vermeeren and Fokker (2007) state that interaction between a user and a product's features, which are designed to support certain intended experiences, leads the user to cognitive processes that will result with the birth of continuously developing and changing user experiences over time. They identify three aspects of user experience as follows: '*compositional aspects*', referring to the pragmatic and functional aspects of a product; *'aesthetic aspects'*, which cover a product's features appealing to the sensory modalities; and '*aspects of attributing meaning*', which contain the sense-making phenomena within cognitive processes.
Similarly in Figure 2.2, Şener and Pedgley (2013) define user-product interaction as a cyclic phenomena that includes several cycles of perception (A), performance (B) and feedback (C).

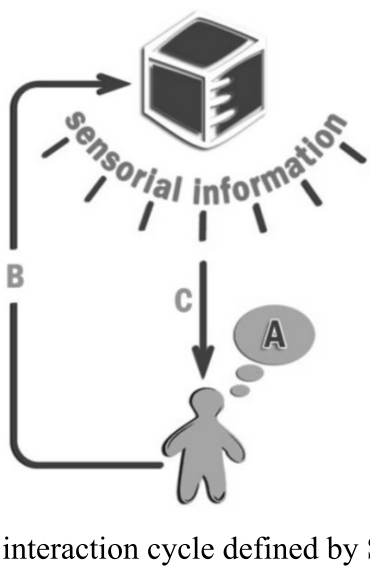


Figure 2.2. User-product interaction cycle defined by Şener and Pedgley (2013)

In addition to these, Wright, McCarthy and Meekison (2005) imply that instead of engaging users to ready-made product experiences, there is a need for active participation of users to the sense-making process. With this viewpoint, they underline the inappropriateness of '*design an* experience' and mentioned the importance of developing a way of understanding users so that designers can '*design for* experience'. 'Wright, McCarthy and Meekison (2005) also added that

> ...design for experience requires the designer to have ways of seeing experience, to talk about it, to analyse the relations between its parts and to understand how technology does or could participate to make that experience satisfying (p. 52).

Another framework offered by Desmet and Hekkert (2007) conceptualizes product experience using three high-level components, namely; aesthetic experience, experience of meaning and emotional experience. Although these components are shown separated in Figure 2.3, within user - product interaction in daily life, they are experienced as intertwined phenomena. According to Desmet's and Hekkert's (2007) conceptualization, the aesthetic level of product experience refers to the capacity of a product to appeal to users' sensory modalities. For example, one can find the closing sound of a car door trustworthy and feel good about touching the upholstery of car seats. The next level of product experience, experience of meaning, consists of cognitive processes such as interpretation, associations, identification of metaphors or assessments of personal attributes to products. The last component of product experience is emotional experience, which focuses on emotions triggered as a result of users' varying product appraisals. The example given by Desmet and Hekkert (2007) for emotional experience is that two different users may appraise a mobile telephone ringtone as desirable or irritating, due to the users' moods or their evaluation of the usage context.

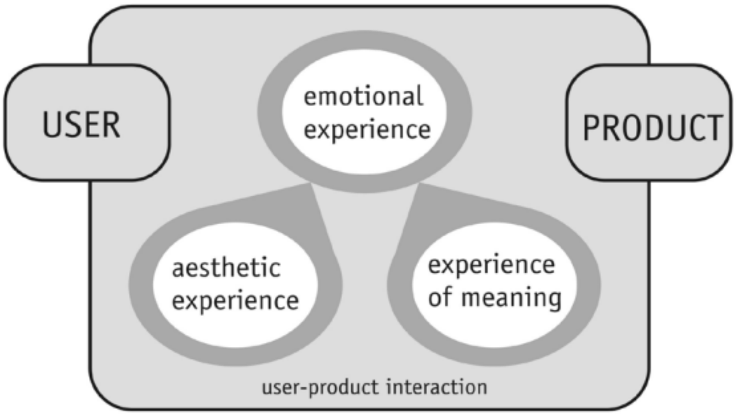


Figure 2.3. Framework of product experience (Desmet & Hekkert, 2007)

In parallel with the aforementioned studies, Crilly, Maier and Clarkson (2008) also another framework about product experiences that focuses on the communicative aspects of design processes and design outcomes, by taking advantage of two different perspectives, namely: design as mass communication and design as interpersonal communication. In Figure 2.4, it is shown that a product plays a mediating role between '*the intentions of the designer*' and '*the interpretations of the consumer'*. The interpretation of the user is shaped by the apparent and experienced qualities of the product, which have previously been created in an intentional manner by the designer, who has anticipated the user and predicted the usage context. However, Crilly, Maier and Clarkson (2008) underline that due to the variety of personal motivations, values and expectations of users, the interpretation process of a product will be different for every user in diverse contexts; therefore, the experience of products is not a finite phenomenon, but instead differs amongst people and their situations.

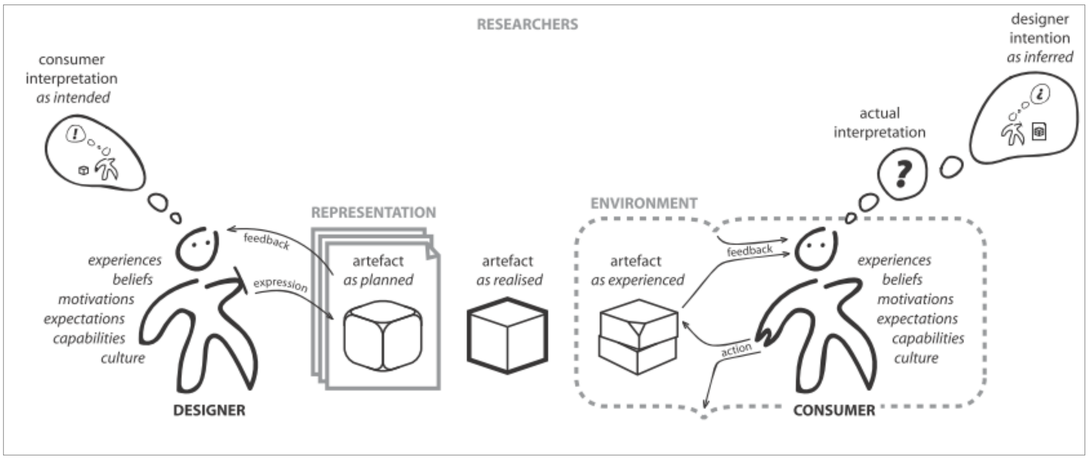


Figure 2.4. The integrated communication-based model of design (Crilly, Maier & Clarkson, 2008)

Considering the fact that product experience is a combination of (i) sensorial information, (ii) meaning attribution in response to that information, and (iii) emotions that are elicited during interaction, it can be argued that product sounds – as one form of sensorial information – will have a role within all these processes.

2.1.2. Product Sounds Experience

As mentioned in the previous section, product experience is a holistic phenomenon comprising the dynamic combination of users' sensorial, motor and cognitive processes. Schifferstein and Desmet (2008) mention that sensorial information emitted from products can affect users' perception, cognition, experience and behaviour towards and from that product. As a component of sensorial information elicited by products, product sound has an important role influencing these aforementioned components of product experience.

The experience of product sounds has been investigated by several researchers from a variety of perspectives. For example, Robare (2009) examines ways of creating or promoting usefulness, usability and desirability and engaging product interactions with the use of sounds. He mentions the persuasiveness of sound in terms of creating emotions that might not be created by other sensory modalities and for contributing to the desirability of products.

Jekosch (2005) focuses on semiotics to analyze and describe different processes of product sound design and its experience. To summarize his viewpoint, he sees auditory events as sign carriers within the communication process between products and users, arguing that implementation of sounds on the basis of users' sound perception can make a positive contribution to the meaning of products, users' attraction to products, access to products, as well as overall perceived product quality. By referring to Louis Sullivan's philosophy, he suggests that "the product sounds follow the function of the product as expected by the user" (p.218).

As cited in the doctoral dissertation of Nykaneen (2008), McAdams (1993) examines human processes that have effects on the recognition of sound sources and events, by not just focusing on 'product' sounds but covering a wider range of sound events, although excluding speech and musical sounds. He explains that there exist two distinct views on experiencing sound events, namely: the information processing approach, and the ecological approach. The information processing approach is a multi-staged process that links perceptual features of a sound source, the representations it elicits in the memory, meanings that users attach to it and its associations with other events or objects. In contrast, for the ecological approach to sound sources, it is stated that perception of the auditory event does not undergo a process of cognitive analysis, matching or association processes; instead, "…physical nature of the sounding object, the means by which it has been set into vibration, and the function it serves for the listener (as well as its name, presumably) are perceived directly" (McAdams, 1993, Introduction chapter).

In addition to these perspectives, Van Egmond (2008) explains the effects of the spectral and temporal structure of product sounds and the process of auditory perception of these sounds on the experience of product sound events. He states "sounds are described by an amplitude fluctuation as a function of time in the temporal domain and as a sum of sinusoids (overtones) in the spectral domain" (Van Egmond, p.71).

Özcan and Van Egmond (2007) argue that the extent to which product sounds are recognized and remembered by users is determined by the level of 'structure' in the spectral and temporal domains of product sounds. They separated the levels of structure within spectral and temporal domains of product sounds into three. In the spectral domain, these are: highly structured product sounds containing almost no noise, such as digital beep sounds of an interface; medium-structured product sounds, in which noise is present – for example the rotation of gears or other parts of a mechanism; and least-structured product sounds, consisting of noise or sounds that have a continuously changing spectral structure. For the temporal domain of product sounds, a similar categorization is employed, as follows: highly structured sounds that have rhythm-like structure, such as alarm clocks; medium-structured sounds, for example engines running across certain rpm (revolutions per minute); and least structured product sounds, the generation of which depends on airflow or liquid-flow.

For both the spectral and temporal domains of product sounds, Van Egmond (2008) states "not only will the memory and recognition decrease with the amount of structure, the possibility of designing a sound experience for a product will be much more difficult if structure is lacking" (p. 73). Additionally, he underlined that temporal and spectral structures of product sounds are also affected by users' involvement within the (sound) controlling processes of products. The correlation between the spectral and temporal structure of product sounds generated by a single or related events will decrease in the following order; autonomous, partly autonomous, and user-dependent controlling of products (Van Egmond, 2008). In order to clarify, the sound generated by air conditioner which has autonomous control system will be less dependent on user's action than the sound emitted by a blender which is dynamically controlled by user in kitchen.

In addition to categorizing sound based on spectra and temporality, a complementary approach is to make categorizations according to human perception of sounds, which is covered by the research domain of '*psychoacoustics*'. Zwicker and Fastl (1990) state that in order to measure quality of sound, for example in terms of sensory pleasantness, psychoacoustical measures such as loudness, roughness, sharpness, tonalness and pitch are often used. On this point, Özcan (2008) argues that attributes of product sounds affecting user perception of the term '*pleasantness*' (for example) can be determined, and fed back into product design processes. Some of the basic psychoacoustic parameters are defined as follows:

Loudness is a psychological correlation to the intensity of a sound. Johansen (2006) defines loudness as a subjective measurement concerning the level of sound.

Sharpness is, according to Von Bismarck (1974), explained as the measure of tone '*colour*'. Fastl (2005) further explains that an excessive amount of sharpness can make the sound of a product '*aggressive*', while a carefully considered amount is effective for creating the character of '*powerfulness*'.

Pitch is explained by Fastl (2006) as the auditory sensation for the comparison of sounds on a musical scale such as high or low. Fletcher (1934) adds that there is a requirement of judgement tests which are based on users' feedbacks due to the subjective nature of measuring the pitch of a sound as relatively high or low.

Fletcher (1934) also explains ***timbre*** as a "characteristic which enables one to judge that two tones are dissimilar while still having the same loudness and pitch." (p.67). Handel (1995) states that timbre of a sound may be related with the actions needed to cause that event and one may perceive the objects according to their physical actions such as the distinctive sound during rolling or bouncing a ball.

Van Egmond (2008) indicates that manipulation of sharpness may be effective in order to directly arouse basic emotions for users; however, for more complex emotions, an intermediate meaning attribution process becomes more influential.

Apart from these, Özcan (2008) conducted several investigations about the identification of product sounds and meaning attributions to those sounds at various stages of an identification process. Özcan and Van Egmond (2005) mentioned that the representation of everyday sounds in users' minds can exist in several ways, such as "encoded acoustical information, emotional experiences or structural properties" (p. 1). Because of this, there can be associated and mixed meanings of product sounds. According to the framework offered by Özcan (2008), four stages of the identification process of product sounds exist, namely: perception, recognition, categorical identification, and lexical identification.

In order to summarize her framework, as shown in Figure 2.5, perceptual processes consist of perception and recognition of product sound. While the user is perceiving the acoustical features of the product sound in a certain context by focusing on the sound's spectro-temporal structure at the perception level, he/she tries to recognize the current sound against previous auditory data stored in his/her long-term memory. If there is no similar representation of the product sound being listened to at the time in the user's memory, then semantic associations based on the sound's acoustical attributes will be created by the user, such as ‘high pitched sound’, ‘irritating noise’ etc. (Özcan, 2008). At the cognitive level of experience of product sounds, according to Özcan's framework, there are two identification processes: categorical and lexical. She argues that categorical identification is a process that for the first-time user tries to make meaningful implications about the sources of the product sound. If there is no representation of the concept of the sound source, the user identifies the sound into a category that contains similar product sounds. For example, if one cannot identify the sound of a shaver, it may be categorized within the similar sounds of other ‘electric powered tools’ such as epilator or a drill. The last stage defined by Özcan (2008) is a process that results with the lexical identification of the sound source, in other words the verbalization of the sound perception in a way that can be communicated to other people.

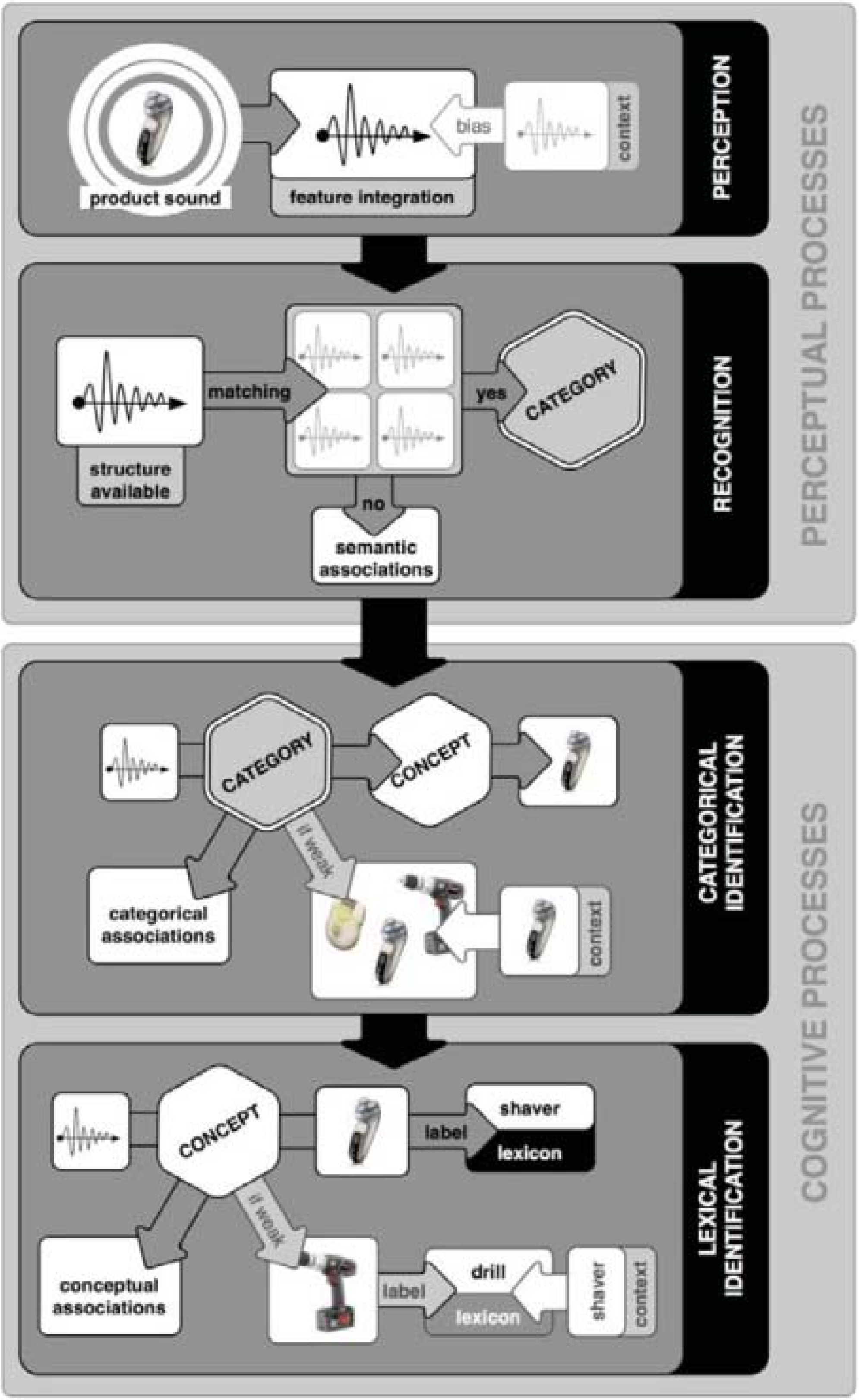


Figure 2.5. Theoretical framework for the product sound identification process (Özcan, 2008)

2.2. Anatomy and Classification of Sounds

2.2.1. Anatomy of Sound

Everest (2001) defines sound as "a wave motion in air or other elastic media (stimulus) or as that excitation of the hearing mechanism that results in the perception of sound (sensation)." (p. 1). Hass (2003) further explains that vibrating body of an object such as guitar string, loudspeaker or jet engine generates sound waves. The surrounding air particles move and hit each other due to force applied by the vibration over the surfaces of objects and propagate the sound. The science which is dealing with the origin and propagation of sound is acoustics (Kuttruff, 2006). Liljedahl and Fagerlönn (2010) stated that properties of space such as the density of air and the construction of a place influence the sound which is omni-directional and reaching the ears from all directions nearly at the same time.

According to Hass (2003) there are four basic properties that characterize a sound wave, namely; ***frequency, amplitude, waveshape*** and ***phase***.

Frequency is the number of oscillations per seconds that a sound wave makes. Kuttruff (2006) gives the example that in ancient times, people relate the pitch (perceived frequency) of the tone of an instrument to the lenght of the string which directly affects the number of oscillation in turns. The measurement unit for the frequency is Hertz (Hz) which is equal to per cycle of sound wave. The human capability to hear is limited within the sounds of which frequencies are approximately from 20 Hz to 20kHz (Hass, 2003). The sounds out of this range are either infrasound which is lower than 20 Hz or ultrasound which is higher than 20 kHz.

Another basic property of sound, ***amplitude*** is "the objective measurement of the degree of change (positive or negative) in atmospheric pressure (the compression and rarefaction of air molecules) caused by sound waves." (Hass, 2003, What is an Amplitude chapter). Accordingly, there is a direct relationship between the amplitude and the intensity of a sound. Everest (2000) states that the levels in decibels aid to better understand the range of human sensitivity in hearing phenomena. In the light of these, in Figure 2.6, the limitations of human capability to experience an auditory event in terms of sound pressure level and frequency are shown by two threshold curves, A and B.

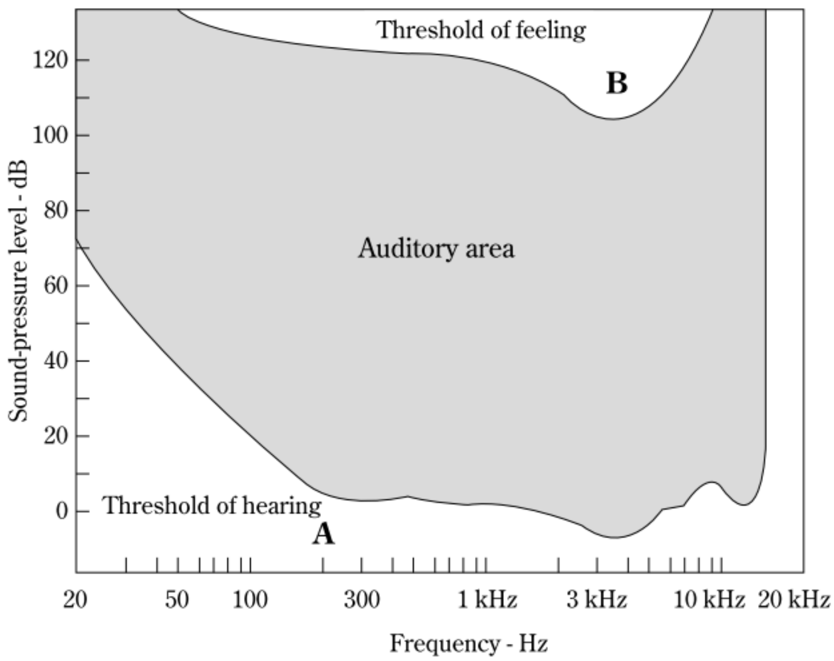


Figure 2.6. Human capability to experience an auditory event (Everest, 2000)

Another parameter that characterizes the sound is ***waveshape***. Hass (2003) states that waveshape is directly associated with its spectral content which is defined by Truax (1999) as the combination of sine waves with different amplitude and frequency values (see Figure 2.7.). Hass also added that the spectral content of a sound is one of the fundamental element that affects its perceived timbre. Additionally, it is argued that every sound event, independent from its complexity of waveshape, can be synthesized by sine waves with different frequency, amplitude and time values in theory (Everest, 200o).

The last important component that is characterizing sound is ***phase*** which is another prominent factor within the process of interaction of multiple waves in acoustic or electronical domain. While constructional interference is the creation of sound wave with greater amplitude as a result of the interfering of multiple waves, destructive interference refers to the cancellation of two identical waves of which phase difference is 180 degrees (Hass, 2003).

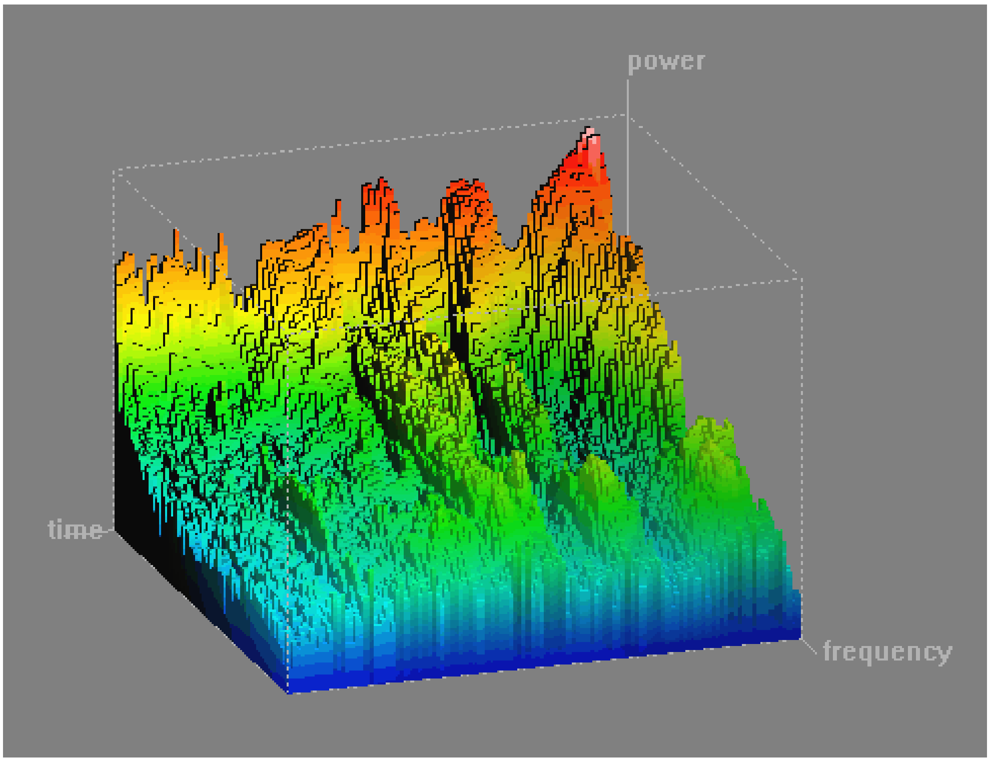


Figure 2.7. Spectogram which is a 3D representation of the spectrum of frequencies in a sound varying with a time in terms of amplitude and frequency (retrieved from http://www.st-andrews.ac.uk/~wjh/dataview/sonogram.html, on 08.11.2014)

2.2.2. Types of Environmental Sounds

Just like aforementioned examples given in introduction chapter; in daily life, there are numerous objects that communicate with people by using their sounds. This auditory communication between objects and people occurs within the sensorial boundaries of the person and affects their perception through these objects in a positive or negative way. Van Egmond (2008) indicates that these auditory events surrounding and affecting us constitute environmental sounds. As an umbrella term, environmental sounds contains various subcategories.

As cited in the work of Guastavino (2007), Schafer offered four main categories of environmental sounds. These categories are mechanical sounds of which example is traffic noise, human sounds like daily dialogues or hand clapping, collective sounds that are the results of social activities, and lastly, sounds conveying information about the environment. Schafer also pioneered the usage of the term "*soundscape*" of which focus is on the way environmental sounds are perceived and understood by people or by a society (Torija & Ruiz, 2013). Additionally, it is also explored with soundscape that how sounds define spatial location.

Ferrington (1994) cited from Schwartz (1973) states that there are three layers of acoustical information for every soundscape. These are '*foreground sound*' which is drawing one's attention quickly, '*contextual sound'* that surrounds the foreground sound and the '*background field'* which is the combination of other ambient sounds. He explains these three layers with the example of a fire scene; the sound of fire truck's siren is perceived as the foreground sound while the sounds like crackling fire and shouting are the contextual ones, and other irrelative sounds such as car horns or aircraft landing noise form the background field.

Apart from Schafer's categorization, Gaver (1993) offered another view for categorizing everyday sounds, which is the term he used instead of environmental sounds. He claimed that "sound provides information about an interaction of materials at a location in an environment" (p.4) and underlined the need for a more ecological approach to describe everyday sounds instead of categorizing sound events only by focusing on the measurable properties of sounds such as frequency, amplitude or phase (Gaver, 1993). Fundamentally, he categorized everyday sound events under three sub-categories, namely vibrating solids, liquids and gases (see Figure 2.8). In more detail, these are the sounds produced by the vibrations on the solid surfaces, the sounds that are generated because of the changes in the surface of a body of liquid and the sounds which are created by aerodynamic means. According to Gaver (1993), while the causal interactions are determinant for the sounds under liquids and gases categories; both causal interactions, the type of a material used or the form of the vibrating object can all affect the kinds of sounds generated by vibrating solids.

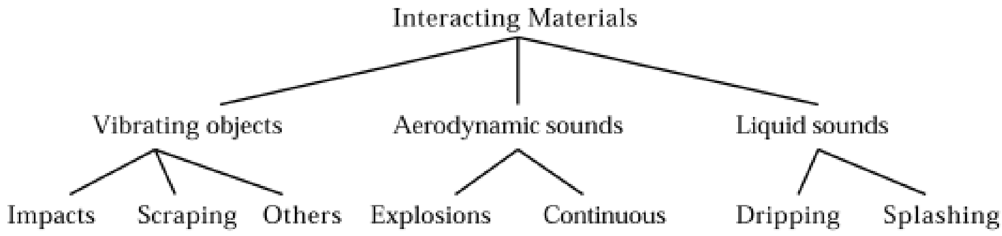


Figure 2.8. Categorization of everyday sound events (Gaver, 1993)

2.2.3. Types of Product Sounds

Within another sound categorization study conducted by Marcell et al (2000) environmental sounds are determined to contain product sounds as a sub domain along with the natural sounds such as dog barking, bird chirping, sound generated by ocean waves and wind etc. As a sub domain of environmental sounds, or in other words everyday sounds, the domain of product sounds is defined as sounds which are created by industrial products and the investigation of this domain separately from other environmental sounds may provide perspective to designers for increasing the quality of auditory experience and eventually product experience of users (Van Egmond, 2008).

According to Van Egmond's (2008) definition, there are two types of product sounds; these are consequential product sounds and intentional product sounds.

2.2.3.1. Consequential Product Sounds

Van Egmond explains consequential product sounds as the auditory consequences of how appliances are constructed and working. Langeveld et al. (2013) have shown four main aspects about the generation process of consequential product sounds, namely; sources, transmission in product, radiation and transmission to receiver (see Figure 2.9).

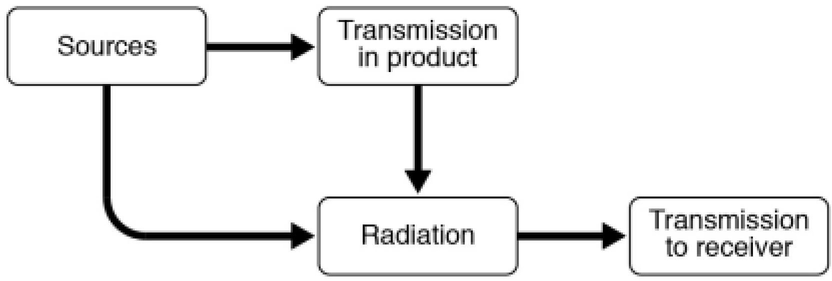


Figure 2.9. Four main aspects of consequential product sounds (Langeveld et al., 2013)

All sound events that are formed by products are experienced by users after the sound source generates vibrations due to the movement over its surfaces and radiates them to receivers by air as sound. Generated sound's transmission in product depends on the product's formal attributes such as cavities, holes, shape of the reinforcements (ribs etc.) and material attributes such as wall thickness, propagation speed.

However, especially for the designing process of consequential product sounds, Langeveld et al. (2013) underline the lack of knowledge about the relation between resulting product sound and the physical product properties such as sound transmission properties of materials used in products or tolerances which are used within the manufacturing processes. Similarly, Van Egmond (2008) indicates the difficulty of the consequential product sound-designing task for designers especially in the conceptual stage of product design process in which there is no realistic prototype or no existing parts of the intended product to test or simulate.

Similar to Gaver's everyday sound categorization, Langeveld et al. (2013) divided product sound sources into three as: airborne sounds, liquid borne sounds and structure borne sounds. The sound of the hot air flow through the hairdryer for airborne sounds, dishwasher's cyclical rinsing sound for liquid borne sounds, and clicking sound which is radiated after pushing the on/off button of television for structure borne sounds can be given as examples from daily life for the sources of consequential product sounds. In parallel with those, Gaver (1993) explains in his article, *What in the world do we hear?: An ecological approach to auditory event perception,* that sudden or continuous pressure differences on air such as explosion or gas leak form the airborne sounds, while the continuous or discontinuous drips, splashing, rippling and pouring actions shape liquid borne sounds. Likewise, he illustrates the activities that generate structure borne sounds with interactions like scraping, pressing, impact, etc. As these sounds can be experienced one by one like with the afore-mentioned examples, users often encounter them simultaneously in their daily lives.

Apart from the four main aspects (*sources, transmission in products, radiation, transmission to receiver*) for consequential product sounds, these sounds can carry information to users about what kind of interaction is taking place between users and products or inside the products. In order to give an example for the auditory result of interaction between users and products, pressing the plastic buttons of a telephone harshly will generate shorter and louder sounds in comparison with the auditory outcome of slowly dialling the number on the same telephone.

Likewise, consequential product sounds can also give information about the interaction that occurs inside the product such as what kind of energy and mechanism are being used to give movement to certain parts, or existence of a possible problem between the gears of a mechanical product because of the irregular patterns within the resulting product sound.

Additionally, consequential product sounds can be informative for users about the structural and material quality of a product such as the sound emitted by car door's closing or the sound of knocking on a wooden table. In his article, *Knocking Sound as Quality Sign for Household Appliances and the Evaluation of the Audio-Haptic Interaction*, M. Ercan Altinsoy (2012) investigates the perceived quality of washing machines in terms of psychoacoustical features of knocking sounds generated by these products.

2.2.3.2. Intentional Product Sounds

Apart from consequential sounds that are caused by the operating of products, there are also another type of sounds, which are emitted from appliances, called intentional product sounds (Özcan, 2008). Verviers (2010) stated that intentional product sounds are frequently used with designers' intention in products containing user interfaces. The beep sounds emitted from washing machines or dishwashers indicating the process is completed, the finishing bell sound of a microwave oven, feedback sounds of computers or mobile phones are all the examples of intentional product sounds.

In comparison with consequential product sounds, these sounds are mechanically, electronically or digitally produced with the help of speakers and electrical components and they are close to musical sounds or audible passages (musical motives) in terms of their spectral and temporal specifications. Additionally, Langeveld et al. (2013) explained the usage areas of intentional product sounds as communication of abstract meanings or providing information about a certain process such as a ‘finishing bell’ sound of a microwave oven. They also divided intentional product sounds into four main classes which are as follows; i) *earcon - auditory icons ,ii) sonification,* and iii) *continuous sonic interaction* (pg.56).

i) Earcons and Auditory Icons

In order to describe these terms; Blattner, Sumikawa and Greenberg (1989) have explained earcons as structured and nonverbal audio messages which are mostly used in information providing process of human computer interaction; however, they added that these kind of sounds were also being used in the auditory alarming and signalling area many years before computer's widespread uses. They also described earcons as the counterpart of graphical icons in the auditory realm and categorized earcons into three classes by benefitting from the area of graphical icon design. These classes are as follows; '*representational', 'abstract'* and '*semi-abstract' (p.21).*

Usage of natural sounds within auditory interaction constitutes representational earcons. Additionally, representational earcons were also examined by Gaver (1986), although he named these sounds as auditory icons. He explained that by making use of people's familiarity to relate sound events to their sources, auditory icons or representational earcons imitate the attributes of everyday sound events for creating the auditory model for human-computer interaction (Gaver, 1989). In other words, Gaver (1986) described his approach briefly with the statement that "auditory icons are the caricatures of naturally occurring sounds such as bumps, scrapes, or even files hitting mailboxes"(p.169). For example, when a text file is dragged on the trash bin icon, the sound which is mimicking the auditory output of real world-throwing away event is emitted from computer's speakers. Additionally, in parallel with Gaver's viewpoint, McGookin & Brewster (2004) underlined that if there is a possibility to find intuitive relation between the product and sound, it is feasible to use auditory icons. However, Mustonen (2007) stresses the fact that the repetitive usages of these kinds of sounds within products or user interfaces may cause annoyance for users in the long term.

The second class defined by Blattner et al. (1989) is abstract earcons which are the single or combined usage of one or many pitches together. They further explained that the '*rhythmicized sequence of pitches*' constitute the *'motives'* which are used for creating larger families within abstract earcon class. These sounds are inherently abstract and one needs to learn their meaning in order to understand what they indicate. At this point, in comparison with representational earcons (or auditory icons depending on the terminology), abstract earcons are more challenging to learn (Frimalm et al., 2014). Beep-like sounds such as finishing indicators of washing machines or microwave ovens and sounds generated while changing the mode of an air conditioner can be given as examples for abstract earcons. Considering these kind of examples, users may have difficulties to perceive the desired indication of abstract earcons especially at very first usages of products or interfaces. At this point, Mustonen (2007) stated, "Abstract earcons need to be learned before becoming useful, therefore they may not be suitable for first-time users or applications used infrequently"(p. 22).

The last class of earcons is the semi-abstract ones which can be summarized as the combination of representational and abstract earcons (Blattner et al.,1989). Mustonen (2007) defined semi-abstract earcons as "abstract earcons that have strong motivation, or in other words, they are intuitive." (p. 67). A project called 'The world's deepest bin' of which aim is to courage people to throw their rubbish into it instead of onto floor by using an engaging sound can be given as example for semi-abstract earcons (see Figure 2.10). This electronically generated sound's pitch level is continuously decreasing just after any rubbish is put into bin by user; therefore, it is supposed as a very deep and it creates a surprising experience for users just by using auditory modality.

Figure 2.10. Usage of semi abstract earcon within "world's deepest bin" (retrieved from http://www.thefuntheory.com/worlds-deepest-bin, on 10.11.2014)

ii) Sonification

After explaining the earcons and auditory icons, according to the classification of Langeveld et al. (2013) third class of intentional product sound is sonification which is generally implemented in areas requiring continuous data display. They further explained that "with sonification, an ongoing awareness of a total system can be created, by including both alarming sounds and reassuring sounds for ‘normal’ states" (p. 57). Likewise, Kramer et al. (2010) described that sonification transforms the dynamic data into auditory output in order to provide better communication.

Main advantages of using sonification within products or systems are enabling users to understand complex data sets, supporting other sensory modalities through data communication process and assisting user groups with special conditions such as pilots in cockpit or doctors conducting a surgery (Kramer et al., 2010). For the successful implementation of sonification within product, '*Geiger counter*' can be given as an example. Invented by Hans Geiger in 20th century, it gives a dynamic auditory feedback about the radioactivity level of an object or place as sequential clicking sounds. Another example for usage of sonification is sonar, in other words sound navigation and ranging, which is used by submarines to navigate and communicate underwater. Apart from these, a distinct example is SusLab project's '*Powerchord*' that tries to sonify the amount of electricity being used at home with the jungle-like sounds changing accordingly in order to make energy consumption more visible to users (see Figure 2.11). However, Kramer et al. (2010) summarizes the disadvantageous side of sonification process for designers as the complexity of the current tools for non-composers and non-audio engineers to create sonification suggestions for products and "ad hoc trial-and-error design" due to the lack of an established process (p. 15).

Figure 2.11. Powerchord sonifying the amount of electricity usage at home (retrieved from http://suslab.rca.ac.uk/2014/09/drawing-energy-and-powerchord-at-the-london-design-festival-2014, on 12.11.2014)

iii) Continuous Sonic Interaction

The last class of intentional product sound is continuous sonic interaction. Langeveld et al (2013) argue that instead of being an indicator of system states such as earcons, auditory icons or auditory outputs of sonification; the purpose of continuous sonic interaction is "sonifying expressiveness in human-product-interaction" (p.57). In order to better explain continuous sonic interaction; Rocchesso, Polotti and Monoche (2009) said that;

> ...with continuous interaction, the main sound design problem is not that of finding which sound is appropriate for a given gesture. Instead, the main problem is that of finding a sensible fitting of the interaction primitives with the dynamical properties of some sound models, in terms of specific perceptual effects (p.13).

In comparison with other intentional product sound classes, implementation of continuous sonic interaction to products requires more effort and equipment such as increased amount of time that will be spent by designer - engineer for creating suitable sound as well as necessary electronic hardware. Also, Rocchesso et al. (2009) mention the difficulty of designing continuous interaction for products in auditory realm for designers who are generally educated within the border of visual domain. However, the advantages of using continuous sonic interaction within products can be better demonstrated with successful examples such as Blendie which is designed by Kelly Dobson as an interactive blender that reacts the level of user's voice with spinning action. Instead of controlling the spinning speed of blender with buttons on interface, Blendie offers an exciting way of user experience with the usage of continuous sonic interaction (see Figure 2.12).

Another good example would be Bluetooth hands-free connectivity of a mobile phone by a car driver – using voice commands. The interaction is made possible only through sonic instructions, rather than classic tactual instructions of button pressing or screen confirmations.

Figure 2.12. Blendie - sonically controllable blender (retrieved from http://www.fringexhibitions.com/images/mit_4.jpg, on 13.11.2014)

Another set of implementations of continuous sonic interaction can be given from exercises of Rocchesso et al. (2009) through which their aim was taking the advantage of basic design principles to add auditory dimension to continuous user-product interaction. For example, they designed a continuous sonic feedback for the tightness degree of an aluminium moka pot's screw connection in order to inform user about the most appropriate tightness level (see Figure 2.13). The tighter the user rotates moka pot, the higher the pitch level of sound, that is generated from moka pot with the help of a pressure sensor and speakers implemented on the body, will be.

While the consequential product sounds depends heavily on the physical properties of products such as the material used, shape, size, working mechanism of product, tolerances between parts and so on; the outcome of the sound is mostly independent from these features within the intentional product sound area.

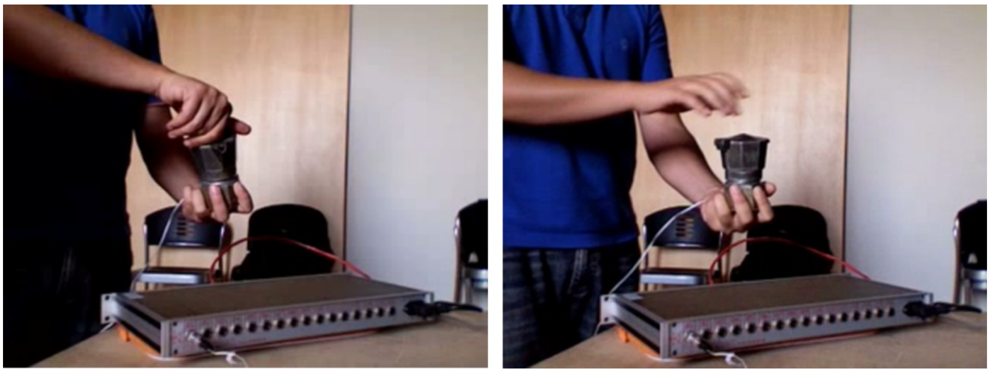


Figure 2.13. Sonic Moka Pot (retrieved from http://vimeo.com/898836, on 13.11.2014)

2.2.4. Descriptive Concepts for product sounds

Apart from aforementioned categorization of consequential and intentional product sounds, by conducting several experiments, Özcan and Van Egmond (2005) conceptualized a framework for the categorization and the description of products sound including both consequential and intentional sounds. In order to summarize, different product sounds, e.g. the sound of a vacuum cleaner, dishwasher, computer and shaver; were listened by participants of the study and were grouped in terms of their perceptual similarities. Then, participants described each of these sounds and sound groups separately by free identification task.

As a result of classifying (in terms of 'loudness-sharpness' and 'noisiness-low frequency' levels of sample sounds) the sound group descriptions made by participants, Özcan and Van Egmond (2005) categorized the product sound groups as *air, alarm, cyclic, impact, liquid* and *mechanical* (see Figure 2.14). In a similar fashion, the descriptions which had been made for each of the product sound in the study were used to classify the group of descriptive concepts for product sounds as follows; *action, emotion, location, material, meaning, onomatopoeia, psychoacoustics, sound type, source, source properties* and *temporal*.

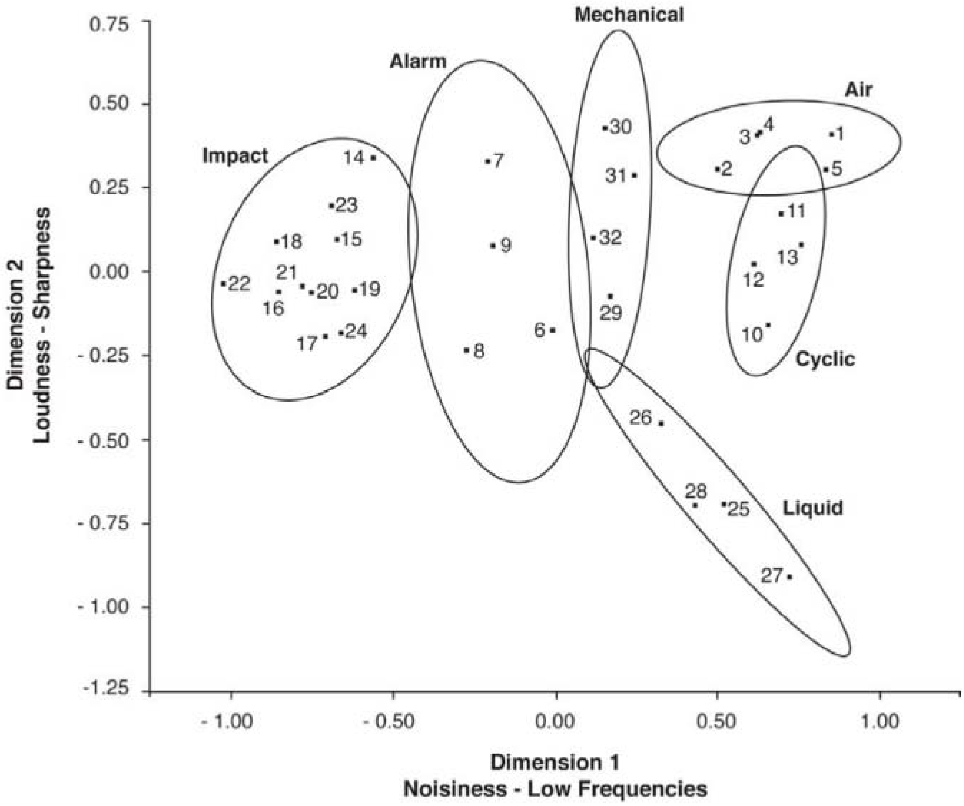


Figure 2.14. Product sound categories depending on psychoacoustical properties of sounds (Özcan, 2008)

As mentioned in the previous chapter, process of product sound identification is consisted of three levels, namely; perception, recognition and identification. Accordingly, Özcan (2008) explains that these different levels of product sound identification process can lead users to obtain different types of semantic associations with product sounds. While users describe product sounds by psychoacoustical (e.g. high pitched, sharp) and temporal (e.g. long, repetitive) features or by using onomatopoeias (e.g. dıdıdıdıt, buzz) at the perceptual level of sound identification process; descriptions regarding to source (e.g. dishwasher, hairdryer) and possible location (e.g. kitchen, bedroom) of the sound, action (e.g. rotating, scraping) causing the sound, meaning (e.g. error, low-battery, time to wake up) assigned to the sound and emotions (e.g. irritation, calmness) raised by the sound can be encountered at the cognitive processing level of product sound identification.

In Figure 2.15, the differing frequencies of the words used by the participants, who attended to the Özcan and Van Egmond's study, to describe particular product sounds are shown with different hatching for 11 descriptive concepts and the each product sound category relatively (Özcan & Van Egmond, 2005). As the frequency of descriptive concepts varies from one product sound category to another, it can be stated that the importance of these descriptive concepts for distinguishing product sounds depends on the sound category. For example; while *source information* is of importance for liquid sounds, information about *material* has nearly no effect on the same sound category (Özcan, 2008). Similarly, while *action* and *onomatopoeia* are the most frequent categories for describing the impact sounds, *meaning* becomes the most prominent descriptive concept for alarm sounds.

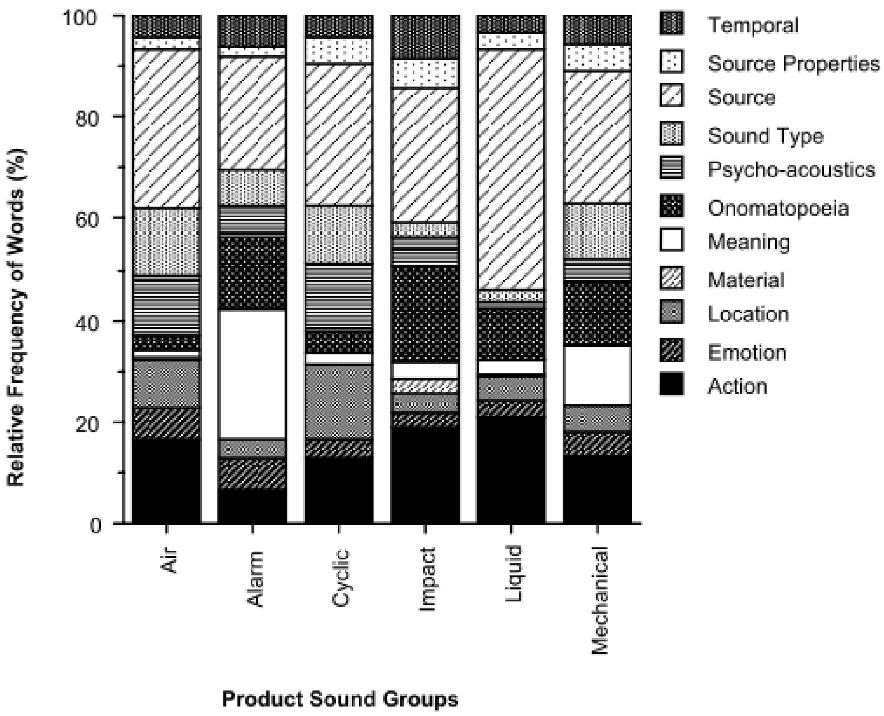


Figure 2.15. Relative frequency of words as a function of product sound descriptive groups and of product sound groups (Özcan & Van Egmond, 2005)

2.3. Design for Product Sounds

In this chapter, the multi-disciplinary nature of product sound design processes, the frameworks offered for the implementation of product sound design, examples for the current practices and methods applied within the design of product sounds, and industrial designers' potential contribution to the development of product sounds will be discussed.

2.3.1. Multi-Disciplinary Nature of Product Sound Design Processes

Product design processes consist of several sub-processes that utilize expert knowledge from varied disciplines. For this reason, the effective communication of design decisions between all parties contributing to the overall product development process is an important issue (Özcan, 2008).

As a part of a product development process, Özcan and Van Egmond (2008) state that the practice of product sound design also inherently requires contributions from diverse disciplines at different levels of product design processes. The main contributing disciplines are, as shown in Figure 2.16; acoustics, engineering and psychology. In addition to these, psychoacoustics and musicology also play a role within the design process of product sounds. Langeveld et al. (2013) explain the roles of these main contributors to product sound design, as follows:

Acoustics is the science which is dealing with the origin and propagation of sound (Kuttruff, 2006). The main concerns for acousticians, Langeveld et al. (2013) added, are the physical properties of the sound source such as shape, size and weight and the measurement of sounds in terms of physical and mathematical models (see section *2.2.1. Anatomy of Sound* for detailed information).

There are three main branches of ***engineering*** supporting product sound design processes: mechanical, electrical-electronic and material engineering. The working principle, shapes and the materials of the parts and the order of interaction between them can be engineered in order to fulfil the design requirements of products to generate intended sounds.

The role of ***psychology*** for the design process of product sounds is exploring the cognitive and emotional effects of product sounds on users.

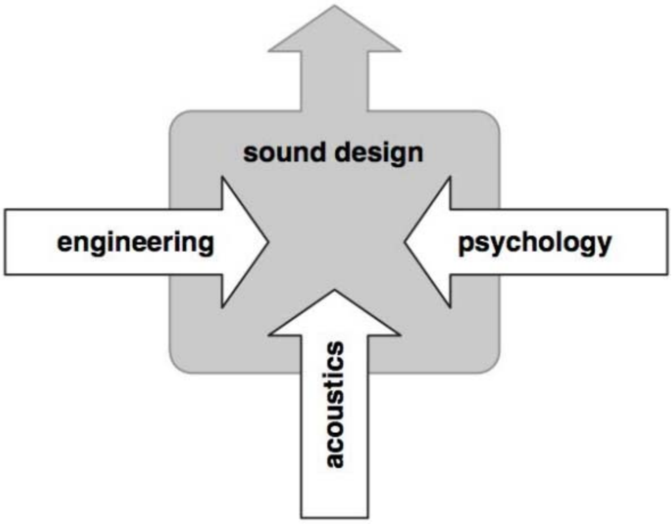


Figure 2.16. Main contributors to product sound design process (Özcan, 2008)

Apart from the above mentioned specialties, Özcan and Van Egmond (2008) mention two other important fields contributing the product sound design process: ***psychoacoustics***, which involves analyzing the reactions of users to acoustic events to understand the perception of sound; and ***musicology***, which is required within the design process of intentional sounds such as alarm sounds or keystroke sounds of mobile phones.

Due to its multi-disciplinary nature, Özcan (2008) underlines that there should be effective communication channels within the product sound design process; yet, she adds that both graphical and verbal methods remain incapable of describing the properties of sounds because of a lack of shared language for auditory events. Consequently, it can be said that the process of product sound design becomes recursive and decreases the overall product design process speed (Özcan, 2008). Additionally, Langeveld et al. (2013) describes the product sound design process as challenging for designers, in the sense that one needs to gather related knowledge from distinct fields - i.e. acoustics, engineering and psychology – and communicates it to different parties within the design process.

2.3.2. Practice of Product Sound Design

The practice of product sound design has been traditionally implemented by engineers to make products more silent in order to please users (Özcan, 2008). According to Van Egmond (2008), making products silent may be an option for a designer; however, improving a user's auditory experience should be the main goal of a product sound design process. In parallel, Özcan and Van Egmond (2009) states that in order to improve users' product experiences in relation to functional and hedonic aspects, the act of product sound design needs to be performed in parallel to the main design process. In this sense, it is also added that although the product sound design process has started to be undertaken within product development processes in recent years, the role of designers and methods for designing product sound are still ambiguous. Due to the fact that product sound design lacks global attention from design circles, current terminology which would be comprehensible to a regular industrial designer is insufficient for product sound design process (Özcan, 2008).

Apart from these, Robare (2009) underlines the positive effects of technological advancement on the production of high quality sounds and inclusion of these sounds within the rising number of products at low costs. Likewise, Ekman and Rinot (2010) foresee that the usage of the auditory domain for user-product interaction will gain importance as designers create more mobile products, thanks to miniaturized technology.

In literature, from the 1980s until now, the domain of human-computer interaction (HCI) has been interested in the usage of auditory elements for various aspects of product design, for example: to present information (Bly, 1982); to increase usability for visually impaired users (Edwards, 1988); and to provide information and feedback to users (Blattner, Sumikawa & Greenberg, 1989; Brewster & Clarke, 2005). Additionally, there are several works mentioning the product sound design processes conducted by the automotive industry. These have focused on auditory signals (Fagerlönn, Lindberg & Sirkka, 2012; Liljedahl & Fagerlönn, 2010), quality of car door sounds (Kuwano, Fastl, Namba, Nakamura & Uchida, 2006) and improving engine sounds (Sellerbeck & Nettelbeck, 2007; Nykanen & Sirkka, 2009). Other than these, design processes for product sounds have been put forward for consumer electronics and household appliances, such as: feedback sounds of digital cameras (Maeda, Matsuo, Matsumoto & Saito, 2002), mobile phones and microwave ovens (Lee, Kim, Chae & Chung, 2009); and quality of knocking sounds for dishwashers and washing machines (Altinsoy, 2012).

2.3.3. Product Sound Design Process

Nykänen (2008) pointed out that there are three concepts implemented within the design process of product sounds, namely; *product sound character, product sound quality* and *product sound design*. *Product sound character* is related with the acoustical features of a sound, which have been covered in the previous sections of this work. In order to identify the character of a product sound, the acoustical features such as frequency or amplitude are analyzed (Özcan, 2008). These features can be changed to try to change intended meanings, elicit intended emotions (Asutay & Västfjäll, 2012) or support the concept of a brand value (Klink, 2000).

The term *product sound quality* is explained by Blauert and Jekosch (1997) as the assessment of the suitability of sound emitted from a product in terms of users' subjective appraisals. Özcan (2008) also indicate that along with acoustical measurements, the contribution of users is necessary in order to estimate the judgements on product sound quality.

Nykänen (2008) approached the process of *product sound design* in parallel with the framework offered by Ulrich and Eppinger (2008) for industrial design processes, which has the following steps: investigation of customer needs, conceptualization, preliminary refinement, further refinement and final concept selection, control drawings or model, coordination with engineering - manufacturing and external vendors. However, he underlined that within the early levels of a product development process, in which several concepts are generated and evaluated by designers, engineers and other team members, there is nearly no inclusion of ideas about product sounds. In parallel with Nykänen's argument, about product sound design process, Özcan and Van Egmond (2008) also proposed a framework, which is based on the conceptualization of processes for product development by Roozenburg and Eekels (1995). As shown in Figure 2.17, the proposed method for a product sound design process consists of four levels, namely; *problem analysis, conceptual design, embodiment design* and *detailing*.

Within the ***problem analysis*** level, after the demonstration of a product's sound, which is going to be designed or improved, current or possible auditory problems of the product sound are discussed verbally by designers (Özcan & Van Egmond, 2008). Additionally, Langeveld et al. (2013) stated that "the conceptual and functional role of sound in human-product interaction" is investigated at this level (p.60).

The ***conceptual design*** level of product sounds is explained as the process during which auditory ideas regarding to conceptual product are raised and exemplified by sounding sketches. Özcan (2008) describes the term sounding sketches as the "recordings of any object that has the potential to represent the sound desired" (p.217).

During the ***embodiment design*** level, Langeveld et al. (2013) stated that in order to achieve the intended auditory experience, physical models that can generate representative sounds are built and recursive processes of assembling and disassembling are conducted.

Within the last stage of product sound design, which is the ***detailing*** phase, a functional prototype of the intended design concept and consequently the product sound representing the intended auditory interaction is created. At this point, research for product sound quality assessments can be conducted with users (Özcan & Van Egmond, 2009).

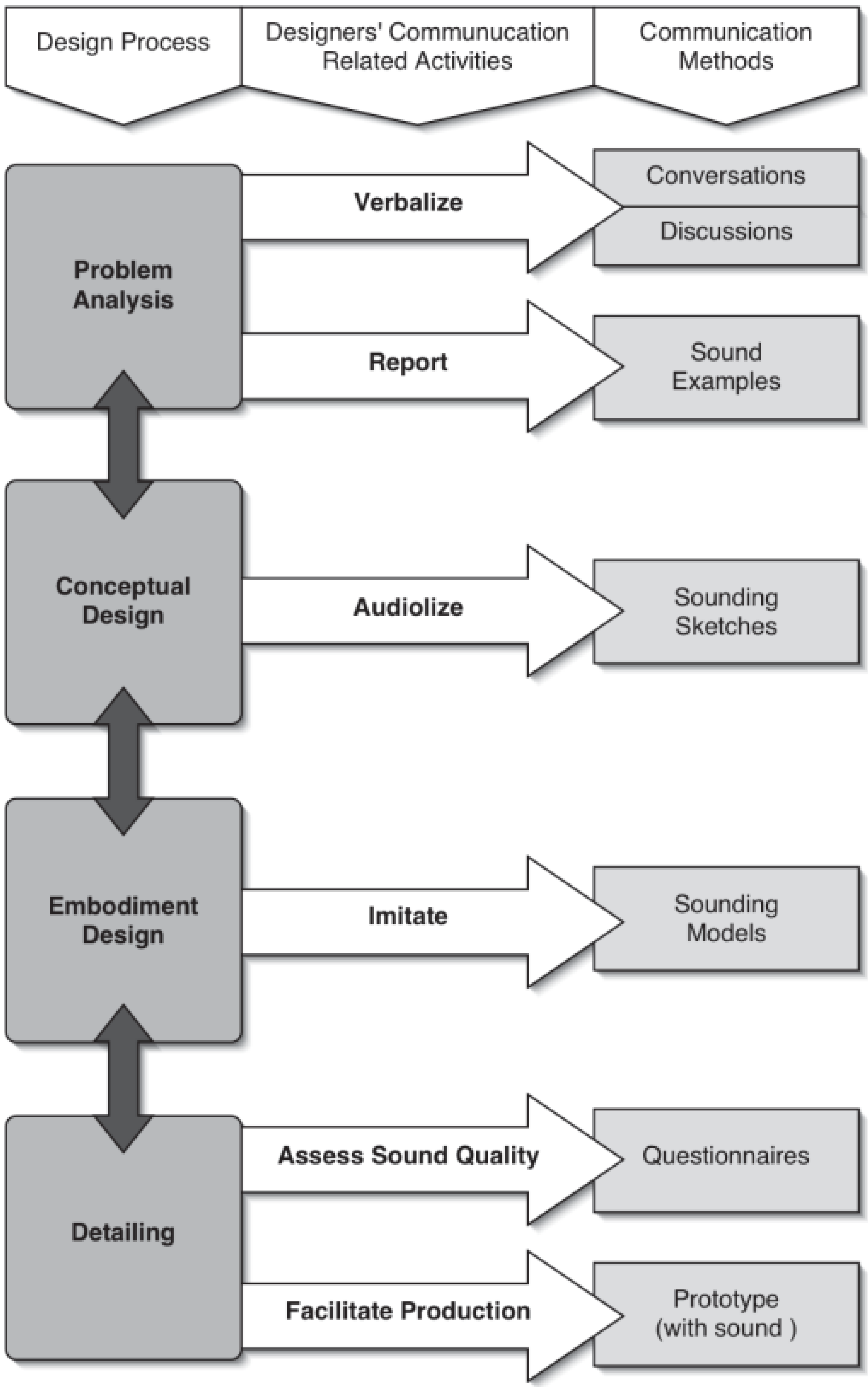


Figure 2.17. Proposed method for product sound design (Özcan & Van Egmond, 2009)

Within the sound design process of products, there is a need of different approaches and methods for both intentional and consequential categories of sounds. Langeveld et al. (2013) stated that for the implementation of intentional product sounds such as alarm and feedback sounds, the designer needs a musical knowledge in order to create musical motifs. These motifs are generally created with the help of music software and during the user-product interaction they are played via digital-to-analogue converters and a loudspeaker (Langeveld et al., 2013). To mention a few of these software helping experts to create and manipulate intentional product sounds are: *Max Signal Processing* and *PureData* – these can be given as examples of tools allowing the creation of physical sound models which present dynamic changes by the usage of sensors in relation with the actions of users (Ekman & Rinot, 2010). *Propellerhead Reason, Cakewalk Sonar, Steinberg Cubase, Apple Logic, Image-line FL Studio* and many similar others are examples of DAWs (digital audio workstations), which allow audio signal processing, synthesizing, recording, sequencing and mixing of sounds. Apart from these, *Adobe Audition, Sony Sound Forge, Pro Tools* and *Audacity* can be given as examples for digital audio editing software products allowing to record and re-shape the sounds, and applying a variety of effects on them. Yet, as mentioned by Ekman and Rinot (2010), these software solutions and the work methods they require are specialist in nature – actually the preserve of audio engineers and artists – and are difficult to be practiced by industrial or product designers.

For the design process of consequential sounds such as the sound generated by a vacuum cleaner, Langeveld et al. (2013) underlines that there will be a requirement of an adequate level of know-how in terms of manufacturing, materials and aesthetics.

As it can be understood from the viewpoints of several authors, the product sound design process requires information from distinct disciplines and should be included in the product development process from the beginning. However, as Özcan (2008) stated, in the current situation, product sound related issues are often started to be included in design discussions later on, at the embodiment level, in which there is a prototype of an intended design. Additionally, Robare (2009) mentions that the consideration of sounds is commonly postponed to the end of the product development process; yet, he underlined, "…in order to best take advantage of the possibilities sound has to offer, designers should begin considering the sound as an element of user experience at the concept-generation stage" (p.14).

2.3.4. Current Methods for Designing Product Sounds

Although an increasing interest from several industries has been shown to the design process of product sounds, instead of universal and well-accepted design methods, the sound design process is conducted with intuitive and ad hoc practices (Liljedahl & Fagerlönn, 2010).

To give an example of the methods applied, Lee et al. (2000) utilized a study to design the sounds that are essential for the operation of a portable microwave oven for outdoor use. In the course of this process, they described different sound concepts for a defined action or situation, such as pressing the button of a microwave oven or the end of cooking signal. These sounds were adopted from existing products or specially created for an experiential study aiming to get feedback from target users. During the experiential study, target users were shown a set of images of a microwave oven representing the user-product interaction and asked to rank the most favourable sounds in relation with these particular interaction steps. Finally, they added that the auditory experience is designed based on the evaluation of the responses and the opinions of target users; from this perspective, they argue that the auditory product experience would be more satisfactory in terms of meeting the expectations of users.

In a similar way, Liljedahl and Fagerlönn (2010) developed a tool called '*PART*' (Participatory Audio Research Tool), for the design process of product sounds. With PART, they explained that, "participants express opinions of sound in the medium of sound, without having to translate the experience into other modes of expression" (p.2). In Figure 2.18, it is shown that the user interface of PART is separated into two main areas – the upper area containing the image or video of the product or context with a textual definition, and the bottom area containing a button matrix enabling users to adjust the potential product sound in accordance with the context. These adjustments made by users are based on changing sound properties such as pitch, amplitude, reverb type and amount, and rhythmic structure. Liljedahl and Fagerlönn (2010) underlined that thanks to the technological development of computer systems, there is an opportunity for developing new tools to aid design and evaluation processes, by mixing traditional questionnaires and non-textual media.

Figure 2.18. PART - Participatory Audio Research Tool (Liljedahl & Fagerlönn, 2010)

Apart from these two tools, Ekman and Rinot (2010) offered a method called '*Vocal Sketching'* to lessen the technical challenges of the product sound design process for inexperienced designers, and to make sound design ideas easily communicable between a design team. They also emphasized the ease of using one’s own voice for mimicking non-speech sounds such as product sounds. Especially within the early conceptual stages of product design, vocal sketching may counteract the complexity of dealing with sound synthesizing techniques, which as previously mentioned require familiarity with concepts in a sonic domain that are beyond the normal scope of industrial design education (Ekman and Rinot, 2010).

In a similar fashion, Franinovic, Gaye and Behrendt (2008) conducted a workshop that aimed to make use of everyday object sounds to create and communicate an intended sonic interaction for conceptual product ideas. For example, participants of this workshop interacted with several objects such as rubber bands, tubes and fabric in order to explore the dynamic changes within the sounds emitted from these objects and try to link the outcomes to user-product interaction ideas.

Another stimulating example for the product sound design process is the Electric Vehicle Interactive Sound Signature System or, in short, ELVIS3. The aim of ELVIS3 is to create a dynamic auditory signature for electrical vehicles depending on the current driving parameters of the car, such as acceleration, load or torque. By rendering sounds to both the car exterior and interior, ELVIS3 builds a personalized auditory brand for a vehicle, warns pedestrians of its presence (they are used to hearing louder sounds of traditional cars), and creates an emotional connection between the car and its driver.

Another project, named CLOSED (Closing the Loop of Sound Evaluation and Design), aims to develop measurement tools and criteria for supporting the sound design process of interactive products (Franinovic, Hug & Visell, 2007). There are four main components of this project, namely; *building blocks, sound product design, human reception,* and *measurement definition*. The *building blocks* component provides sound synthesis modules fitting to the properties of real life sound events to enable designers to develop auditory interaction concepts and build prototypes in *sound product design* process. Within the *human reception* component, the aim is to obtain users' evaluations based on perception, cognition and emotion for auditory design suggestions, through the use of prototypes. As shown in Figure 2.19, in the course of the last stage of CLOSED, which is *measurement definition*, a correlation is searched for between the patterns generated with building blocks to create intended product sounds and evaluation outcomes for these sounds.

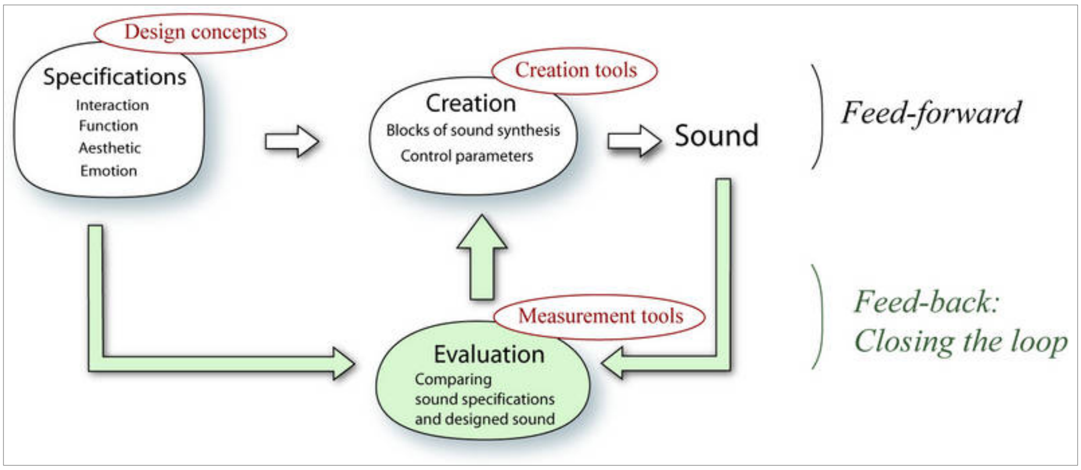


Figure 2.19. Closing the loop of sound evaluation and design (http://closed.ircam.fr/)

To support designers in creating sound design ideas for products at a conceptual level, Jansen (2009) also developed a tool named '*PSST!', Product Sound Sketching Tool*. As shown in Figure 2.20, PSST! offers a tangible approach to interaction for designers using physical controllers, each of which has an identifying icon to represent a variety of different parameters such as low frequency oscillator, pitch shifting and types of filters. These controllers are manipulated to affect the sound, until a 'sketched' sound suitable for the product being considered is found. In this way, Jansen (2009) added that novice designers may integrate auditory concerns to the initial phases of their product design processes and share their conceptual sound ideas with other team members in design meetings. In the course of developing PSST!, Jansen (2009) conducted experiments during which participants were assigned to create a number of product sounds that convey certain meanings such as efficient, energetic and inconspicuous, for a set of chosen products, namely: electric toothbrush, vacuum cleaner and washing machine. Designers participating in the experiment created product sound sketches by moving, rotating and twisting the physical icons and appreciated the tool as easy to use and playful (Jansen, 2009).

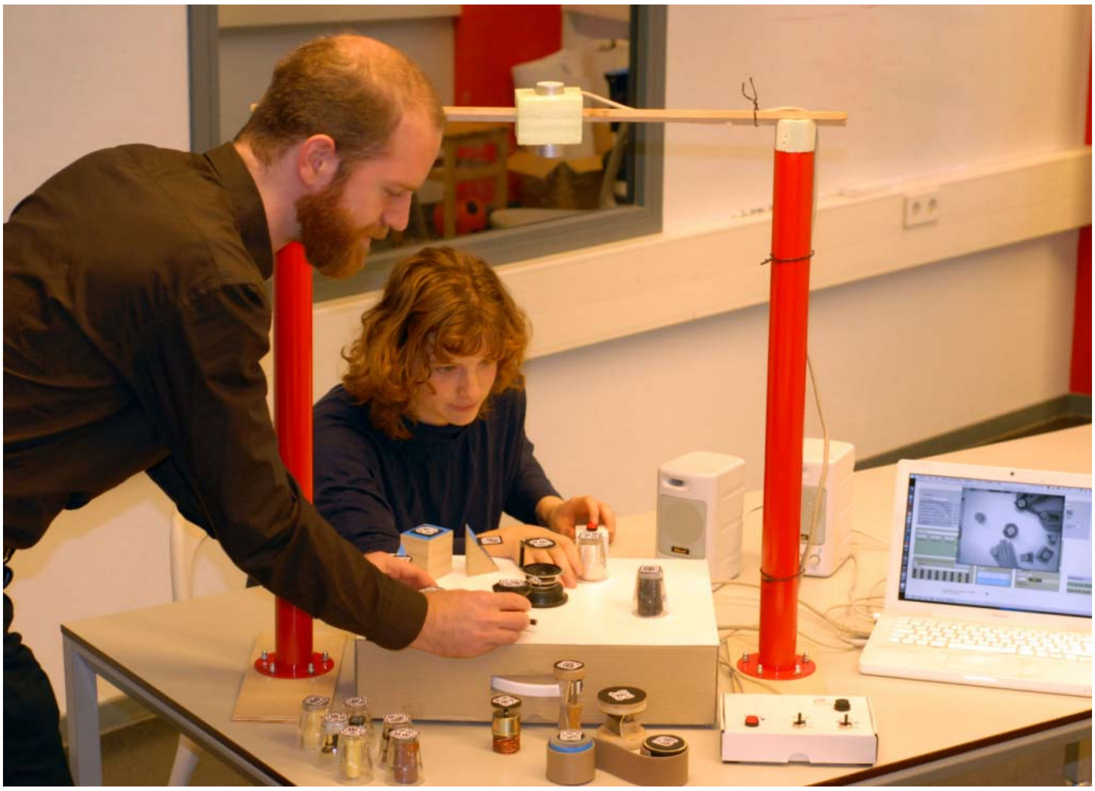


Figure 2.20. PSST! - Product sound sketching tool (Jansen, 2009)

Although there is an increasing interest for the design of product sound both from academia and practice, the number of tools and mediums that can aid novice industrial designers to work on and discuss product sounds is limited (Liljedahl & Fagerlönn, 2010; Nykaneen, 2008). As with many others, Van Egmond (2008) mentions "…just like one designs visual concepts for products and tests the experience of these concepts, there is a need to design auditory concepts that a future product will produce" (p.81). Therefore, it can be said that there is a requirement for simple tools that can help industrial designers to think, create and share ideas about auditory product experience.

CHAPTER 3

METHODOLOGY

As stated in the Introduction, this thesis attempts to explore the practice of sound design over the course of the product design process and to derive suggestions for designers and design students to enhance their perspectives towards the idea generation stage for auditory user-product interaction. To achieve this, the study must first reveal the current condition of the act of product sound design, from both professional designers' and design students' perspectives, so that potential enhancements for designing the auditory interaction between users and products can be identified. In this regard, it is important to uncover key aspects of how designers perceive the sound design process and how they incorporate these into their overall product design process. Such work requires the exploration of a designer's inner experiences with the sound design process as a part of the wider product design process. Thus, a qualitative approach to the research is adopted, focused on revealing the inner experience of participants and how meanings are shaped for the research subject.

Besides, this study also attempts to provide suggestions for both design professionals and students in a way that they can be useful for adoption in the course of their idea generation process and/or during the time they are designing for auditory interaction between users and products. In this regard, a *'research through design'* approach was adopted. Namely, the research has underpinned a particular practitioner activity in the sense that a conceptual tool was developed at the beginning of the study and iteratively improved through several rounds of user research and design development, arriving at an improved tool and improved understanding of user needs. Archer (1995) defines research through design approach as "gaining knowledge through the process of designing, building and testing highly experiential prototypes"; accordingly, the present study is in line with this definition because the field study was grounded on a designed conceptual tool and improvement of this conceptual tool was in line with the data acquired from the participants of fieldworks.

The conceptual tool (SoundsGood) is explained in detail later in the thesis. Although the conceptual tool was used to devise information, ideas, reflections and procedures, it was not in itself the sole aim. Rather, through designing, developing and evaluating the tool, the study's purpose is to generate communicable knowledge about sound design for industrial designers.

At an overview level, as shown in Figure 3.1, the research was structured into two major parts corresponding to a literature review and a field study. The former includes investigation of related literature from secondary sources through examination of related publications. The latter comprises qualitative research techniques to gain insights and understandings of designers' perception and applications of sound design within the wider product design process, especially at the earlier stages of design process. These two parts of the thesis are examined in detail as separate sections.

3.1. Exploration of Secondary Sources

At the beginning of the study, firstly, related literature was investigated under three main areas namely *'Experience of Product Sounds'*, '*Anatomy and Classification of Sounds*' and '*Design for Product Sound'*. Each area was examined thoroughly. In this respect, related published books, academic journal articles and PhD dissertations were examined.

For the first area, *'Experience of Product Sounds'*, issues related with user-product interaction & user experience traceable to product sounds were covered. This area also included meanings attributed to sensorial information gained from product sounds, and emotions evoked as an outcome of user-product interaction.

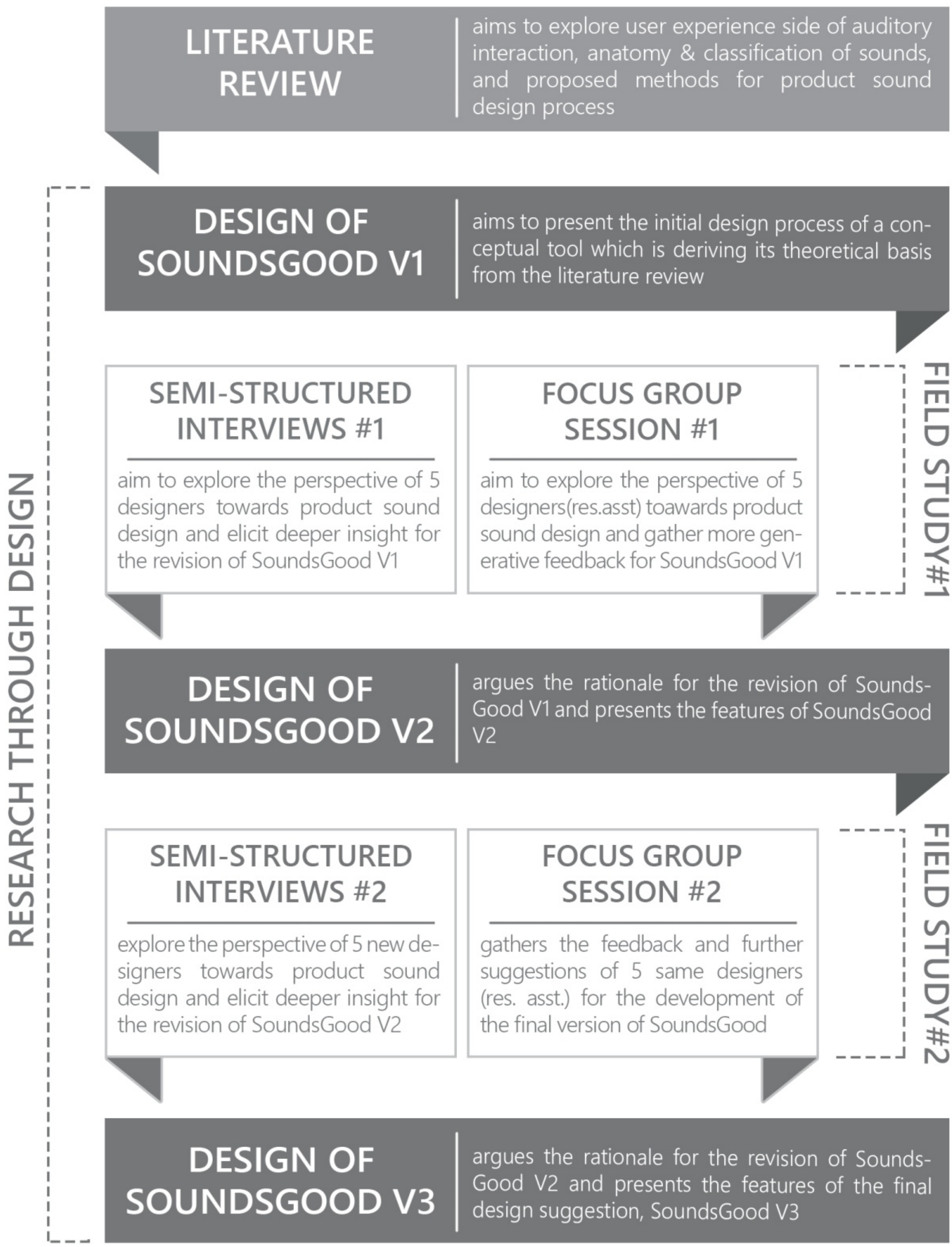


Figure 3.1. Overview of research stages

The '*Anatomy and Classification of Sounds*' area mainly focused on basic physical properties that shape sounds, as well as categorizations that have been made for environmental sound events generally, and for product sounds specifically.

Lastly, the '*Design for Product Sound*' area explored the requirement of knowledge contributions from a variety of sound-relevant disciplines, as well as examples indicating current methods, frameworks and practices utilized within the design process of product sounds.

3.2. Design of the Field Study

The field study was designed in two stages. For the initial stage, a conceptual tool (SoundsGood V1) was designed, deriving its theoretical basis and design rationale from the literature review. The conceptual tool occupies an important position in the structure of the field study design because it was used to assist participants while they reflected on their experiences with product sounds and evaluated their own product sound design processes. Since the conceptual tool took its theoretical root from the literature review, it was important to see how participants perceived and reacted to the theoretical terminology within the sound design realm. Accordingly, in the first stage, semi-structured interviews and a focus group study were conducted with the introduction of SoundsGood V1. On the basis of the outcomes, SoundsGood V1 evolved and was revised to become SoundsGood V2, which was then utilized in the second stage of the field study. This second stage again comprised a set of semi-structured interviews and a focus group session. After acquiring data from the second set of participants, SoundsGood V2 was further developed into a final proposal (SoundsGood V3). The 'research through design' approach was experienced as a fluid activity, where product and knowledge ideas and evaluations evolved in a dynamic way and fed off of each other.

3.2.1. Design of the Conceptual Tool – SoundsGood V1-V3

The reason for conceptualizing an initial tool before conducting the fieldwork was the absence of equivalent tools or media utilized by designers for developing and communicating sound design ideas within their product design process. In line with this argument, the primary aim of developing the conceptual tool was to elicit

designers' generative ideas and suggestions about how an intended audible user experience can be taken into consideration and practiced within the product design process.
As previously mentioned, three iteratively improved versions of SoundsGood were designed, which will be presented in detail in later chapters.

The conceptual tool, SoundsGood and its two later versions were designed and revised on Adobe Photoshop. The web applications called *'Prezi'* and *'Invision'* were also used to transform SoundsGood V2 into a partially interactive prototype. Hence, these applications makes participants experience the partially real-time usage of the tool.

The initial version (SoundsGood V1) was designed as a non-interactive visual depiction of an intended interactive software design. The aim was to gather the first impression and reflections of designers without distracting them to detailed interaction elements such as sliding menus, navigating through pages etc. (see folder 'SoundsGood V1' in DVD).

The first revised version (SoundsGood V2) was developed through use of Invision, an online tool for creating partially interactive prototypes from still images (see folder 'SoundsGood V2' in DVD). The purpose of developing a partially interactive prototype was to receive more detailed feedback from participants about elements of the software functionality, accessibility and user experience. In the course of interviews and focus group session, SoundsGood V2 was introduced to interviewees and participants and their initial ways of interacting with the tool were observed without excessive guidance.

The final version (SoundsGood V3) was developed based on the principal outcomes of both stages of the field work. In comparison with the earlier versions, SoundsGood V3 was built using Microsoft Office PowerPoint, in such a way that it was possible to communicate intentions for software interaction with regard to visual and auditory features (see folder 'SoundsGood V3' in DVD).

3.2.3. Data Collection Techniques

Two complementary data collection techniques were chosen for the field study: semi-structured interviews and a focus group study. As stated earlier, the field work intentionally had an exploratory nature. Namely, professional designers' and design students' thoughts, experiences, feelings, motives, concerns and needs related with product sound design were sought to be uncovered in a discursive and relaxed manner.

3.2.3.1. Semi-structured Interviews

The semi-structured interviews aimed to grasp the perspectives of 10 designers concerning the product sound design process and to gain deeper insights with respect to both conceptual and practical thinking. The conceptual aspect was mainly related with how designers' ways of communicating their ideas are formed, how they place sound design in their overall design process, to what level they give importance to sound design phenomena, and how they practice sound design in terms of user-product interaction. On the other hand, in a practical sense, the semi-structured interviews focused on introducing the conceptual tool, SoundsGood, and receiving participant feedback on it.

Accordingly, the developed guidelines for the semi-structured interviews comprised three parts referring to '*communicating the interaction*', '*designing for sound phenomena*' and '*reflecting upon the conceptual tool (SoundsGood)*'. In the first part, the attention was on the industrial designer's ways of communicating their design ideas to third parties such as other designers, engineers or users. The second part aimed to understand each participant's approach towards product sounds in terms of user-product interaction cycles, and to gain insights about whether or not (and if yes, how) industrial designers think about auditory attributes of products at a conceptual level in their design processes. In the last part of the interview, the SoundsGood tool was introduced to receive feedback from interviewees about usage issues of the tool, such as affordances of the interface, missing or over-designed parts, and so on. For both rounds of semi-structured interviews, five design professionals were recruited.

3.2.3.2. Focus Group Studies

The focus group studies aimed to explore the perspectives of five participants (different from the interviewees) towards product sound design, and to gather more generative feedback for the SoundsGood tool. Accordingly, the group dynamics and interactions among respondents within a focus group were intended to provoke new insights that may not have arisen in the one-to-one interview setting.

One focus group session was conducted for each of the two parts of the field work. The guideline structure used for the interviews was carried over to the focus group sessions. Different from the interviews, the participants were drawn from graduate industrial design students presently employed as Research Assistants at the Department of Industrial Design, METU. Both of the focus groups were conducted with the same five participants, to be able to follow changes in the SoundsGood tool and to offer the most informed levels of feedback. In other words, using the same participants for both focus groups allowed the researcher to receive deeper insights, since those participants were already familiar with the initial version of the conceptual tool.

3.2.4. Sampling

Sampling was used to determine who should be the interviewees and focus group participants. As Patton (1990) states, purposeful sampling is powerful in a way that it allows the researcher to choose *'information-rich cases'* to analyze thoroughly. Hence, *'information-rich cases'* help the researcher to grasp *'issues of central importance'* to the questions being asked.

Hence, sampling for the interviews was made amongst professional designers. Emphasis was placed on approaching designers from a variety of industries in which industrial design is actively participating the process. The chosen interviewees represented toy design, telecommunications, medical products and home appliances. The decision to interview five designers was taken as a balance of practicality and sufficient exploration of the subject matter.

For the focus group sessions, the main criteria for short listing participants was to be a graduate student of Industrial Design and to have studied one particular graduate course at METU (ID535 '*Design for Interaction*'). For the first criterion, it was thought that graduate students have experience with contemporary approaches to designing products, as well as experience working across different product sectors from both their undergraduate and graduate education. For the second criterion, it was considered that students who studied on the '*Design for Interaction*' benefited from an elevated awareness and understanding of user-product interaction, user experience, aesthetics of interaction, multimodal interaction including the role of sound and designing for sound phenomena. In this respect, five graduate students (Research Assistants) of the Department of Industrial Design, METU were selected for participation.

3.2.5. Venue and Equipment

Throughout the entire research, '*DocEar*', an academic literature management program, was used not only for managing literature (such as PDF management and reference management) but also for creating mind maps for exploring the frequency of codes and for defining sub-themes and themes. Its user-friendly interface was found ideal for making systematic categorization of literature and field work findings (see Figure 3.2).

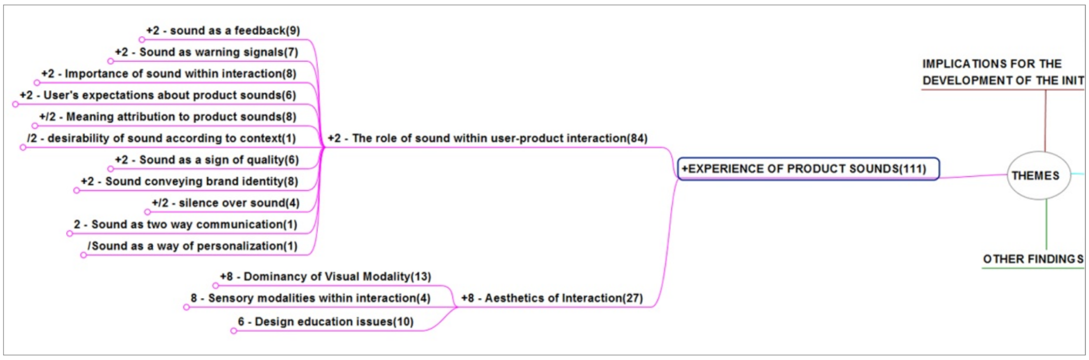


Figure 3.2. Example of categorization made by using DocEar

During the field work, a Sony recorder and Apple iPad Mini were used as voice recorders (for subsequent transcription and analysis). The focus group sessions were held in the METU Department of Industrial Design archive room. The interviews were held in various places according to accessibility of the interviewees. Those who were located outside of Ankara were interviewed via Skype. Similarly, those whose office or workplace were located in Ankara were interviewed at their own premises, at a time convenient to the interviewee. Some interviewees preferred to visit METU, in which case they were interviewed at the researcher's office.

3.2.6. Data Analysis

As shown in Figure 3.3, the data analysis process was carried out in a sequential manner.

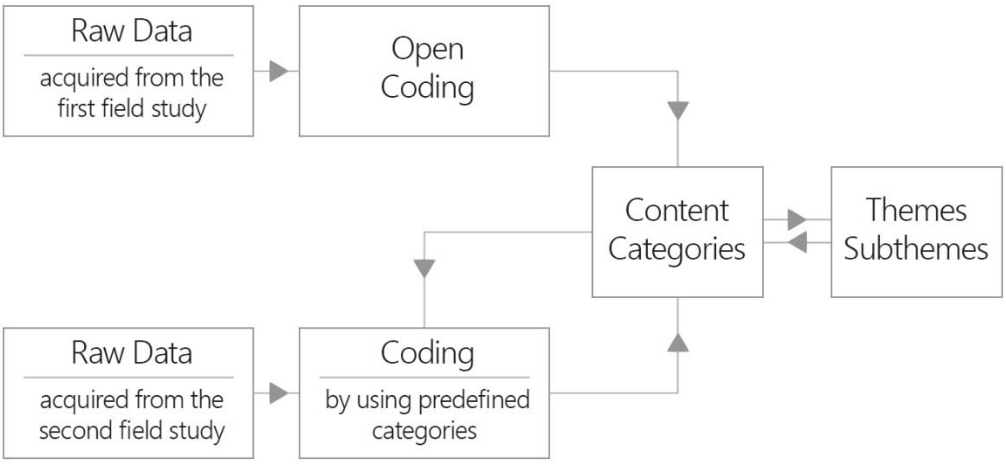


Figure 3.3. Overview of the data analysis process

For the outcomes of the first field study, firstly, audio records of the five interviews and focus group session were transcribed into Microsoft Office Word. The raw data acquired from those studies was read and re-read several times. While reading and examining this ‘raw data’, an open coding technique was used to identify codes, subcategories and categories that could be used to categorize the ‘essence’ of what different passages or excerpts referred to. That is, ideas, concepts and meanings that were detected in the data were grouped together based on their commonalities. After defining content categories through the open coding technique, content categories were examined for their relatedness with each other, using an axial coding technique. In this way, axial coding was used to create sub-themes and themes after analyzing the relations between content categories. Lastly, content categories were finalized and grouped according to these relations.

For the outcomes of the second field study, again, raw data were read and re-read many times but instead of commencing with an open coding technique, content categories previously defined from the first field study were taken as a basis (see Appendix C). The raw data were examined thoroughly to see how the outcomes of the second field study repeated, elaborated or differed from the outcomes of the first field study, and whether new content categories were needed. In the event, data gathered from the second field study did not require new categories to be created (see Appendix D).

3.2.7. Known limitations of the Adopted Approach

The first known limitation was related with sample size. Determining the 'right' sample size for qualitative research has always been a controversial issue. In this study, ten interviewees and five focus group participants (across two sessions) were conducted, as already explained. The idea size of a sampling is determined through saturation of data; yet, the concept of saturation is itself controversial. After ten interviews, there emerged *almost* no new and relevant data. Therefore, the choice of employing ten interviewees was decided. However, to be sure of reaching a saturation level, and given more time, the number of interviewees might have been doubled.

Another known limitation relates to the nature of the *'research through design'* approach. The approach is generally considered as relatively "subjective" and "situation specific" (Archer, 1995). Accordingly, the development of the SoundsGood conceptual tool might be seen as limited by the context in which it was conceived, i.e. relatively few interviewees and relatively small-scale focus group studies. As Archer (1995) has stated, "findings (of research though design) only reliably apply to the place, time, persons and circumstances in which that action took place". This opens the plausibility that different respondents (particularly as a group sample) might have led to somewhat different outcomes, which in turn may have led the revision of the tool in some different directions. This becomes a more serious matter if the participants in the 'research through design' process were not felt to properly represent a wider population (e.g. in this case, industrial design professionals). Such concerns were not present for the research as conducted, so confidence in the applicability of the method can be said to be high.

CHAPTER 4

RESEARCH THROUGH DESIGN - PART 1

As described in detail in the Methodology chapter, the fieldwork of this thesis contains progressive steps which are a combination of the development of design suggestions (SoundsGood V1, V2, V3) and the generation of research data through qualitative studies (interviews and focus group sessions).

Accordingly, this chapter introduces the rationale derived from relevant literature about product sound design, so as to develop an initial design suggestion for how intended audible user experiences can be communicated and manipulated within the context of design for interaction.

After the "Rationale for Initial Design Suggestion" section is presented, the main features of SoundsGood V1 are introduced in the section entitled "Initial Design Suggestion: SoundsGood V1". In the final part of this chapter, the outcomes of the first field study, which comprised semi-structured interviews and a focus group session, are presented and analyzed.

4.1. Rationale for SoundsGood V1

As mentioned in the previous chapters, product experience is a holistic phenomenon that is dynamically constructed by users' sensorial, motor and cognitive processes. It is argued that sound emitted by products, as a component of sensorial information, affects these aforementioned processes and that sound therefore shapes the overall product experience (Schifferstein & Desmet, 2008). In this sense, there is an opportunity for industrial designers to enhance user-product interaction by auditory means. However, as addressed in the literature section '*Design for Product Sounds*', the current practice of product sound design is conducted with intuitive and ad hoc approaches, instead of well-established design methods (Liljedahl & Fagerlönn, 2010). Additionally, in the realm of sound design there is a need for contributions from distinct disciplines, such as acoustics, engineering and psychology, which makes the product sound design process more challenging for industrial designers to take part in (Özcan, 2008). Consequently, it can be stated that the multi-disciplinary nature of product sound design processes and the dearth of proven methods for designing product sounds renders the role of industrial designers unclear within this domain.

Considering the challenges of product sound design, it can be proposed that industrial designers are in need of adequate tools and methods to participate in an effective product sound design processes and to suggest design ideas for enhancing auditory user-product interaction. At this point, it is important to note that any future tools and methods helping designers to focus on the auditory side of interaction should work in harmony with the ways that designers have already been accustomed to in the realm of 'design for interaction' and product design.

4.2. Utilization of Scenarios and Frame-based Storytelling within Design Process

For developing and communicating ideas about user-product interaction, one of the most frequently practiced methods by industrial designers is to build 'usage scenarios'. These are often communicated through textual and visual narrative – as written stories and as illustrated frames of a storyboard. While written stories explain the features of intended user-product interaction textually, storyboards help designers to visually communicate interaction ideas to colleagues from other backgrounds. Effective storyboards describe the product use, specifications of user groups and the usage context ("Use Scenarios", n.d.). In a similar way, Van der Lelie (2006) argues that storyboards can be useful for helping designers to transfer their design ideas and concepts to other parties having varying backgrounds or expertise, especially to lever evaluations and feedback. Within the early stages of a design project, building a robust user-product interaction scenario is known to be valuable as a means to explore design ideas and communicate amongst design team members

(Suri & Marsh, 2000). Similarly, Nardi (1992) mentions the role of a scenario as "a basis for discussion among researchers working on different aspects of the technology" and a "good reference point for making design decisions" (p.13). Caroll (2002) also mentions that with the help of a user-product interaction scenario, all the stakeholders in a design process are encouraged to participate in design discussions and contribute to the work under consideration.

Suri and Marsh (2000) specified the benefits of using scenario techniques in product design as follows: *representation of user experience, evaluation of early design ideas, communicating issues, individualisation of the user, focus for interdisciplinary teams,* and *consideration of systems and contexts*. In summary, the benefits of scenarios is that they allow members of interdisciplinary design teams to focus on exploring different design solutions, to consider different physical and social contexts in which user-product interaction takes place, to contribute their particular expertise, and to communicate design ideas amongst one another.

In light of these views, it may be argued that the product sound design process, which requires even more multidisciplinary contributions (i.e. industrial design, engineering, psychology, acoustics, musicology), can take advantage of user-product interaction scenarios – since as mentioned by Suri and Marsh (2000), scenarios can be seen as a channel that provides communication and exploration of ideas related with user experience within the conceptual levels of a design process. Additionally, Van der Lelie (2006) mentions that scenarios can create a common ground through which contributors with different backgrounds can project their own expertise onto a design problem, which in the case of this thesis is auditory interaction.

Within the scope of this work, a medium enabling designers to create, manipulate and communicate intended audible user experiences will be suggested. In order to specify design suggestions regarding the communication aspects of this medium, the ways that designers are accustomed to creating user-product interaction scenarios and storyboards will be briefly explored.

In the course of generating user-product interaction scenarios, designers exploit traditional, digital or mixed techniques using a variety of media, e.g. photographs, textual stories, annotated sketches, cartoons, role-playing and videos (Suri & Marsh, 2000). In Figure 4.1, a traditional approach to creating a storyboard is shown, consisting of hand drawn frames and textual information explaining the interaction between a user and product.

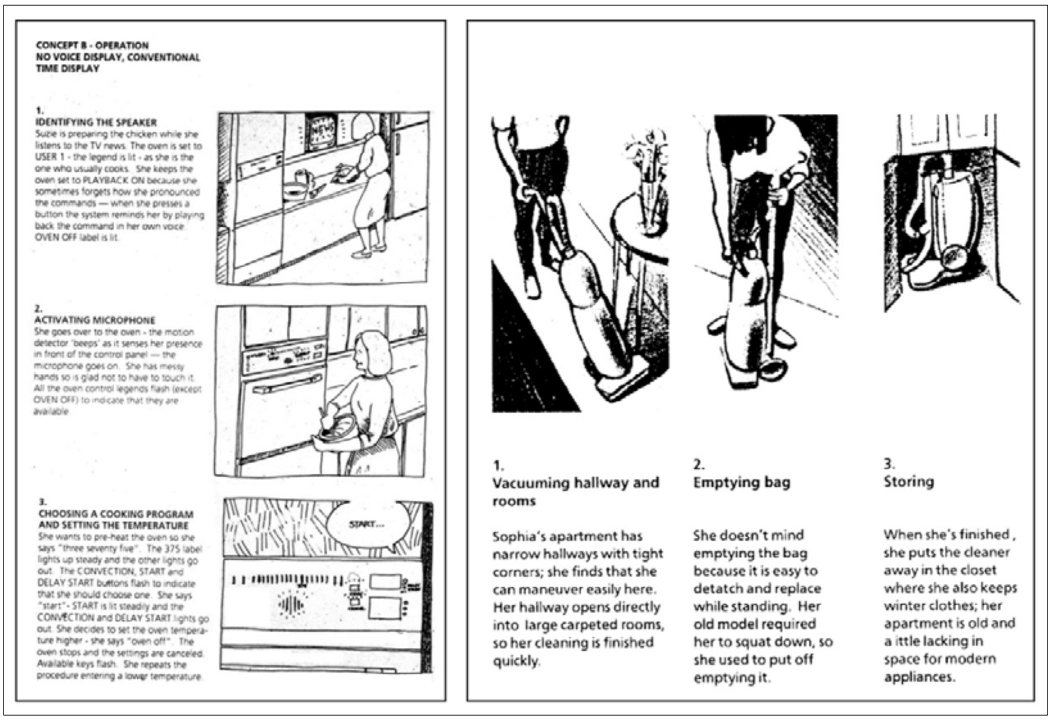


Figure 4.1. Examples for hand-drawn user-product interaction scenarios (Suri & Marsh,2000)

In addition to hand-drawn sketches and illustrations, designers also use digital sketches to build user-product interaction scenarios, as shown in Figure 4.2.

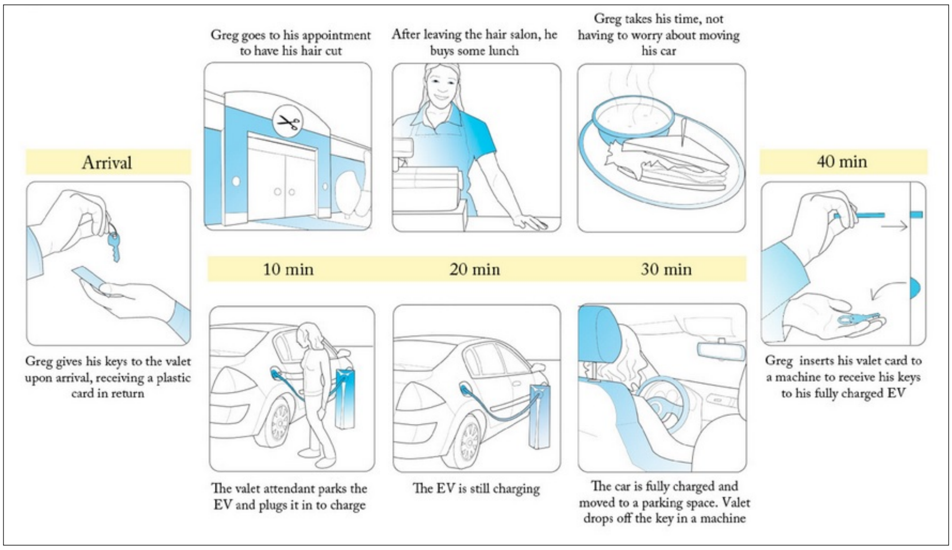


Figure 4.2. Interaction scenario of an online booking platform, generated from digital illustrations (Ghasemi, Tollington & Lee, 2011)

Apart from these, as shown in Figures 4.3 and 4.4, taking and assembling photographs of the usage context, users, mock-ups, prototypes, or manufactured versions of products, is another technique familiar to designers for creating and communicating user-product interaction scenarios.

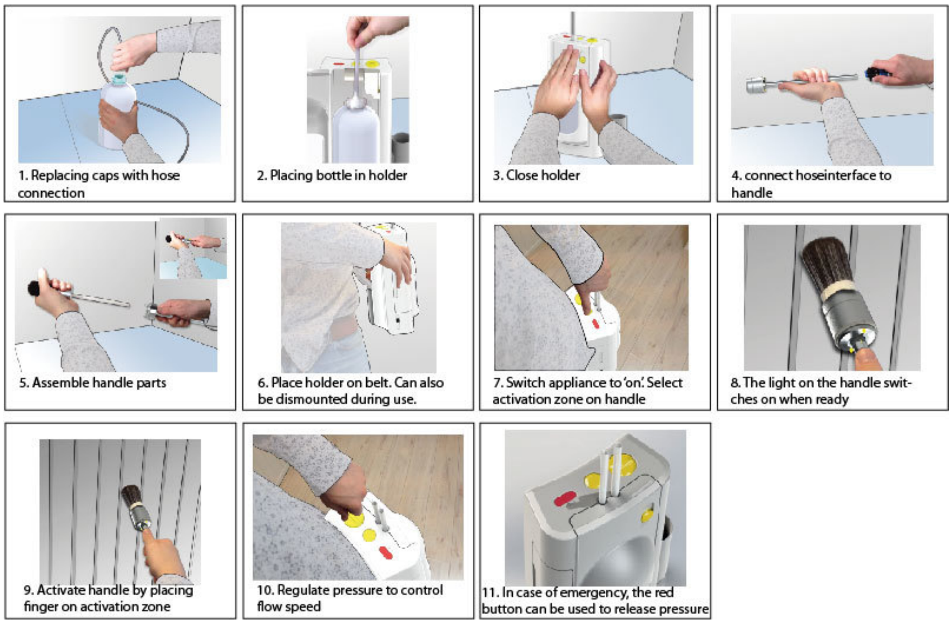


Figure 4.3. Usage scenario merging user photographs and 3D product renderings (Groen, 2014)

In addition to these mentioned techniques, there are certain dedicated software solutions for building storyboards although these have been developed with the film and advertising industries in mind. As far as is known, there is currently no storyboard or scenario visualization software aimed specifically for designers.

Amazon Storyteller (Figure 4.5) is an online application used for turning movie scripts into visual storyboards. Users can choose different background images, characters and objects from a stock library, or upload their own images and drawings to create a visual context for each scene. Additionally, textual explanations for each frame are generated to explain the storyline.

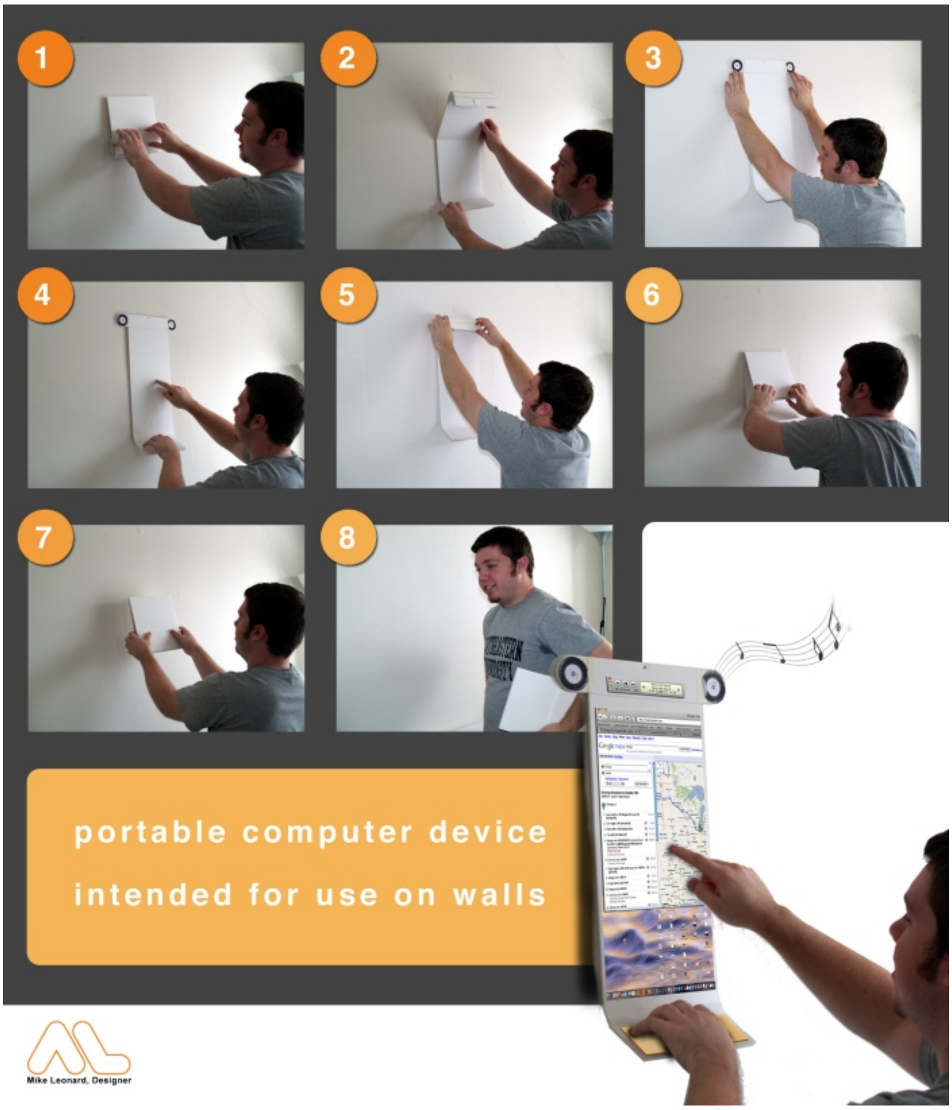


Figure 4.4. Interaction scenario generated through user and mock-up photographs and superimposition of digital product content (Stuparitz, 2014)

Another tool for developing storyboards is *Cinemek Storyboard Composer*, which can be run on both desktop systems and mobile devices. Mainly used by the cinema industry, this software is similar to *Amazon Storyteller* in that it allows users to upload their own material to create each frame of the storyboard. However, it is also possible for users to arrange camera movements in a 2D environment within each frame, such as zooming in/out, panning or tilting (Figure 4.6).

Figure 4.5. Amazon Storyteller - Online application for developing storyboards for movie scripts (Amazon Studios, 2014)

Figure 4.6. Arranging camera movements for each frame in Cinemek Storyboard Composer (Cinemek, 2014)

A similar application allowing users to upload images and make instant sketches for a storyboard is *Celtx Shots*. As shown in Figure 4.7, by hitting the plus (+) icon shown on its interface, users can add new frames to extend the length of a storyboard.

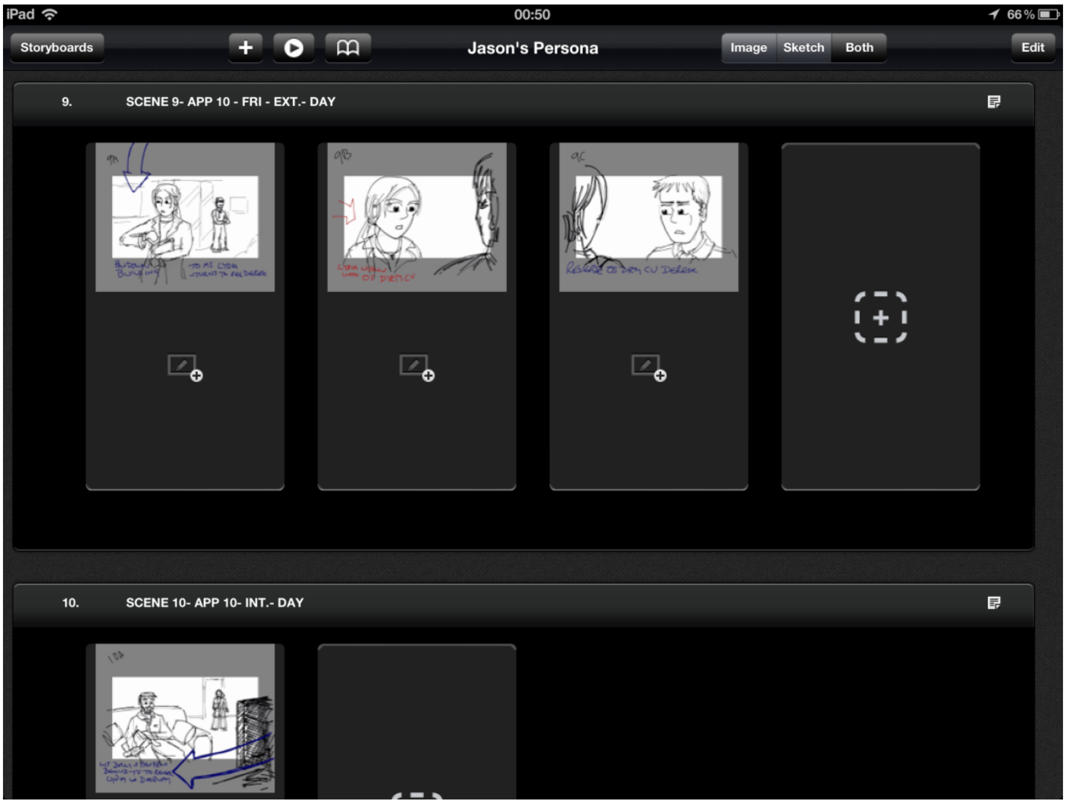


Figure 4.7. The plus (+) button in Celtx Shots allows new frames to be added to a storyboard (Celtx, 2014)

Although storyboards created to fulfil the purposes of film and advertising industries will inevitably differ from those needed to explore and define user-product interaction, due to the dearth of storyboarding tools aimed for the product design profession, the exploration of these specialist software can provide insights for how a design-specific tool or software might be specified. This is in relation to user-product interaction scenarios generally and intended audible user experiences specifically.

4.3. Initial Design Suggestion: SoundsGood V1

As mentioned before, the aim of this thesis is to explore how an intended audible user experience can be effectively communicated and manipulated by industrial designers, within the context of design for interaction. In order to gather ideas and commentary concerning the possibilities for designing, manipulating and communicating auditory interaction between users and products, an initial design concept (which had been planned to be used in the course of qualitative studies) was designed (SoundsGood V1). The insights derived from the literature review helped direct important design decisions for the first version of the design concept. Accordingly, it was asserted that the designed medium (e.g. tool, software), which primarily focuses on designers' idea generation and exploration of auditory experiences of users, should be built around a platform of interaction scenarios and storyboards, so that designers find familiarity in its general approach and can become easily accustomed to its usage. In other words, the vision for the design proposal realized through SoundsGood V1 was for designers to explore and express their ideas about product auditory properties by building and revising user interaction scenarios and associated storyboards.

In Figure 4.8., an initial version of SoundsGood V1, allowing designers to focus on the auditory aspects of user-product interaction, is shown. Through generation of this first version of SoundsGood, it would be possible to stimulate interviewees and focus group participants to generate and express criticisms and ideas about such a tool and thus open-up the possibility for many improvements in an iterative cycle.

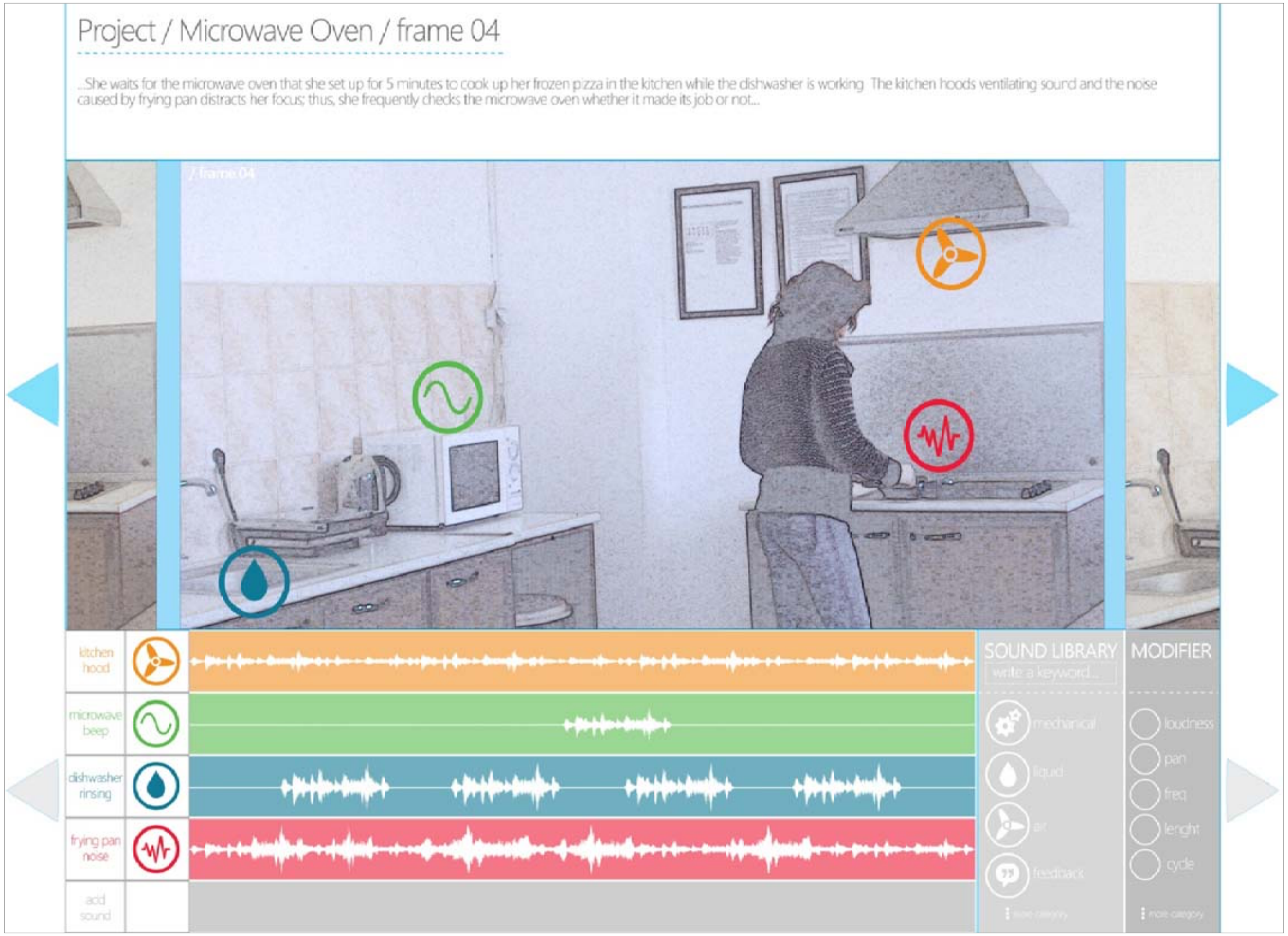


Figure 4.8. Initial design suggestion (SoundsGood V1)

As shown in Figure 4.9, the interface of SoundsGood V1 has been divided into four main working areas: A, B, C and D.

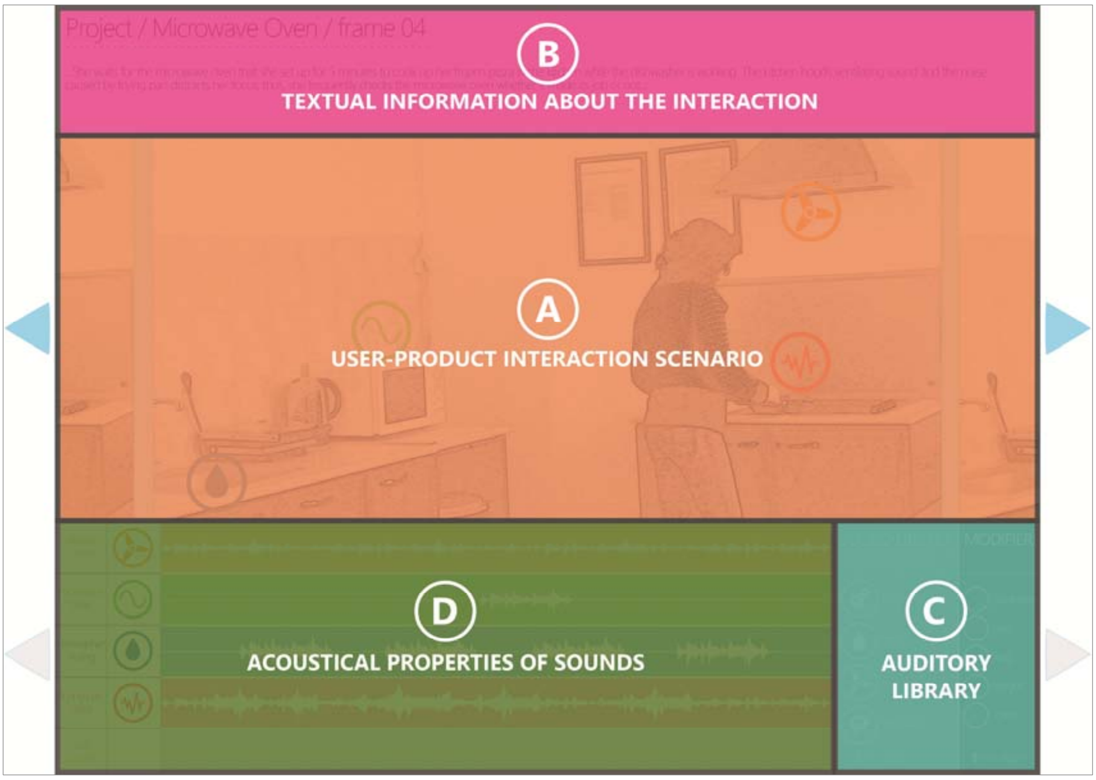


Figure 4.9 Four main working areas of SoundsGood V1

The central area tagged ‘A’ (see Figure 4.9), was decided to contain content related to individual steps (frames, scenes) of a user-product interaction scenario, which are determined by designers in the course of their product design process. Thus, in the area ‘A’ designers are encouraged to use their sketches, illustrations, photos, video shots or renderings to visually depict individual user-product interaction steps. Auditory interaction would thus be tied to the visual material presented in area ‘A’.

The upper part of SoundsGood V1, tagged as area ‘B’ (see Figure 4.9), contains a textual explanation for each interaction step, to accompany the visual information contained in area ‘A’. The purpose of having this kind of textual information is to strengthen the communication of user-product interaction by providing explanatory notes. Apart from the textual explanation of interaction steps, the name of the project and the frame number/name also appear in this area.

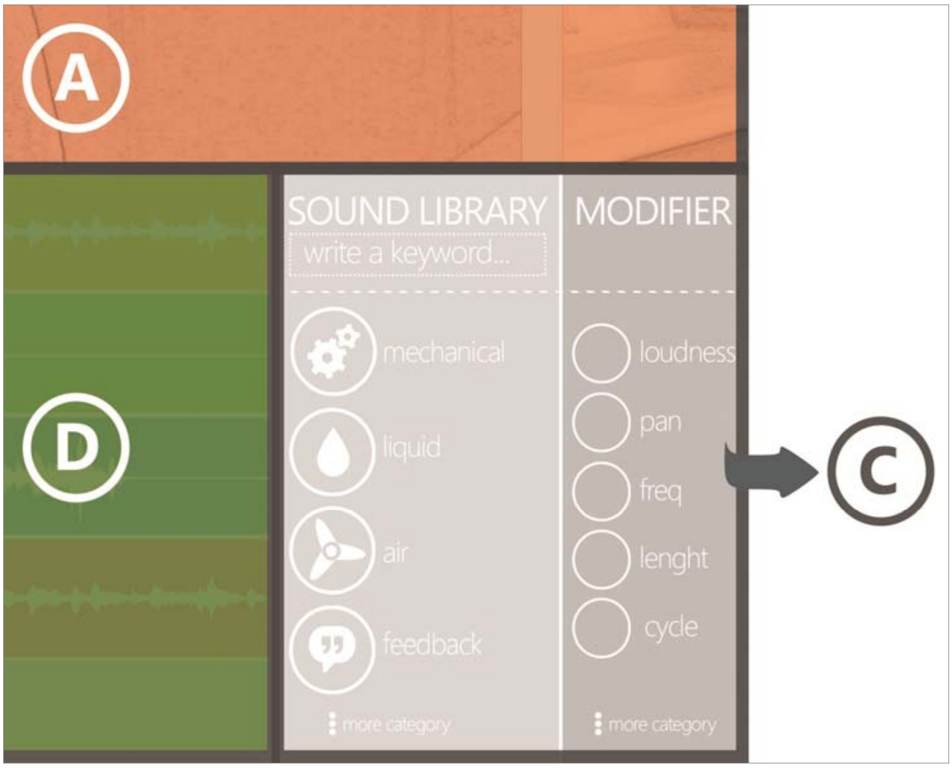


Figure 4.10. Sound library and modifiers

The bottom right area of SoundsGood V1, tagged as 'C' (see Figure 4.10), contains sound-related functions, namely: sound library and modifier. As the main focus of this medium is aiding designers to develop ideas for product sounds and creating suggestions for auditory user-product interaction, it is thought obligatory to provide a sound library through which designers can explore a variety of product sounds. A pre-existing sound categorization (Özcan, 2008) has been used to aid navigation of the library. This categorization sorts sounds into mechanical, liquid, air, feedback (termed "alarm" in Özcan's original categorization), cyclic, and impact types. This initial version of SoundsGood was generated as a static (non-dynamic) visual proposal, which although was able to communicate the main features it could not communicate the tool interactivity. Hence, in SoundsGood V1, it was not easy to communicate the action of clicking on the 'more category' text (see Figure 4.10). Nor was it possible to show the effect of menus or sliding controls.

The ‘modifier’ section contains sound design parameters that can be used to change the acoustic characteristics of a sound selected from the library. Common sound manipulation controls such as loudness, pan (stereo field position), frequency, and length (duration) are provided. Using the modifier section, designers will be able to modify pre-selected sounds in a playful manner to reach satisfactory auditory results. As previously mentioned, since SoundsGood V1 was designed as an initial design concept, instead of attending to every aspect in detail, some aspects were intentionally left incomplete (such as the sound library and modifiers). This way, the first set of interviewees and focus group participants would be encouraged to offer their own ideas and suggestions to be considered for SoundsGood V2.

The last area of SoundsGood V1 to be mentioned, located in the bottom left section and tagged ‘D’ (see Figure 4.9), visualizes the waveform view of selected product sounds (in which the loudness of a sound is shown as a function of time). Each sound selected from the sound library is intended to be dragged onto the related scenario frame (area ‘A’), and then becomes automatically shown in area ‘D’ to give ideas to designers about the differences of selected/modified sounds regarding loudness levels and temporal aspects.

With the help of the arrows located on the far left and right of the SoundsGood V1 interface, designers can move back and forth between consecutive frames of an interaction scenario. Such navigation is intended to support the revision and communication of auditory user-product interaction ideas.

4.4. Outcomes of the Field Study #1

In order to understand industrial designers' approaches to product sounds within the product design process, two tracks of field study were carried out: semi-structured interviews with five professional industrial designers, and a focus group session with five research assistants from the Department of Industrial Design at METU, who had successfully completed the graduate course *'ID535 Design for Interaction'*. In the course of these studies the first version of the conceptual tool, SoundsGood V1, has been utilized in order to gather more comprehensive feedback from designers for the further development of the medium.

This section presents the findings and conclusions under three headings, namely: *experience of product sounds, consideration of product sounds within industrial design processes*, and *implications for the development of a product sound 'design tool' (SoundsGood V1).*

4.4.1. Experience of Product Sounds

In this section, the outcomes of the first set of interviews and the first focus group session which are related to the experience of product sounds will be discussed under two topics, namely: *the roles of product sounds within user-product interaction*, and *the aesthetics of interaction*.

4.4.1.1. The Roles of Product Sounds within User-Product Interaction

Both the interviewees and participants of the focus group research mentioned several roles that product sounds can play within the process of user-product interaction. These roles are as follows:

i) Role of product sound as auditory feedback

As shown by the data, sounds within products are dominantly used as auditory 'feedback'. Based on interviewees and participants' views, auditory feedback can refer to the usages of sound as an indicator of function, malfunction or process. To give examples for the usage of feedback sounds as indicators of processes that products undergo during use: one of the interviewees mentioned that due to the silent drying cycle of current dishwashers, it is almost impossible to understand whether or not the process is finished without hearing the digital feedback sound. Others also exemplified the microwave oven's bell that conveys completion of the cooking process. Another interviewee interpreted digital feedback sounds as a replacement for mechanical sounds that would otherwise be present during product operation, adding that:

> In the old days, washing machines were working so loudly that one can understand when the spinning process finishes by the absence of the machine's sound. However, as the technology improved and these products became silent, digital feedback sounds are added to products to inform users about the processes.

Apart from digital feedback sounds, the interviewees and the participants also drew attention to the usage of consequential product sounds as feedback on product functioning. The mechanical click sounds emanated after closing the door of a washing machine and a car's glove box were given as examples, and underlined as significant factors of interaction that indicate the success of a closing action.

Another role that product sounds can play was mentioned as indication of product malfunction. One of the interviewee exemplified that in order to convey the type of failure, computers generate different sound patterns named as ‘beep codes’. In parallel, another interviewee stated that a skilled mechanic can detect the malfunction of a car just by listening to its sounds.

ii) Role of product sound as a warning signal

Two of the interviewees also addressed the usage of sounds as warning signals within user-product interaction processes. They added that the use of sounds as warning signals is especially crucial when the user's attention is focused on a specific action, event or situation such as driving a car, using an industrial machine, performing a surgery or operating an aircraft.

iii) Satisfying the expectation of users in the course of interaction

Other than these, nearly all the interviewees and the participants of the focus group session implied that the importance of sound within products depends on the expectations of users and the type of the product. In the case of a vacuum cleaner, one of the interviewees said that users expect the product to make a loud sound due to their prior experiences with the same or similar products. Another interviewee gave the example of electric cars, which are quite silent in comparison with vehicles having an internal combustion engine. Because of its silent working principle, electric cars both affect the conventional car driving experience of users in terms of product sounds and create a danger for pedestrians, who expect to hear the sounds of approaching cars while crossing the road. Besides the positive contribution of product sounds to the interaction process, most of the interviewees and participants stated that implementation of sounds within products can also be irritating for users during product operation. For example, to inform users about voice messages left, a sound emanating 'off and on' from a desktop telephone may irritate both the user and other people in the vicinity. The experience of one of the participants with an alarm clock was stated as follows:

> I bought a visually attractive and expensive alarm clock without trying it in the store. After purchasing, when I started to set the alarm at night, a very loud beep sound was emanating from the clock each time I pressed the setting button. So, in order to set the alarm to 08:30, I needed to press the button thirty eight times and this means thirty-eight loud beep sounds in the middle of the night while all others were sleeping at home. Due to this loud feedback sound, it conflicted with the usage context and I have not used it again after the first trial.

As with the aforementioned circumstances, the constant or frequent use of product sounds to inform users about normal states of operation was mentioned to be annoying by several participants.

iv) Role of product sound in terms of conveying a meaning

Another significant point raised about product sounds within user-product interaction was users' meaning attribution to these sounds. For example, the closing door sound of a car can convey the meaning of feeling (un)safe depending on the user's interpretation. Similarly, one of the interviewees explained that the sound generated during operation of a blender or vacuum cleaner may be interpreted as 'powerful' and this will affect the overall experience of users about the product performance as a result.

v) Role of product sound in terms of user's product involvement

One of the focus group participants mentioned that sound of products enhances the product involvement of users, by forming certain associations between the product and users. This participant also gave an example over the sound of a motorcycle's engine, with which some motorcycle drivers have emotional bonds.

vi) Role of product sound as a sign of quality

Other than these, one of the interviewees claimed that sounds created by products can be received as a sign of quality by users, such as the non-reproducibility of a leather jacket's authentic sound compared with its vinyl counterparts. Another example given for this issue was knocking on a product's surface so as to understand its material and structural qualities, by comparing the generated sound with previous auditory experiences. Additionally, some participants related a feeling of quality with the properties of sounds emitted from products, such as frequency and rotundity.

vii) Role of product sound as a contributor to brand identity

Some of the interviewees also mentioned the role of sound for conveying brand identity. For example, one of the interviewees stated that

> When Blackberry launched a touch screen smart phone, instead of mentioning visual properties or great music quality, its advertisement was

majorly built on the original keypad sounds of Blackberry for protecting the brand identity in order to reach its loyal customers.

The same interviewee also gave the example from the FastCo Porsche Challenge 2012 competition, where the brief was to get inspired by the Porsche 911 model and design a conceptual product reflecting its identity. The idea behind the winning project was a hairdryer concept inspired from the form of the 911 exhaust pipe and the sound it emanates. Another interviewee commented about the ring tone of Cisco branded office telephones, which become quite popular in the late 1990s in the same way as the Nokia cell phone classic ring tone – and added that product sounds can be very effective within the formation of brand identity. In contrast, some of the participants of focus group session highlighted efforts to make products as silent as possible, which can also be a strategy for brand communication and reinforcement.

As a result, it can be said that sounds generated by products are a part of users' everyday lives and play different roles within users' interaction with products. Consequently, apart from meanings loaded on product sounds – including encouragement to interact with certain product elements, and providing product involvement and association with symbolic values such as brand identity – the sound of products (and related process of sound design) is substantial for functional aspects, with respect to ensuring healthier and better communication between products and users. Although both the interviewees and participants of the focus group session accepted this fact as an essential attribute of products, they underlined their experiences of a lack of effort given to product sounds within the design process. In Figure 4.11, the roles of product sounds within user-product interaction mentioned by interviewees and focus group participants is summarized.

FS#1

- as auditory feedback : as an indicator of product function, malfunction and process
- as warning signals
- as a factor affecting the satisfaction of user's expectation
- as a factor affecting on the desirability of products
- as carriers of meanings attributed by users
- as a factor enhancing product involvement of users
- as a sign of quality
- as a part of brand identity

Figure 4.11. Outcomes of the first field study about the roles of product sound within user-product interaction

4.4.1.2. Aesthetics of Interaction

During the interviews and focus group session, two aspects within the scope of 'aesthetics of interaction' seemed to be significant: the dominancy of the visual modality over other sensorial modalities, and issues related with design education. (see Appendices A and B)

The interviewees and participants of the focus group session both indicated that designers mostly put their efforts on the design of visual properties of products such as form, proportion, texture and colour. While some explained the dominance of visual qualities with the plentiful amount and types of products requiring visual sensitivity, others criticised the situation with the richness of tangible details that designers can focus on and offer solutions. One of the interviewees pointed out the effect of sales channels on this dominancy, stating that:

> It is quite difficult to experience auditory, olfactory and occasionally tactual features of products while they are packaged on the shelf. Yet, visual properties of a product are always apparent to users in terms of interaction;

thus this domain inevitably becomes the most important playground for industrial designers.

Another interviewee evaluated the dominancy of visual concerns within product design with the argument of a hierarchy of senses. That is, he saw ‘sight’ as a dominant sense for people to perceive their environment. The other senses – such as touching, hearing and smelling – come after ‘first sight’. However, he also highlighted that designers are quite saturated in terms of designing visual properties of a product and he could foresee a gradual shift to the realms of other modalities, including auditory features, in the future. Yet, the field study overall revealed a view on the difficulty of creating and communicating ideas in the auditory realm, in comparison with the design of visual properties. In line with the aforementioned views, it was also stated that a visually unsuccessful product will not be taken into consideration by users in terms of other sensory modalities, unless the product in question is within the scope of niche products specifically related to those modalities (e.g. focus on sound, tactility, odour etc.). Thus, it can be inferred that nearly all of the interviewees and participants regarded attention to visual product properties as a ‘must’ and considered auditory properties as auxiliary elements that support the overall design of a product.

Three of the interviewees concurred with an opinion that design education is also overly focused on the visual appearance of products and neglects other sensory modalities. One of the interviewees added that there is nearly no consideration of auditory properties of products that can broaden the student's horizon within current design education curricula. However, this view was tempered by an acknowledgement that the amount of time available to develop a high school graduate into an industrial designer – even just in terms of visual maturity – is insufficient.

As a result, it can be inferred from the views raised by interviewees and participants that the main focus of the industrial design profession is on the visual properties of products and that other modalities such as auditory features can be taken into account as auxiliary properties. However, the importance given to these ‘supporting modalities' in the design of products is likely to increase with the introduction of successful examples in market and more discerning users.

4.4.2. Consideration of Product Sounds Within Industrial Design Process

In this section, the findings related with the consideration of product sounds within industrial designers' work processes will be discussed under three subheadings: communicating with other team members or parties within the design process, the current position of product sound design, and designers' reflections on product sound design.

4.4.2.1. Communicating with other team members or project stakeholders

The views of interviewees and participants of the focus group session converged on the principle that product design frequently requires a multi-disciplinary approach. In this sense, the industrial designer – as one of the professionals contributing to product design – needs adequate communication skills in order to exchange knowledge and opinions with other parties such as fellow designers, engineers, customers or users within the product design process.

In the course of the focus group study, participants were asked to write down possible ways of communication which as a designer they have used, or are available to use, in their next projects. At the end of this activity, they created a repository to which they could refer and discuss, at the later stages of the focus group session, about designerly ways of communication. In this repository, participants mentioned a wide variety of channels (including sketches, digital sketches, speaking, stock images, previous products, photographs, videos, animations, mock-ups, 3D digital models, scenarios, story boards, role playing, body language, metaphors and augmented reality techniques) that could be utilized by industrial designers to communicate their design ideas to other parties. From the interviews, the interviewees also emphasized the importance of communication. According to one interviewee, in order to communicate design ideas, for example about the auditory properties of a conceptual product, designers should try to find out the other party's previous auditory experiences and revise the way of communicating accordingly. Otherwise, there will not be a common ground to discuss on a design idea. Another interviewee mentioned the importance of consulting users about design ideas and added that:

> In addition to the professionals from other disciplines, the 'target user' is also another party that should be communicated with during the design process, due to the fact that a designer's imagination and empathy will never be enough for understanding user's needs or experience.

Another interviewee remarked on a further important point, which is the difficulty of gathering the attention of parties such as customers or users in order to transfer the design ideas to them and to get feedback. At this point, he stated:

> Animations of a product concept can be quite useful; and thanks to technology, creating these animations from 3D data gets easier in comparison with the past years. Also, communicating the design ideas with animations or videos can be also quite useful in terms of explaining the usage scenarios to others.

As another view on transferring design specifications and usage scenarios of a conceptual product to other stakeholders or design team members, one of the interviewees pointed out the effectiveness of presenting a prototype of a conceptual design. The reason for this is the fact that people - other than those in design-related professions – find it hard to perceive the three dimensionality of a design concept from sketches or high quality renders. Additionally, when there is a full-scaled, coloured prototype of a design proposal including its intended interface, the interviewee claimed that the communication process becomes much smoother. Yet, even if there is a full-scaled prototype, sometimes it can still be confusing to imagine the usage context of conceptual products. In order to minimize this confusion, during the focus group session, the participants emphasized the importance of using usage scenarios within product design and development. One participant interpreted that building usage scenarios is quite similar to ethnographic research. In this way, the usage context and possible problems can be foreseen by designers and easily transferred to others involved in the product design. In parallel

with these, Caroll (2002) states that "scenarios anchor design discussion in the work to be supported, encouraging input and participation among all stakeholders".
To increase the comprehensibility of the communication of design ideas about the interfaces of products, one of the interviewees also offered that designers either need to present the intended interaction scenario diagrammatically, or visualize all the possible interaction steps as visual or auditory feedback, in order to better communicate the design concept.

As it is underlined so many times, communication is one of the key skills for the industrial designer, especially a competence in generating usage scenarios that make explicit intentions for user-product interaction. Accordingly, as the claim of this study, the product sound design process requires even greater attention to (new) communication skills, since the number of adequate tools or methods are not enough. In Figure 4.12, the ways of communicating the design intend to other team members or project stakeholders remarked by the interviewees and participants are summarized.

FS#1

- use of traditional sketching
- use of digital sketching
- use of verbal description
- use of textual descriptions
- use of videos & animations
- use of mock-ups & prototypes
- use of 3D digital models
- use of augmenting reality techniques
- use of user-product interaction scenario
- use of storyboards
- use of existed products
- use of stock photos
- use of role playing
- use of body language
- use of metaphors

Figure 4.12. Outcomes of the first field study about the ways of communication to convey design ideas

4.4.2.2. Current position of product sound design

Even though it seems like there are no widely-accepted or common techniques for creating sound design ideas within the work practices of industrial designers, both the interviewees and participants of the focus group session mentioned examples from which the current position of product sound design practice can be determined.

Nearly all of the interviewees and participants voiced concerns that consideration of auditory features of products, especially within conceptual stages of product design, is overlooked and remains immature. One of the interviewees exemplified this overlooked practice as follows:

> The sound design process of our products, desktop phones, has been conducted with the initiative of one or two members of the software engineering department in our company. The reason for this situation is that the sounds of our products, especially keypad sounds and ringtones, are electronically generated and need to be coded within the electronic components of the product. However, the suitability of the sounds proposed by these engineer peers has never been a topic of evaluation from different professions. At this point, programming knowledge (which is required in this process) makes the situation impenetrable for us, industrial designers.

The interviewee also added that the creation and implementation of digital sound into products has become easier due to the advancement of technology; yet, industrial designers still do not ponder about auditory interaction within their design processes. Another interviewee mentioned the effects of working as an in-house designer or design consultant on product sound design, and gave examples from his own experiences as follows:

> Consideration of product sounds changes from one project to another. If we work on a project with a corporate like Hasbro, which already has its own sound design department and specialists about product sounds, we cannot engage in the product sound design process. However, if we are developing a

> product concept as a design agency; especially at a play testing level of a toy design, we try to imagine the sounds required within the usage process of the conceptual product and generate these sounds vocally by using our own voice.

Additionally, the same interviewee stated that at the prototyping stage of the product development process, they use the Lego Mindstorm Kit, which is an Arduino-based physical tool, to demonstrate the auditory interaction between the user and product, such as pressing a button on the interface and hearing the sound emitted.

Apart from these examples of the consideration of intentional sounds, another interviewee emphasized the significant effect of ‘consequential product sounds’ on design decisions. For example, because of the fact that the sound generated by an electric motor was appraised as not sufficiently ‘technological’, the design team he was involved with changed the model of the motor to one having a different sound, to increase the overall product quality and consequently the inner structure of the vacuum cleaner also was modified.

One of the participants of the focus group also gave example from his internship experience in a home appliances company for the consideration of sounds within a design process. He mentioned that in order to discuss the auditory feedback of an induction cooker interface, one of the senior designers developed and presented an idea that would support the increase in heat with an incrementally sharpening sound in the course of interaction via tablet computer. After that, the participants of a design meeting evaluated the solution with reference to a usage scenario and considered its suitability to the company's brand identity. On a related matter, one participant of the focus group session summarized his project experiences during which he considered the design of auditory features:

> Due to the scope of the project, an interactive alarm clock, it was the first time I have considered sound within the design process. After deciding the visual attributes of the conceptual product, I searched on the Internet to find a

> suitable sound which would fit into the overall concept of my project. In order to make the auditory interaction consistent with the smoothly blinking LEDs located inside of the alarm clock's body, I used software called Audacity to give a delay effect to the sound. Finally, with the help of augmented reality techniques, I presented the intended interaction that this alarm clock will offer to users.

As mentioned by the designer, the auditory side of interaction can also be simulated and anticipated within the initial phases of product design, with the use of specialist tools. At this point, another remark on the design process of product sounds was raised by one of the interviewees: the shortage of simple tools for industrial designers to create auditory ideas about user-product interaction. He added that current tools for sound creation are more suited to audio engineers or experts and require technical knowledge about sound and its related terminology.

To summarize, current practices of product sound design are lacking in contributions from industrial designers, especially within the initial phases of product design projects. Yet, the dearth of tools to offer industrial designers to create ideas about auditory interactions is a problem. They require designers to have an unreasonably deep technical knowledge about sound. This, combined with the inadequacy of communication channels to discuss sound design ideas with third parties, may be referred to as the primary reasons for why the consideration of sound within new product development is presently a difficult task. The remarks of the interviewees and the participants regarding to the current position of product sound design are briefly shown in Figure 4.13.

Current techniques used for product sound design	Problems remarked for the current position of product sound design process
FS#1	
- Use of Arduino based Lego Mindstorm kit for experiencing the intended auditory features at prototyping level of design process - Trial-and-error based prototyping for the design of consequential product sounds - Searching on Internet to find a suitable sound for the intended auditory interaction - Use of audio software for modifiying sounds to create the intended auditory feature - Interactive presentation of auditory interaction idea by using tablet applications - Vocally imitating the intended auditory interaction at conceptual product design level	- Overlooked practice of product sound design task within product design process - Technicality of the current tools for product sound design task - Requirement of the terminological knowledge - Lack of communication between sound design expert (if there is any) and product designers within the product development process

Figure 4.13. Outcomes of the first field study about the current position of product sound design

4.4.2.3. Designers' reflections on product sound design

In relation to designers' opinions about the future consideration of product sound design, both interviewees and participants of the focus group session came up with several ideas.

One of the interviewees indicated that as technology improves and the number of products with electronic components rises, the sound design process for products (at least for intentional sounds) will gain prominence for industrial designers. However, he also mentioned the difficulty of designing consequential product sounds, which are beyond the control of designers. At this point, one of the participants of the focus group session emphasised that in a sense, the design process for auditory properties containing both intentional and consequential sounds, can be seen as quite similar to the way industrial designers make decisions on mechanical, structural or material properties of products. As industrial designers do not have expert knowledge in these areas, they require an expert's assistance to refine design decisions. Ideas about the auditory properties of products can be expressed conceptually by industrial designers, within the reference frame of user-product interaction, and these design ideas can then be refined iteratively alongside experts.

On the other hand, another interviewee referred to the limitations that consequential product sounds bring to the design process, such as the complication of predicting these kinds of sounds prior to product realization. Nevertheless, in the case of non-designed product sounds, there will always be the possibility of having undesirable results once the auditory properties of the realized product are experienced.

Another interviewee gave an example about the initial conceptual level of design processes, where there is usually almost no consideration about product sounds. He argued that just like the comic book illustrators' usage of sound effects (such as "crack", "smack", "ouuuv"), industrial designers can represent sound within a 2D realm on paper, to give an impression of product sounds such as feedbacks or warning signals. On a similar topic, one of the participants also suggested that the textual representation of sound, or use of musical notes for conveying the idea about the product's sound, can be useful to stimulate design discussion.

Another suggestion for the communication of conceptual product sounds to third parties was the use of videos in which intended user-product interaction can be shown in a more fluent manner than is possible with a set of static images. However, no matter which channel is used to communicate the product sound design ideas to others, there is a requirement of creatively designing the sound in first place. To enable the usage of sounds for enhancing user-product interaction, one interviewee supported the idea of a sound library, which could include several types of feedback and warning sounds. He added that the designer could choose suitable sounds for the context of intended user-product interaction during the conceptual phases of product design. In accordance with this, two of the focus group session participants raised an idea about using audio software such as GarageBand and Audacity to creatively form and transform sound ideas for products. Another participant added that industrial designers can vocally imitate intended product sounds, and then record and transform these imitations via similar audio-processing software.

Whilst these suggestions seem to facilitate the design of intentional product sounds, one of the interviewees stated that the application of simulation techniques for the anticipation of consequential product sounds, such as the sound that an object with a defined shape and material properties will generate, can be suitable for the working style of industrial designers. He added that such a sound simulation tool could conceivably be a plug-in to current CAD software, such as SolidWorks. In this way, industrial designers could predict consequential sounds at some level while they are deciding the formal, structural and material properties of products in a digital environment, before the realization of a finalized design.

Apart from these, there were also suggestions for the sound design process of products at a prototyping level. For consequential product sounds, making several prototypes, for example with different wall thicknesses, can be useful for deciding the preferred specifications in relation to product sound. Yet, this kind of empirical trial-and-error method will increase the cost and the amount of time spent for the design process. For the implementation of intentional product sounds, two of the interviewees offered the use of simple electronic components and controllers, such as the Arduino system, for making prototypes interactive and bringing sound features ‘to life’.

Nearly all of the interviewees and participants remarked that the reason designers are kept from focusing on the auditory features of user-product interaction is a lack of technical knowledge about sound and its related terminology. Elaborating on this, one interviewee stated that industrial designers hesitate to express their opinions about the sound features of products, in contrast to visual properties which are considered a specialty. Another interviewee added that "in order to create meaningful product sound design suggestions, when I change the parameters of sound, I need to know which parameters will create the intended effects on users".

At this point, a focus group participant suggested that there can be a more comprehensible language for product sounds, by taking the advantage of how users describe the sounds of products.

Another interesting point raised by one of the interviewees was that when compared with ergonomics standards about the dimensions of product components, as far as the interviewee was aware, there exists nearly no standardization about product sound design such as the range of frequencies or loudness for a telephone ringtone. Additionally, the interviewee mentioned the possible difficulty of evaluating product sound even if there was any standard, in comparison with the visual evaluation process of products.

The points reflected by the interviewees and the participants of focus group study regarding to the potentials and challenges in terms of product sound design practice are briefly shown in Figure 4.14.

4.4.3. Implications for the Development of a Product Sound Design Tool

Both the interviewees and participants of the focus group session expressed their opinions about initial design explorations for SoundsGood V1, where the aim was to support industrial designers in communicating and manipulating an intended audible user experience within the context of design for interaction.

Most of the designers who participated in the field study reacted positively to the exploration of this kind of medium. One of the interviewees stated that it is possible to anticipate the auditory interaction between users and products with SoundsGood. He also mentioned that it may provide designers, who do not have expert knowledge about sounds, with an easier task to define the auditory side of interaction. Another interviewee added that at the prototyping phase of product design, SoundsGood can provide an opportunity to show an intended auditory interaction to users and lever feedback from them.

Potential techniques suggested for product sound design process	Challenges for the future consideration of product sound design process
FS#1	
- Using textual representations of product sound ideas at conceptual level - Use of videos and animations for the communication of product sound design ideas to other contributors - Use of Arduino system for making the prototypes interactive in terms of auditory features - Possibility of creating more comprehensible language for product sound design - Utilization of a future medium that categorizes the pre-existed usages of product sounds - Application of simulation techniques for the anticipation of consequential product sounds prior to product realization - Manipulation of the properties of product sounds by digital means to create intended auditory results (in conceptual level of design process). - Possibility of creating universal meanings and standarts for product sounds (e.g. graphical on/off icon, ergonomic metrics)	- Difficulty of evaluating the product sound proposals in comparison with the evaluation of visual attributes - Increased amount of time and cost due to utilizing empirical trial-and-error method for product sound design process - Technical complexity of designing auditory elements of products which is beyond the capabilities of designers - Complications of anticipating consequential product sounds prior to working prototype of design

Figure 4.14. Outcomes of the first field study about the designers' reflections on product sound design

Additionally, according to two of the other interviewees, one of the most important aspects of this or a similar kind of medium is to make ideas about product sound design communicable to other parties, prior to the finalization of product specifications. One interviewee also added that the communication of sound design activity within the product development team may affect the design process positively by paving the way for expressing alternative ideas and mutual design decisions, avoiding the imposition of one person's approach.

Although most of the participants agreed on the potential of SoundsGood V1 for the design of intentional product sounds, some questioned the accuracy or worth of consequential sounds that will be generated or manipulated. One of the interviewees pointed out that consequential product sounds, which are caused by mechanical parts and product functioning, are beyond the control of designers and can only be fully experienced after the realization of products. However, he added that the prediction of consequential product sounds before the realization of products may become possible through simulation within the digital realm. He exemplified that the simulations of material fatigue, buckling, torsion and the reaction of a defined form under certain pressure or vibration are all available with current technologies and specific softwares (e.g. finite element analysis, computational fluid dynamics) and underlined that this kind of simulation approach for consequential product sounds may also be possible. In parallel, another interviewee gave the example of other types of simulations that industrial designers currently, use such as photorealistic rendering and IES (Illuminating Energy Society) lights, which are digital profiles of real-world lights and lighting conditions, used for the realistic visualization of interior design projects. After that, he speculated about the possibility of product sound simulation for the anticipation of consequential product sounds as follows:

> There are 3D model libraries from which mechanical engineers or interior designers can obtain the actual parts or the products manufactured by certain companies and use them in their design processes. This kind of method for product sounds also may be put into practice like that – companies can share the sounds of the components they produce, such as the sound generated by an electric motor and the industrial designer can use this motor and its sound within the design process, then simulate the sound accordingly.

Another interviewee compared the similarity between the proposed usage of SoundsGood V1 with the preparation of a scene in a 3D environment for visual rendering. He added that just like the process of arranging a material's visual properties such as glossiness, opacity, and reflection, as well as the scene lights for acquiring realistic renderings, one may also arrange properties of sounds for generating better (more realistic, more complete) results for conceptual products.

Another review for the development of SoundsGood V1, in relation to increasing accuracy of contextual sounds, is its usage connected to a surround sound system. With such a system, the evaluation of product-specific sounds and their relation with the wider world of contextual sounds can be made more realistically and evaluated more accurately. On this topic, the interviewee offered that there can be a plan elevation image representing the spatial context in which a new product is planned to be used, onto which the designer can 'drag and drop' sounds from a product sounds library.

During the focus group session, participants also remarked on ideas concerning the advantages of using SoundsGood within a product sound design process. The opportunity to show intended user-product interaction step-by-step, and within a usage context, makes the discussion and evaluation of sound design ideas more practical. Additionally, after evaluations and receiving feedback on a design idea from several contributors, a designer using SoundsGood can continue to revise the sound design ideas on the same document, as an alternative product sound design scenario.

Apart from these, one of the interviewees suggested an idea that there can be alternative auditory interaction scenarios for each scene in SoundsGood. For example, he continued, if the scene focuses on the triggering of a microwave finishing bell sound, there can be alternatives of this sound along with different environmental sounds affecting the evaluation of it. In this way, there can be more than one alternative for each step in the design of the auditory interaction scenario for an intended product concept. Another consideration raised both by interviewees and focus group participants was the possible channels of interaction with the SoundsGood tool. In comparison with tangible usage, they implied that the digital realm would be more suitable for this kind of medium because of the mobility it provides. Moreover, if there is a possibility to develop a tool which can be used online for creating, manipulating and sharing auditory interaction ideas for products, it would become more accessible and sharable.

Other than the aforementioned comments for the improvement of SoundsGood V1, designers participating in the focus group session and interviews also found favourable the idea of having access to a product sound library in which they can make searches with different keywords, such as sound categories, contexts, products or labels defined within the course of previous projects. They stated that there is a good supply of software for designers to consider visual properties of products, material selection, or anthropometric data, but currently not for product sounds. One of the interviewees also indicated that SoundsGood, or a similar kind of medium, may contain several types of cues about the appropriate usage of product sounds in certain contexts, for example the range of frequency for the warning signal sound that will be used in a medical device in a hospital. In this way, there might be some intelligence and expert advice 'built in' to the interface.

The overall impression from the outcomes of interviews and focus group study was that SoundsGood – and the kind of medium/tool that it represents – may be valuable to industrial designers for creating, expressing and sharing their sound design ideas within the remit of user-product interaction.

CHAPTER 5

RESEARCH THROUGH DESIGN - PART 2

This chapter first presents rationale for the revision of the initial design suggestion (SoundsGood V1), based on information derived from the outcomes of the first field study. After that, the main features of SoundsGood V2, which was subsequently used during the second set of interviews and focus group session, will be introduced. Following this are the outcomes of the second field study, concentrating on issues of (i) experience of product sounds with regard to user-product interaction, (ii) consideration of product sounds within industrial design processes, and (iii) implications of the findings for the further development of SoundsGood.

5.1. Rationale for Revision of SoundsGood V1

The outcomes of the first set of interviews and focus group session were reviewed, in order to identify points that could be used to positively revise the initial version (V1) of SoundsGood.

Considering the variety of suggestions from interviewees and focus group participants, the points raised for the development of SoundsGood V1 can be divided into those that were applicable (within the scope of the thesis subject) and those that were not applicable (outside the scope of the thesis subject).

5.1.1. Non-Applicable Revision Suggestions

One of the points highlighted by designers was the possibility to integrate a digital simulation feature into SoundsGood. In this way, designers would be able to simulate consequential product sounds, such as the sound of a car door closing, by

building relevant auditory data into 3D CAD models. Such a facility would allow product sound to be prototyped and evaluated before committing to the manufacture of a product.
Another non-applicable suggestion was a mapping feature that would allow a surround sound system to be used within SoundsGood, providing the designer with a directionally correct soundscape. This was said to be useful for more accurately simulating real-life usage contexts, in which the intended auditory interaction can be more accurately evaluated. A proposed solution was to offer a plan image of a room in which an intended user-product interaction will occur, for which designers can arrange the spatial relations of intended product sounds along with background product sounds and other contextual sounds. The on-screen mapping would then be encoded in 5.1 surround sound and realized audibly through a connected surround sound speaker system.

5.1.2. Applicable Revision Suggestions

A variety of suggestions were made that could be readily applied to SoundsGood. One of these suggestions was the possibility of creating more than one alternative auditory interaction scenario for each frame in SoundsGood. Interviewees and the participants of the focus group session indicated that with such a facility, discussion and evaluation of auditory interaction ideas would be more practical especially in the course of design meetings.

Another applicable idea to take into consideration was an online usage of SoundsGood, which would have a growing sound library with the active participation of SoundsGood users. Additionally, with online usage, auditory user-product interaction scenarios would become shareable with other project members, consultants and target users, helping designers develop and evaluate the design ideas faster.

In addition to these, most of the designers indicated that the sound library offered by SoundsGood should be developed in a way that the designer would be able to easily search and find appropriate sounds. Different types of keyword were mentioned, covering product sound categories, the context of product usae, and the features of products. Moreover, it was indicated that a more comprehensible language (which perhaps refers to users' ways of describing product sounds in daily life) would better suit the categorization of product sounds in SoundsGood.

Another point suggested for the improvement of SoundsGood was the feature of importing sounds. By importing sounds to the sound library, designers would be able to use any sound they wished, such as pre-existing product sounds, natural sounds or their own vocal imitations.

In the next section, the main features of a revised version of SoundsGood (V2) will be introduced, by referring to the aforementioned rationale. Additionally, it is important to note that the reason for describing some of the suggestions derived from the first field study as ‘non applicable’ is that the realization of these suggestion (even to just a conceptual level) is beyond the scope of this thesis and requires distinct technical knowledge in variety of fields, e.g. computer engineering, software development.

5.2. Revision of Design Suggestion: SoundsGood V2

SoundsGood V1 was revised according to the rationale derived from the outcomes of the first field study, in which SoundsGood V1 had been used as a means to gather designers' opinions about the possible advantages and disadvantages of using this kind of medium within the product sound design process.

In Figure 5.1, the interface of SoundsGood V2 is shown. By using Invision, an online tool for transforming graphical user interfaces (GUIs) into partially interactive prototypes, the intention was to elevate the level of realism in SoundsGood V2. This would contribute positively to the feedback sought in the subsequent set of interviews and focus group discussion. Participants, for example, would be able to experience transitions between pages and options from menus because of the increased level of interactivity. By using the following web links, two interactive prototypes of SoundsGood V2 can be experienced in any kind of web browser.

- Partially interactive prototype of SoundsGood V2: http://invis.io/ZK1TQ489X
- A conceptual design example in SoundsGood V2: http://invis.io/JH1LUXKCP

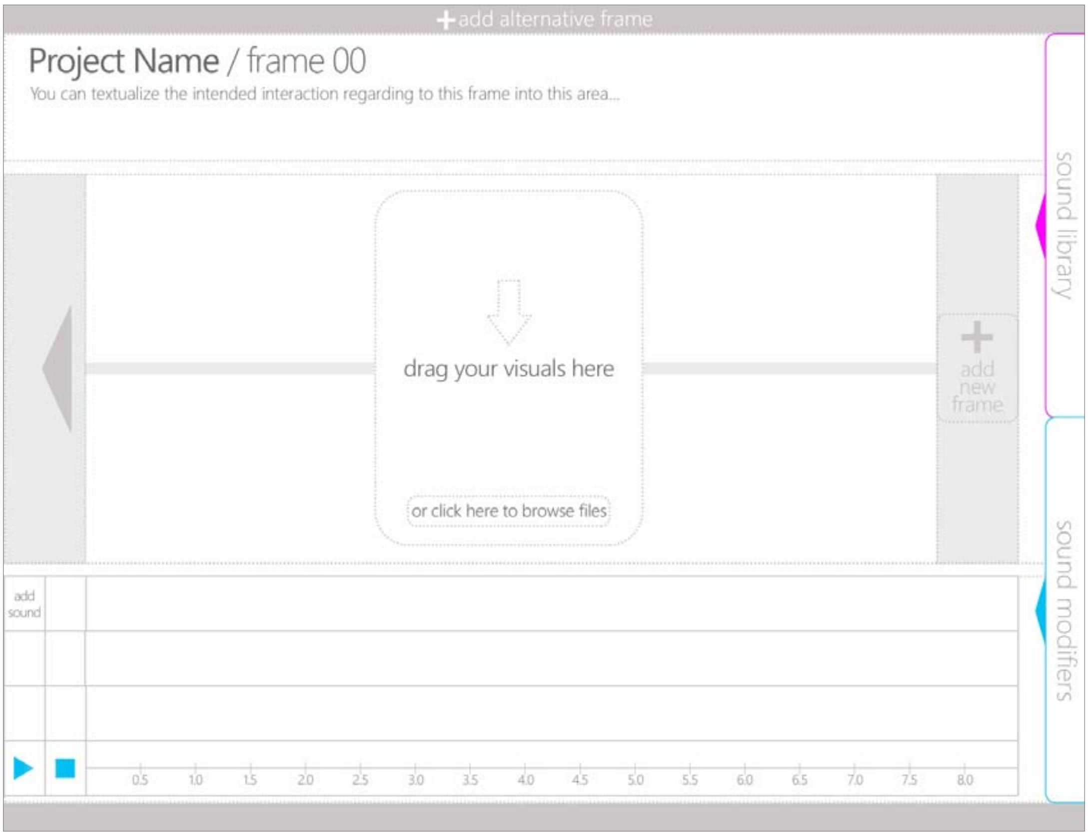


Figure 5.1. Interface of SoundsGood V2

As shown in Figure 5.2, the user interface of SoundsGood V2 is divided into four main parts regarding to its main features which are as follows: user-product interaction scenario (A), textual information about the interaction (B), auditory library (C) and acoustical properties of sounds (D).

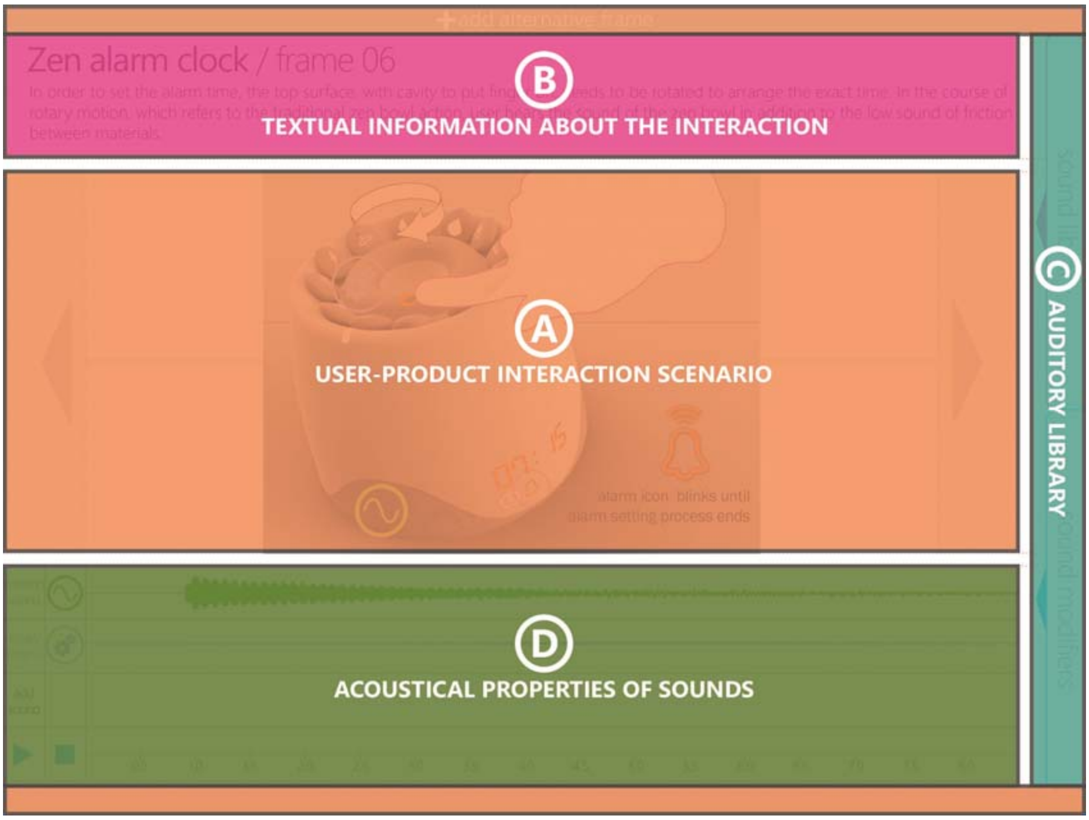


Figure 5.2 Four main parts of SoundsGood V2 shown on the example project

A) User-product interaction scenario

The area tagged 'A' (see Figure 5.2) comprises the frames of a user-product interaction scenario. In order to form the frames, designers can utilize any type of visuals that have been previously created in the course of design ideation or later stages of product design. By choosing and dragging related visuals onto the dedicated area or by browsing and selecting them from a project folder, as shown in Figure 5.3, the visual representation of an interaction frame or scene will be built. In the later stages of a project, designers can add new frames to the scenario by hitting the plus (+) icon located on the right side of the SoundsGood interface. After forming the interaction scenario, it is possible to navigate through the frames horizontally by clicking the arrow icons (see Figure 5.4). Additionally, there is an option to create alternative frames for any or all of the pre-existing frames in the scenario. By clicking the dedicated area as shown in Figure 5.4, designers will be able to create an alternative to the existing frame at a given timeline point.

Navigation between the alternatives and the original frames will be possible through arrow icons visible on the top and bottom edges of the interaction scenes.

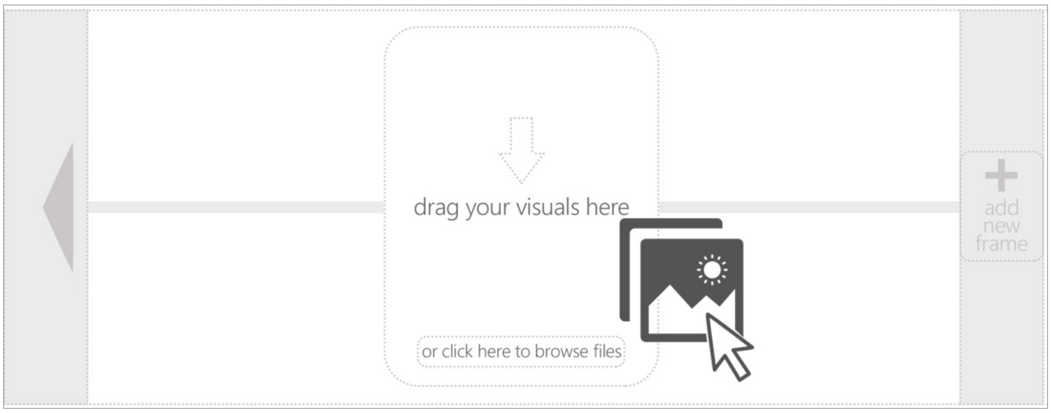


Figure 5.3 Adding a visual to a user-product interaction scenario frame

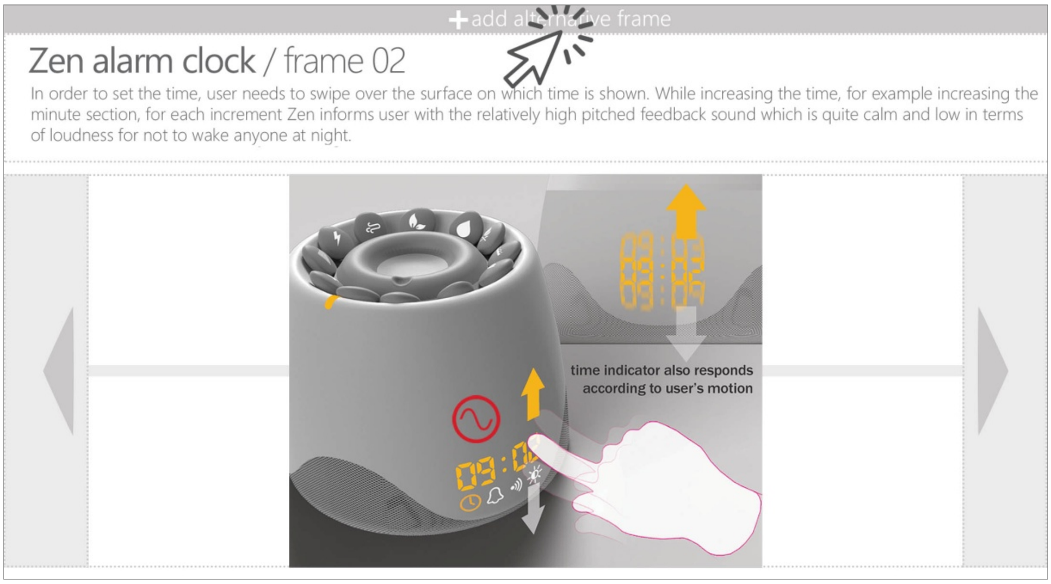


Figure 5.4 Navigating through a user-product interaction scenario and adding alternative frames

The idea behind being able to create alternative frames is to accelerate the design process, by suggesting alternative ideas for each user-product interaction step. With this functionality, in a design meeting the designer may navigate through multiple ideas for each user-product interaction step, instead of just focusing on a single idea.

B) Textual information about the interaction

To accompany and reinforce the visually depicted interaction steps, designers can also type text describing the details of each user-product interaction event into a dedicated area (tagged with 'B' in Figure 5.2), located on the upper side of SoundsGood V2 (see Figure 5.5). In this area, the project name and the number of each frame is also shown, to assist navigation. The reason for having this feature is to provide designers with an option to describe the auditory interaction in a textual way, thereby strengthening communication of auditory ideas amongst the stakeholders and contributors of a project. Additionally, as shown in Figure 5.6, each alternative frame (e.g. alternatives for frame 02) are suffixed with a letter (e.g. 02A, 02B…) to ease identification.

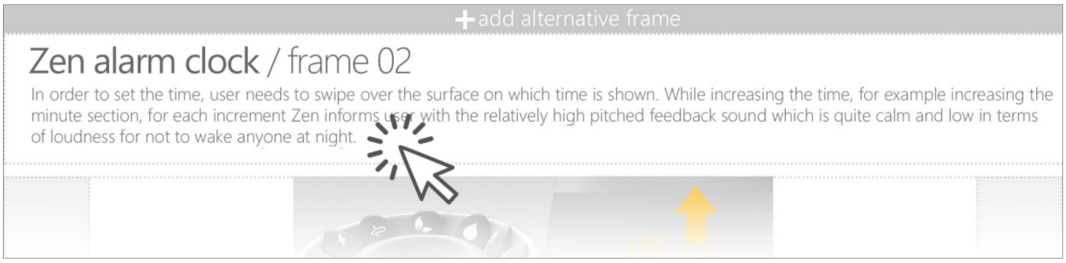


Figure 5.5 Adding textual information regarding to each scenario frame

Figure 5.6 Alphabetical indicator for alternative frames

C) Auditory library

The auditory library consists of two main groups: sound library and sound modifiers (see Figure 5.1). While the sound library contains a variety of sounds that can be used as starting points for defining auditory interaction, the sound modifiers allow designers to modify any sound to fit better to their sound design objectives.

i) Sound library

As previously mentioned in the section "Rationale for Revision of SoundsGood V1", the first set of the interviewees and participants of the focus group session had remarked that there should be a feature for searching and uploading sounds in the sound library. Additionally, it was also stated that instead of using technical terms for sorting product sounds, utilization of more descriptive words derived from daily life would be better understood by designers. Accordingly, first of all, the location of the auditory library has changed from V1 to V2 of SoundsGood: from the smaller bottom right corner to the larger middle right side (see Figure 5.1 and Figure 5.2). The reason for this revision was to provide sufficient space for the (now increased) contents of the sound library and sound modifiers.

As shown in Figure 5.7, when the sound library tab is clicked (1), contents of the sound library become visible via the sliding menu. Likewise, to close the sliding menu, a second click on the sound library tab is required (2). To categorize the sounds in the sound library, in addition to Özcan and Van Egmond's (2005) categorization of product sound types (located at the right side of the library and shown with icons), various descriptive sound categories have been added. As mentioned earlier in the section "Anatomy and Classification of Sound" within the literature review, these descriptive sound categories were developed according to the outcomes of several field studies, during which participants had described the sounds of a variety of products (Özcan & Van Egmond, 2005). For this reason, it can be argued that utilizing descriptive sound categories in the sound library of SoundsGood is a way to help ease the process of exploring for appropriate sounds.

Figure 5.7 Interaction steps with the sound library in SoundsGood V2

The sound selection process requires designers to navigate the full sound possibilities and narrow-down to a sound that fits to their design intentions and ideas. For example, as shown in Figure 5.7, the designer chooses *emotion* from the descriptive sound categories and d*igital feedback* from the product sound categories (3). Then, the sound library files fitting this combination of terms is presented as a list. The designer navigates the list and chooses *calm alarm,* because he/she is currently searching for an ideal sound for an alarm clock that provides a calm waking-up experience to its users (4). Using this example, it is evident that designers can restrict the list of potential sounds by creating any combination of subcategories based on design intent, e.g. *onomatopoeia-liquid, action-mechanical, location-air, sound properties-cyclic etc.*

Apart from sound categorization, any sound that can be suitable for creating an intended auditory interaction can be now be imported into the sound library of SoundsGood V2. This functionality allows the utilization of pre-existing sounds from products, sounds emitted from daily objects, natural sounds, sounds synthesized by designers, or even sounds created by vocal imitations.

ii) Sound modifiers

As previously mentioned, the aim of having sound modifiers in SoundsGood is to allow designers to explore auditory variations by modifying selected sounds assigned to scenario frames. Due to the lack of reviews raised by the first set of interviewees and focus group participants on the possible usage of sound modifiers, improved ways of interacting with the elements of sound modifiers could not be elicited in detail. However, in order to obtain more detailed feedback and suggestions on sound modifiers during the second round of interviews and focus group, this aspect of SoundsGood V2 has been conceptualized and improved as shown in Figure 5.8.

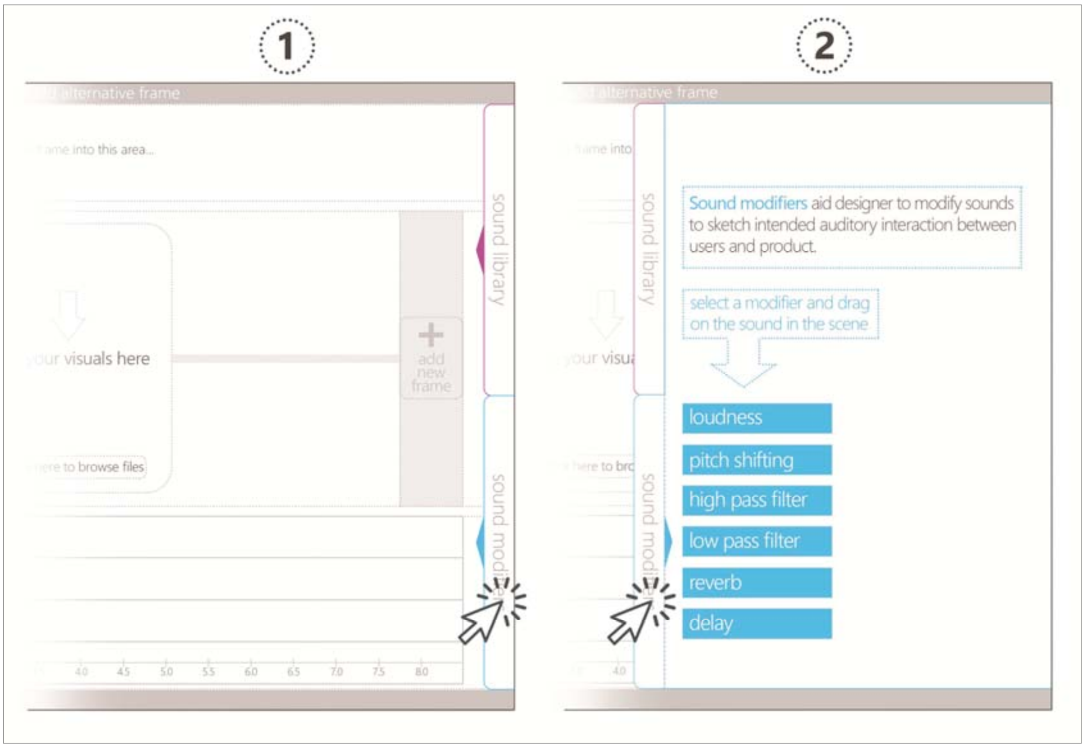


Figure 5.8 Opening and closing sound modifiers

Similar to the sound library, a sliding menu of sound modifiers is opened or closed when its corresponding tab is clicked in the area shown in Figure 5.8. The sound modifiers selected for use in SoundsGood V2 are: i) loudness, ii) pitch shifting, iii) high pass filter, iv) low pass filter, v) delay, vi) reverb.

i) Loudness: As mentioned in the "Experience of Product Sounds" section, loudness is a subjective perception of the intensity level of sounds (Johansen, 2006). It has been thought that designers may modify the loudness level of each sound in order to shape their intended auditory ideas for user-product interaction (also see *amplitude* in the '*Physical Description of Souns*' section).

ii) Pitch shifting: Pitch, as previously mentioned, is a sensation of comparing sounds on a musical scale such as high or low (Fastl, 2006). In connection with this, there is a non-linear relation between frequency and perceived pitch (*How do we perceive pitch?*, 2003). In this sense, by utilizing pitch shifting, designers may change the pitch of the selected sound to convey an intended effect. For example, as the frequency of a sound (related to the pitch) is one of the most important factors influencing the sharpness of a sound (Fastl & Zwicker, 2007), a designer may modify the sound by using pitch shifting to increase or decrease the perceived sharpness level of a sound. Consequently, these changes can affect the perceived character of products such as powerfulness and aggressiveness (Fastl, 2005).

iii) Frequency selective filters: In SoundsGood V2, two types of frequency selective filters are provided: high pass filter and low pass filter. By using these filters, the frequencies above or below a certain threshold will be attenuated. Respectively, while the high pass filter allows higher frequencies to pass through the filter, the low pass filter works in exactly the opposite way (Schlette, 2013). It is thought that designers may utilize these filters to partially suppress or silence, for example, the high frequency rattling noise of a motorcycle to discuss the resulting 'less noisy' motorcycle sound.

iv) Delay: A sound can be repeated as a pattern using a variety of different time-based delay effects (*Audio Effects*, n.d.). For example, generating single or multiple echoes with decreasing sound level is possible for designers by using delay.

v) Reverb: As previously mentioned, sound propagates in an omni-directional manner. Especially in closed environments, sound reflects from a variety of surfaces and creates a stream of continuing sound based on the original sound source. This is known as reverberation, or in short 'reverb'. It is speculated that designers may use reverb effects to modify selected sounds to fit into different use contexts and to provide ambience, such as suitability for bathrooms, classrooms or large meeting halls.

D) Acoustical properties of sounds

Similar to SoundsGood V1, the area tagged 'D' (see Figure 5.2) for SoundsGood V2 consists of basic acoustic properties of sounds. Changes within the waveform of any sound within a specified time frame will be shown visually in this area (see Figure 5.8). In this way, designers are provided a chance to arrange the temporal relation between sounds, to create an intended multi-layered auditory interaction for a specific scenario frame, with the help of the dynamic timeline. By clicking the play button located on the bottom left corner (see Figure 5.9), the intended auditory interaction will be played from the beginning.

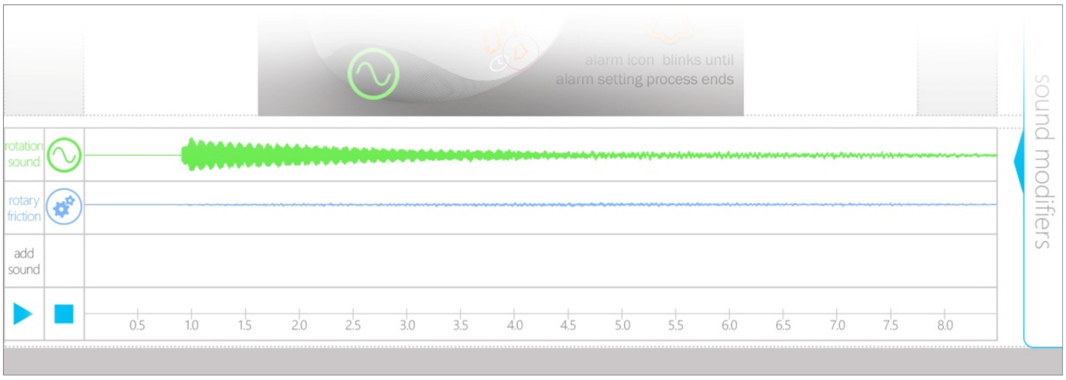


Figure 5.8 Waveform views of the sounds used in the current scenario frame

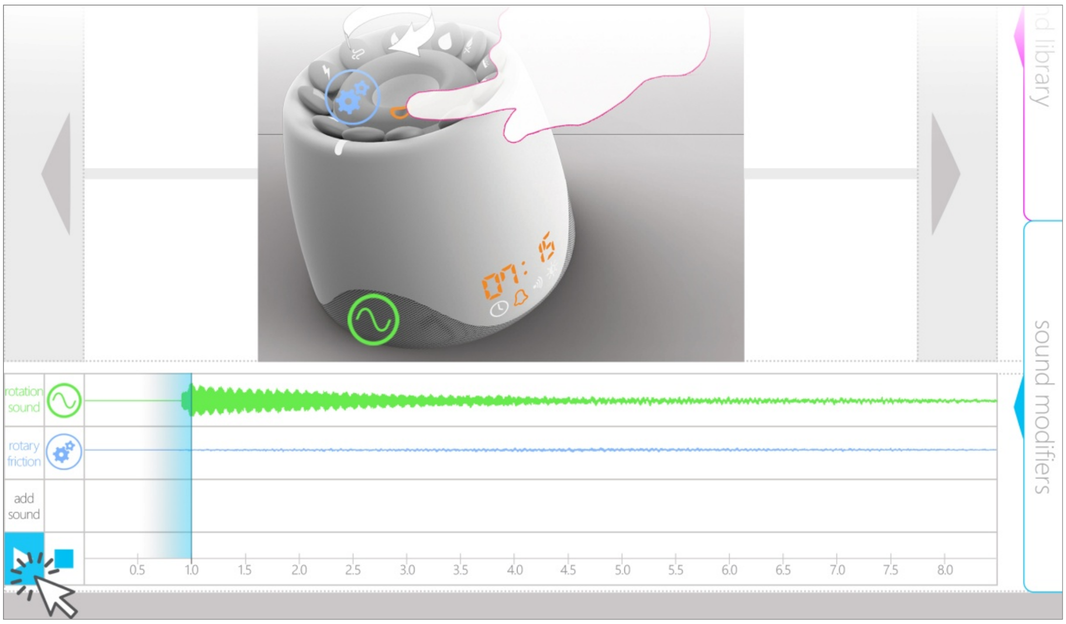


Figure 5.9 Playing / stopping the intended auditory interaction for the current scenario frame

5.3. Outcomes of the Field Study #2

A set of semi-structured interviews with five professional industrial designers and a focus group study with five research assistants, who had taken the course "ID535 Design for Interaction" from the Department of Industrial Design at METU, had been conducted in order to understand industrial designers' approaches to product sounds within the product design process. Based on the outcomes of the first field study, the initial version of SoundsGood, which aims to aid industrial designers to think and design auditory interaction ideas and share them with other contributors to product design and development, was revised and used in the course of a follow-up (second) field study. In order to compare the outcomes, another set of semi-structured interviews with five different industrial designers was carried out. Additionally, another focus group session was conducted – using the same participants as for the previous focus group study, for the evaluation and further discussion of the revised version of SoundsGood.

This chapter presents the outcomes of the second field study, organized under three headings in a similar structure to the *Research Through Design I* chapter, namely: *experience of product sounds, consideration of product sounds within the industrial design process,* and *implications for the development of the design suggestion.*

5.3.1. Experience of Product Sounds

In this section, the outcomes of the second set of interviews related to the experience of product sounds will be discussed under two topics in parallel with the first field study, namely: the roles of product sounds within user-product interaction, and the aesthetics of interaction.

5.3.1.1. The Roles of Product Sounds within User-Product Interaction

In parallel with the views derived from the first field study (FS#1), the second group of interviewees (FS#2) mostly mentioned similar points about the roles of product sounds within user-product interaction. The repeated, new and omitted points are shown in Figure 5.10, and will be briefly explained under separate subheadings.

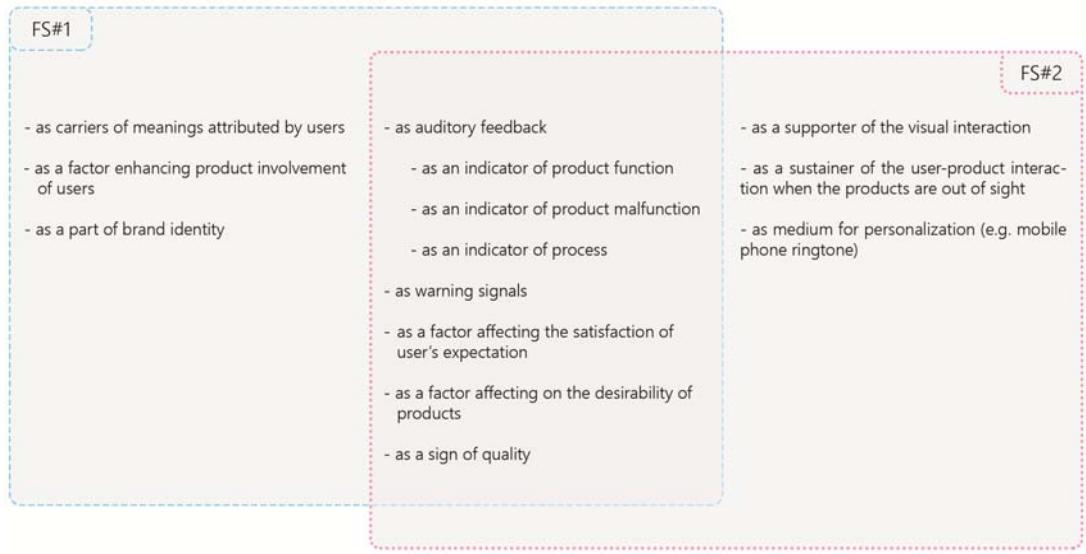


Figure 5.10. Outcomes of the first and second field study about the roles of product sound within user-product interaction

Repeated points about the roles of product sounds within user-product interaction

i) Role of product sounds as auditory feedback

As with the outcome of the first study, auditory feedback types were categorized based on their use as an indicator of function, malfunction or process. In a similar fashion, the auditory interaction examples illustrated by the second set of interviewees can be discussed under the same categorization.

1) As an indicator of function

For the usage of sound as an indicator of function, one of the interviewees gave the "tick" sound emitted from a jar lid when it is correctly closed and all kinds of snap-fit sounds as examples. Another interviewee exemplified the sound of a working paper shredder, washing machine and vacuum cleaner. Apart from the usage of consequential product sounds as an indicator of function, one of the interviewees stated that concepts like increasing - decreasing (e.g., the sound level of an Apple MacBook) can be successfully given by digital feedback sounds.

2) As an indicator of malfunction

For the usage of sound as an indicator of malfunction within products, one of the interviewees narrated his experience as follows:

> Every time I start the car, I listen to the sound of the brake and the sound emitted from the engine before leaving the parking area. If there is a sound that I am not accustomed to hear, it indicates the possibility of malfunctioning. However, it is nearly impossible for me to detect the cause of a defect just by listening to the sound, due to the complex nature of cars.

Another interviewee underlined the requirement of prior auditory experience to interpret sounds indicating malfunctioning, otherwise the unusual sounds emitted from products may be misinterpreted by users especially in the course of initial usage of products, i.e., the unexpected (but operationally normal) sound of a DVD-rom drive in personal computers.

3) As an indicator of process

In addition to the usage of feedback sounds as an indicator of function and malfunction within user-product interaction, interviewees also mentioned the role of feedback sounds as indicators of processes that products undergo during use. The difference between feedback sounds as an indicator of process and as an indicator of function or malfunction can be implied from one of the interviewee's explanations, as follows: "If I left a product to automatically complete its task, then there should be auditory feedback that indicates whether the process is ongoing, finished or requiring my attention". An electric kettle's switch sound (consequential sound) showing that the water has boiled, as well as Homend electrical tea maker that informs the user through speech sounds (intentional sound) were examples given for feedback sounds as indicators of processes.

ii) Role of product sounds as warning signals

Apart from feedback sounds, in parallel with the previous field study, interviewees also addressed the usage of product sounds as warning that indicate emergency situations or convey messages about the requirement of urgent user intervention with products.

iii) Satisfying the expectation of users in the course of interaction

One of the interviewees remarked on the positive contribution of consequential sounds, such as the click sound of push buttons or sounds of an adjustable rotary button, in terms of satisfying the expectation of users in the course of interaction. Without hearing the consequential sounds emitted from products in the course of interaction, users may not be sure about the success of the intended action, such as closing the door of a washing machine many times until hearing the satisfying clicking sound.

iv) Role of product sounds in terms of affecting the desirability of products

In comparison with the satisfying feature of product sounds, according to two of the interviewees, sounds that emanate from a product may be irritating for users depending on the context. The usage context of products – such as indoor or outdoor, public or private – and spectro-temporal attributes such as frequency level and the frequency of repetition of product sounds were mentioned as some of the factors affecting the desirability of product sounds. One interviewee exemplified the contextual effect on the desirability of a product sound as follows:

"For example, I would not prefer a digital feedback sound added to a kettle for indicating the boiling process, because it naturally gives me feedback with the steam-triggered mechanism of its on-off switch. However, due to the importance of hearing the door lock sound of a car, there will be positive contribution of a digital feedback sound to the mechanical locking sound, which can be quite difficult to hear in a loud outdoor environment."

Therefore, it can be said that the desirability of the product sounds is highly context dependent.

v) Role of product sounds as sign of quality

As already mentioned by the first set of interviewees and the participants of the first focus group session, another significant point raised by the second set of interviewees was the role of sound as a sign of quality for products.

One of the interviewees gave the example of the loudness level of a vacuum cleaner and its effect on the perception of users in terms of the powerfulness of product.

Additionally, the same interviewee also added that the most influential factor affecting her mouse purchasing decision and the overall appraisal of the product (pc mouse) was the level of sonority of the clicking sound. Other interviewees stated that the sound of a car door closing, the sonorous sound of a push pen, the (pssss) sound emanated from the pistons of a kitchen cabinet and the sound generated by the washing machine door switch are all examples of how product sound can affect the overall perceived product quality. In addition to consequential product sounds, one of the interviewees highlighted that intentional product sounds such as the lock/unlock sounds of smart phones have effect on the perceived product quality as well.

New points about the roles of product sounds within user-product interaction

i) Role of product sounds in maintaining user-product interaction

Nearly all of the interviewees expressed views about the different roles of product sounds in contributing to user-product interaction. One interviewee touched upon the difficulty of visually keeping track of products that occasionally stray out of sight and added that in these kinds of situations, product sound plays an important role in maintaining user-product interaction. At this point, another interviewee gave the example of distinct sounds used by mobile phones for different types of events, such as receiving a call, a message or a notification for Twitter/Facebook that can be sometimes negligible. The same interviewee highlighted that in the absence of visual information, users can decide whether it is important or not to pay attention to their phones just by hearing auditory cues.

ii) Role of product sounds in supporting the visual user-product interaction

Apart from previously mentioned roles of the product sounds, one of the interviewee underlined that sometimes users can misinterpret graphical elements of product interfaces – in such cases, a sound emitted from a product may play an assistive role within the interaction.

iii) Role of product sounds in terms of personalization

Lastly, one of the interviewees interpreted the varying mobile ringtone selection of users as showing that sound has a personalization role within user-product interaction. Users can choose, or even modify the intentional sounds emanated from the products according to their tastes.

As a result, in parallel with the outcomes of the first field study, the sounds emitted from products play a variety of roles within the course of user-product interaction. The repeated roles of product sounds can be summarized as follows: feedback sounds as indicators of functioning, malfunctioning and the processes that products undergo during normal functioning; warning sounds signalling users about an emergency situation; changing importance and desirability of product sounds depending on the usage context and users' expectations; and sound as a sign of product quality. The new roles of product sounds mentioned only in the course of second field study were; maintaining user-product interaction in visual absence of products, supporting visual elements (e.g. user interface) of products, allowing personalization of products. However, different than the outcomes of the first field study, views on the role of product sound as a contributor to brand identity and the appraisal of silent products over the sonorous ones were not observed in the course of the second set of interviews.

5.3.1.2. Aesthetics of Interaction

In parallel with the outcomes of the first field study, the aspects related to the aesthetics of interaction can be mainly categorized as i) the dominancy of the visual modality over other sensorial modalities and ii) issues related to design education.

i) Dominancy of the visual modality over other sensorial modalities

Most of the interviewees implied that in terms of user-product interaction, the visual modality is seen as the most important. According to some of the interviewees, the amount of effort spent for designing a product’s visual qualities overshadows the effort spent for auditory properties of products. One of the interviewees stated that auditory information would be unsatisfactory in the absence of good visual information, because of the fact that sonic interaction requires far more attention of users to be received well. Yet, some of the other interviewees highlighted the importance of auditory interaction by appraising the usage of product sounds in order to maintain user-product interaction when products are out of the sight of users.

ii) Issues related to design education

In a similar way with the first set of interviewees and the participants of first focus group session, within the design process of user-product interaction, most of the second set of interviewees attributed the dominancy of the visual modality to their experiences during design education. Interviewees stated that there has been almost no inclusion of the aspects related with auditory interaction within their student design projects. Consequently, one of the interviewees stated that it is difficult for an industrial designer to have opinions on, or offer suggestions for, auditory user-product interaction due to a lack of educational background.

5.3.2. Consideration of Product Sounds Within the Industrial Design Process

In this section, the findings related with the consideration of product sounds within industrial designers' work processes will be discussed under three subheadings: communicating with other team members or parties within the design process, the current position of product sound design, and designers' reflections on product sound design.

5.3.2.1. Communicating with other team members or parties within design process

In the course of the second set of interviews, different communication channels to convey design ideas between the contributors of a design process, and the methods used by designers to communicate interaction scenarios were discussed. The relation of the outcomes of the second field study to the first one is shown in Figure 5.11 Interviewees exemplified ways of communicating their design ideas as follows: using verbal and textual description, using traditional and digital sketches, making 3D models, creating photorealistic renders in an intended visual context and showing these from a computer screen or by using smart devices (i.e. tablets, phones), creating animation or video by using mock-ups or prototypes, and utilizing user-product interaction scenarios, interaction maps or storyboards.

Figure 5.11. Relation between the first and second field study about the ways of communication channels to convey design ideas

Apart from these, all interviewees stated that the suitability of the methods for transferring the design idea depends on whether the communication takes place among designers or with other collaborators, such as engineers, users or clients. In order to convey design ideas to other designers, interviewees said that as designers they generally use verbal descriptions and 2D sketches. Yet, for a healthy communication with third parties and non-designers, interviewees indicated that there is a requirement to use more explanatory methods such as full-scale working prototypes or interactive 3D models that can be viewed from all angles. Otherwise, most of the interviewees explained that an intended design idea will be imagined differently by those who are viewing it and this will negatively affect the product design process.

Apart from these, according to interviewees, there are several ways that industrial designers convey scenarios that explain intended user-product interaction to other contributors. In addition to a traditional frame-by-frame scenario building method, two of the interviewees exemplified from their own design experiences that in order to fully cover all the possible user-product interaction steps and transfer them to third parties, creating interaction maps with textual and visual explanations is efficient. However, one of the interviewees added that in the case of showing the moving parts that a conceptual product will have, these printed interaction maps remain incapable of communicating intended interaction. In such situations, while one of the interviewees favoured an increase in the number of visual descriptions of interaction steps, another mentioned the use of computer generated animations or at least simple 2D animations showing intended actions. At this point, another interviewee gave an example about communicating an interaction scenario as follows:

> In order to convey the product idea that has blinking LEDs with different intervals and synchronous auditory feedback to our electronic engineer peer, at first we used static images and verbal description. However, the result was not as expected due to the miscommunication; so, we had to create an animation explaining our idea.

To conclude, it can be drawn from the outcomes of both of the field studies, industrial designers need communication skills and media to convey their design ideas and user-product interaction scenarios to other parties contributing to product design processes.

5.3.2.2. Current position of product sound design

In order to understand the current position of product sound design practice within the product design process, the experiences exemplified by the interviewees have been analyzed. In Figure 5.12, the outcomes of the first and the second field study is briefly shown.

In parallel with the outcomes of the first field study, it is observed that there is no shared approach of designers to the practice of product sound design. For example, two of the interviewees stated that in the course of product design, they have never thought about auditory interaction ideas that may improve the overall user-product interaction. One of the interviewees narrated the design process that he contributed to as follows:

> We conducted the product design process of a bus card validator project from a conceptual phase to the production level as a team. However, none of us thought about the auditory interaction that will be offered by this product. We only designed the cavity where the speaker will be placed, and mounted the speaker at the last stage of the design process; yet, I still do not have an idea about the feedback sound emanated from the product during use.

The same interviewee explained the reasons causing the auditory interaction to be overlooked as a lack of time and the absence of any sound related criteria in the project brief. Another interviewee gave examples from his own design experience that whilst building an interaction map for a design project, ideas about auditory interaction are proposed as textual information such as "high pitched sound indicating the emergency is required for this interaction" and he added that by this way, the constraints that shape the sound of a product can be discussed among team members and then can be revised. However, the same interviewee also mentioned that due to the restricted amount of time, instead of dealing with sound related issues, designers generally prefer to focus on designing visual properties of products. One of the interviewees also indicated that because of the relatively high cost of modules generating complex sound, they used low cost buzzers to emanate positive or negative feedback sounds.

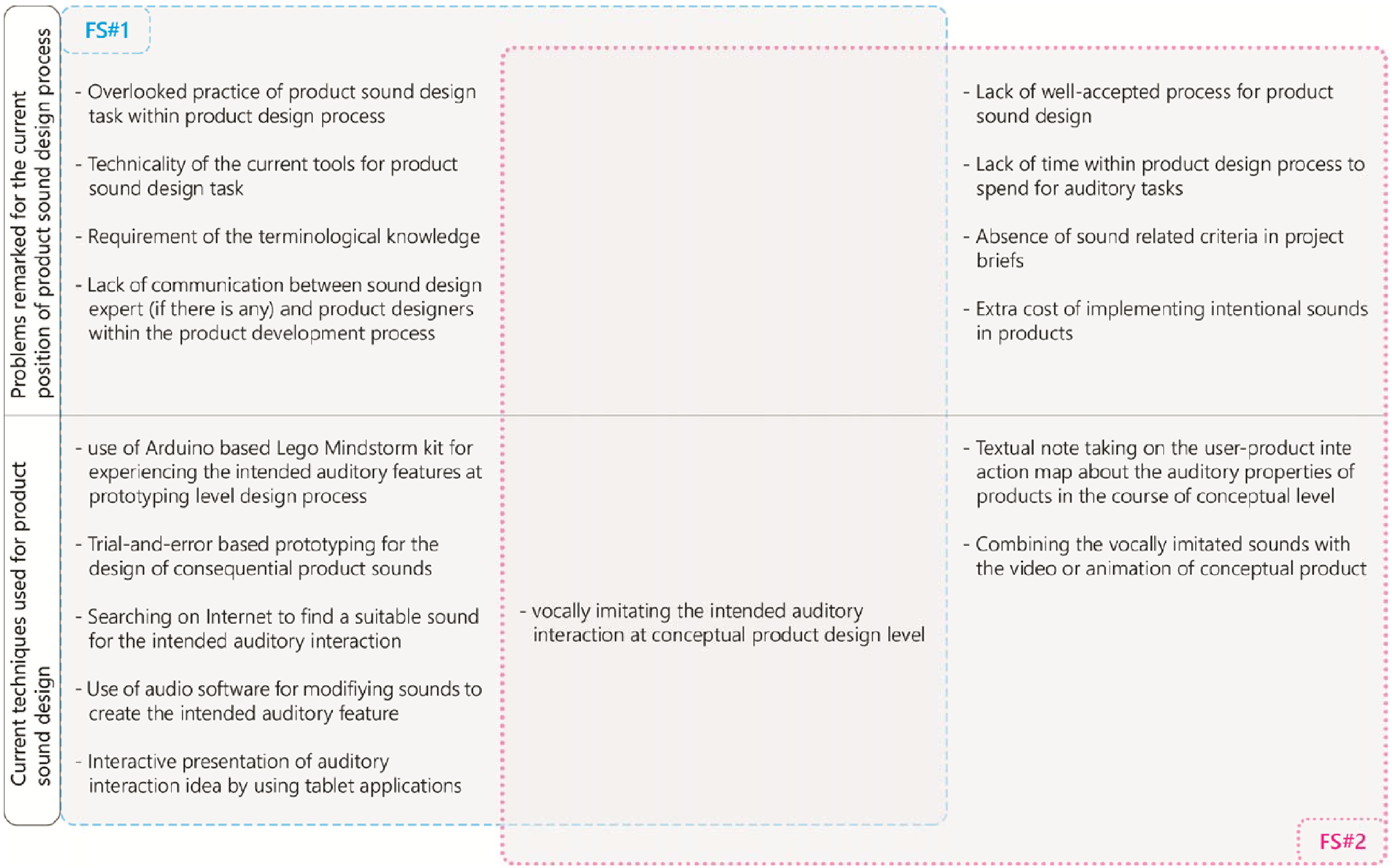


Figure 5.12. The outcomes of the first and second field study about the current position of product sound design

For the consideration of auditory interaction within the conceptual level of product design process, one interviewee shared his own design experience as follows.

> In order to convey the auditory interaction, I created a quick animation explaining the visual feedback in the course of user-product interaction. Then, I vocally produced the sound that I shaped in my mind and combined this low quality sound with the animation to confer my idea with colleagues.

Apart from intentional product sounds, one of the interviewees gave an example for the consideration of consequential product sounds within a design process from his working experience at a home appliances company. He indicated that the design team was not concerned with product sounds, however the engineer, who was responsible for the auditory properties of products, was only considering the sonority level of consequential sounds such as a door of a refrigerator closing .
Another point remarked by another interviewee was that if a project is not directly related with the auditory realm (i.e. a musical instrument, speaker), the consideration of sounds, especially consequential sounds, generally stays in the background.

To sum up, as it was mentioned within the previous field study, product sounds require more attention and effort from the industrial design circle. However, the technical complexity of dealing with sound, the lack of well accepted methods and tools to create sound ideas, and the difficulty of communicating an intended auditory interaction to other parties can be considered as the main problems within the realm of product sound design.

5.3.2.3. Designers' reflections on product sound design

In parallel with the first field study, designers reflected their views on the challenges of designing for product sound and expressed a variety of opinions on the future consideration of sound design processes for products. The outcomes of the both field studies are briefly shown in Figure 5.13.

	FS#1	FS#1 and FS#2	FS#2
Challenges for the future consideration of product sound design process	- Difficulty of evaluating the product sound proposals in comparison with the evaluation of visual attributes - Increased amount of time and cost due to utilizing empirical trial-and-error method for product sound design process	- Technical complexity of designing auditory elements of products which is beyond the capabilities of designers - Complications of anticipating consequential product sounds prior to working prototype of design	- Usage of generic sounds for the effort of referring to users' conventional auditory experiences - Challenge of creating intended effect on users via auditory features of products
Potential techniques suggested for product sound design process	- Using textual representations of product sound ideas at conceptual level - Use of videos and animations for the communication of product sound design ideas to other contributors - Use of Arduino system for making the prototypes interactive in terms of auditory features - Possibility of creating more comprehensible language for product sound design	- Utilization of a future medium that categorizes the pre-existed usages of product sounds - Application of simulation techniques for the anticipation of consequential product sounds prior to product realization - Manipulation of the properties of product sounds by digital means to create intended auditory results (in conceptual level of design process). - Possibility of creating universal meanings and standarts for product sounds (e.g. graphical on/off icon, ergonomic metrics)	

Figure 5.13. The outcomes of the first and second field study about designers' reflections on product sound design

One of the interviewees described the product sound design task as part of a detailing process and speculated that most of the intentional sounds of products are beyond the control of a design team, whether they are already embedded in an audio module as standard beep sounds or decided by engineers. From this perspective, it is difficult for designers to take part in the design of auditory interaction processes. Another interviewee attributed the usage of generic sounds to the effort of referring to users' conventional auditory experiences; i.e, a fire alarm sound or the sound indicating an error in a product. The same interviewee added that the reason behind the overlooked nature of product sounds may stem from the fact that designers mostly deal with products that have equivalent competitors; therefore, equivalent sounds for the intended interaction generally exist. Thus, products that have no prior examples in the market will provide more freedom to designers for performing the creative sound design task.

Another issue raised by the interviewees was the challenge of creating an intended effect on users through auditory properties of products. For example, one of the interviewees questioned how certain functions of products can be conveyed or supported by sounds. Yet, the same interviewee also underlined that there is a possibility of creating universal meanings for product sounds in the long run, if an analogy is made to the graphical on/off icon which is known by almost every user nowadays. In parallel with this, another interviewee stated that as the number of research studies on the effect of product sounds on user-product interaction quality increases, so the design of auditory interaction within the product design process will eventually become more important. Another interviewee also suggested that in order to understand user experience about certain product sounds, conducting a survey based exploration with users may be an efficient approach

Apart from these, interviewees underlined that dealing with consequential sounds of products, such as the sounds generated by the working washing machine or a motorcycle, is an another challenge of the product sound design process. One of the interviewees stated that consequential sounds originate from the nature of the products' mechanisms and material properties; therefore, it would be quite difficult for designers to change these kinds of sounds according to an intention. Additionally, another interviewee attributed the challenge of dealing with consequential sounds for designers to the unforeseeable nature of these types of product sounds and added that the anticipation of consequential sounds depends on prior experience of the designer, especially before the realization of a first working prototype of a conceptual design. As previously mentioned in the first field study, one of the interviewees also emphasized the possibility of using simulation techniques for the anticipation of consequential product sounds; and, the interviewee further explained that in the course of modelling a conceptual design, designers may simulate the sound that will emanated from a 3D model just like the simulation of a product's behaviour under a certain pressure or torsion force (stress analysis) before making any working prototype.

Other than these, all of the interviewees mentioned that the existence of a tool to help designers to make design decisions about sounds would have been useful to consult in the course of a product sound design process. One of the interviewees expressed that there can be a set of categorizations for sounds that have been previously used in products up until now. In this way, designers can express their auditory ideas by referring to pre-existing usages of sounds. However, although this kind of approach may decrease creativity levels, it broadens the perspectives of designers who have no prior experience of product sound design practice. Another interviewee also mentioned a future tool that can categorize applicable sounds according to a product usage context. That is, feedback sounds suitable for domestic products or medical devices can be ‘looked up’. With the help of this kind of tool, suitable sounds for products can be decided by a designer alone or after conducting a study with users, to fulfil auditory expectations.

In line with these, another interviewee remarked on the difficulty of creating a sound from scratch for products and added that presentation of a list of alternative sounds for a defined mood would be helpful in the course of thinking about auditory properties of user-product interaction. One of the other interviewees suggested that the idea of having a library in which different types of product sounds are listed would be useful and added that in this library, designers may change the properties of sounds to create an intended auditory result, just like they are preparing a scene in 3D software programs for visual rendering. The same interviewee also underlined that the interaction with this kind of library should be very easy, unlike the interaction offered by various visual rendering software products, which contain complex sets of parameters. By this way, it will be possible for designers to create and express their auditory ideas even in the conceptual stages of product design.

To conclude, the outcomes of both the first and second field studies indicate that designers need guidance in terms of the technical (i.e. acoustical properties) and psychological correlates (i.e. meaning of a certain sound) of sounds in order to design auditory interaction for products. As offered by many of the interviewees, this guidance may be provided with a specialized medium focusing on product sound design.

5.3.3. Implications for the Development of the SoundsGood V2

In the course of the second set of interviews and focus group session, the revised version of SoundsGood was shown to the interviewees and the participants, in order to get their reviews and suggestions for the development of the design proposal. Prototypes of the revised version (v2) of SoundsGood, which were used within the second field study, had been built using a combination of 'Invision' – an online interactive prototyping tool for creating graphical user interfaces, and 'Prezi' – an online presentation tool allowing audio files to be added. Thanks to the interactive nature of the prototypes of the design suggestion, such as the clickable menus and sub-menus, movable pages and auditory feedbacks, the second field study provided more practical suggestions for improvement of SoundsGood than the first field study.

Most of the interviewees and participants of the focus group reacted positively to the prototypes of SoundsGood and remarked several points that can be categorized as; *i) the opportunities offered by SoundsGood, ii) the limitations of SoundsGood, iii) reviews for the type of interaction with SoundsGood, iv) reviews for the sound* *library, v) reviews for the sound modifiers,* and *vi) reviews on the user interface*. These reviews will be presented under separate subtitles.

i) The opportunities offered by SoundsGood

For the opportunities offered by SoundsGood, most of the interviewees stated that this kind of medium would widen the horizon of designers in terms of auditory means and consequently contribute to the richness of the interaction offered by products. One of the interviewees further explained this contribution as follows:

> For example, I can explore the possible sound selections for the intended interaction and decide which one is suitable by trying and listening. After that I can share my ideas with colleagues or with target users to get feedback about the suitability of the sound idea in terms of user-product interaction.

Similarly, other interviewees and the participants also underlined the potential of SoundsGood in terms of the shareability of the auditory interaction ideas with other contributors. One of the interviewees stated that instead of superficial conversation for conveying sound ideas to colleagues, this kind of medium can provide a healthier basis for communication between members of product design team.

Apart from these, both the interviewees and the participants remarked that the anticipation of product sounds can be possible for designers with the use of this kind of medium, before the realization of the final product or a working prototype. However, most of the participants and the interviewees indicated that anticipating consequential product sounds such as the sound of a working vacuum cleaner would not be realistic without the existence of working prototype. Yet, some of the interviewees noted that the complexity of consequential product sounds can be emulated by simulation techniques with the help of engineer peers in a design team. Additionally, the participants of the focus group study highlighted that while designing the intentional product sounds, hearing the consequential sounds and other contextual sounds may provide a more realistic perspective to designers. For example, in the course of designing the auditory warning signal of a car, there would be positive contribution to hearing consequential and contextual sounds such as the engine sound and the dialogues of passengers.

Yet, all of the interviewees and participants mentioned that the applicability of SoundsGood would best suit for the anticipation of intentional product sounds such as digital feedback and alarm sounds. One interviewee mentioned the suitability of this kind of medium to the design process by giving an example from his own design experience, as follows:

> For example, there was a need of designing the auditory feedback of one of our current projects. However, after having a hard time on the Internet to find a sound that partially represents the sound in my mind, I also had difficulty for imagining the overall impression that the product will make with this sound. However, due to the limited time, it was impractical to create an animation of the visual interaction that the product will make and to combine the sound with this animation. At this point, a medium like SoundsGood can provide fast solutions especially at the conceptual design level, for the anticipation of auditory interaction in combination with the visual context.

Another interviewee also stated that the idea of having alternative sound scenarios for each user-product interaction step requiring sounds would be useful in the course of collaborative product design. The same interviewee gave an example scenario for this kind of usage of SoundsGood as follows:

> I imagine using SoundsGood in a collaborative design project of a kitchen cabinet. Our engineer peer can send us three alternative sounds of the opening-closing hinges and I can try to combine these hinge sounds with other types of sounds offered by SoundsGood such as the closing sounds of a wooden cabinet. Additionally, I think it is also possible to modify the sound according to the room size such as kitchen, bathroom or a large meeting room. By this way, all the design team can get an idea about the possible auditory outcomes of using different parts or materials.

Other than these, some of the interviewees and participants indicated that the existence of this type of medium can affect a designer's overall approach to projects, due to the fact that designers are used to focusing on visual properties of products and not pushing the boundaries of other modalities. Additionally, one of the interviewees suggested that, just like creating moodboards for describing the visual character of a conceptual product, designers can create "soundboards" for communicating the mood of an intended auditory interaction that will be provided by a new product.

The points voiced by the interviewees and the participants for the opportunities offered by SoundsGood can be summarized as follows:

- Possibility of affecting designers' overall approach in terms of inclusion of auditory modality for the design for user-product interaction
- Shareability of product sound design ideas with other team members or target users
- Healthier communication among team members about auditory properties of products
- Applicability of SoundsGood for the anticipation of intentional product sounds such as digital feedback and alarm sounds
- Possibility of considering intentional product sounds (e.g. seat belt sound in a plane) at conceptual design level in combination with consequential (e.g. motor sound) and other contextual sounds (e.g. dialogues)
- Practicality of having alternative sound scenarios for different user-product interaction steps in the course of collaborative product design process
- Possibility of generating "soundboards" (similar to moodboards) for communicating the mood of an intended auditory user-product interaction at conceptual stage

ii) The limitations of SoundsGood

Both the second set of interviewees and the participants expressed a variety of opinions about the limitations of SoundsGood.

One of the interviewees pointed out the complexity of designing for the consequential product sounds and added that by using the sound modifiers, which are offered by SoundsGood, designers can only manipulate sounds in a tentative way which would not be corresponding with real life sound events. The same interviewee further discussed the issue, as follows.

> I can change the parameters of the machinery sound by using this medium, for example I can make the original sound more sharper; however, it would be very difficult for me to estimate what kind of modification makes the machinery sound of the actual product sharper.

Another interviewee also stated that consequential sounds of products contain so many layers of sound which make them too complex to reproduce; therefore, the sounds modified by designers with this medium would be quite artificial for the anticipation of consequential sounds. Moreover, one of the participants also indicated that it would not be realistic to make decisions about the material properties of products to obtain certain sounds only by using SoundsGood; in such cases, there is a need for designers to experience actual products in order to evaluate the sound emitted from them.

Another limitation mentioned by two of the interviewees was the requirement of technical knowledge about the auditory realm, to efficiently utilize this type of medium. One of the interviewees stated that in order to consciously design a sound, one should be a composer or a sound engineer to overcome the technical complexity of sound related issues. Additionally, another interviewee remarked that if there is no sound engineer in the design team, it would not be logical to spend time with this kind of medium; because of the fact that the designer always will be in need of consultancy of a sound professional to create meaningful and applicable sound design ideas.

Apart from these, one of the interviewees criticised that the main focus of SoundsGood is auditory interaction; however, it looks like a scenario building tool at first sight. Additionally, the same interviewee also added that there must be some level of flexibility while designing the frame by frame flow of interaction scenarios. In parallel, another interviewee also remarked on the flow of the interaction scenario as follows.

> If there are so many interaction steps in the course of a product usage scenario, the interaction map of the product becomes too expanded to be covered by this type of linear way of framing. Additionally, it would be disadvantageous for designers to always focus on one frame without having an opportunity to look at the whole interaction scenario steps.

To summarize, the points raised by the interviewees and the participants for the limitations of SoundsGood are as follows:

- Complexity of designing for consequential product sounds by using a digital medium
- Tentative way of modifying consequential product sounds that may end up with unrealistic results
- Requirement of technical knowledge about auditory realm to utilize sound modifiers in SoundsGood V2
- Dominancy of visual elements (especially scenario frames) over auditory elements
- Lack of flexibility for the navigation between user-product interaction scenario frames within SoundsGood V2 (only linear way of navigation)

iii) Reviews for the type of interaction with SoundsGood

Both the interviewees and the participants remarked on the designer's way of interacting with SoundsGood.

For the sorts of visual media that will be used within the interaction scenario part of the SoundsGood, most of the interviewees and participants mentioned the possibility of using photos or a scan of a hand sketch, digital sketch, render, animation, video or gif image.

Apart from this, most of the interviewees underlined that there can be collaborative usage of this kind of medium as a web-based tool, both for the discussion of auditory interaction ideas within the design team and for getting feedback from users. One interviewee added that users may comment on the auditory interaction suggestions offered by designers in a web environment and rate the sounds accordingly; in this way, using this kind of medium for the design process of product sounds can become logical as it forms a basis for the evaluation and the improvement of sound design ideas. Another interviewee also highlighted that there should be an online commenting option for the review of the sound design ideas among the members of design team; i.e., "sharper sound would be more suitable for the third frame, or the tone of sound in the second frame should be changed".

Moreover, two of the participants stated that this medium would be better integrated into tools such as Adobe Photoshop, which is readily being used by designers.

Another view presented by many of the interviewees and the participants was the requirement of augmenting the relation between the visual and auditory elements in SoundsGood. It was criticized that while the part including the visual scenario is too inactive in terms of designer-tool interaction, the auditory part of SoundsGood offers a dynamic way of interaction. One of the interviewees stated that use of static images along with changeable sounds creates incomprehensibility. At this point, in order to improve the designer-tool interaction for the visual aspect of SoundsGood, many of the interviewees and participants shared a variety of opinions. One participant exemplified that in the course of designing an intentional sound for an alarm clock, while hearing the designed alarm sound, it would be better to see the corresponding blinking lights of the alarm clock simultaneously instead of a motionless scenario frame. In line with this, one of the interviewees suggested that there can be a set of predefined interaction elements; for example, clicking, rotating, touching, sliding, increasing or decreasing; and these interaction elements can be used on the static image to trigger the auditory interactions. The same interviewee argued that in this way consistency between the visual and auditory interaction within SoundsGood can be maintained. Likewise, one of the participants also suggested that instead of controlling the using a play/stop button, the action triggering the auditory interaction can be mapped on to the scenario frame, whether it is a static image or an animated video. Correspondingly, another participant highlighted the potential use of the auditory icons, which are currently used only for representing sounds visually on the scenario frame, as play/stop buttons or before mentioned types of triggers such as clicking, rotating, touching etc. One of the interviewees indicated that this type of usage of predefined visual interaction elements for triggering designed sounds may limit designers; however, it would be surely useful especially within the initial levels of design processes of auditory interaction between users and products.

The views offered by the interviewees and the participants about the designer's type of interaction with SoundsGood can be summarized as follows:

- Requirement of the option of using photos or a scan of a hand sketch, digital sketch, render, animation, video or gif image
- Potential usage of SoundsGood as a web-based tool in terms of providing collaborative design process
- Possibility of providing online commenting option for the review of the sound design ideas among the members of design team
- Possible integration of SoundsGood into tools that designers accustomed to use (e.g. Adobe Photoshop, KeyShot)
- Lack of correlation between the static visual attributes and the dynamic auditory attributes of SoundsGood

iv) Reviews for the sound library

The second set of interviewees and participants expressed several opinions about the sound library of SoundsGood.

In general, most of the interviewees and participants found it favourable to have a set of categorization for product sounds, which would allow designers to explore different types of sounds and open-up new horizons for auditory interaction ideas. However, nearly all of the interviewees and the participants pointed out that there were ambiguities about the functions of elements of the sound library (see Figure 5.14).

Figure 5.14 Elements of the sound library in SoundsGood V2

As shown in Figure 5.14, these elements located in the left and right parts within the sound library section are the list of descriptive concepts for product sounds and the list of product sound groups derived from the literature research. The aim of this kind of double categorization in the sound library was to make designers choose one element from the descriptive concepts for product sounds and one element from the product sound groups in order to narrow down the sound options that will be suitable for designers' auditory interaction ideas. However, due to a lack of guidance about this narrowing down process, neither the interviewees nor the participants were able to link the relation between these categorizations and the sound selection course. At this point, many of the interviewees and participants indicated that there should be a title for each categorization as "descriptive concepts for product sounds" and "product sound groups" in the sound library. In addition to the titles, for the narrowing-down process of sound choices in the library, one of the interviewees suggested that there can be visual cues to indicate the requirement of selecting one item from each categorization. The same interviewee further described this suggestion as follows:

> The two types of categorization may be shown step by step to designers. For example, there can be an indicator such as page 1/2 for the first set of sound categorization, and after the designer makes the selection from this first set of categorization, an indicator can change from 1/2 to 2/2 to show that the subcategories on the page belonging to the second set of categorization.

In a similar way, a collective suggestion from two of the participants of the focus group study was as follows:

> All the elements (or subcategories) of the two different categorizations can be shown as faded out prior to the selection of designers. After designers make the first selection, the selected subcategory can be highlighted until the selection process is completed for both of the categories. It is also a good idea to keep the visual icons of selected subcategories on the top section of the sound library page to remind designers about the their choices.

Apart from these, most of the interviewees and participants mentioned that the functions of the subcategories of descriptive concepts for product sounds (action, emotion, location, material, meaning, onomatopoeia, psychoacoustics, sound type, source, source properties and temporal) and product sound groups (air, alarm, cyclic, impact, liquid and mechanical) would be unclear for a designer who has no prior experience of sound design practice. For this reason, participants suggested that there can be explanations about the functions of each subcategory of the two main sound categorizations, at least for the initial phases of use with SoundsGood. One of the participants further explained this suggestion as follows:

When a designer hovers or clicks on any of the subcategories, a pop-up describing the feature of this subcategory, maybe with textual and auditory examples, can appear and be heard on the interface (see Figure 5.15).

In addition to these, most of the interviewees found the idea of sound import to the library favourable. One of the interviewees stated that there should be a record option in SoundsGood, by this way the auditory interaction in a designer's mind can be vocally imitated (sketched) and directly recorded to the sound library for later modification. Additionally, another interviewee indicated that the sounds of everyday objects or events can also be recorded to the SoundsGood sound library. However, one other interviewee mentioned that recorded sounds can be noisy and there can be some kind of feature for eliminating this noise while recording with SoundsGood.

Figure 5.15 Suggestion for adding an explanation for each subcategories in sound library of SoundsGood V2

Furthermore, another view concerned the random use of colours for the sound icons, which indicate what type of sound is being used in the particular scenario frame. One of the interviewees recommended that due to the possible collaborative application of SoundsGood, there should be consistency about colour coding for these sound icons on the scenario frames in order to clearly convey which subcategory sounds belong to.

Figure 5.16 Inconsistency between the colour coding of sound icons in sound library and scenario frame

Other than these, one of the interviewees added that in addition to the current categorizations of product sounds, there can be an option for designers to create and share their own product-based categorizations; for example, "a set of matching feedback sounds for dishwashers" (see Figure 5.17). Although having this type of product sound sets can be restrictive, it would be helpful for novice designers. Relatedly, another interviewee stated that sound professionals such as sound engineers or foley artists who are creating sound effects for movies or games can contribute to the sound library of SoundsGood and exemplified that these professionals can create sound sets for specific products and share them online, in the same way as people creating digital materials for visual rendering and sharing them on related platforms.

Moreover, both the interviewees and the participants underlined that there should be a preview option for listening sounds in the library before choosing and dragging one of the sounds onto the relevant scenario frame. One of the interviewees suggested that the icons being shown in the sound library can be used as preview buttons for experiencing sounds before using them.

Figure 5.17. A suggested feature allowing designers to create their own sound categorization

To conclude, the suggestions for the development of the sound library of SoundsGood offered by the interviewees and the participants can be summarized as follows:

- Utilization of pop up descriptions for each elements of product sound categorizations
- Requirement of textual and visual guidance about narrowing down process of sound selections
- Possibility of adding recording option into SoundsGood for allowing designers to sketch the intended auditory interaction vocally
- Usage of colour coding for different type of product sound categories for visual clearance especially within the collaborative usage of SoundsGood
- Possibility of allowing designers to create their own product sound categories (e.g. sounds for my dishwasher project)
- Possibility of adding preview option for selected sound before using it on the related scenario frame

v) Reviews for the sound modifiers

Both the interviewees and the participants shared their views about the sound modifiers, which aim to enable designers to modify a selected sound to reach an intended auditory interaction in SoundsGood.

One of the interviewees criticized that the sound modifiers look like technical tools which can easily stay out of the designer's conscious control. The same interviewee also added that it is difficult for designers to understand the differences between two sounds, the original one and the modified one, in terms of suitability to the user-product interaction. In other words, guidance or rationale to opt for one direction over another is missing within SoundsGood.

Apart from this, two of the other interviewees complained about the technicality of the terms used for the titles of sound modifiers such as ‘pitch shifting’, ‘reverb’, ‘delay’, ‘high pass filter’ or ‘low pass filter’ (see Figure 5.18). These interviewees both stated that these technical terms do not convey the functions of the modifiers to a novice designer who has no prior experience in the realm of auditory design. After an explanation of the sound modifiers' subcategories to the two interviewees, both suggested that there should be a simple non-technical explanation for every single sound modifier, for example; ‘decaying repetitions of selected sound’ for the ‘delay’ modifier. Another interviewee suggested that the usage of pop-up explanations for the subcategories of sound modifiers should be consistent with the explanations which will be used for the sound library elements. However, one of the interviewees queried whether or not there is an explanation for sound modifiers, the best way to learn is trying out and comparing the effects of these modifiers on selected sounds.

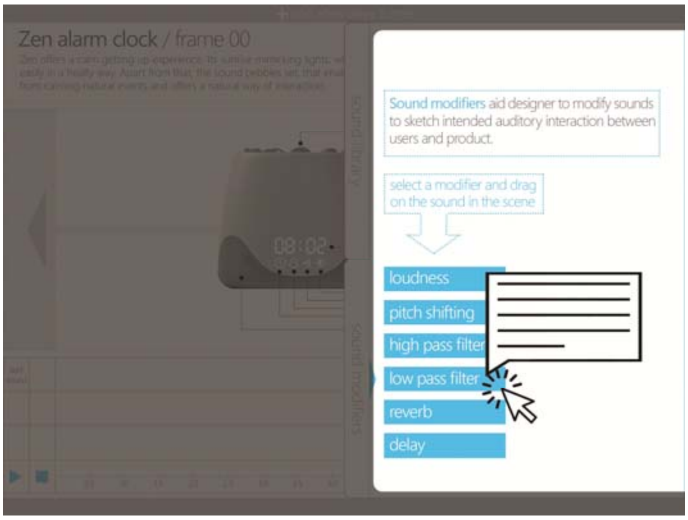


Figure 5.18. Suggestion for adding an explanation for each sound modifiers in SoundsGood V2

Most of the interviewees and participants also commented on the designer's way of interaction with the sound modifiers during the modification of sounds. One of the participants speculated that if there is more than one sound added to the scenario frame, it would be difficult for the designer to keep track of which modifier belongs to which sound. In order to solve this complexity, another participant suggested that it would be more logical to select the sound on the scenario frame as a first step, then trying and applying the modifier on the selected sound as a second.

Apart from selection and application issues, one of the interviewees stated that the types of interaction with the parameters of any sound modifiers should not be as complex as they are in many musical software. Instead of such complex interaction with knobs and sliders, the suggestion of the same interviewee for the type of interaction with the sound modifiers as follows:

> For example, many designers use Photoshop to adjust the brightness/contrast level of a visual via changing the specific parameters which requires a technical approach to some degree and this surely takes time. However, I can reach similar results by practically using PowerPoint's brightness/contrast menu which contains no parameters but the predefined options (previews) for making a visual less or more contrasted. In the case of SoundsGood, these

kind of predefined options would reduce the technical complexity of sound modifiers and would be less time consuming for designers (see Figure 5.19).

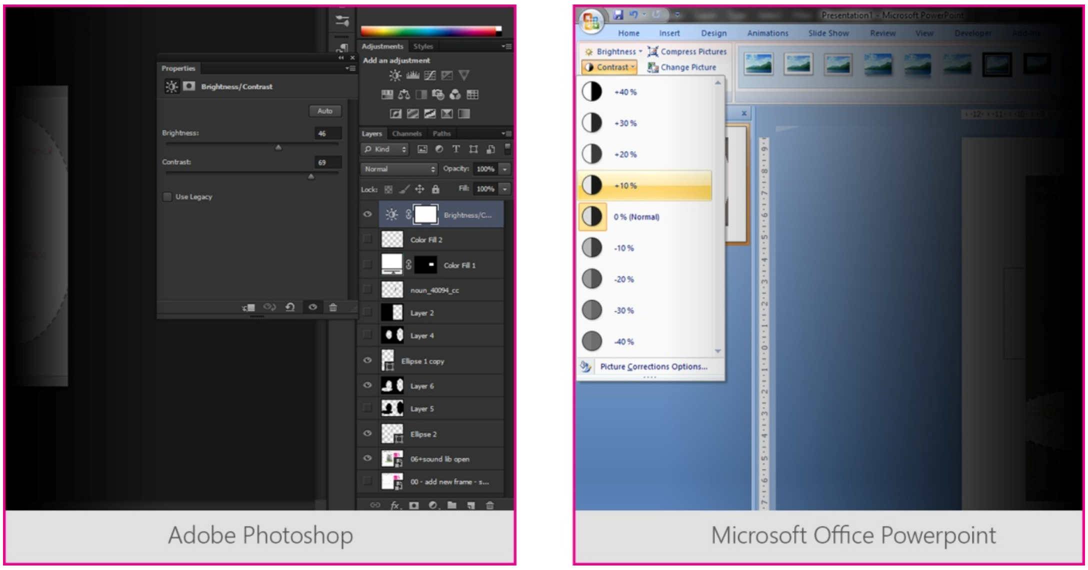


Figure 5.19. Comparing the ways of adjusting contrast level in two different software

Other than these, one of the participants suggested that modifying a simple beep sound from the library in terms of temporal structure and obtaining a "beep beep beeeeep beep" sound as a result would be preferable for designers creating an auditory interaction scenario between users and products. Another participant also advised that there can be a modifying option for trimming or silencing the particular part or parts of a sound.

To sum up, the points suggested by the interviewees and the participants for the development of the sound modifiers in SoundsGood V2 are as follows:

- Requirement of simple non-technical explanation for each sound modifier
- Comprehensible way of tracking which modifier is applied to which sound on a scenario frame
- Providing non-complex parameters for sound modifiers that would be easily utilized by designers.
- Practicality of adding "trimming, silencing and pattern creating" modifiers in SoundsGood.

vi) Reviews on the user interface

About the user interface of SoundsGood, the second set of interviewees and participants explained their suggestions and preferences by giving examples from their prior experiences with several types of software interfaces.

One of the interviewees criticized that the menu bar containing sound libraries and sound modifiers is located on the right side, which may be an unfamiliar placement for users at the first encounter. Another interviewee commented on the static nature of sound icons which are placed on the scenario frame as follows:

> The sound icons can blink on the scenario frame in accordance with the sounds being played at a certain time. By this way, if there are many layers of sounds on the scene, which one of the sounds is being played can also be tracked visually.

Apart from these, another interviewee indicated that there can be a "hide" option for the bottom part of SoundsGood, which contains acoustical features (i.e. amplitude, time) of the sounds on the scenario frame. The same interviewee further explained this suggestion as follows:

> As a designer, if I am going to present my ideas to users in order to get feedback, there is no need to show the bottom part which includes signal waveforms. However, if I am going to consult an engineer about my auditory ideas, then showing the bottom part would be necessary.

One of the other interviewees also mentioned that there can be two main interfaces of SoundsGood; one for designers (in which there is no complex features for modifying a sound), and another for sound engineers (in which there are several parameters about professionally creating or modifying a sound in order to obtain the intended interaction specified by designer).

Concerning the interface of SoundsGood, another interviewee mentioned that the proportion of the bottom area containing the acoustical features of the sounds when compared with the visual scenario area can be increased; otherwise, it would be difficult to focus on the sound for making arrangements such as trimming or creating patterns.

Moreover, in the current version of SoundsGood, when a designer clicks on the "add alternative frame", a new alternative frame is opened in the vertical axis and the designer can navigate between these alternative frames with the help of arrows located on the top and bottom edges. However, one of the interviewees commented that instead of using such navigation in a vertical axis, there can be a new tab for each new alternative frame, taking a similar approach to the tabs in Google Chrome (see Figure 5.20). In contrast, another interviewee praised the comprehensibility of the current interaction solution for adding an alternative frame.

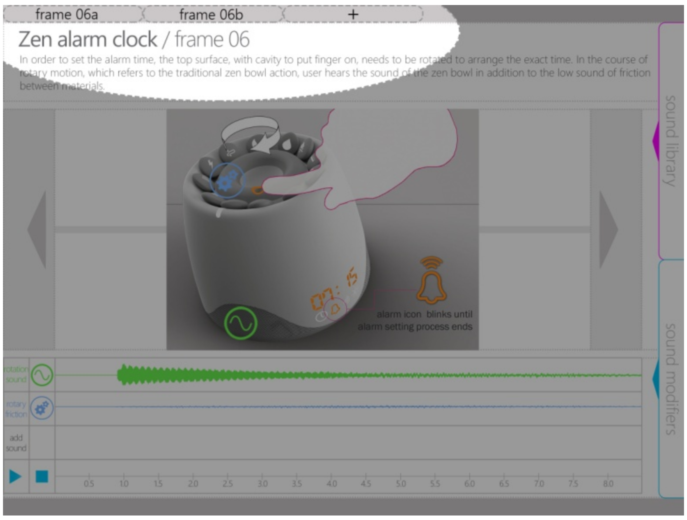


Figure 5.20. Suggestion of interviewee about adding and showing alternative frames

In order to summarize, the issues related with the interface of SoundsGood V2 voiced by the interviewees are as follows:

- Inconsistency of the static nature of visuals (e.g. sound icons on a scenario frame) in comparison with the dynamic auditory attributes (e.g. sounds being played)
- Possibility of adding a "hide" option for the bottom part of SoundsGood, which contains acoustical features
- Possibility of creating two different interfaces/modes for SoundsGood; one for designers, and the other for sound experts
- Dominancy of the visual scenario area over the bottom area that contains acoustical features of the sounds in terms of proportion
- Possibility of changing "add alternative frame" feature from vertical axis to horizontal tab style (e.g. tabs in Google Chrome)

CHAPTER 6

RESEARCH THROUGH DESIGN - PART 3

This chapter begins with the presentation of the rationale derived from the outcomes of the second field study for the revision of SoundsGood V2. This is then followed by a detailed description of the main features of the final version of SoundsGood.

6.1. Rationales for the Revision of SoundsGood V2

The outcomes of the second set of interviews and the focus group session were revisited to determine points that could be taken into consideration throughout the revision of SoundsGood V2. In comparison with the outcomes of the first field study, the second comprised more diverse and applicable suggestions for the development of the design concept.

To begin with, the frame-by-frame flow of the interaction scenario was criticised because of the lack of an option to view and consider all of the interaction elements holistically. In relation to this, it was suggested that there be a zoom-out view feature in the next version of SoundsGood, to easily arrange and re-arrange the branches of interaction scenarios.

Another set of reviews focused on the possibility of online collaborative use of SoundsGood. In line with this, it was indicated that there should be a commenting feature that directly supports collaborative usage; in this way, the 'design for auditory interaction' process would become more efficient and faster. It was also suggested that there could be a hideable / collapsible option at the lower region of SoundsGood that provides access to the acoustical properties of sounds. Thus, the

software would be less complex for non-professionals such as users or customers in the course of making their evaluations on auditory interaction concepts.
Apart from these, considering the current methods of interaction with SoundsGood V2, many of the interviewees and the participants of focus group session mentioned that there could have been more engaging ways of interacting with the scenario frame and the auditory elements at the same time. For example, instead of pressing the play/stop button to listen to auditory elements, the sound icons located on each scenario frame could be used as triggers for playing or stopping (i.e. previewing) each relevant sound independent of chronology or time-base. Also, a blinking feature for sound icons may indicate which sound is active on the scenario frame, in cases where all sounds are being played with the play/stop button.

Furthermore, it was suggested that adding visual cues to direct designers' navigation may solve miscommunications about the process of narrowing-down the sound options by selecting one subcategory from each sound category in SoundsGood V2. In the first place, adding a title for each category and visually depicting the requirement of selecting one subcategory from each sound category would increase the comprehensibility of the process. Additionally, as suggested by interviewees and the participants of focus group session, there should be textual explanations and audio examples for each subcategory of '*descriptive concepts for product sounds*' and '*product sound groups*' from the sound library. Otherwise, it appears to be very time consuming trial-and-error process for designers to understand the features that characterize each subcategory. Moreover, easily previewing the sounds from the sound list before dragging any of them onto a scenario frame was mentioned as crucial for smoother interaction. At this point, the possibility of using sound icons in the sound library as preview buttons was found reasonable.

Should SoundsGood be extended to collaborative use, for healthier communication, it was underlined that there should be consistency among the colours of the sound icons representing the product sound types on the scenario frame (i.e. air, mechanic, digital feedback etc.).

Apart from these, with the advancement of technology, the vast majority of current computers and smart devices have built-in microphones. Thus, it was highlighted that a direct recording option in SoundsGood would be useful for many designers to assign 'vocal sketches' to interactive moments.

Similar to the sound library's elements, it was also suggested that sound modifiers require accompanying simple and non-technical explanations. In addition, it was considered necessary to direct designers textually or visually about the application process of modifiers to sounds. Most of the interviewees and participants of the focus group session mentioned that this process should not consist of complex control elements. Instead, it would be practical for designers to have presets for generating an intended effect, realized through the application of modifiers on library sounds. For example, instead of knobs and sliders, there can be options such as room types (e.g. bathroom, balcony, meeting hall) and room size (e.g. small, large) for the 'reverb modifier'.

It was also mentioned that a current omission is a modifier that provides an easy way to trim and slice sounds, so that designers can quickly realize temporal changes. In parallel, a modifier that would allow designers to create a variety of patterns from a single library sound was considered a valuable addition (e.g. a short beep-like sound, modifiable to a beep repeated consecutively five times).

6.2. Final Design Suggestion: SoundsGood V3

Based on the feedback received from the second set of interviewees and the participants of the second focus group session, SoundsGood V2 was revised. In Figure 6.1, 'frame view' of the final version of SoundsGood (V3) is exemplified. In comparison with the previous versions, a partially working prototype of the design was built in a way that could communicate the dynamic intent of the software interaction with regard to visual and auditory features. The working prototype was created using Microsoft Office PowerPoint 2007 (the final version of the design suggestion can be found in the accompanying DVD folder "SoundsGood V3").

Figure 6.1. 'Ab example Frame View' of the final version of SoundsGood

As shown in Figure 6.2, similar to the previous version, the interface of SoundsGood V3 is divided into five main parts with different colours representing the main features of the tool. These are: user-product interaction scenario (A), textual information about the interaction (B), auditory library (C), acoustical properties of sounds (D) and user panel (E).

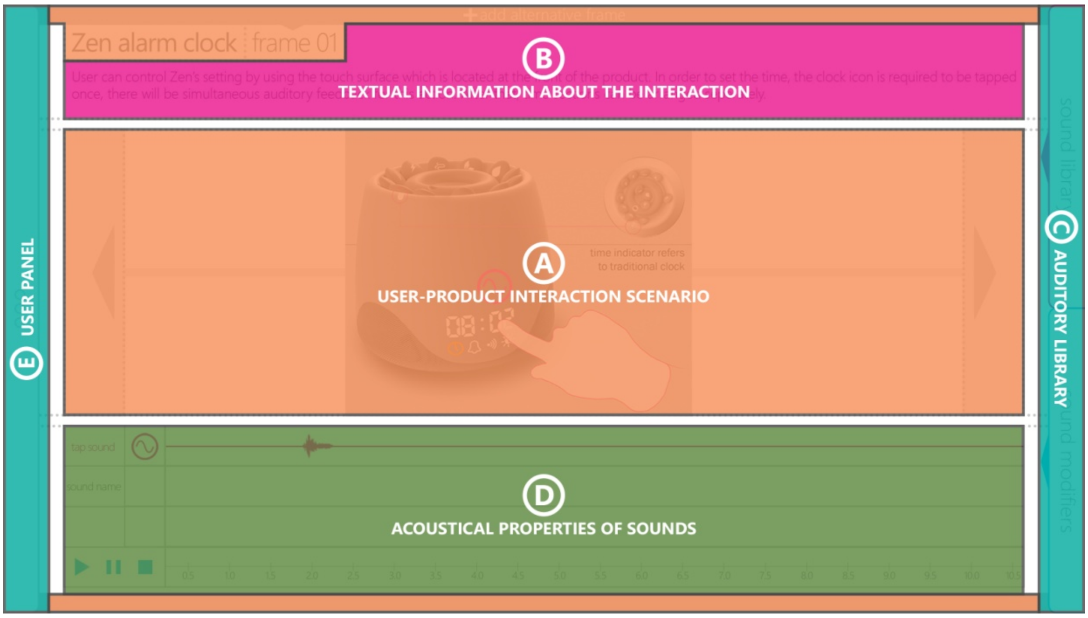


Figure 6.2. Five main parts of SoundsGood V3 shown on the example project

A) User-product interaction scenario

In line with V2, the area tagged with A (see Figure 6.2) consists of visual elements such as sketches, renders or photos that are used to visually describe an important frame in the intended user-product interaction scenario. In addition to adding an image onto the frame, creating an alternative frame, and a linear way of navigating between frames, there is a new feature in V3 to make navigation easier. Designers can now view thumbnails all of the frames in a row when the 'frame' caption is clicked (see Figure 6.3).

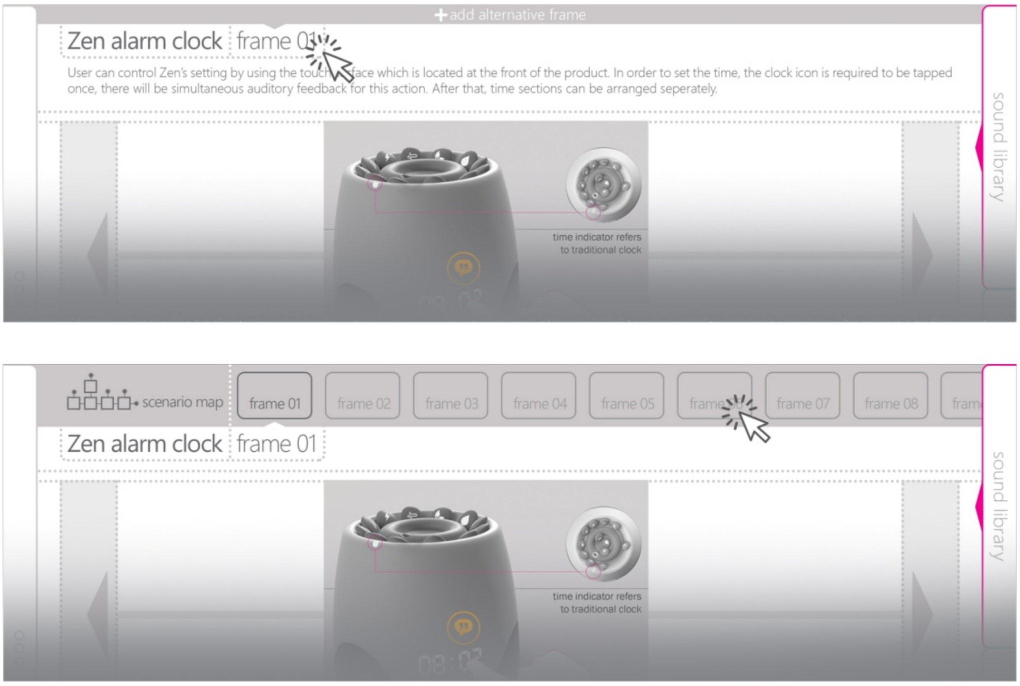


Figure 6.3. Navigating between the frames of an interaction scenario

Apart from that, by clicking the 'scenario map' button (as shown in Figure 6.4), designers are able to view and access the individual frames of the interaction scenario in a more holistic way, on a single page. The plus (+) icons located on the right and upper side of each frame in the 'scenario map' view can be used to add a new frame to the interaction scenario or add alternative frames at the same chronological point as existing frames (see Figure 6.4). Thus, the flexibility that was mentioned by interviewees and participants as a requirement for creating, editing and viewing user-product interaction scenarios and navigating between scenario frames is provided in V3.

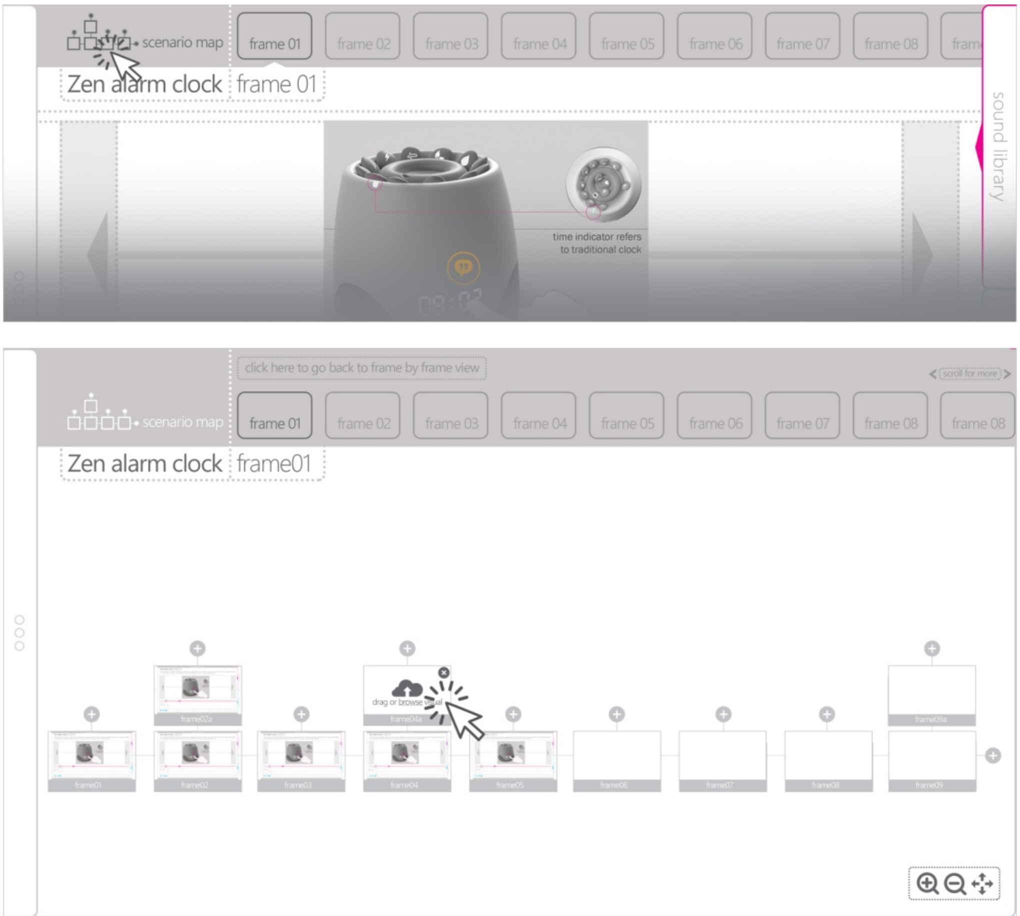


Figure 6.4. 'Scenario map' view in SoundsGood (V3)

B) Textual information about the interaction

Continuing with the principles established for the previous versions of SoundsGood, the area tagged with 'B' contains textual information describing the intended user-product interaction for a particular scenario frame. While the name of the project and the title of each frame can be edited by double-clicking, the 'row view' for scenario frames can be brought into view by clicking the 'frame' caption once (see Figure 6.3).

C) Auditory library

As with SoundsGood V2, the auditory library, which is tagged with 'C' in Figure x.2, contains two main groups: i) sound library and ii) sound modifiers (see Figure 6.1).

i) Sound library

As previously mentioned in the "Rationale for Revision of SoundsGood V2" section, there was a requirement of guidance for designers with regard to narrowing down the sound options suitable for an intended auditory interaction. Thus, SoundsGood V3 was designed to textually and visually inform designers about the steps that should be taken to effectively search for suitable sounds from amongst all sounds in the library.

As shown in Figure 6.5, when the sound library tag is clicked (1), three types of categorization for product sounds contained in the sound library become visible, namely: *'descriptive concepts*', '*product sound groups'* and *'create a categorization'*. Each category contains a list of subcategories or items. These become highlighted when clicked and offer textual information that explains the role of each subcategory or item (Figure 6.5 - 2). As an additional enhancement, the items under the product sound groups (i.e. the different classifications of product sound origins) are now colour-coded, in order to clarify which sound on the scenario frame belongs to which sound group. This is considered especially useful in the context of a collaborative design process.

Figure 6.5. Exploring the elements of sound library in SoundsGood V3

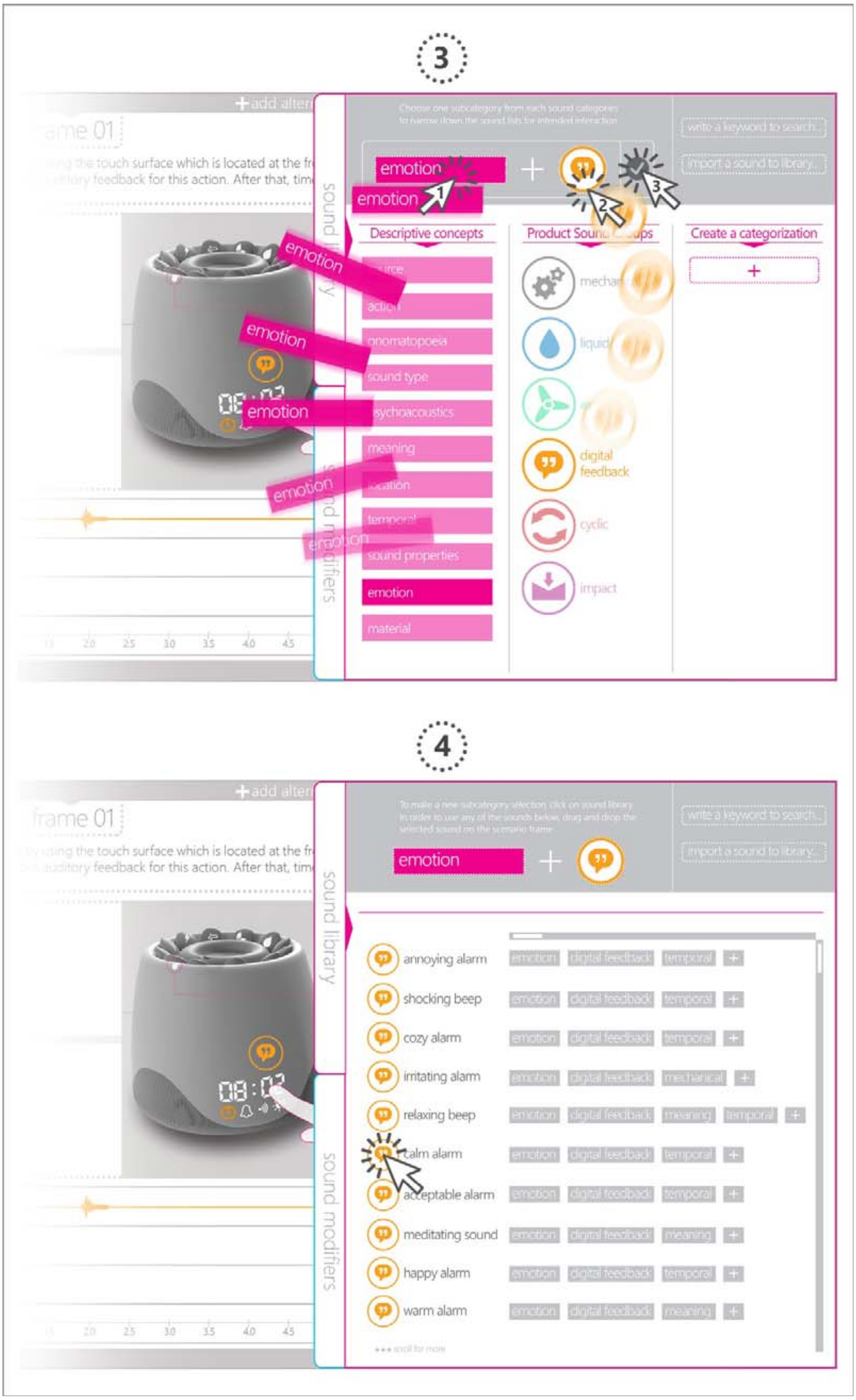


Figure 6.6. Narrowing down process by combining different sound categories

As shown in Figure 6.6, in order to narrow down their choices from amongst the full database of sounds, designers must drag-and-drop the icons of subcategories/items from both the descriptive concepts and product sound groups. The icons are dragged onto a dedicated 'sound selection area' located on the upper side of the interface (3). After confirmation, the software narrows-down the sound options to only those fitting the selected categorical tags, and generates a list of candidate sounds (4). At this point, designers will be able to explore the candidate sounds by previewing any of them from the list by clicking on the each sound icon. If a sound is deemed to fit the designer's intentions, it can then be dragged into the scenario frame. Additionally, it is possible to create a new user-defined tag for any of the sounds presented in the list, to aid subsequent keyword-based sound searches. Besides this method of reaching appropriate sounds, it is also possible to directly search for candidate sounds by using free-text keywords.

Apart from that, in addition to the possibility of importing external sounds to the library, there is a recording option in SoundsGood V3 to enable designers to create vocal sketches easily. Vocal sketches can be a quick and effective way of conceptualizing auditory interaction between users and a product (see Figure 6.7).

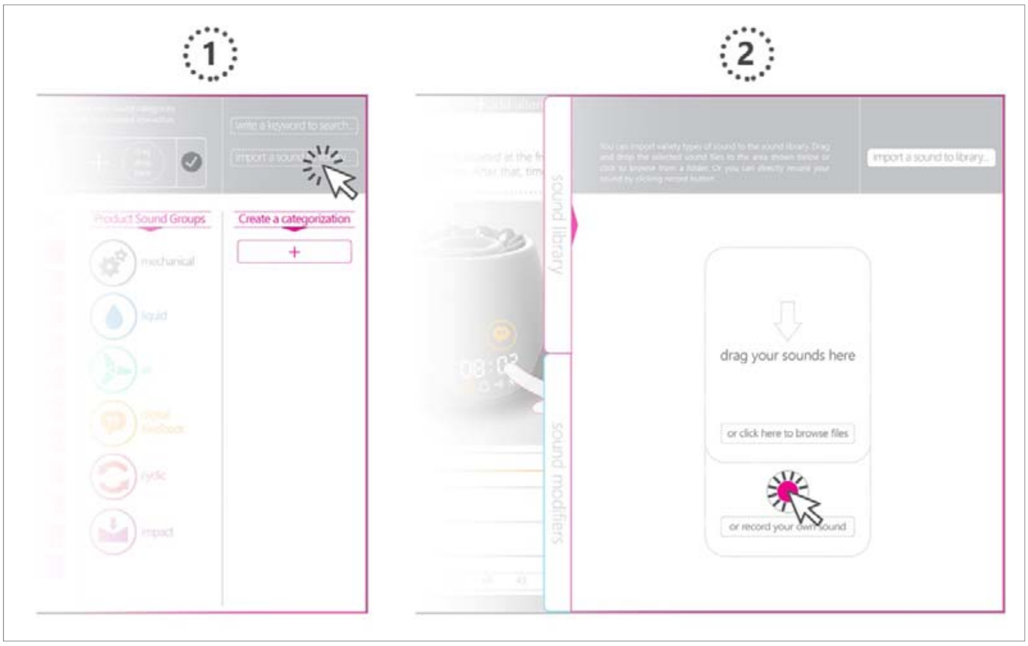


Figure 6.7. Importing or recording a sound (e.g. vocal sketch) into the sound library of SoundsGood V3

After importing a sound into the sound library or recording a new sound, designers are prompted to name the sound and attach existing tags or create new tags for future searches (see Figure 6.8).

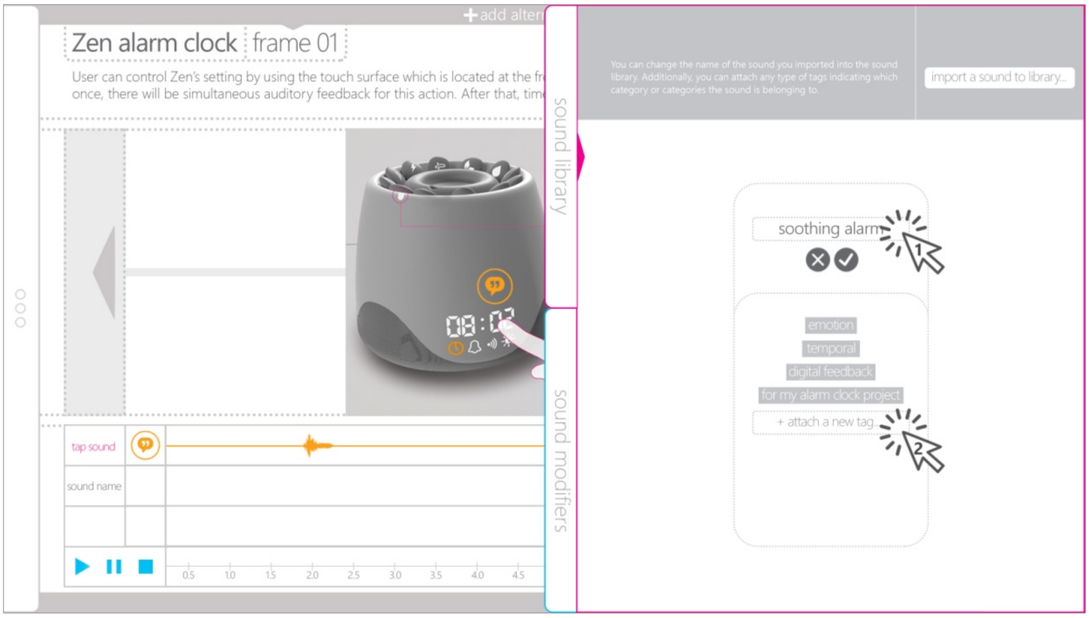


Figure 6.8. Naming and tagging new sounds for the sound library

ii) Sound modifiers

The purpose of having sound modifiers in SoundsGood was to enable designers to modify pre-existing library sounds so that they better fit designers' auditory interaction ideas and intentions.

In the course of the second field study, the interviewees and the focus group participants mentioned that due to the technicality of the terms used for the components of sound modifiers in SoundsGood V2, it would be preferable to have explanations informing designers about the function of each sound modifier and instructions on how modifiers can be used to process sounds assigned to a scenario frame.

As shown in Figure 6.9, after clicking the vertical *'sound modifiers'* tab, a sliding menu containing the main sound modifiers becomes visible. The sound modifiers chosen for the SoundsGood V3 were: *loudness, filters, pitch-shifting, reverb, delay* and *sequence*. The functions of these modifiers, excluding *sequence,* have already been explained in the *'Research Through Design Part II'* chapter (pg.103). The role of the sequence modifier is to allow designers to simply create a pattern (musical motive) with a defined tempo and range from a beep sound.

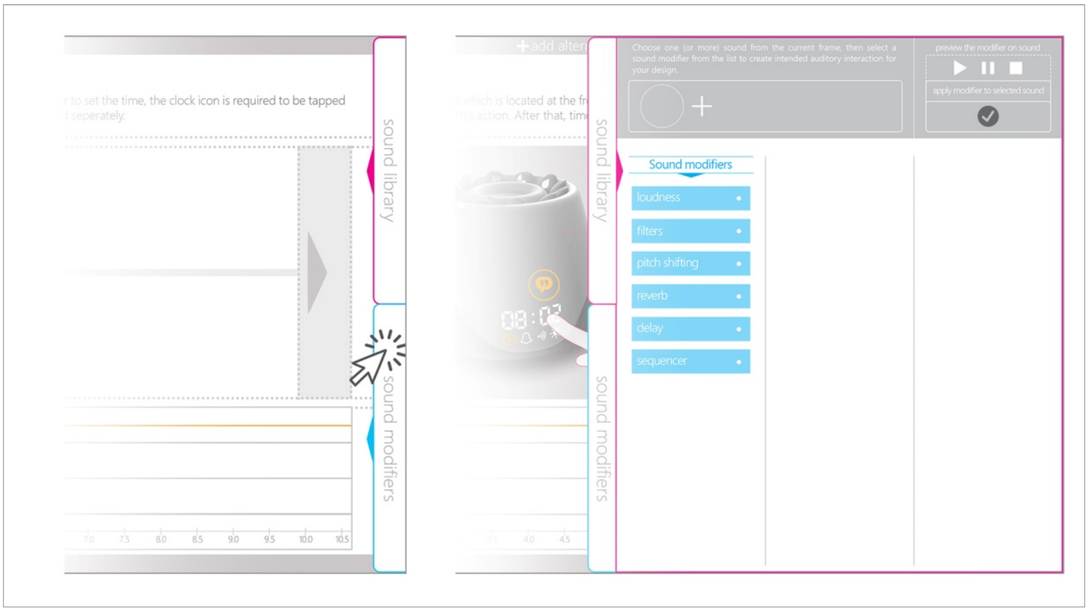


Figure 6.9. Sound modifiers section in SoundsGood V3

For the utilization of modifiers, both textual and visual guidance is now provided for designers (as shown in Figure 6.10). Accordingly, designers must first select at least one sound already allocated to the current scenario frame by clicking the sound icon as illustrated in Figure 6.11. The icon of the sound then appears in the sound modifier ‘working area’.

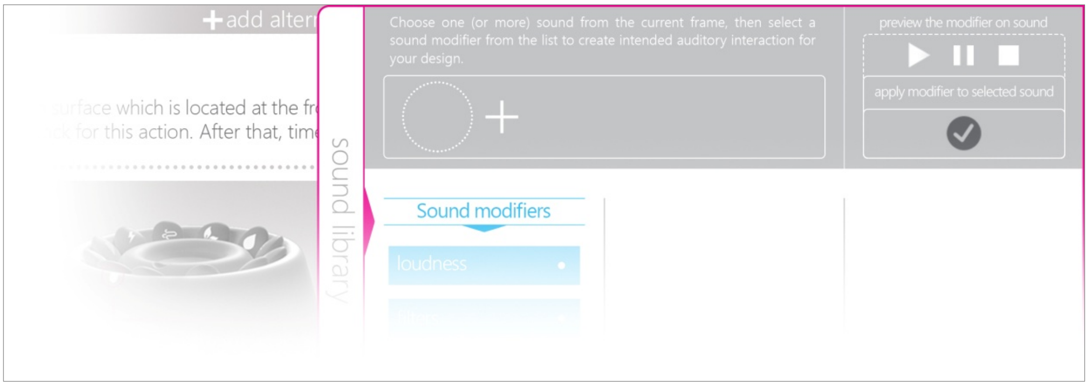


Figure 6.10. Textual and visual guidance for the usage of modifiers

After that, in order to obtain information on the functions of modifiers, the caption of each modifier can be clicked as shown in Figure 6.11. This way, text boxes explaining the specifications of each modifier group becomes visible and guides the designer towards a modifier that will suit to his/her design intent.

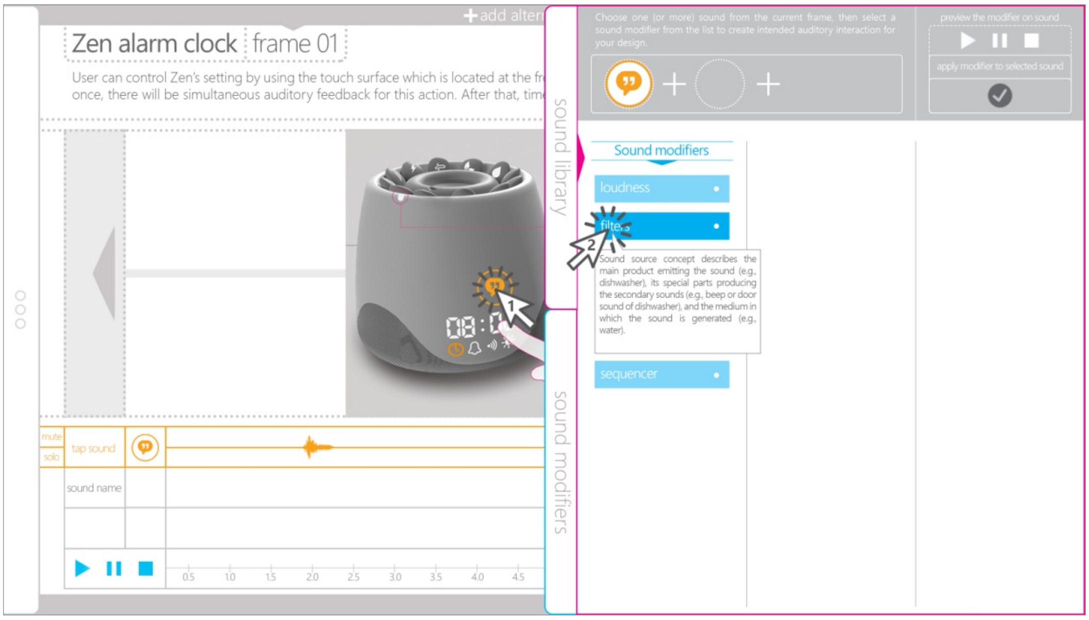


Figure 6.11. Information box for each of the modifiers in SoundsGood V3

After deciding which modifier to apply to the selected sound(s), the area of the modifier button between the caption and small right-sided dot (1) should be clicked, activating the 'modifier sub-menu' as shown in Figure 6.12. The designer should then choose a specific type of modifier preset (2) amongst the listed options. For example, after selecting the 'filter' modifier from the main menu, one of the items listed on the ‘filters’ sub-menu (e.g. 'high pass filter', 'low pass filter', band pass filter' or 'custom') must be chosen. Once chosen, a 'parameters' menu is activated (3), which allows designers to explore and modify the preset values of parameters such as *'amount of filter'* or *'cut off frequency'*. Use of these parameter adjustments is not compulsory, but they are provided so that sounds can be intricately modified to better suit designers’ intentions for audible interaction. The contents of modifier sub-menus and parameters change according to which modifier type is selected. As an example, the 'loudness' modifier does not contain any sub-menu, but it does activate a parameter for adjusting the loudness level of selected sounds.

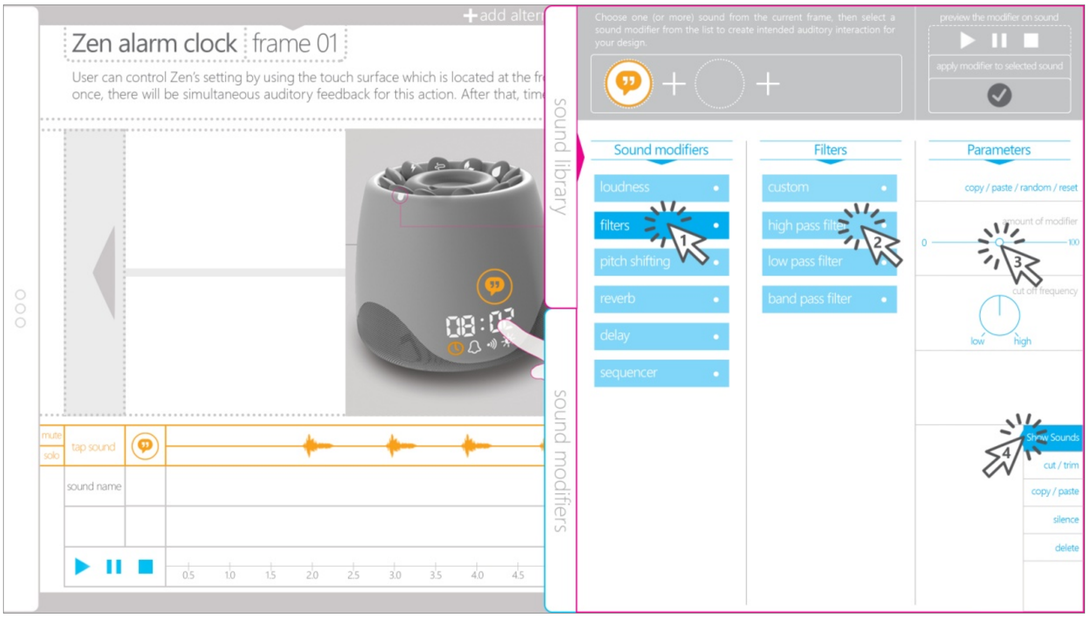


Figure 6.12. Selection, adjustment and the application of the modifier to selected sound or sounds

The final feature in relation to sound modifiers is the possibility to apply a modifier to only a particular region of a selected sound. To do so, the designer must click *'show sounds'* (4) from the bottom right area of the modifier menu (see Figure 6.12). When clicked, an 'amplitude view' of the selected sound is brought into view as shown in Figure 6.13. The designer can then select a specific region of the selected sound that will become affected by the sound modifier. The sound either side of the selected region will not be affected by the sound modifier. If no specific region is defined, the modifier will affect the entire duration of the sound.

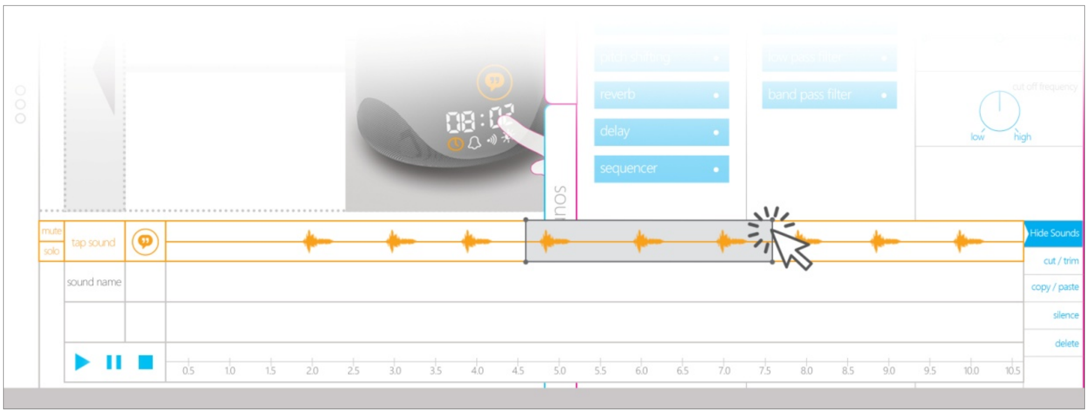


Figure 6.13. Applying the modifier to a particular region of selected sound

After arranging the parameters of the modifier and optionally defining a region of the selected sound to which the modifier will be applied, the designer can preview the modified sound using the controls provided at the top right of the sound modifier working area (see Figure 6.14) and can make changes within the parameters of the modifier for further auditory exploration. As the final step, the application of the modifier to the selected sound (or sounds) can be confirmed by clicking the tick icon highlighted in Figure 6.14.

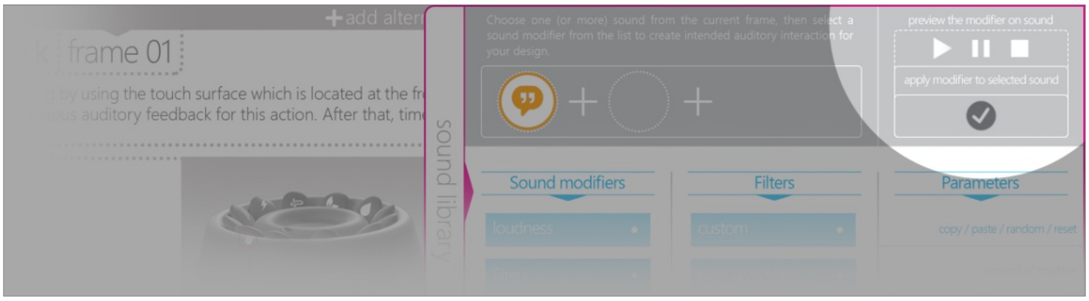


Figure 6.14. Modifier preview and application panel

As a way of checking which modifier has been applied to which sound(s) within a particular scenario frame, as shown in Figure 6.15, the colour of the small dot on the right side of each modifier button can be noted, once sounds have been selected from the frame. A green dot indicates that the modifier is active for the selected sound, whilst a red dot indicates that the modifier has been deactivated by the designer. Clicking on the dot toggles between these states. Additionally, a white dot indicates that the modifier has not been implemented yet.

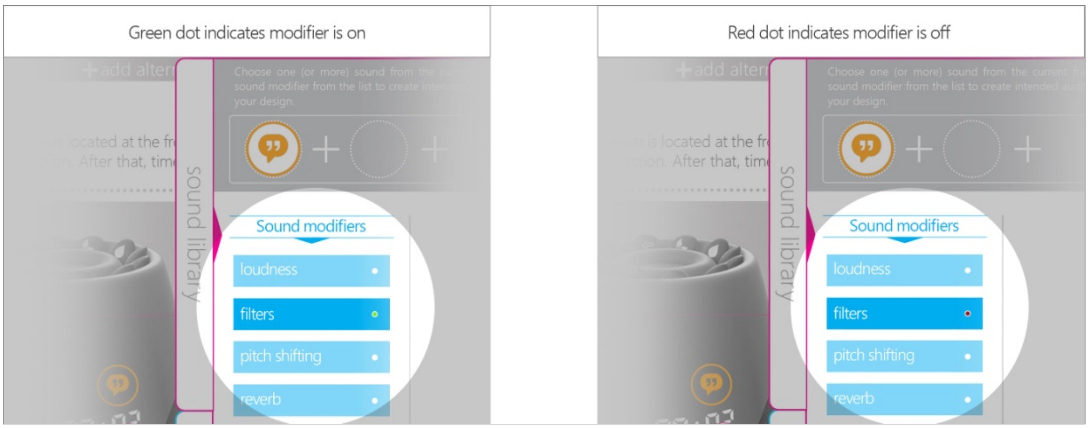


Figure 6.15. Indicators for which modifiers are active/deactive for a selected sound

D) Acoustical properties of sounds

Continuing the features of the previous version of SoundsGood, the area tagged with 'D' in Figure 6.2 contains the basic acoustical features of the sounds utilized in scenario frames. As mentioned in the previous section of this chapter, designers can visually arrange the temporal relation between sounds in a certain frame by benefitting from the waveform views of sounds. By activating the play icon, located at the bottom left corner of the interface (see Figure 6.16), all of the sound tracks for a certain scenario frame can be played together.

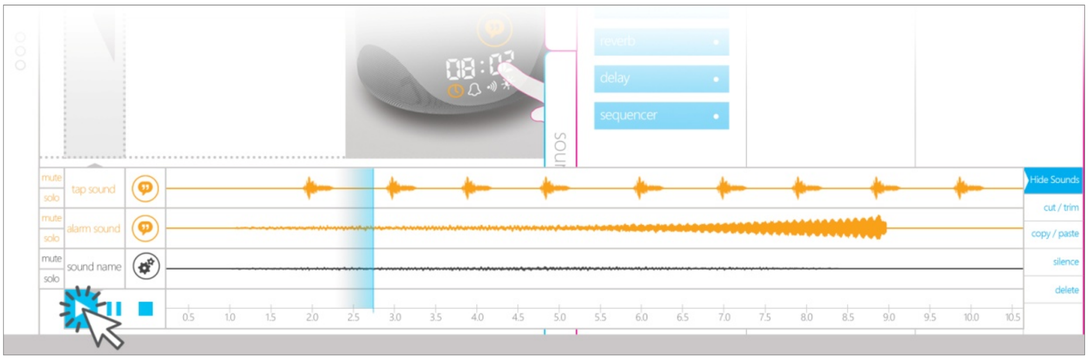


Figure 6.16. Playing/stopping the intended auditory interaction for the current scenario frame in SoundsGood V3

Similarly, any of the tracks of sounds can be muted or played solo by clicking the 'solo' or 'mute' icons as shown in Figure 6.17. Apart from these, it is also possible to select a particular area over any of the sounds and edit this area using editing tools i.e. move, cut, trim, copy, paste, silence and delete (see Figure 6.17).

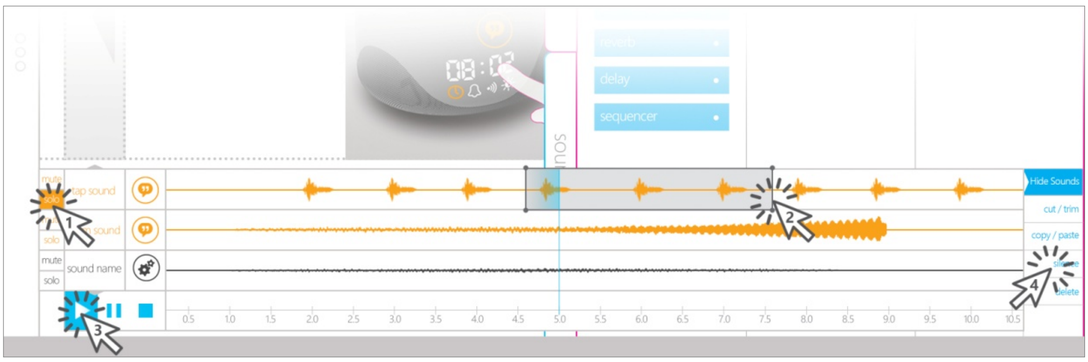


Figure 6.17. Mute/solo, selecting and editing features for sounds

E) User panel

Considering the reviews of the second set of interviewees and focus group participants about the collaborative nature of industrial design, the final version of SoundsGood has been revised so as to support team working via online usage.

Differentiating from the previous versions, SoundGood V3 contains a *'User Panel',* which consists of features that make navigation within the tool and collaboration with other team members (who may be geographically distributed) easier. By clicking the area shown in Figure 6.18, the user panel's features can be brought into view. While the top part of the user panel comprises page links associated with a particular designer's profile information and SoundsGood projects, the bottom part contains features to facilitate collaboration (design team, comment mode, share) and navigation within the current project (scenario map, frame view).

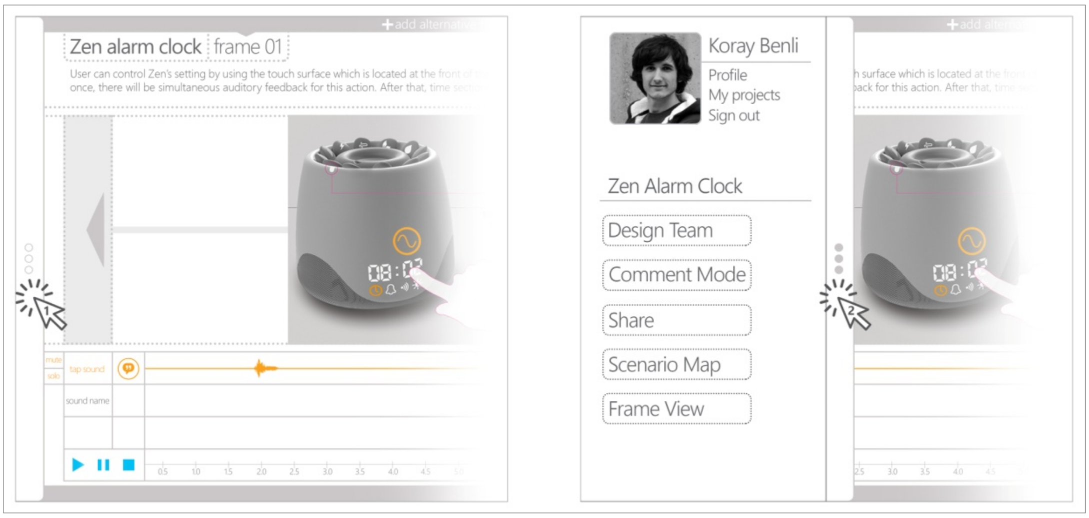


Figure 6.18. Opening and closing user panel

As shown in Figure 6.19, existing SoundsGood projects can be viewed and edited, and new projects can be started by the designer by using the 'My Projects' link.

Figure 6.19. 'My Project' panel in SoundsGood V3

As mentioned within the previous chapters, the realization of auditory features of products designed using a frame-by-frame focus on user-product interaction would require skills and knowledge from a combination of distinct areas including industrial design, engineering, acoustics, and psychology. Thus, in order to conduct a collaborative process for designing auditory interaction ideas, it is possible to add a new team member (collaborator) to an existing or newly created project by clicking on the 'Design Team' button (see Figure 6.20).

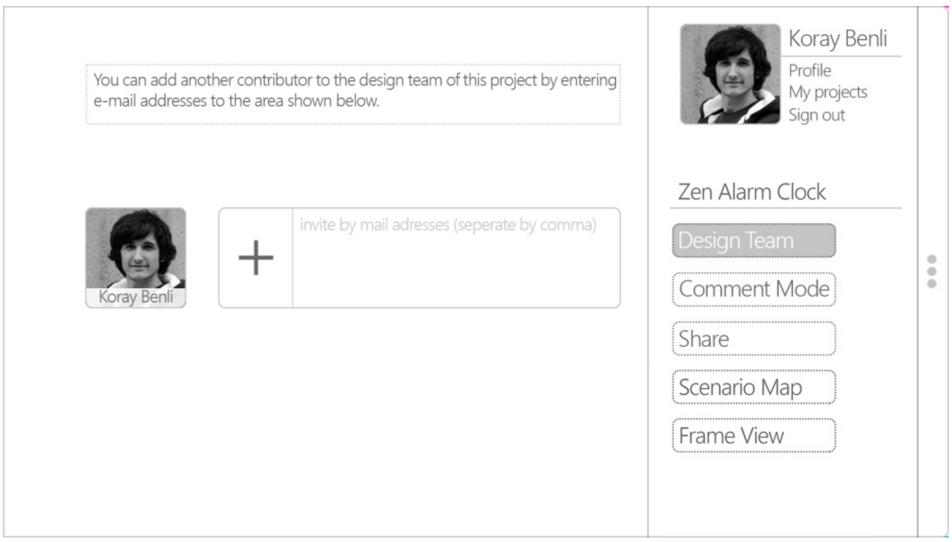


Figure 6.20. 'Design Team' panel for collaboration within projects

Once added, the new collaborator can view the interaction scenario, comment on any of the frames (see Figure 6.21), and edit and create alternative scenario frames within the project. More importantly, by building a multi-disciplinary team, the industrial designer can consult an audio professional and engineer at the same time to receive feedback, for example on the practical feasibility of auditory interaction ideas.

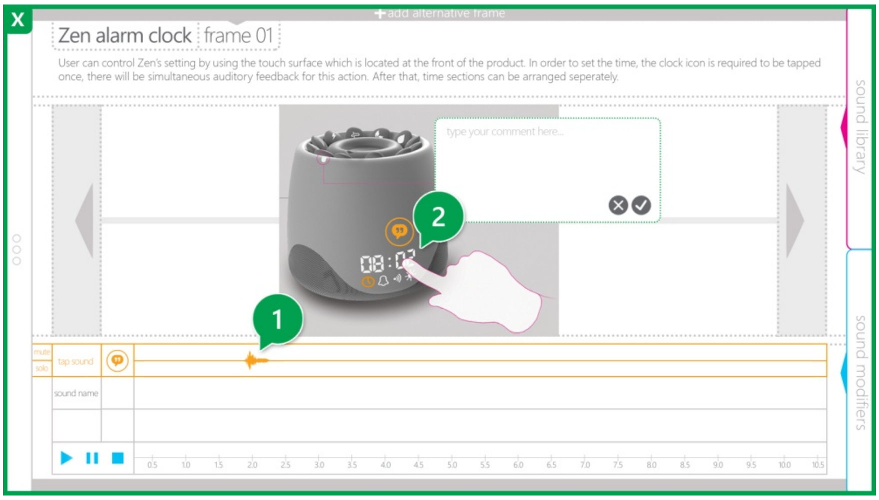


Figure 6.21. Commenting feature for each frame in user-product interaction scenario

Other than adding a collaborator, it is also possible to share the project link with third parties to enable them to explore the audible user-product interaction and provide feedback for further development of design ideas (see Figure 6.22).

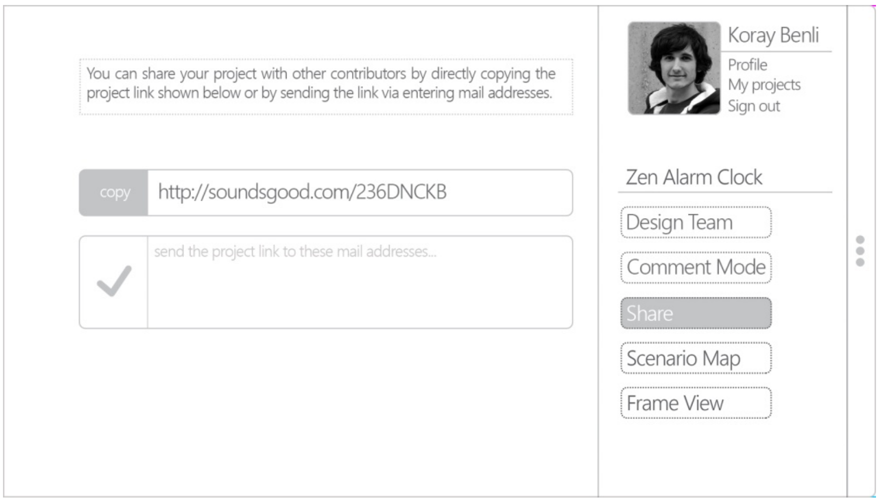


Figure 6.22. Sharing option of projects for gathering review

CHAPTER 7

CONCLUSIONS

The aim of this study was to explore the current and prospective act of sound design for products, and then to conceptualize a set of suggestions for designers and design students to stimulate them to take auditory interaction opportunities into consideration within their design process.

In order to provide answers for the research questions presented in the first chapter of the thesis, two strands of work were completed. Firstly, related areas in literature have been investigated by focusing on the user experience side of auditory interaction, anatomy and classification of sounds, and proposed methods for a product sound design process (see Chapter 2).

Secondly, a progressive field study comprising two sets of interviews and focus group sessions has been conducted in combination with the iterative design of a conceptual tool (SoundsGood), the aim of which is to aid designers to generate and communicate ideas for auditory user-product interaction (see Chapter 3 & 4-5-6).

This final chapter begins with revisiting the research questions, by presenting the prominent insights derived from both from literature review and progressive field studies. The chapter concludes with some notes about the limitations of the study and implications for further research.

7.1. Research Questions Revisited

The main research question of the study was as follows:

How can an intended audible user experience be communicated and manipulated by industrial designers, within the context of design for interaction?

In order to form a basis for answering this question, three interrelated areas were explored throughout the literature review chapter. These areas were *'experiences of product sounds'*, *'anatomy and classification of sounds'*, and *'design for product sounds'*.

Within the *'experiences of product sounds'* section, after briefly investigating various frameworks that conceptualize user-product interaction and user experience, frameworks clarifying product sound experience were focused on. By considering the fact that sensorial information gathered from products, meaning attributed to sensorial information, and emotions evoked in the course of user-product interaction, all affect the user's product experience, it has been argued that the auditory features of products are also as important as other sensorial features in the visual and tactual domains. Due to the intertwined nature of product experience, it was underlined that industrial designers also need to take auditory features of products into consideration within the product design process, in order to enrich the product experience.

Throughout the *'anatomy and classification of sounds'* section, basic physical properties shaping the sounds and types of categorizations for product sounds have been discussed. Accordingly, product sounds are considered to be part of a subgroup of more general 'environmental sounds' and mainly consist of two types, namely; consequential and intentional product sounds. While consequential sounds are the auditory results of product construction and functioning, intentional product sounds are consisted of earcons or auditory icons (depending on the terminology), sonification and continuous sonic interaction, all of which are designed to reflect designer's intention. In other words, these two categories distinguish (i) sound as a consequence of the operation of physical product components, and (ii) sound emitted by products through speakers. Additionally, the framework conceptualized

by Özcan and Van Egmond (2005) for the categorization and description of product sounds, including both consequential and intentional sounds, was presented and utilized within the design aspects of the *'Research Through Design'* chapter of the thesis.
In the last section of the literature review chapter, dealing with *'design for product sounds'*, the requirements for knowledge from distinct areas such as engineering, acoustics and psychology for product sound design processes was highlighted. Current examples of sound design practice were explored. Apart from these, theoretical frameworks for product sound design and currently available methods and tools for designing auditory features of products were examined.

Deriving the theoretical basis from the literature review, field studies were conducted to further explore the approaches of designers towards how an intended audible experience can be designed and communicated to other parties who are contributing to the product design process. A 'research through design' approach was adopted throughout the field study, which comprised of two sets of interviews with five professional designers and two sets of focus group session with five METU Research Assistants. Prior to the first set of field studies, to obtain more grounded reflections from interviewees and participants, an initial conceptual tool called SoundsGood V1 was designed – taking into account insights gained from the literature review. To obtain answers for the main research question, both the interviews and the focus group session were conducted by following the same set of questions, which can be categorized under three titles: (i) communicating an intended interaction, (ii) designing for sound phenomena, and (iii) reflecting upon SoundsGood.

In order to provide a more explanatory background for the main research question, the conclusions for both of the secondary research questions will be presented first. After that, the main research question will be addressed again making use of the overall outcomes of the literature review combined with the field studies.

i) What are the challenges that industrial designers may encounter during the incorporation of sound design into industrial design processes?

In line with the outcomes of the literature review, both sets of field studies revealed that the design process of auditory features of products is overlooked within the product design process. As highlighted by the most of the interviewees and participants, one of the most prominent reasons for this situation is the dominancy of visuality over other sensorial modalities within the domain of product design. Therefore, the design of product auditory features is overshadowed by the amount of time and effort spent by designers for visual features.

In parallel, nearly all of the interviewees and participants stated that due to a lack of technical background, it is difficult for industrial designers (generally) to have an opinion on – and create design suggestions for – sound-based interaction.

Apart from the dominancy of the visual modality over other sensory modalities, and the inadequacy of designers' educational backgrounds in the auditory realm, a lack of well accepted methods and tools for the design process of auditory features of products also hinders the consideration of sound-based interaction. Furthermore, the technical terminology required for utilizing currently available audio tools is a barrier to designers being more involved in a sound design process.

As derived from literature review and both of the field studies, due to the technical complexity of dealing with sound, the product sound design process is generally performed by engineers, without participation from industrial designers. Beside the technical knowledge required for the task of sound design, another factor preventing designers to participate in the process is a lack of communication channels through which designers can convey their sound design ideas to other contributors of a design process. This is found to be especially the case at an early (conceptual) level of a new design project.

The final challenge identified from the field studies is the difficulty of evaluating product sound proposals with regard to their suitability for intended user-product interaction. Most of the interviewees and participants underlined that without knowing the effects of changing auditory features of a product on user perception, it would be trial-and-error and challenging to offer design suggestions for auditory interaction.

ii) What kinds of considerations should be taken when designing for product sounds?

Both the literature review and the outcomes of the field studies have revealed several considerations for the design of auditory features of products within the context of user-product interaction.

To begin with, as mentioned by most of the interviewees and participants, auditory features of products are overlooked within the conceptual design process. They tend to be taken into consideration later on, at the embodiment level, in which the prototype of an intended design is built. However, as underlined by Özcan and Van Egmond (2009) and Robare (2009), sound design practice for products should be performed in parallel to the main design process and should be considered as an integral element of user experience. In line with these points, it can be argued that by beginning from the conceptual level of a design process, industrial designers would be well advised to develop design ideas for auditory user-product interaction, alongside their conceptualization of design suggestions for visual properties.

As previously mentioned, within the sound design process of products, there is a requirement for distinct knowledge from a variety of disciplines, which bring diverse approaches and methods depending on whether the sound is considered 'consequential' or 'intentional'. For the design process of consequential product sounds, for example the sound emitted by a blender, the designer needs a sufficient level of knowledge or consultancy on the manufacturing, structural, mechanical, electro-mechanical, and material properties of the product being designed. However, for the consideration of intentional product sounds, for example the alarm sound of a clock, there will likely be a requirement for expert contribution in the realm of musical knowledge. Additionally, for the implementation of both categories of product sounds, acoustics and psychology play an important role in correlating sound parameters with the meaning attribution process of users. Thus, due to the requirement of multi-disciplinary contributions to achieve a comprehensive design process of auditory features of products, the communication between collaborators from distinct disciplines becomes crucial. For this reason, it can be argued that industrial designers need to maintain a healthy communication between these collaborators (as a kind of central negotiating figure), since they have a full command of the overall design intention and user-product interaction scenario. Otherwise, as underlined by Özcan (2008), the product sound design process recursively decreases in pace behind the overall design process.

How can an intended audible user experience be communicated and manipulated by industrial designers, within the context of design for interaction?

As previously mentioned, the sound emitted from products, as audible sensorial information, is one of the important factors affecting overall product experience. For this reason, to design an enriched user-product interaction, industrial designers should start to take auditory interaction possibilities into consideration from a problem analysis level to a production level, throughout the course of a design process. However, to be able to create auditory interaction concepts for products, designers need certain tools, adequate skills and consultancy from distinct disciplines. Thus, within the scope of this thesis, a conceptual tool called SoundsGood has been designed to explore the requirements of industrial designers for being able to actively participate in the auditory user-product interaction process, as one concern within a wider product design project.

The outcomes of both field studies have revealed that by providing a basis for the generation and communication of auditory ideas in line with the visual and textual user-product interaction scenarios, SoundsGood (or a similarly specified medium) may allow designers to conceptualize auditory user-product interaction ideas for future products, even at conceptual design level. By utilizing previously created sketches, illustrations, photos or renders that explain the design intent for user-product interaction visually, it is possible for designers to create alternative usage scenarios within SoundsGood and sketch out alternative sound design ideas in an audible form. Additionally, by allowing collaborative design process, SoundsGood facilitates deep discussions not only about what kinds of sounds to add to a product, but more fundamentally what actions sounds should be associated with in the course of user-product interaction. Therefore, it can be said that SoundsGood combines the need for generating user-product interaction scenario with designers' requirements for sound design and manipulation to conceptualise auditory interaction ideas.

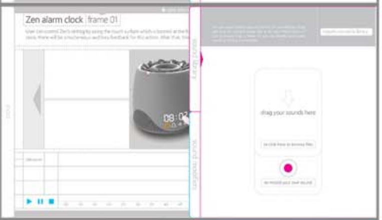
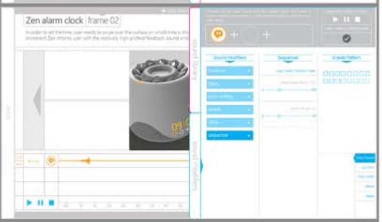
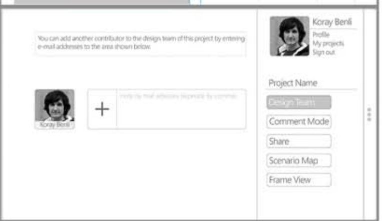
The overall features offered by SoundsGood V3 can be summarized as shown in the Table 7.1. By combining these features with their design skills, industrial designers may conceptualize, communicate and manipulate an intended auditory experience within the context of design for interaction.

7.2. Limitations of the Study

The scope of this thesis was to explore the current and future act of sound design throughout the product design process and to conceptualize a set of 'tool' or 'software' suggestions for designers and design students regarding the consideration of auditory user-product interaction.

Due to the fact that the design process for auditory features of products has not been taken seriously into consideration as an integral part of design practice, whether at educational or professional levels in Turkey (and indeed globally), one of the most challenging parts of this study was to gather well-grounded feedback from the participants of field studies. In order to overcome this drawback, a partially working prototype (in terms of interface/HCI) of the conceptual tool SoundsGood was designed. The period of research through design that led to the SoundsGood concepts (V1, V2 and V3) required a considerable amount of time and effort. For this reason, the number of the interviewees (10) and the participants of focus group sessions (5x2) fell somewhat short of the target number, due to time limitations. Although the outcomes of the field studies were both satisfying in terms of gathering designers reflections on conceptual tool and experiences related to product sound

Table 7.1. The final features offered by SoundsGood V3

Supporting the auditory interaction intent by creating user-product interaction scenarios with the usage of text and visuals (sketches, illustrations, photos, renders etc)	
Holistic approach for generating user-product interaction scenario with 'scenario map' feature	
Exploring the different set of sound categorizations from a built-in sound library and utilizing these categories to sort out the candidate sounds which will be suitable for generating the intended auditory interaction	
Importing the recorded sounds of existing products to sound library to explore the results of modifying auditory properties of these products in terms of enhancing product experience	
Directly recording a vocal imitation of an intended auditory interaction to the sound library for sketching the audible user-product interaction	
Modifying a selected sounds to create a certain impression and to affect overall user experience	
Possibility of online or face to face collaboration with other colleagues in order to get insight, feedback and consultancy especially about the technical considerations regarding to auditory realm	
Communication of audible user-product interaction to third parties (e.g. target users, customers) for gathering feedback for the revision of design suggestion	

design, there would have been more diverse suggestions especially for the development of SoundsGood if further interviews were conducted with designers from other industries such as white goods, automotive etc.

Apart from these, because of the partially interactive nature of the SoundsGood prototype, the comprehension of the proposed features of the tool was sometimes challenging for the interviewees and focus group participants. A fully working prototype, with regard to function, navigation and screen shot accuracy, would have assisted the evaluations and helped participants through the practicality and believability of SoundsGood.

7.3. Implications for Further Research

This study has explored and discussed possible ways of integrating the practice of product sound design into the wider product design process by adopting 'research through design' approach. Exploration of this subject and its related topics can be extended by iteratively designing a working prototype of SoundsGood running on an established OS/application platform. Then, it would be possible to integrate SoundsGood into a variety of product design projects through which designers will consider the auditory features of their conceptual designs within the frame of design for interaction. In this way, the effectiveness of SoundsGood and the influence of exploration of the auditory realm on developing more engaging design proposals could be analyzed and evaluated.

Apart from these, the current concept of SoundsGood V3 might be considered a 'Lite' version, suitable for the target users (industrial designers without specific sound design training), but that a 'Professional' version might also be developed for designers with a sound design specialty. In which case, the 'Professional' version would be technically more advanced in the sense that it would offer much greater sound shaping or synthesis parameters.

Furthermore, due to the time limitation, this present study has been conducted with a limited number of industrial designers from various industries, as well as industrial design graduates working as Research Assistants. Therefore, it would be helpful to conduct more extensive field studies with an increased number of participants from more distinct industries, thereby revealing in more detail and variety any nuances of designers' needs for the design process of auditory features of product.

Lastly, with 'research through design' approach, an exploratory perspective was adopted for this study in terms of both gathering data from related literature and fieldworks, and designing process of the conceptual tool, SoundsGood.

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APPENDIX A

INTERVIEW GUIDE

Session01 - Communicating the Interaction

In this part of the interview, focus will be on the industrial designer's ways of communicating their ideas, concepts to second parties such as; other designers, engineers, users etc. By getting insights about this, future tool for product sound designing can be tailored to fit in the designers' previous designing processes.

Q1 - Sizce endüstriyel tasarımcı, fikirlerini /konseptlerini diğer kişilere hangi yollarla aktarabilir?

Q2 - Siz proje sürecinizde diğer kişilerle iletişim kurmak için bu bahsettiğiniz yöntemlerden hangisini ya da hangilerini daha sıklıkla kullanıyorsunuz? Niçin?

Q3 - Ürünlerin kullanım senaryolarına odaklanacak olursak, sizce tasarımcılar ne gibi yöntemler kullanıyorlar?

Session02 - Designing For Sound Phenomena

In this part of the interview, the main aim is to understand the interviewee's approach towards product sounds in terms of user-product interaction cycle; and, get insights about the ways how industrial designers can think about auditorial attributes of products at conceptual level in design process.

Q4 - Ürün ve kullanıcı arasındaki etkileşim sürecinde,sizce ses ne derece önemlidir? Peki, neden?

Q5 - Sizce sesin önemli olduğu ürünlere ya da ürün gruplarına örnek verebilir misiniz?

Q6 - Tasarımcı, tasarım sürecinde ürün-kullanıcı etkileşimi açısından sesi nasıl düşünüp, ele alabilir?

Q7 - Şimdiye kadar yürüttüğünüz ya da parçası olduğunuz tasarım süreçlerini düşündüğünüzde, ses tasarımını bu sürece ya da süreçlere nasıl dahil ettiniz?

> Q7P1 - (Eğer dahil etmemişse) Peki, süreç boyunca ürüne dair sesle ilgili özellikleri ele almama ya da alamama nedenleriniz nelerdi?
> Q7P2 - (Eğer dahil etmişse) Peki, sizce bu süreçlerin ses tasarımı açısından eksik ya da geliştirilebilecek olan yanları nelerdi?

Q8 - Tasarımcıların, ürün-kullanıcı etkileşimini diğer kişilere aktarabilmelerini sağlayan bir araç düşünsek; sizce, bu araçta ne gibi özellikler olmalı?

Q9 - Tasarımcıların, ürünlerin sesleri üzerine fikir geliştirmelerine yardımcı olacak bir araç düşünsek; sizce, bu araçta ne gibi özellikler olurdu?

Q10 - Eğitim projelerinde, konsept ya da üretime yönelik projelerde; ses tasarımının da göz önünde bulundurulması, sizce ürün-kullanıcı etkileşimi açısından ne gibi avantajlar/fırsatlar yaratabilir?

Session03 - Reflecting on Conceptual Tool

In the last part of interview, the very initial version of the intended tool will be shown to designers to get feedback about the possible usage scenarios of the tool, affordance of the interface, missing or over-designed parts etc.

Q11 - Sizce bu ya da buna benzer bir araç, tasarımcılara ne gibi avantajlar / fırsatlar sunabilir?

Q12 - Sizce bu araç nasıl bir kullanım süreci önermeli? Fiziksel mi, yoksa dijital mi olmalı? Ya da ikisinden de mi faydalanmalı?

Q13 - Kendi tasarım süreclerinizi düşündüğünüzde, böyle bir aracı kullanmak ister miydiniz? Bu araç sizin tasarım sürecinize ne şekilde adapte olabilirdi?

APPENDIX B

INTERVIEW GUIDE (English Version)

Session01 - Communicating the Interaction

In this part of the interview, focus will be on the industrial designer's ways of communicating their ideas, concepts to second parties such as; other designers, engineers, users etc. By getting insights about this, future tool for product sound designing can be tailored to fit in the designers' previous designing processes.

Q1 - How can industrial designers communicate their ideas/concepts to others?

Q2 -Which ways do you prefer mostly for communicating your design ideas to others? Why?

Q3 - If we focus on the usege scenarios of products, what kind of techniques/methods do industrial designers use in your opinion?

Session02 - Designing For Sound Phenomena

In this part of the interview, the main aim is to understand the interviewee's approach towards product sounds in terms of user-product interaction cycle; and, get insights about the ways how industrial designers can think about auditorial attributes of products at conceptual level in design process.

Q4 - Within the course of user-product interaction, do you think sound is important? Why?

Q5 - Can you give examples for the products/product groups that sound is of importance?

Q6 - How can designers think and discuss product sounds within the design process in terms of user-product interaction?

Q7 - How did you consider the sound design aspects of products in the course of projects that you have conducted or taken part in?

Q7P1 - (If not considered) What were the reasons for not taking the sound related aspects into consideration during the product design process?

Q7P2 - (If considered) What were the points that can be improved in terms of considering sound related aspects within design process?

Q8 - Let's think about a tool with which designers can convey their user-product interaction ideas to others. What kind of specifications that this tool would contain?

Q9 - Let's think about a tool helping designers to generate auditory ideas for user-product interaction. What kind of specifications that this tool would contain?

Session03 - Reflecting on Conceptual Tool

In the last part of interview, the very initial version of the intended tool will be shown to designers to get feedback about the possible usage scenarios of the tool, affordance of the interface, missing or over-designed parts etc.

Q11 - What are the advantages/disadvantages that this or similar tool provides to designers?
Q12 - What type of interaction should this tool offer to designers; physical, digital or mixed?
Q13 - Would you like to utilize this tool within your design projects? If yes, how?

APPENDIX C

FOCUS GROUP GUIDE

Designing For Sound - Focus Group Research Guide

Session 01 - Etkileşimi İletmek

Sizce endüstriyel tasarımcı, fikirlerini, konseptlerini diğer kişilere hangi yollarla aktarabilir?	
Siz proje sürecinizde diğer kişilerle iletişim kurmak için bu bahsettiğiniz yöntemlerden hangisini ya da hangilerini daha sıklıkla kullanıyorsunuz? Niçin?	
Ürünlerin kullanım senaryolarına odaklanacak olursak, sizce tasarımcılar kullanım senaryoları geliştirmek için ne gibi yöntemler kullanıyorlar?	
(atlayabilirsin duruma göre) Tasarımcıların, tasarım konseptlerindeki etkileşimi diğer partilere aktarmalarını sağlayan bir araç düşünsek, bu aracın ne gibi özellikleri olurdu?	

FOCUS GROUP GUIDE (continued)

Designing For Sound - Focus Group Research Guide

Session 02 - Ses ve Ürün Tasarımı

Ürün tasarımında etkileşim estetiği hakkında ne düşünüyorsunuz?	
Ürün ve kullanıcı arasındaki etkileşim sürecinde,sizce ses ne derece önemlidir? Peki, neden?	
Sizce sesin önemli olduğu ürünlere ya da ürün gruplarına örnek verebilir misiniz?	
Tasarımcı, tasarım sürecinde ürün-kullanıcı etkileşimi açısından sesi nasıl düşünüp ele alabilir?	

FOCUS GROUP GUIDE (continued)

Designing For Sound - Focus Group Research Guide

Session 02 - Ses ve Ürün Tasarımı

Şimdiye kadar yürüttüğünüz ya da parçası olduğunuz tasarım süreçlerini düşündüğünüzde, ses tasarımını bu sürece ya da süreçlere nasıl dahil ettiniz? (Eğer dahil etmemişse) Peki, süreç boyunca ürüne dair sesle ilgili özellikleri ele almama ya da alamama nedenleriniz nelerdi? (Eğer dahil etmişse) Peki, sizce bu süreçlerin ses tasarımı açısından eksik ya da geliştirilebilecek olan yanları nelerdi?	
Tasarımcıların, ürün-kullanıcı etkileşimini diğer kişilere aktarabilmelerini sağlayan bir araç düşünsek; sizce, bu araçta ne gibi özellikler olmalı?	
Tasarımcıların, ürünlerin sesleri üzerine fikir geliştirmelerine yardımcı olacak bir araç düşünsek; sizce, bu araçta ne gibi özellikler olurdu?	
Eğitim projelerinde, konsept ya da üretime yönelik projelerde; ses tasarımının da göz önünde bulundurulması, sizce ürün kullanıcı etkileşimi açısından ne gibi avantajlar/fırsatlar yaratabilir?	

FOCUS GROUP GUIDE (continued)

Designing For Sound - Focus Group Research Guide

Session 03 - Kavramsal Araç Tasarımı

Sizce bu ya da buna benzer bir araç, tasarımcılara ne gibi avantajlarve fırsatlar sunabilir?	
Sizce bu araç nasıl bir kullanım süreci önermeli? Fiziksel mi, yoksa dijital mi olmalı? Ya da ikisinden de mi faydalanmalı?	
Kendi tasarım sürecinizi düşündüğünüzde, böyle bir aracı kullanmak ister miydiniz? Bu araç sizin tasarım sürecinize ne şekilde adapte olabilirdi?	

APPENDIX D

FOCUS GROUP GUIDE (English Version)

Designing For Sound - Focus Group Research Guide

Session 01 - Communicating the Interaction

How can industrial designers communicate their ideas/concepts to others?	
Which ways do you prefer mostly for communicating your design ideas to others? Why?	
If we focus on the usege scenarios of products, what kind of techniques/ methods do industrial designers use in your opinion?	
(can be skipped) Let's think about a tool with which designers can convey their user-product interaction ideas to others. What kind of specifications that this tool would contain?	

FOCUS GROUP GUIDE (English Version continued)

Designing For Sound - Focus Group Research Guide

Session 02 - Sound and Product Design

What do you think about aesthetics of interaction?	
Within the course of user-product interaction, do you think sound is important? Why?	
Can you give examples for the products/ product groups that sound is of importance?	
How can designers think and discuss product sounds within the design process in terms of user-product interaction?	

FOCUS GROUP GUIDE (English Version continued)

Designing For Sound - Focus Group Research Guide

Session 02 - Sound and Product Design

How did you consider the sound design aspects of products in the course of projects that you have conducted or taken part in? (If not considered) What were the reasons for not taking the sound related aspects into consideration during the product design process? (If considered) What were the points that can be improved in terms of considering sound related aspects within design process?	
(skip if it's asked before) Let's think about a tool with which designers can convey their user-product interaction ideas to others. What kind of specifications that this tool would contain?	
Let's think about a tool helping designers to generate auditory ideas for user-product interaction. What kind of specifications that this tool would contain?	
(can be skipped) What would be the advantages/disadvantages of considering sound based interaction within the projects conducted through industrial design education?	

FOCUS GROUP GUIDE (English Version continued)

Designing For Sound - Focus Group Research Guide

Session 03 - Conceptual Tool Design (SoundsGood)

What are the advantages/disadvantages that this or similar tool provides to designers?	
What type of interaction should this tool offer to designers; physical, digital or mixed?	
Would you like to utilize this tool within your design projects? If yes, how?	

APPENDIX E

ANALYZED STRUCTURE OF DATA (FIELD STUDY 1)

THEMES	SUB-THEMES	CONTENT CATEGORIES
EXPERIENCE OF PRODUCT SOUNDS(111)	The Role of Product Sounds within User-Product Interaction (84)	Sound as Feedback(9) Sound as warning(7) Meaning Attribution to Product Sounds(8) Sound as an Indicator of Function(6) Sound as an Indicator of Malfunction(4) Desirability of Sound According to Context(1) Silence Over Sound(4) Sound as an Irritating Feature(9) Contribution of Sound to the Usage Process(5) Sound Conveying Brand Identity(8) Importance of Sound Within Interaction(8) Sound as Attraction Factor(1) Sound as Two-way Communication(1) Users' Expectations about Product Sounds(6) Sound as a Sign of Quality(6) Sound as a Way of Personalization(1)
	Reflections on Aesthetics of Interaction(27)	Dominancy of Visual Modality(13) Sensory Modalities Within User-Product Interaction(4) Issues Related with Design Education(10)
CONSIDERATION OF PRODUCT SOUNDS WITHIN INDUSTRIAL DESIGN PROCESS(112)	Communicating with Other Team Members or Parties Within Design Process(34)	Communication Channels Used in Product Design Process(21) Communication with Manufacturers(2) Communication with Designers(1) Communication with Customers(3) Communication with Non-designers(7)
	Current Position of Product Sound Design(23)	Practice of Product Sound Design(20) Product Sounds' Influence on Design Decisions(3)
	Designers' Reflections on Product Sound Design(55)	?Designers' Reflections on Product Sound Design(32) Complexity of Consequential Sounds(12) Controllable Nature of Intentional Sounds(3) Importance of Context for the Design of Product Sounds(8)
IMPLICATIONS FOR THE DEVELOPMENT OF THE INITIAL TOOL(57)	Related to Interaction & Application(57)	Anticipation of Sound Based Interaction(20) Strengths(7) Weaknesses(3) Usage Ways of the Tool(5) Simulation of Product Sounds(12) Integration into Current Tools(3) Sound Library for Products (7)

*Numbers in brackets refer to number of occurrences identified through content analysis of Field Study 1

APPENDIX F

ANALYZED STRUCTURE OF DATA (FIELD STUDY 2)

THEMES	SUB-THEMES	CONTENT CATEGORIES
EXPERIENCE OF PRODUCT SOUNDS(57)	The Role of Product Sounds within User-Product Interaction (41)	Sound as warning(2) Meaning Attribution to Product Sounds(1) Sound as an Indicator of Function(3) Sound as an Indicator of Malfunction(5) Sound as an indicator of Process(3) Desirability of Sound According to Context(4) Sound as a Sign of Quality(8) Sound as an Irritating Feature(3) Importance of Sound Within Interaction(11) Sound as a Way of Personalization(1)
	Reflections on Aesthetics of Interaction(16)	Dominancy of Visual Modality(3) Sensory Modalities Within User-Product Interaction(5) Issues Related with Design Education(8)
CONSIDERATION OF PRODUCT SOUNDS WITHIN INDUSTRIAL DESIGN PROCESS(117)	Communicating with Other Team Members or Parties Within Design Process(33)	Communication Channels Used in Product Design Process(20) Communication with Designers(5) Communication with Non-designers(8)
	Current Position of Product Sound Design(29)	Practice of Product Sound Design(26) Product Sounds' Influence on Design Decisions(3)
	Designers' Reflections on Product Sound Design(55)	Reasons for not considering product sounds within initial design processes(7) Unforeseeable results of product sounds (consequential sounds) (11) A medium aiding designers to design product sounds(19) Need of technical/expert knowledge about sound design(5) Potentials of considering product sounds within design process(3) Types of Product Sounds(3) Importance of Context for the Design of Product Sounds(3) Other Reflections on Product Sound Design(11)
IMPLICATIONS FOR THE DEVELOPMENT OF THE INITIAL TOOL(186)	Related to Interaction & Application(186)	Opportunities offered bt SoundsGood(36) Limitations of SoundsGood(26) Type of Interaction with SoundsGood(30) About Sound Library(43) About Sound Modifiers(22) On the User Interface Design(13) Simulation of Product Sounds(1) Other Suggestions(15)

*Numbers in brackets refer to number of occurrences identified through content analysis of Field Study 2

APPENDIX G

CONSENT FORM

Değerli Katılımcı,

Bu çalışma Orta Doğu Teknik Üniversitesi Endüstri Ürünleri Tasarımı Bölümü yüksek lisans öğrencisi tarafından yüksek lisans tezi için bir araştırma niteliğinde olup, ürün ve kullanıcılar arasındaki ses tabanlı etkileşim bağlamında, tasarımcıların ürün seslerini tasarım sürecine ne şekilde dahil ettikleri hakkında bilgi edinmeyi amaçlamaktadır. Yapılacak olan görüşmenin tahmini 60 dakika sürmesi beklenmektedir. Kimliğiniz ve görüşme sırasında vereceğiniz kişisel bilgileriniz saklı tutularak, sizden ve diğer katılımcılardan edineceğimiz konu bağlamındaki iç görüler yalnızca tez kapsamında kullanılacaktır.

Çalışmanın sonucuna dair bilgi almak isterseniz, ilgili iletişim adresi üzerinden irtibata geçebilirsiniz. Bu çalışmaya vermiş olduğunuz destek ve katkı için teşekkür ederim.

Araştırmayı yürüten kişi, Katılımcı imza

Koray Benli ....

benlikoray@gmail.com

Dear Participant,

This study will be used for the thesis that has been carried out in Middle East Technical University, Department of Industrial Design, exploring the act of sound design throughout the (industrial) product design process for the auditory interaction between users and products. This interview will approximately take 45 minutes and your views will be used only within the scope of this thesis without sharing any personal information of yours.

You can leave the study at anytime you want without indicating any reason.

Please sign if you admit the written above.

Thank you very much for your participation.

Researcher, Signature

Koray Benli ....

benlikoray@gmail.com