INTERNAL AND EXTERNAL DETERMINANTS OF PRODUCT SOUND PERCEPTION: EFFECT OF PRODUCT COLOUR AS A CONTEXTUAL FACTOR ON AFFECTIVE RESPONSES TO PRODUCT SOUNDS

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ABSTRACT

INTERNAL AND EXTERNAL DETERMINANTS OF PRODUCT SOUND PERCEPTION: EFFECT OF PRODUCT COLOUR AS A CONTEXTUAL FACTOR ON AFFECTIVE RESPONSES TO PRODUCT SOUNDS

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Sounds are signs informing us about the environment surrounding us and the products that we are interacting with. Product sound designers have recently focused on reducing the psycho-acoustic sensations of sounds such as loudness, sharpness or dB(A) levels to change affective responses towards product sounds to lessen their unpleasantness. Product sound perception is a more complex field than perception of environmental sounds since cognitive factors such as identifying and evaluating these sounds can change the overall perception that products create or evoke. Besides, there are non-auditory factors which affect how the product sounds are perceived. The aim of this study is to combine the data supporting the idea that the psycho-acoustical measurements are not enough if cognitive processes (internal factors) and environment (external factors) are not analyzed within the product sounds. The literature review focuses on the existing studies about how the theoretical data are relevant to the above-mentioned argument and the existing experimental studies about the manipulation of sounds and the manipulation of contexts respectively. An experimental research was conducted to see the effect of product color as a contextual factor on the affective responses towards product sounds.

Keywords: Product Sound Perception, Affective Responses, Auditory Perception, Internal Determinants, External Determinants

ÖZ

ÜRÜN SESİ ALGISININ İÇSEL VE DIŞSAL BELİRLEYİCİLERİ: ÜRÜN RENKLERİNİN BAĞLAMSAL BİR FAKTÖR OLARAK ÜRÜN SESLERİNE OLAN DUYUSAL YANITLARA ETKİSİ

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Sesler, çevremiz ve etkileşim halinde olduğumuz ürünler hakkında bizi bilgilendiren işaretlerdir. Ürün sesi tasarımcıları, ürün seslerinine olan duyusal yanıtları değiştirmek için seslerin şiddet, sertlik gibi psikoakustik özelliklerini ve dB(A) seviyelerini azaltma odaklı çalışmaktadırlar. Ürün sesi algısı, çevre sesi algısından daha karmaşık bir süreçtir çünkü kaynak sesini tanımlama ve değerlendirme gibi bilişsel faktörler ürünlerin algısını değiştirebilmektedir. Ayrıca ürün sesi algısını, ses ile ilgili olmayan faktörler de etkilemektedir. Bu çalışmanın amacı, psikoakustik ölçümlerin, içsel ve dışsal (çevresel) faktörler dahilinde incelenmediği takdirde yeterli olamayacağı görüşünü bilgi kombinasyonu ile desteklemektir. Literatür araştırması, yukarıda belirtilen argüman dahilinde derlenmiş, ses manipülasyonu ve sırasıyla çevresel faktör manipülasyonlarını içeren saha araştırmalarını incelemiştir. Bir dışsal faktör olmak üzere ürün renklerinin ürün sesi algısına olan duyusal yanıtlara etkisini analiz edebilmek amaçlı küçük bir deneysel çalışma yapılmıştır.

Anahtar kelimeler: Ürün Sesi Algısı, Duyusal yanıtlar, İşitsel algı, Dışsal Belirleyiciler, İçsel Belirleyiciler

To Mom & Dad

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CHAPTER 1

INTRODUCTION

Human beings have been involved in an active interaction with the environment surrounding them while experiencing products. Furthermore, people sometimes try to identify or give meanings to certain stimuli that they sense affecting their perception about the objects or inputs around. Sensory perception is a crucially important aspect for products since people have different senses and each sense plays a role in product experience. Supporting that, companies have been focusing on creating positive emotions by manipulating some aspects of products in order to make them feel more pleasant or less unpleasant.

Sound is one of the most important factors affecting human perception. It goes without saying that just like the other senses, hearing, also affects overall perception of the product on people. However, sound perception is hardly studied in product perception area as it was believed that visual stimuli had more influence on product perception. Nevertheless, there are few studies attempting to understand auditory perception in the light of product sound perception. On the other hand, it is admissible that auditory perception is a very hard field to study that is because researchers should have multidisciplinary knowledge including engineering, acoustics and psychology together to conduct efficient studies (Ozcan, 2008).

To analyze sound perception, its psycho-acoustical aspects such as pitch, frequency and loudness should be understood. There are some studies concerning sound manipulations after analyzing the sound structure to have a pleasant product experience in products having mechanical parts (e.g., Bezat et al., 2014; Bodden & Iglseder, 2002; Vastfjall et al., 2003). But psycho-acoustical studies are not enough for analyzing product sound perception as it has already been clarified by Ozcan & Schifferstein (2014) that sound itself can change overall perception of a product within a specific context. So, it is admissible that internal (psycho-acoustical) factors and external (contextual) factors both contribute to product sound perception.

In this study, we focus on product sound perception and the internal and external factors influencing emotions with sounds and try to understand if an external context has an effect on product sound perception.

1.1. Background to the Problem

In the field of psycho-acoustics, as most of the studies concerning product sound manipulation have focused on changes of the physical aspects of sounds, it was commonly believed that mainly psycho-acoustical factors had played a role in product sound perception. For example, acoustic engineers are dealing with improving the sound quality of car sounds (Van Egmond, 2008) by changing the physical properties causing the sound. In another study conducted by Bezat et al., (2014) engineers classified the sounds due to the components such as door panels, locks of car doors to analyze their physical function in producing impact sounds. Especially for the products that were believed to be noisy and annoying such as products with strong engines, manipulating sounds of them could be useful for transforming them into less unpleasant products.

For quite a long time, engineers studying acoustics were engrossed with the reduction of the acoustic energy produced by products themselves by taking vehicles down to 70 dB, (Blauert & Jekosch, 1997) with the understanding that 'lower was always better', that is because many products had very high acoustic energy that disturbed the ears of potential users or when users were exposed to products while using them. By doing that, 70 dB does not bring about a problem for the ears of drivers even when they drive for an extended period of time, which makes the sound level safer.

Manipulating sounds also worked for creating identities for products. A PhD thesis at the University of Michigan conducted by Don Malen investigates the improvement of solidness of the sound of a door closing with a lower cost (cited in Lyon, 2003). Further, It is also believed that people can spot the brands from their sounds as Lyon (2003) argued that there is an identifiable difference between the door closing sounds of Audi A4 and Ford Escort cars. However, Blauert & Jekosch (1997) put it in their study that products having the same dB(A) levels could be perceived differently according to the cognitive factors during the perception process. That is to say, sounds having the same physical aspects can be perceived differently. For instance, Menzel et al. (2008) studied that colors have an effect on loudness perception; although the same type and brand of a car was used in the study, manipulating the colors had a notable effect on the sound perception. It is interesting to have this argument since color is a visual input that has no direct dependency with auditory input, but apparently has an effect on the overall sound perception. Ozcan & Schifferstein also studied in 2014 that auditory and visual stimuli separately have some effects on the overall perception of a product which are rather different from each other. Moreover, multisensory combinations can affect overall perception differently (Ozcan & Schifferstein, 2014). Having had this information from the previous studies, this study will investigate how contextual factors affect product sound perception.

1.2. Aim and Objectives of the Study

The main aim of this study is to question how people perceive product sounds emotionally and to demonstrate that contextual factors that are not physically related to sounds can have a significant impact on product sound perception. In the light of that, it would be clarified that researchers studying psycho-acoustics should take into consideration that the physical aspects of sound are not enough to analyze if we are dealing with how people perceive product sounds, as the external factors may contribute perception.

The overall aim by conducting this study is to support the studies concerning multisensory interaction in product perception and effects of external factors influencing product sound perception as there have been very few studies in the literature about them so far.

1.3. Research Questions

The main question of this study is:

-How do the internal and external factors influence affective product sound perception?

The secondary questions are as follows:

- How do people perceive and react to product sounds?
- How can the affective responses towards product sounds be manipulated?
- How do product contexts influence product sound perception?
- What is the effect of product color on affective product sound perception?

1.4. Structure of the Thesis

Chapter 1, *Introduction* explains the background of the study and the research problem, as well as the reasons which lead us to work in this field. It mentions the aim and the objectives of the study and explains the research questions.

Chapter 2, *Literature Research* starts with an introduction explaining sounds as auditory signs and firstly explains human perception and how we perceive products. Then it discusses product sound perception and gives brief information about sound fields, classifications and product sound types. After that, product sound experience and the determinants of this experience are explained. Psycho-acoustical factors, that is to say the physical properties of sounds are discussed and followed by arguments concerning sensory perception. Inefficiency of psycho-acoustical measurements, auditory evaluation systems and overall auditory experience are analyzed afterwards. Following that, affective reactions to sounds are discussed by explaining internal factors, affective reactions, appraisal theory and core effect. Measuring emotions and how affective reactions to sounds are measured are being explained then. After talking about affective auditory experience, which underlines the basic aspects of emotional perception of product sounds, product sound manipulations for enhancing pleasantness are discussed. Finally, contextual (external) factors are explained and overall conclusion is derived from all of the findings we have had during the literature review.

Chapter 3, *Methodology* includes findings concerning the influence of color as an external factor on product sound perception and explains how three tests (two pilot tests and a main experiment) which were conducted for supporting the arguments given in the *Literature Research* section. Following that, research questions and the aim of the experimental study are explained. Then, the technical aspects of the tests, visual and auditory inputs, subjects and the expectations regarding these tests are explained in detail. Following that, *Results* explains the data analysis and discusses about the results of the tests, compares the data with the previous studies and the expectations we had before the experiment by revisiting the research questions concerning the experiment.

Chapter 4, *Conclusion* reflects the overall conclusion about the study by revisiting the main research questions of the thesis and answers them. It discusses the limitations of the overall study and the test, then gives implications for further studies concerning affective auditory perception.

CHAPTER 2

LITERATURE REVIEW

2.1. Auditory Signs

Sounds are believed to be informative about the events happening around and in our surroundings as they let users know about how products work and how the current state in a given context is. As an example, a sound as the sign of a product could tell people that it is a high quality shaver with its psycho-acoustical aspects, such as speed and rotation.

Product sounds do have a language concerning the products: through product sounds, people can understand the current situation of products or at least compare their functions with different types of products from their working sounds. For example, considering an electric razor, users are expected to understand and know the language employed for electric razor devices so that they can decode the messages delivered by the device itself (Blauert, & Jekosch, 1997). This is because they are familiar with the sound of the razors they previously used and now they can judge products with their sounds. Again, frequent users of the device should definitely have a certain idea about how well a razor resonates during proper function (Blauert, & Jekosch, 1997). So checking the function of the products with their sounds are not limited to musical instruments; mechanical products are also checked and their ability to function is confirmed by examining their sounds.

On the other hand, it is considered that people can have meanings attributed to products that can be evoked by sounds. For example, if one sees an advertisement of a noisy motor with an elegant looking motorcycle, then one would label the sound and name the motorcycle as high quality as a consequence. For that reason, it seems logical for this study to name these kinds of sounds as 'auditory signs' of products that they are attached to. But first, it is crucial to mention the process of human perception.

2.2. The Process of Human Perception: Sensory and Knowledge Based Processes

We are in interaction with the environment around us. Perception, by all means, gives us the opportunity to collect data and information about our environment utilizing inputs of sensory nature as well as analyze and pinpoint objects and events involved within our environment (Altinsoy, 2012). We sense objects and we perceive them using our senses, such as auditory, tactile and visual, and process them in our cognitive systems. During everyday perception, people who perceive, disintegrate events and objects first, and then implement some certain calculations to obtain a logical correlation and interrelationship among not only sets of pieces concerned but also internal representations of events and objects themselves (Guski, 1997). Moreover, the action of perception that refers to the processing of things in the mind could be different from one person to another. We might perceive the same environment quite differently due to the cognitive factors, to our psychology or our selection system. The environmental energy which emits in all directions of the same kind is able to provide a rise to various emotional results, because these are deliberate selection processes in the course of perception as there are various internal illustrations of our world (Guski, 1997).

In conclusion, we could admit that the environmental factors such as auditory or visual signs can be perceived differently from one person to another. This argument will be elaborated on, from the point of auditory perception in the following sections. Depending upon those processes, a complete interaction with our environment presumes that signals of external nature have sufficient information to shape competent representations of our environment as well as this particular information being neither incomplete nor doubtful or questionable (Bigand & Tillmann, 2005).

Sensory perception is how people perceive the environment with their senses. So basically sensory-driven processes are dealing with auditory, tactile and visual perception. We will be focusing on auditory perception in this study, which concerns how humans perceive some certain sounds. Figure 1 was prepared to illustrate two basic types of human perception process as sensory and knowledge based processes, explained by Bigand and Tillman in 2005.

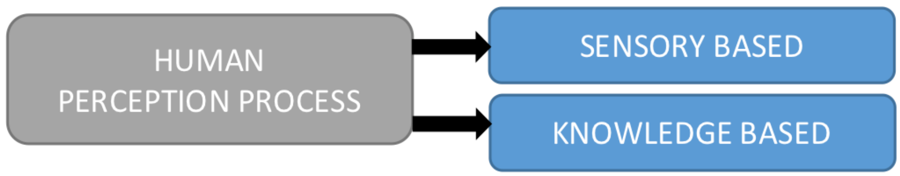

Figure 1. Perception process.

Processes which are sensory-driven confirm us all that the cognitive system itself keeps being informed on the objective design of environmentally provided signals, perhaps fairly automatically. By contrast, doubtless, top-down processes can promote signals from low levels (like signal detection) to a lot more complicated levels like emotional expectancies or object recognition (Bigand & Tillmann, 2005). As long as we have different senses, we perceive the environment by using this complex system in Figure 1. So we have multisensory perception including visual, auditory, tactile, etc., for the things we perceive. These come together and compose an overall perception that is affected by each of the senses. Quite interestingly, each sense in the perception process may affect each other. Ozcan & Schifferstein (2014) also found that the absence of different stimuli affects overall perception in different ways. For example, when we perceive a sound, we do not only perceive it by the acoustical properties. We also perceive the environment that we are involved in. To name a few: the color of the room, and the smell of the environment. On the other hand, It is also believed that we have internal aspects that influence our perception, such as our culture, our mental situation and psychology. So it is admissible that both factors play a role in the perception process.

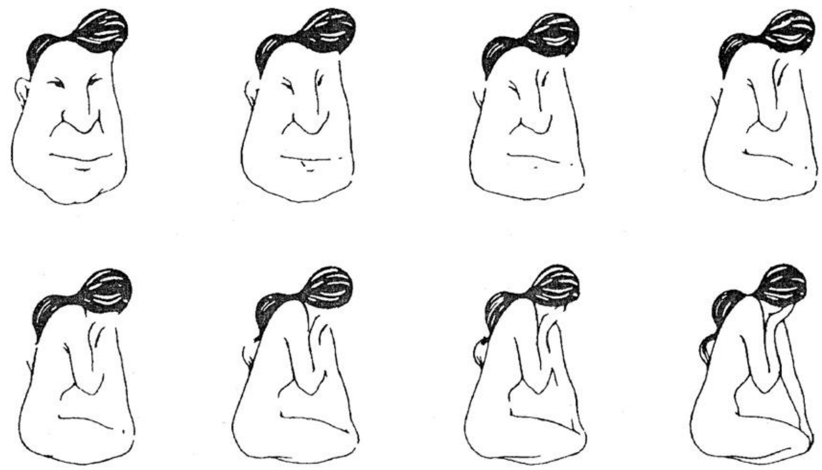

Figure 2. Top-down process in vision (Fisher, 1967; cited in Bigand & Tillmann, 2005, p. 309).

The importance of top-down processes was also cited by Bigand and Tillmann in 2005, referring Figure 2, firstly used by Fisher in 1967. Looking at the first line, one can see a face and the perception will stay stable if one also looks at the right part. Further, when the same is done to the second line, then one will see a human body. The important thing here is that the fourth and the fifth drawings are the same but they are perceived differently according to the given context although the sensory input remains the same. So here, it is argued that particular deviation in terms of perception can as well be interpreted by way of interruption of top-down, context-reliant processes which ascertain perception itself. In the following sections, it is questioned whether this argument could be true for auditory input also.

In conclusion, we experience the world via the combination of two factors, namely knowledge and sensory-based processes, which are also believed to be slightly complex when we try to understand them altogether in a given situation. However apparently, these two are intertwined and shape how we experience products. And it is crucial to understand this experiential process. Thus in the next section, product experience and its relation to auditory aspects will be discussed.

2.3. Product Experience

We are in interaction with the environment and we use auditory, tactile and visual perceptual systems. These multisensory aspects of human perception come together and help us experience the products. Each sensory perception is crucial in this process.

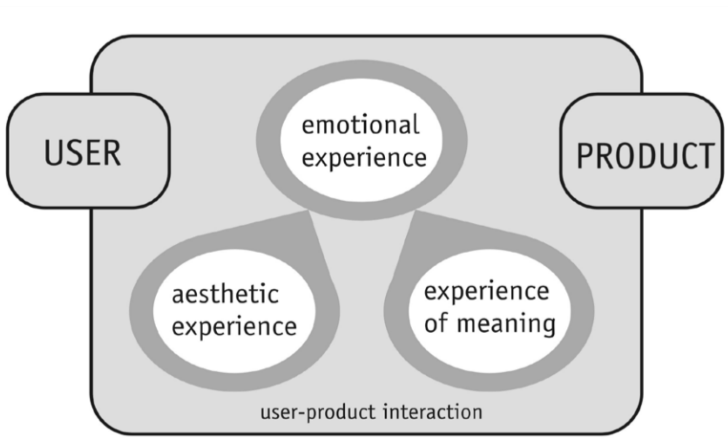

Figure 3. Product experience framework (Desmet & Hekkert, 2007, p. 4).

Desmet & Hekkert (2007) show three stages concerning product experience (Figure 3), stating that an aesthetic experience deals with the experience gained by listening to the sound produced by the product. Experience of meaning is basically what a product means to the user such as evoking an attribution. The emotional experience is the match among user expectation and the efficiency of the product. Apparently, the user has an image concerning the product in mind and he/she has a particular image and meaning that contributes to the expectations from the product. To what extent it matches with the product shapes the emotional experience. Aesthetically, a product's dimensions and capacity are considered to please at least one or even more of our sensory modalities and naturally, a definite product might as well be lovely to have a glance at, produce a nice sound and feel great to touch somehow (Desmet & Hekkert, 2007). So here, we are considering sensory pleasantness as a determining factor for aesthetic experience of sounds.

Products have languages and especially intentional sounds have less abstract meanings such as an alarm clock and a microwave sound which refers to the end of the cooking process. So users' expectation here is the efficient communication among the users and the product alarms. Nonetheless, the experience of meaning is not our main focus here, in which cognition has a role and is believed to be a determinant. However, analyzing the experience of meaning can be a trigger for further studies concerning product sound experience.

According to Desmet & Hekkert (2007) certain experiences can trigger and stimulate some other levels of common experience. That being the case, any experienced meaning can promote responses of emotional nature as well as experiences of aesthetic kind, and even vice versa. For example a product's outlook might give the feeling that it is a high quality or low quality product attached to the memory and experience of feelings gained before. In addition to the other things, the outlook of desired characteristics is not bound to the sound by itself, but at the same time to the other characteristics of our product also (Blauert & Jekosch, 1997). Primarily, the potential user hopes to have a perfect and impeccable functioning with the product itself, but it should be kept in mind that some other features, such as the aesthetic appearance and the product image, are also equally significant since they play an important role within a social context (Blauert & Jekosch, 1997). That is to say, a user could have an expectation concerning the sensory properties of the product, a specific color to see, a smooth surface to touch or a pleasurable sound to hear or listen. But what is more is that the social context can also be an expectation while considering the product or its aspects. In that sense, it is admissible that product experience covers more than sensory perception or the users' psychological situation, it also covers the external factors.

2.4. Product Sound Perception

Sound perception deals with how people perceive sounds generally including the psycho-acoustical aspects of sounds and how these sounds are perceived with the help of senses by analyzing physical and cognitive factors which contribute to this process. Within the frequency of hearing-ability, people who listen are almost always exposed to the emissions of acoustical nature of the product, such as waves and mechanical vibrations (Blauert & Jekosch, 1997). As a result, those listeners are able to hear something. Whatever they can hear remains as an 'auditory event' that is the direct result of their auditory recognition process, or what might as well be called solely, 'sound' (Blauert & Jekosch, 1997).

Product sound perception is an overall process including the cognitive process (internal factors) of individuals and the context (external factors) as product sounds are inevitably part of how the product is perceived in a given context. It is also notable to mention that product sounds are unique in terms of listening practices as they are not musical compositions but sounds belonging to the working parts of products. Gaver (1993b) proposed some alternatives for listening purposes derived from psycho-acoustical properties of sounds used in everyday life and music since everyday listening is closely connected to our environment and the contextual aspects including the physical characteristics of sounds. That is to say, everyday listening is the perception of sounds in a given environment or a context strongly differing from musical listening. Seemingly, product sound perception is closer to everyday listening as it includes physicality of sounds within contexts and thus far to musical listening. It is crucial to add that product sounds are not made for having an auditory balance that is basically gained by having a harmony which normally happens in musical compositions. For that reason, it is rather meaningful to assume product sounds as 'auditory events'.

There are various categorizations concerning the analysis of sound perception as the cognitive and psychological factors are cannot easily be classified in the same categorization due to their different nature of characteristics. So firstly and generally the physical aspects of sounds are analyzed. Secondly, it is necessary to find out how the sensory perception progresses which basically refers to the physical conditions of an individual. The third element, which is the perception process, is the most crucial one since it can have a lot of variables such as biases, mood, emotion thus, is hard to analyze.

Genuit (1997) divides auditory quality perception into three categories explaining that emotional and personal reactions towards product sounds, when examined and perceived in accompaniment, can be decomposed within three reciprocal components (Figure 4):

1. Physical (sound field),
2. Psycho-acoustic (auditory perception), and
3. Psychological (auditory evaluation and reaction).

Figure 4. Auditory quality perception.

The very first component (physical) deals with different ways of describing as well as recording the emitted sound by the product itself in objectivity. The second component in a row (psycho-acoustics) also deals with the description and collection of the product sound, however it places importance on the nature of human ear hearing and obviously auditory perception of ours (Genuit, 1997). The third component (evaluation and reaction) represents the perception process regarding individuals' psychological state and reactions towards these sounds, such as how they evaluate them and what their reactions are concerning the sounds they perceive.

It is beneficial to analyze the physical aspects of sounds since they are easily measured via magnitude estimation as argued by Zwicker & Fastl (1990) because loudness, sharpness, tonality and roughness are related with each other. Generally, it is also useful to analyze the frequency, pitch and speed in a detailed way to note and classify the physical details of sounds properly.

On the other hand, analyzing auditory perception could be facilitated by simplifying groups, such as taking a specific age, gender or a culture group and then testing their sensitivity to sounds.

The psychological factors affecting the evaluation and reaction stage need more consideration and effort to analyze, since they are believed to be affected by internal and external factors. Moreover, internal and external factors are different from each other and therefore necessitating different kinds of empirical studies. Interestingly, these two could also interact with each other: sound perception, beyond psycho-acoustical factors, can also vary due to the knowledge of people, expectations attached to sounds or products, memory, attributed meanings and context (Ballas & Howard, 1987). For instance, Gaver (1993b) differentiated five types of sounds of environmental sound classification. Two of them are classified as solid sounds which called *scraping* and *discerned impact*, one of them is *liquid* as dripping and two of them are named as complex events: one for temporally complex events (interaction between liquid and solid) and one for complex events with different sources such as machine sounds. Seemingly, this sort of classification would still remain abstract for classifying sounds as we would not directly refer to the physicality (psycho-acoustical factors) of sounds when we name them as liquids, however we refer to how they are produced (knowledge-based). Subsequently, it is remarkable to take a look at the sound fields and classifications.

2.5. Sound Fields and Classifications

Sounds have been classified in many ways in the existing literature. According to the various research, a number of classifications have been made. Most of the classifications done so far have been done according to the source or at least referring to the sources of the sounds. According to Payne (2007), mostly employed terms within the text are *mechanical*, *human* and *natural* as the classification types of this kind depend on our correct and flawless identification of our source of the product as well. For instance, Schafer (1977) divided sounds according to their sources into six categories: *mechanical sounds*, *indicators*, *natural sounds*, *human sounds*, *quiet and silence sounds* and *society*. This is a basic and a very general division including overlaps in sub-groups that might be perceived as identical. However, Schafer (1977) also explained these overlaps by arguing that one of the most crucial factors in discriminating sounds is the environment in which they are listened. That is to say, the context also matters when a sound source is perceived and could be crucial for identification of sounds.

Gaver (1993a) classified sounds according to their source as they are having a certain piece of information about an occurring event: he puts forward that materials and the type of interaction produces the sound (Figure 5). Sound production is grouped into three classes: *vibrating objects*, *liquid sounds* and *aerodynamic sounds*. Gaver (1993a) also gives an example that solids which vibrate create sounds that are caused by scraping or other impacts. On the other hand, explosions and suddenly-changing pressure can also cause aero-dynamic sounds, sounds of various liquids produce drips, what is more, pouring, splashing and waving are also widely witnessed.

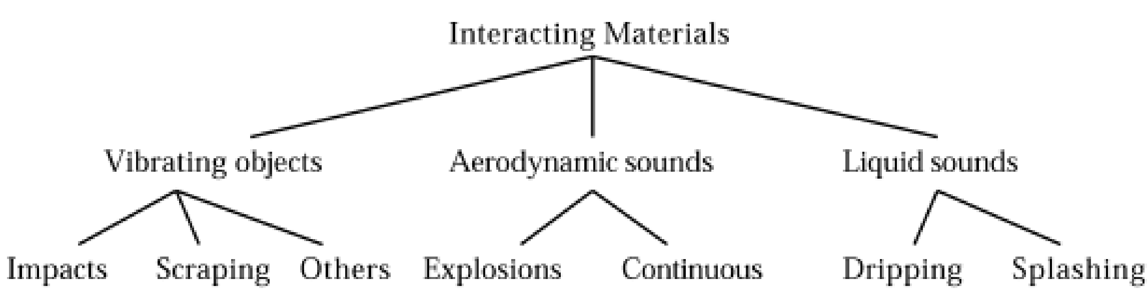

Figure 5. Classification of everyday sound events (Gaver, 1993a, p.22).

That is because sound is involved in every kind of environments, we see that to facilitate sound classification, knowledge derived from different fields are used to support sound classifications, as the psycho-acoustical factors do not suffice to do so. These classifications are crucial but still not to the point concerning product sounds. A broader classification including the analysis of various products will be done later.

2.5.1. Product Sound Types

Ozcan & Van Egmond (2008) explain that product sounds can be divided into two large groups as intentional and consequential sounds (Figure 6). As a direct result, products of all kinds emit consequential sounds related to their regular functioning, therefore one can denote the sounds of vacuum cleaners, hairdryers or washing machines as common examples to this. Intentional sounds, on the other hand, are implemented, worked on and designed by professionals known as sound engineers. To exemplify, it is possible to show finish bells of microwave ovens, alarm clocks, and such, which are most of the time, abstract and digital (Ozcan & Van Egmond, 2008).

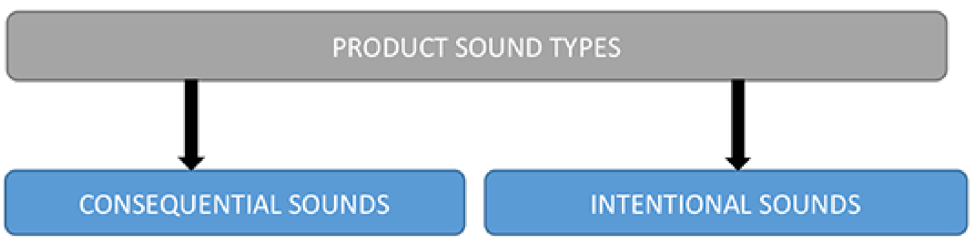

Figure 6. Product sound types.

Langeveld et al. (2013) argue that this particular difference remains highly crucial, the two categories of sounds may need various design styles and the utilization of knowledge of various disciplines is required. As for the intentional sounds, they are, most of the time, considered, felt and perceived as sounds of musical nature so it is quite possible to create a musical composition in a small scale (that is to say musical motive) which might as well be employed to carry brand values of some firms and companies.

Intentional sounds are grouped into three as *earcon-auditory icons*, *sonification* and *continuous sonic interaction* that are usually abstract and informative about the progress such as bell sounds for microwaves which refer to the 'end of the process' (Langeveld et al., 2013).

Ozcan (2008) also divided six categories of product sounds considering the experience that they create. These classifications are, as can be seen in Figure 7, *mechanical*, *liquid*, *alarm*, *cyclic*, *impact* and *air*. It is notable that Ozcan (2008) states her classification was relevant with Gaver's classification (1993a) shown in Figure 5; so that is a further step having the same base of classification.

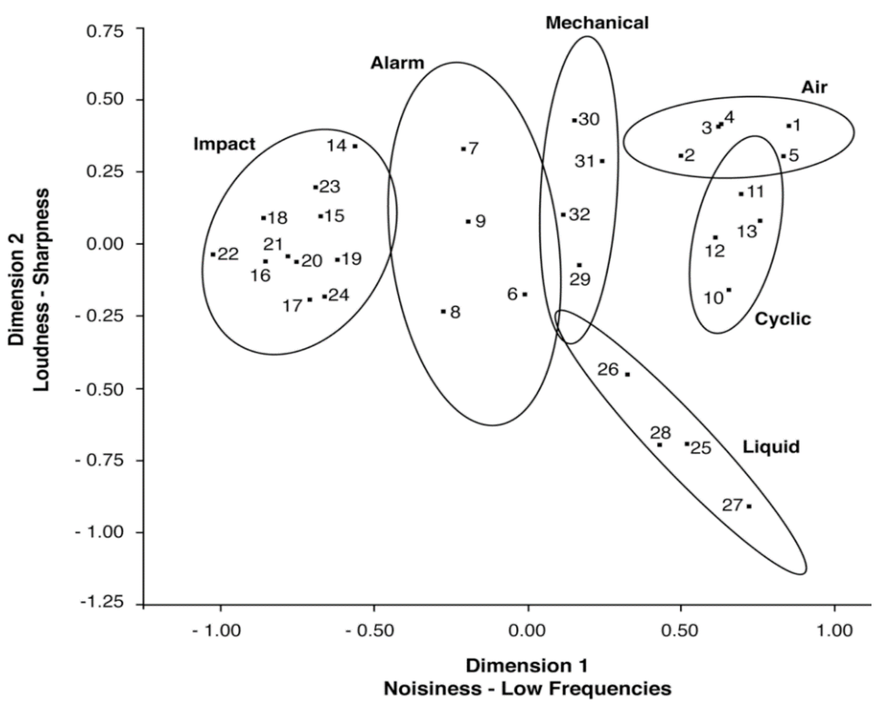

Figure 7. Six categories of product sounds (Ozcan, 2008, p. 37).

As it can be seen in the Figure 7, Ozcan (2008) explains impact sounds as very short sounds born out of the interaction with product parts, for instance, like in the case of door-shutting, that makes a pulse-resembling sound with high frequency. Alarm sounds of different kinds are digital and designed sounds. A microwave's alarm sound is not very noisy in this context. On the other hand, toothbrushes and shaving machines, as a natural result of functioning engines, and turning parts represent mechanical sounds (Ozcan, 2008). Products which contain liquids produce liquid sounds, or, quiet sounds are also emitted by water and coffee-makers. Temporal aspects like vacuuming, fan or blowing are represented by cyclic sounds. As for air sounds, they are quite loud and sharp, as an example, vacuum cleaners and hair-dryers can be given as they are related with air in their environment (Ozcan, 2008).

All in all, it is clear that sound classifications tend to be based on sub-classifications, which are experience and context in the given environment. We can also admit that psycho-acoustical properties are hardly mentioned by the sources and how people perceive sources is more common in classifying. This section did not give detail on how the classifications were done or decide on which of them is the most convenient for further studies. But it aimed to explain current studies and give basic knowledge about sound types that will be mentioned in the study. It also aimed to support the fact that contextual factors are needed to classify sounds as where they are heard is always important.

2.6. Product Sound Experience

Langeveld et al., (2013) state that product sounds of consequential nature are perceived a little bit 'noisy'. If we specifically consider about motor sounds that we are exposed to in everyday life, such as mixers, motorcycles and cars, we could probably agree on how noisy their sounds are because of their engines.

When it comes to interpretation, it becomes quite hard for designers, acoustical designers and inevitably for those who use those products to express how they, themselves, experience and perceive sounds. People usually mimic the sounds if they do not know the sources they come from (Langeveld et al., 2013). Obviously, there is not enough vocabulary for sounds yet; moreover, users do not have any education behind to know how a perfectly working product sounds like. The reason of this could be that people generally have difficulty in finding the right words to explain the problems with the sounds. Normally people say that a certain product makes a bad noise or sound (Langeveld et al., 2013). On the other hand, product sounds can refer to certain aspects of products, how fast they are working or whether they include air or water inside. So they are not completely unknown sounds just like the sudden environmental sounds in daily life. It apparently has some hint behind about the sound source of a product. Langeveld et al., (2013) state that because of the engine/motor characteristics of products and of resonance, completely random noises are not produced by products. That is to say, these sounds have some more characteristics than being a coincidence. Thus these sounds might have some characteristics behind that can refer to where they come from which might affect product sound experience as well.

Langeveld et al., (2013) made a classification about product sound sources and defined three main sources through which product sounds exhibit themselves as liquid, airborne and structure-borne sounds (Figure 8). Within a product, people focus on structure-borne sound sources which, somehow, manage to make their way into the outside surrounding through radiation Langeveld et al. (2013), which denotes that the environment does matter where these sounds are transferred. Transfer paths are responsible for the emission of the sound coming directly or indirectly from its source to the surrounding of the product itself. On the other hand, structure-bound sounds exhibit themselves within solids as well as in structures which have been made from shafts, beams, girders and plates (Langeveld et al. 2013).

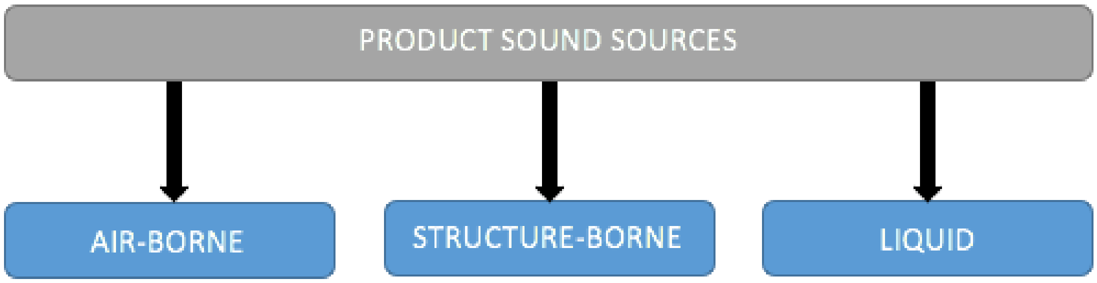

Figure 8. The three main sources of product sounds.

Apart from that, when it comes to question product sound experience, we should analyze every detail concerning sound such as the location where it is produced and how it is produced. Langeveld et al. (2013) suggested a model for product sound perception, mainly for consequential sounds stating four steps: Sound source, sound transmission occurring in the product, radiation and receiver transmission (Figure 9).

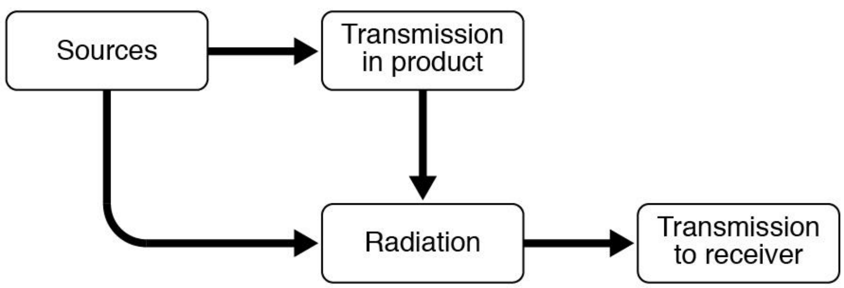

Figure 9. Consequential product sound model (Langeveld et al., 2013, p.7).

Radiation is known to be the action of sound which is air-borne through surfaces and related else parts of a certain product as sound transmissions happen via the transfer of the leading medium like air, construction of different kinds and liquid (Langeveld et al., 2013). Sound transmissions of construction are executed by various components; however, liquid and air sound transmissions are made possible via liquid and air filled hollows and cavities as Langeveld et al. (2013) have discussed. This is a small representation of a product sound context where the transmission of sound is interacting among the parts of the product and in the environment, before people perceived it. Attempts for the purpose of defining environmental quality through those behavioral phenomena become a lot more confusing by the reality that an individual's personal reactions towards environment and other people are greatly affected by some factors, like the setting where the noise in question is produced and the significance of the interrupted activity relatively (Craik, 2013). Moreover, the person who receives sounds constantly goes through the product sounds instantly in a given environment, however, the subject sound is emitted from the product via air. But, the sources are felt following the transmission within the product and the simultaneous radiation towards the environment (Langeveld et al. 2013). Thus, it is admissible that the atmosphere will also add something to the sound perception. If we suppose that we are in a cooking process in a kitchen, it is not only the product sound itself we perceive while cooking, it is also the substance coming out and the environment we are in, such as the room that we cook in and also the level of isolation in there, where the echo of the walls may also play a role in sound process.

2.7. Psycho-acoustical Factors

2.7.1. Sensory Perception

We, humans, perceive everything through our various sensors by our nature. Different sources of data coming from other sense-based modalities like touch as well as vision promote mental portrayal of the perceived and sensed environment, our judgements certainly depend on multi-sensorial portrayal and representations we get (Viollon et al. 2002). Supporting that, a certain product remains as a multi-sensory object and every single sensory characteristic is able to add to the particular experience belonging to a product and involvement.

Sensory pleasantness focuses on the physical aspects of sounds such as loudness, sharpness and analyses how they are perceived by the listeners. Perception through our senses is a very perplexing issue since our auditory sensations like tonality, sharpness, loudness and roughness influence this matter extensively (Zwicker and Fastl, 1990). Auditory perception has a huge impact on product perception depending on the dominancy of sound. The difference between an alarm of microwave oven and a noisy motorcycle might be a good example for this argument as their dominancy in influencing the overall perception might differ. That is to say, a noisy engine sound, because it is saliently loud and unpleasant might evoke negative emotions more intense than a slight alarm of a microwave does. Further, auditory perception is also influenced by other sensations (so there is more than one determinant factor) such as tactile sensation which can contribute to auditory perception (Altınsoy, 2012) and it also affects visual and overall pleasantness (Ozcan & Schifferstein, 2014). Some studies also demonstrate that auditory perception gets much better when supported with visual input (Southworth, 1969; cited in Cox, 2008). It was also found that the intensity of feelings (such as annoyance) is also increased when a visual input is added to auditory input (Cox, 2008).

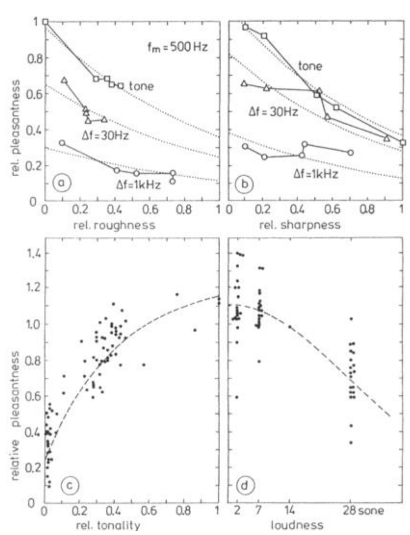

Figure 10. Model of sensory pleasantness (Zwicker & Fastl, 1990, p. 244).

The relationship among sensory perception and the other senses were shown by Zwicker and Fastl (1990) in Figure 10, stating that sensory pleasantness declines with escalating sharpness. Natural tones we hear show the biggest sensory pleasantness as the band-pass noise remains to be a certain sound having little sensory pleasantness. Everything considered, it is possible to see that sharpness aims sensory pleasantness. Loudness, on the other hand, affects sensory pleasantness solely for values bigger than the standard loudness of usual communication between at least two individuals in a quiet environment (Fastl, 1990). It goes without saying that the louder a sound is, the more annoying it is while being perceived. The influence of sensory perception seems inevitable and it is clear that almost every product with a sound can create unpleasantness if it is beyond the sensory borders. A surge within loudness, sharpness or loudness level will certainly cause a decline of sensory pleasantness; however, interestingly, any increase within tonality will result in a sudden surge of sensory pleasantness since product sounds, as we hear or sense them, are almost always noisy, rough, sharp and loud, and those measures remain to be crucially significant while describing natural and normal aspects of the resonance of those sounds under consideration (Van Egmond, 2008). Pleasantness of sensory nature can be developed describing the properties of our hearing system and physical parameters involved (Fastl, 1990). That is to say, sensory pleasantness could only be manipulated by changing the psycho-acoustical aspects of the sounds. For that reason, the idea of diminishing the loudness levels of sounds seems to be partially worked for weakening the noisiness of cars.

Unpleasant sensory experiences, on the other hand, can initiate a bad intention on the products so, companies are focusing on the product sounds as well as the visual design of the products. This is a critical notion especially for consequential sounds since their psycho-acoustical aspects cannot completely be changed because of their inner functions. Sound manipulations such as changing the frequency and loudness could be done but it would still be restricted to the types of products. When an example is needed, it is possible to give a hair epilator with a rough, high-pitched and loud noise, and this loud noise can attract adverse reactions from its users towards the appliance itself (Ozcan 2008). But the sound of it is not easily manipulated to lower the noisiness because it is a sound which is caused by the components of the product and it is expensive to rebuild it again. This is also the same for modern shavers, Philips shavers, for example, where a very noisy sound is emitted, which is quite contrary to their elegant outlook. However, sense-based pleasantness does not necessarily result in absolutely nice and favorable experiences from people (Ozcan, 2014). Psycho-acoustical factors can work for diminishing the unpleasantness and noisiness. But it does not refer to a pleasurable experience of products because the sounds are not completely changed.

2.7.2. Inefficiency of Psycho-acoustical Measurements

There are some studies discussing inefficiency of psycho-acoustical measurements of product sounds. As we have mentioned in previous sections, product sounds differ from musical sounds and environmental sounds functionally. So it is crucial to mention why psycho-acoustical measurements are not enough to analyze product sound perception.

Blauert & Jekosch (1997) suggested informative visuals (Figure 11 and 12) and put forward that the current data on auditory perception may not be sufficient to thoroughly examine complicated product sound notion and their understanding. That is to say, physical measurements of product sounds may not suffice to have reliable data concerning sound perception. Figure 10 represents the old way of analyzing product sounds which includes psycho-acoustical measurements or auditory events where auditory perception is measured physically and shows clearly the fact that acoustic waves have a certain source and a product behind (Blauert & Jekosch, 1997).

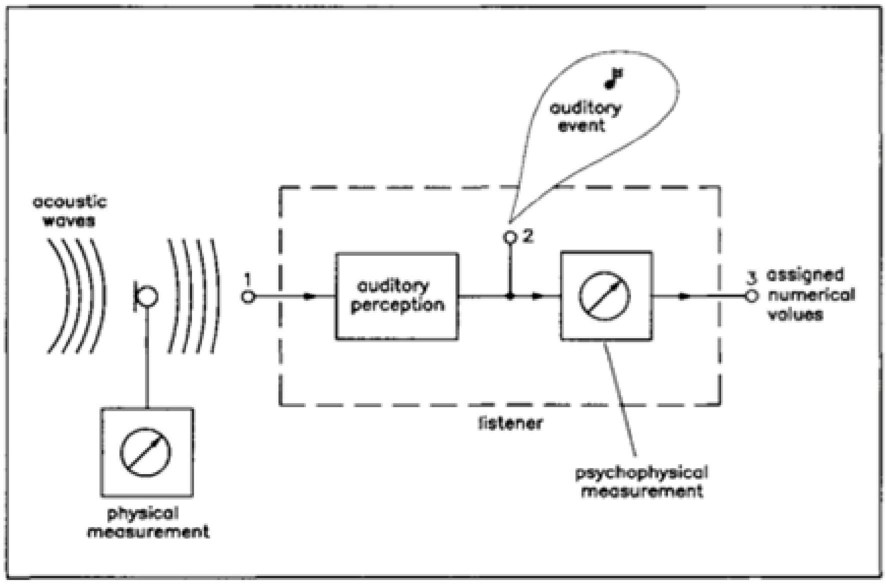

Figure 11. Old way of psycho-acoustical measurements (Blauert and Jekosch, 1997, 750).

Considering that, Figure 11 represents the new version with some adjustments concerning auditory perception. A process of judgement has replaced the process of psycho-acoustic measurement and a block named ‘action’, ‘cognition’ and ‘emotion’ was included having up-and-down links to judgement and perception (Blauert & Jekosch, 1997). This version is also relevant with the *Consequential Product Sound Model* proposed by Langeveld et al. (2013) where they took the physical factors in environment affecting acoustical radiation. As it is shown in the Figure 12, The very first item clarifies that the source of the acoustic waves remains as the eventual object of interest here, namely, the sound propagating product.

The oncoming item is also announced to reveal that transparent psychometric measurement by itself is not enough to clearly evaluate product-sound nature and quality (Blauert & Jekosch, 1997). That is to say, users perceive product sounds beyond the properties of products where cognition and emotion also play a role, such as non-auditory factors have a significant importance too. These altogether, affect product sound perception.

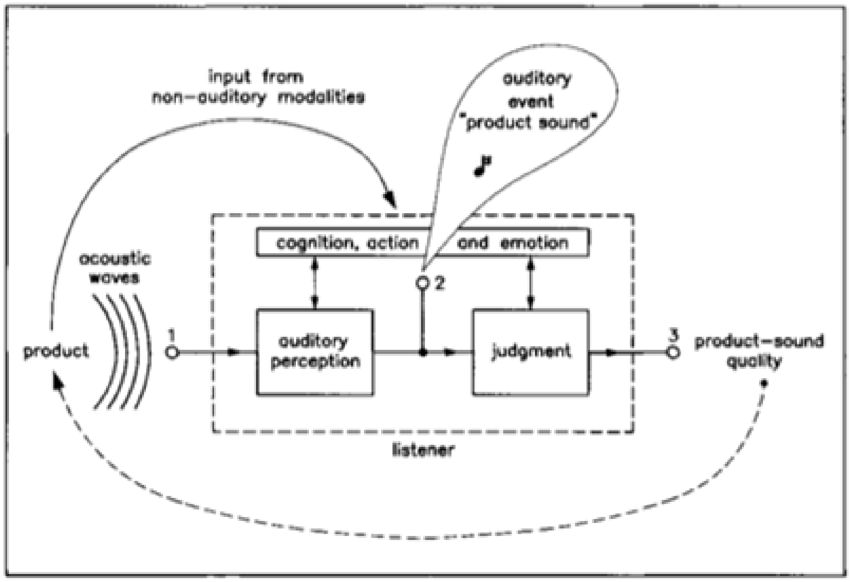

Figure 12. New version of product sound perception (Blauert and Jekosch, 1997, 750).

The relevancy of the new version could also be supported by taking identification of product sounds into consideration since they are not clear to users and people might need extra information to identify their sources. In that sense, psycho-acoustical measures are not enough. As Payne (2007) also admits in his study, same sound sources may have similar acoustical properties that might need any other input derived from other sensorial properties belonging to a product, in order to be identified correctly. Aside from that, the judgement concept can cover some processes comparable to psycho-acoustic measurement and perhaps goes beyond it since it involves complex and analytic assessment and evaluation with sophisticated balancing and measuring about some issues like data about our non-auditory senses, knowledge attained previously and necessary association to movements and related emotions people might have (Blauert & Jekosch, 1997). Having had these information, we have clarified that other senses also play a role in auditory perception. Furthermore, we might be in a need of having a different sensory input than auditory input (such as visual) to analyze product sounds. Moreover, Ballas & Howard (1987) also argued in earlier times that apart from the psycho-acoustical factors, non-auditory events, such as the setting and other visual factors, play a role in how sounds are perceived. This is crucial and supports evidence to the findings of Ozcan (2014) who argued that in most of the situations encountered, sound design mainly about adjustments through acoustical parameters may only be a fragmentary solution. So contextual factors should be also considered while analyzing product sound perception.

2.8. Auditory Evaluation

After discussing the importance of other sensorial factors and contextual factors in product sound perception, it is beneficial to have a look at the overall auditory evaluation in which external and internal factors play a role. Because how people evaluate sounds is as important as how people perceive sounds. Bodden (1997) argues that there is a number of tendencies that people are selective in evaluating sound sources; however, the actual problem surrounding this particular concept is the fact that the choice of attributes may remain affected by entirely cognitive as well as emotional aspects. That is to say, people might have a tendency to evaluate sounds but how they tend to evaluate is shaped by cognitive and emotional factors as well. Thus, it would be useful to analyze how humans chose these attribution systems and under which conditions. Amid other things, it should be clarified that the output of auditory perception should not mainly be predetermined only through the acoustic input to the auditory system but it is the result of a complex and complicated interaction of the auditory input, and mood as well as one’s expectations (Blauert & Jekosch, 1997).

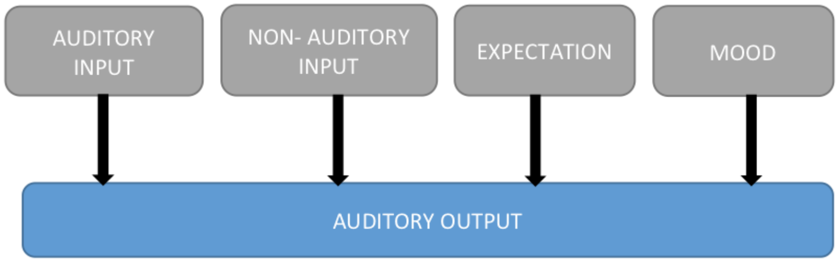

Figure 13. Auditory output.

Figure 13 clarifies what is meant by auditory input, non-auditory input, expectation and mood as the pre-determinants of the auditory output. Auditory input, as mentioned, is the consequential sounds emitted in a certain environment (the physical aspects of the sound and environment which have an effect on the sensory perception of the sound). Non-auditory input is the main focus of this study, which is the contextual (namely external) factors, the setting of the environment as well as multi-sensorial inputs that users might take in which are not related with sounds.

When it comes to expectation, Blauert (2005) states that sounds have certain meanings and people judge them due to their expectations. It is stated that as customers' demands change in time, companies are trying to understand people's acoustical expectations about certain products (Frank et al., 2015). Altınsoy (2011) conducted a study concerning people's expectations about car sounds and found that people who like to use luxury cars in daily life had lower pleasantness ratings on sporty car sounds and demonstrated the effect of expectations in discriminating car sounds. On the other hand, there are internal factors which could affect these expectations and hence judgements such as emotions and mood which are apparently individual-dependent and therefore not easy to classify and generalize. These issues will be discussed in section 2.9 (Internal Factors) after talking about overall auditory experience.

2.9. Overall Auditory Experience

Ozcan (2014) suggests a framework concerning auditory experience (Figure 14). The framework under consideration here reveals this: auditory experience is caused by product sounds and this particular affective experience is converted into a comprehensive auditory experience having the reciprocal influence and effect of internal as well as external factors. The prime components of this framework remain as the overall and affective experiences of the product sounds together with internal and external factors affecting those experiences concerned (Ozcan, 2014).

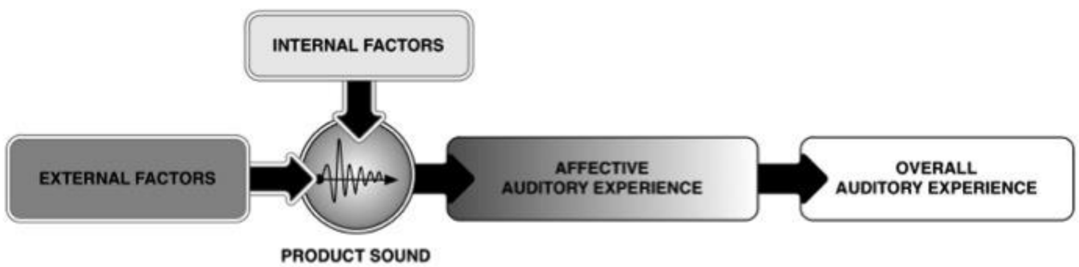

Figure 14. Overall auditory experience (Ozcan, 2014, p. 6).

Two major inputs prompting the emotional auditory experiences are internal and external factors. In the previous sections, we had a draft idea about internal and external factors where internal factors refer to cognitive issues and the external factors deal with the contextual factors of products. As it can be seen in the Figure 14, the former are quite intrinsic to the quality of sound and they outline the product's sensory pleasantness, the latter tend to result from a context which is product-related and have the necessary potential to make auditory pleasantness experiences necessarily better (Ozcan, 2014). The proposition here is that the strength and tone of our auditory pleasantness practice is dependent upon two things: the acoustic nature and the level of our interaction. The acoustic nature by itself has been predefined by how some internal factors and external factors mould the interaction level (Ozcan, 2014). That is to say, external factors which are not related with sounds can change the pleasantness of the product sounds in some ways. It is notable to clarify that in the rest of our study, we assume that the external factors are the non-auditory factors belonging to the product or its context.

When it comes to the internal factors influencing auditory perception, it was argued that they affect auditory pleasantness practices and at the same time, they are not any different from the physical properties of sounds examined via the acoustic as well as psycho-acoustical sizes (Ozcan, 2014). However, Blauert and Jekosch (1997) had stated that it is suitable to think process of judgement as an important matter of psychology as opposed to pure psycho-acoustics, as it should be noted that internal factors target at this judgement process but at the same time affect the auditory perception process also. So here, it is argued that psychology could oppose psycho-acoustics in a way, which could oppose with the previous argument of Ozcan (2014). On the other hand, Siegel and Stefanucci (2011) had proven that people having bad mood perceive the tones louder than people having neutral mood. That is to say, mood can also manipulate auditory perception. Apart from mood, we also believe that emotion studies will lead demonstrating shifts in judgements concerning auditory experience beyond the psycho-acoustical properties, since there is another study of Asutay and Vastfjall (2012) which shows that emotion has an influence on loudness judgements too, where negative emotions might induce loudness judgements of people. So we find it reasonable to dive into internal factors.

2.10 Internal Factors

There have been some studies concerning internal factors in auditory perception. Internal factors refer to the psychological state which individuals have while hearing product sounds. Especially when we talk about the noisy sounds, Ouis (2011) stated that the non-auditory expels of loud sound and noise on people have been evaluated as being stress-related. In other words, the factors which affect noise reactions are considered to be coming from internal factors.

Further, most of the time subsequent to observations that being exposed to loud sound and noise causes reactions of physiological nature and the reactions are supposed to be typical to these of stress (Ouis, 2011).

Guski (1997) explained how people perceive sounds radiated by a product into three psychological states, adding one more to the categorization by Blauert & Bodden (1993):

(1) Suitability of a sound for a special (technical) purpose, or stimulus-response compatibility. This refers to the match of the sound and the product according to the aim of sound.

(2) Pleasantness or unpleasantness of sounds, meaning that a sound should be pleasant or less unpleasant and

(3) Identifiability of sounds or sound sources, meaning that users could easily identify the source itself, as it would be complicated for the users if they do not have information on sources of sounds.

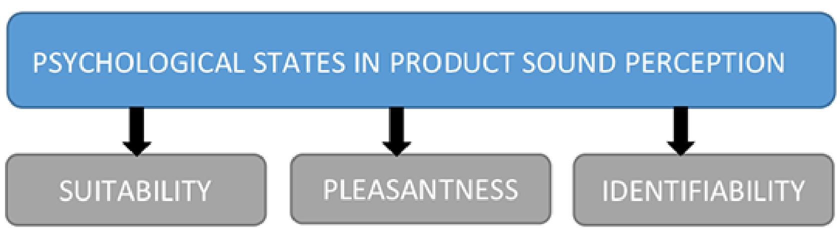

Figure 15. Psychological states in product sound perception.

This type of classification (Figure 15), though open to discussion as we believe, lacks the ‘expectation’ aspect, which has a major role in product perception. However, suitability for a technical purpose part can be remained open to discussion as we could think it might be counted as an “expectation” concerning its technical properties. Apart from that, Namba (1994) had explained that evaluation based on sound-quality contains a two-step process, through which (1) a definite sound source is recognized or identified on a basis of timber and level concerning cognitive functions like expectations, memory and perceptual processes (cognitive) and (2) when the sound in question is (or not) identified, it is immediately evaluated for pleasantness or unpleasantness of people as they react to the stimuli provided (affective).

Figure 16 brings together these classifications under a new structure, where memory, perception and expectations play a role in the identification of sounds, and sounds are in turn evaluated as pleasant and unpleasant. Moreover, in the light of the literature, Figure 17 visualizes the new adjustment of auditory perception field, for more detail.

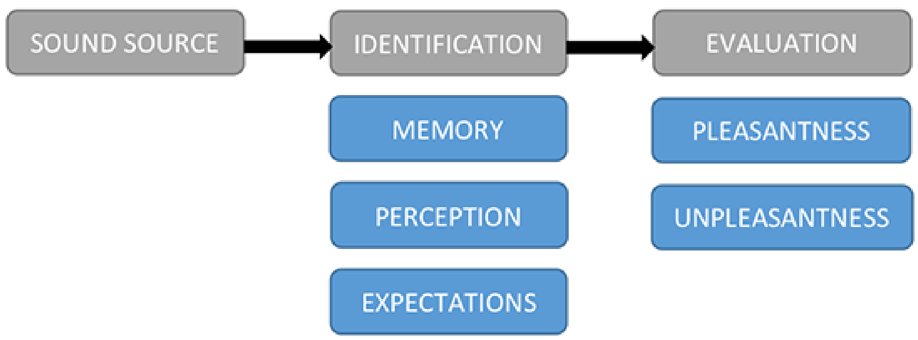

Figure 16. Auditory perception.

The identification process includes the internal determinants, such as cognitive factors, memory and expectations, it is therefore useful to name these elements under the title of ‘internal factors’. Further, it is admissible that pleasantness and unpleasantness can be subject to an affective evaluation, which is basically an emotional aspect, therefore they can be grouped under the name of ‘affective reactions’. Thus, we made another illustration (Figure 17) which is the visualization of the sound evaluation process including the comments on the yellow boxes that we added after having an overall view. According to that, people perceive the sound source according to their internal factors, namely during the identification process where users try to identify it using their memory, and compare it with the existing knowledge and give an affective reaction after evaluating it.

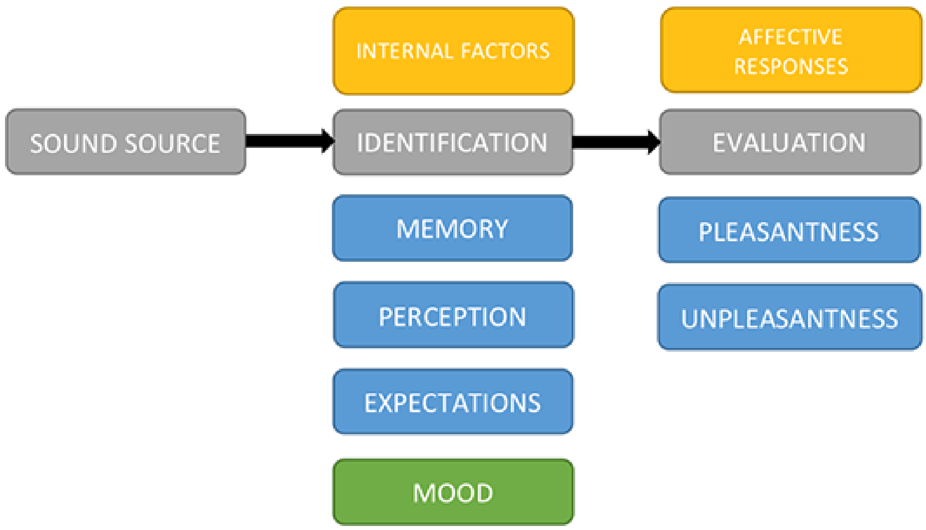

Figure 17. Auditory perception (new version).

Having the knowledge about the significant effect of mood on sound perception (Siegel and Stefanucci, 2011), we have also added "mood" under the internal factors which might also play a role in the identification process. On the other hand, mood is treated as a background sensing and feeling state, not brought about by some specific events, objects or stimuli (Vastfjall & Kleiner, 2002). So for that reason, mood seems to be a long term process that is not easily affected by the short-term inputs, which is thus open to discussion. On the other hand, studies now are more focused one the emotions, which are short-term feelings evoked by events. Furthermore, as products are believed to create emotion, there are more studies concerning emotion than mood in analyzing product perception. In auditory perception as well, Vastfjall & Kleiner (2002) stated that a certain systematic approach towards affective reactions will definitely increase our ability to understand and predict human responses. However, it is still not clear when exactly we feel emotions towards products or product sounds. For instance, when we take Figure 17 into consideration, we might think that affective responses would occur in the evaluation phase, but it is also possible that people could have emotions or biases before the evaluation phase in some cases. Blauert and Jekosch (1997) stated that users make use of their personal experience with a certain product and regard its product sounds seriously while judging on that product itself, moreover, user experience must have come from an earlier contact with this particular product, in preference, multiple times on many different occasions.

Amid other things, Kariel argues that (1990) the determinant of assessment of sounds being as annoying, pleasing or acceptable is the clear-cut combination of those physical properties of sounds as well as their socio-psychological characters and appearance. However, there have been studies (Ozcan, 2008; Cox, 2008) reporting that people feel unpleasant when the source of a sound is not clear, pleasantness could change if people know the source of the sound. Cox (2008) found that people's unpleasantness increased when they saw the sound sources while hearing annoying sounds.

All in all, what is clear is that people have affective responses to auditory stimuli no matter how they are processed. The identification process as an internal factor can be affected by various factors, such as memory, perceptional factors and expectations, which are indigenous to individuals. Next, it is useful to clarify how exactly the affective factors play a role in product sound experience before stepping into the contextual analysis, that is because people also use affective-based words describing product sounds such as pleasant, happy or irritating (Ozcan and Van Egmond, 2005; Ozcan, 2008).

2.10.1. Affective Reactions

Affective sounds are part of the daily life of people interacting with products; we are annoyed by the sounds of mechanical products, and sometimes enjoy the pleasant sounds of coffee machines. Affective reactions seem to play a dominant role when evaluating products and also product sounds. Affective or, in other words, emotional reactions, as implied before, are known to be fundamental components of our responses towards auditory stimuli (Vastfjall & Kleiner, 2002).

According to the findings from literature, it is seen that there is not a well-structured approach towards affective product sound perception, thus it seems beneficial to go deep down into affective experience. According to Bradley & Lang (2000), investigations concerning reactions towards emotional sounds remain comparatively new. The reason of this might be that the amount of the research based on auditory perception are, considerably few. Also, analyzing emotions is quite hard to deal with as they are dependent on countless variables. For instance, its elaboration through visual input can make it hard to confine effects emerging especially from acoustic stimulation's affective features (Bradley & Lang, 2000). Apart from that, there is an extensive literature on the emotional analysis of visual experience which might be used as a base for auditory experience.

In the study of psychology, the term affective state is mostly employed to show all kinds of subjective-looking experiences that are valenced, namely, experiences involving a certain goodness, pleasantness, badness or in some cases, unpleasantness. Other than that, the theory of emotions argues that a certain emotion is obtained by a thorough evaluation (or appraisal) of any event as well as situation as being harmful or beneficial (Arnold 1960; Scherer, Schorr, & Johnstone, 2001; cited in Desmet & Hekkert 2007). These evaluation processes seem essential to discuss as they could affect auditory experience.

2.10.2. Appraisal Theory

Appraisal Theory is a theory that suggests how a certain person emotionally reacts towards an unexpected confrontation depends on an assessment of what this particular confrontation implies in terms of wellbeing, which comes to mean 'appraisal' in our terms (Smith & Lazarus, 1990). Therefore, it can be admitted that appraisal is dependent on the evaluation phase of humans. Russell (2009) puts forward that human beings have attribution to discriminate reason and emotion, recently a certain appraisal is considered to be a part embedded in the emotion or, it can be taken as a happening which mediates between a former event and the emotion itself.

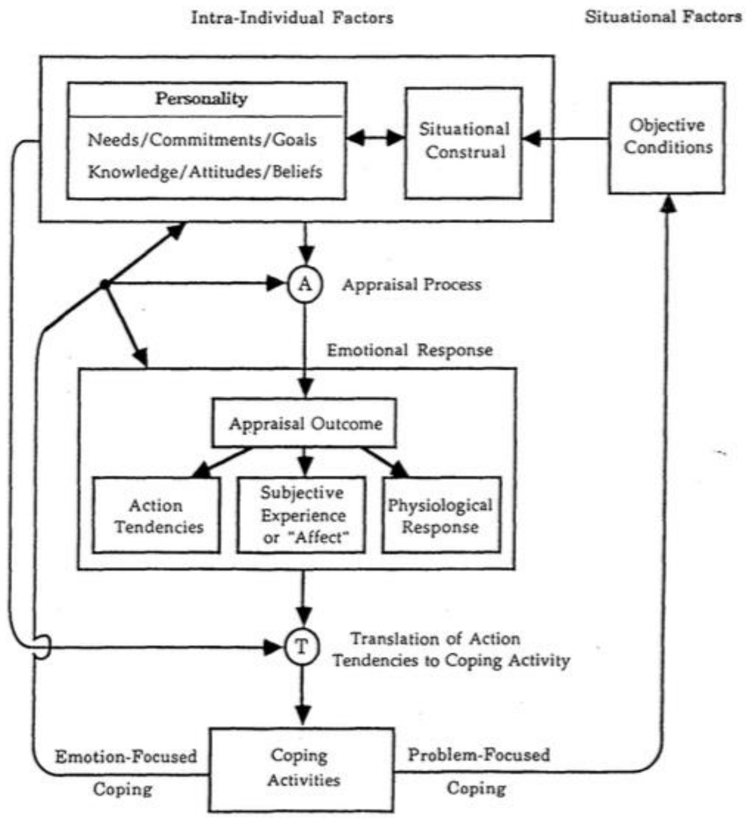

Figure 18. A model of the cognitive-motivational-emotive system (Smith & Lazarus, 1990, p. 623).

The overall emotional response system is shown in Figure 18. What is assumed by Smith and Lazarus (1990) is that humans as well as animals have been biologically constructed to be continuously occupied within appraisals of current and alternating relationships with the environment. That is to say, how we interact with the environment shapes appraisals. These relationships under consideration are assessed in terms of comparatively small and innately ascertained appraisal issues, as appraisals advocate the evaluation and detection of adaptationally suitable conditions that require immediate action (Smith and Lazarus, 1990). Although there are not many studies concerning these relationships, it can be seen that it is a complex process and needs to be understood including internal and external factors intertwined to each other. Similarly, appraisals also can determine our emotional state that motivates and prepares a person to handle adaptational implications of what is occurring (Smith & Lazarus, 1990). That is to say, it is the internal factors that affect the emotions, how people feel in a given time, but the determinants are beside individual factors, the environmental factors also. Thus, the contextual situation influences the appraisal system of human beings.

Following the tradition of appraisal theory, Desmet (2002) introduced a basic model of product emotions, as shown in Figure 19. The model remains very basic according to Desmet (2002), since it can apply to almost all probable emotional responses obtained by a human–product interaction and pinpoints three universally known key variables within the process of emotion elicitation: (1) stimulus (2) concern and (3) appraisal.

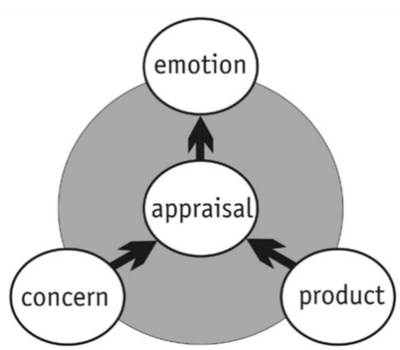

Figure 19. Basic model of product emotions (Desmet, 2002, p.4).

According to this model, users have concerns about a product that creates appraisal as a leading emotion. For example, we can desire a motorcycle that we might have an appraisal about, because we think that it represents strength and being fast. In contrast to that we could give frustration as an example, experienced in response to a chair that is appraised, while it is mismatching with the concern for comfort (Desmet & Hekkert, 2007). Thus, it can be suggested that emotions can be manipulated and they can also be related with negative feelings, such as discomfort and frustration.

Desmet & Hekkert (2007) state that, in brief, appraisal can be said to be an evaluation of the importance of a certain stimulus concerning an individual's well-being. This importance of a product causes emotion we place emphasis on. Here then, it can be admitted that appraisal is an evaluation regarding the product by an individual, followed by an affective reaction such as comfort, discomfort, etc. Similarly, if the personal significance of the product is the main reason of creating emotions, then it is something more than the product, which is a 'representation' popping up in the users' mind as a mixture of the product properties and how users perceive it. This representation plays a role in the evaluation and in the affective reaction processes rather than the product itself. Figure 20 illustrates the events related with Desmet & Hekkert's (2007) work concerning the appraisal theory.

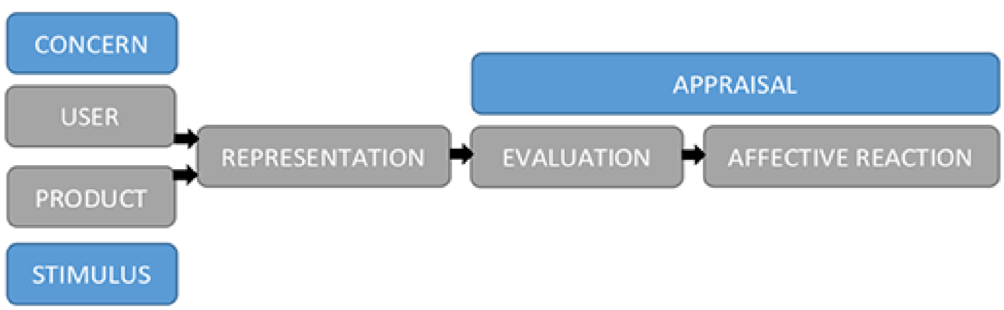

Figure 20. Process of appraisal.

Mainly, users have some concerns and expectations in mind that react when they interact with the product and these two together, create a representation of the product. For example, the effect of emotions on memory explaining that *memoric* processes are seldom mentioned, however, emotional episodes may be the reason of a situation through its association in relation to a recalled event (Clore & Ortony, 2008; LeDoux, 1996 cited in

Russell, 2009). Thus, it is admissible that emotion has also an effect on memory. After the cognitive process concerning memory and expectations, users evaluate products and give affective reactions due to the degree of match of the object with users' expectations or images in mind. The most crucial thing here is that 'concern' is the representation of the internal factors that belong to an individual, because this is a cognitive process and is progressing in the mind.

However, seemingly, appraisals are mainly considered for product perception and there are no studies concerning product sound appraisals, so we will propose a framework (Figure 21) regarding product sounds after detailing appraisal theory.

Because a product sound, if it strongly represents something people match with their concerns (such as a coffee maker sound) and that might evoke human appraisals too. Blauert & Jekosch (1997) also put forward that the quality of the sound within the context of products produced industrially has got something to do with the relevance of a certain product concerning specific predetermined demands. These predetermined demands can also be considered as the concerns of a product sounds in the context of the usage. That is to say, it is admissible that users also have a certain concern or expectation about a product sound. Moreover, Blauert & Jekosch (1997) exemplified sound quality as the 'competence' of a certain sound in a given context of a particular technical task or goal. Although the relation between the product sound and the technical goal of a person concerning the product has not been studied yet, we suppose that it can be an alarm sound of a microwave which gives an auditory feedback when cooking is done. The sound might be clear and understandable to the user; for instance, it has enough volume to be heard in a kitchen where a lot of cooking events can occur at the same time. But the alarm should be in a convenient frequency that does not damage anyone's ear so people can efficiently understand that the meal is ready. So the intentional sound completes what is expected from it, thus it has a good quality.

On the other hand, how users associate meanings to sounds is also important. The meaning attributed to a certain sound stimulus remains to be closely related to a person's personal experience: aroused sensations and affective responses are frequently learned and conditioned through time that are directly linked to some associations established as soon as the stimulus is confronted (Asutay et al., 2012). All in all, concerns, meanings and expectations are the determinants of a sound being judged by the users.

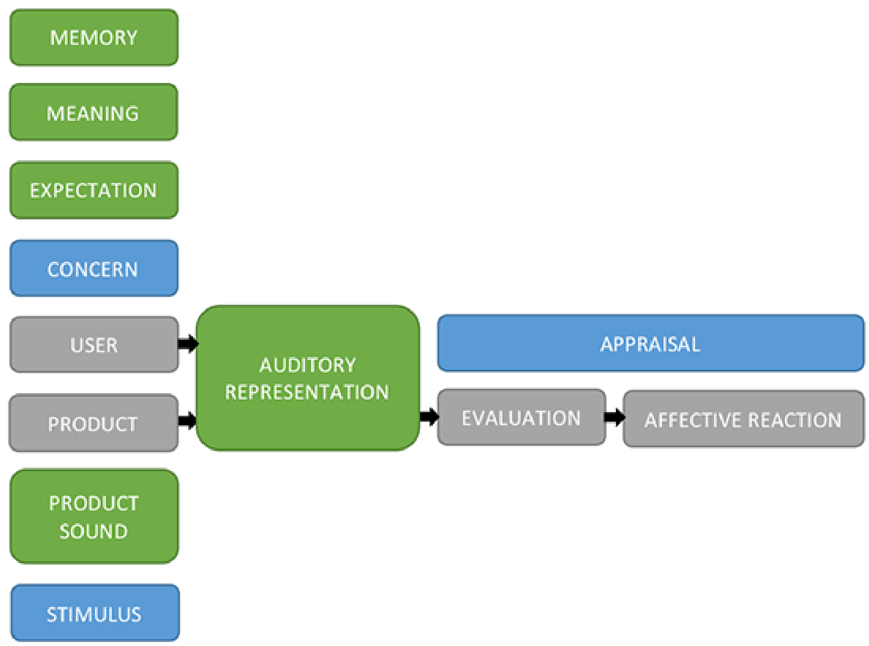

Figure 21. Process of appraisal for product sounds.

In the light of the arguments discussed, a framework is offered for a possible affective reaction of a product sound (Figure 21). What basically this framework refers to is that a product sound, either consequential or intentional, might have an auditory representation concerning its sound source and the product itself. This auditory perception is also based on users' memory, how users attached meaning to the mentioned product, which directly would reflect on the expectations of users. So this auditory representation comes from both the product sound itself and the internal background of the users, and leads to its evaluation and an affective reaction. Subsequent to the discussion based on Blauert & Jekosh's (1997) arguments, it is seen that feelings and emotions have negative and positive components; when a positive affective experience is attached to a definite sound, we can judge it of very high quality (Asutay et al., 2012). Following this argument, we can also check whether people have positive attributions on a certain product sound depending on the experience or the meaning behind.

Nonetheless, in a study about how mountaineers react to noise, mountaineers were found to be more sensitive to sounds, rating nature-related sounds as more pleasant than did the general public, and both man- and technology-related sounds as more annoying (Kariel, 1980; cited in Cessford, 2000). That is to say, their perception system was shaped due to their habits. This is a good example for internal factors influencing sound perception as cognitive processes seem to lead mountainers' perception.

2.10.3. Core effect

As for the properties of the product, it is also believed that the product properties lead emotional responses with their sensory aspects. There exist quite convincing reasons about why personal appraisals are required: noises at very high levels do have a myriad of negative effects on individuals (Kryter, 1970; U.S. Environmental Protection Agency, 1971b, 1974b; cited in Craik, 2013). That is to say, apart from being perceived as "unpleasant", loud sounds physically harm auditory senses. Furthermore, when environmental quality in terms of human health is in question, a certain limit of maximum 70 decibels is considered to be safe for the purpose of protecting hearing, even while the human ear is exposed to noise for a long time (Craik, 2013).

The most general emotion that is in question regarding product experience seems to be pleasure as it is a general term and it usually refers to a positive factor influencing product experience. Pleasantness of noise remains highly influential in terms of user practice since all experiences might have some sort of perception-tone which can be classified as neutral, unpleasant or pleasant. On the other hand, feeling and perception tones are argued to be inevitably controlled by our emotions (Ortiz et al., 2014). Subsequently, Desmet (2012) states that products evoking positive and pleasant emotions on the side of customers are more often bought, they remain in use longer and, doubtlessly, are more enjoyable to utilize. For that reason, designing products evoking positive emotions is reasonable. Customarily, feeling something to be nice or cute is really a very pleasant experience, similarly, to perceive something bad is rather unpleasant. Such kinds of perception are reasonably connected with core effect: perceiving something as being pleasant and nice is the way to evaluate it to be suited to produce pleasure (Russell, 2009). We can also name it as pre-judgement about a product that it might give pleasure. In his study, Desmet (2012) suggested 25 positive emotions leading for pleasantness (that is because a type of pleasure is dependent on the type of interaction among users and products). Having studied these complex systems concerning human emotions both containing internal and contextual factors in different ways, we also know how the positive emotion strategies are popular in terms of producing pleasurable products. To understand how people experience products, it is valuable to talk about core effect.

Core effect or influence is a state of neuro-physiological nature underlying easily feeling drowsy or stimulated, good or conversely bad. Core effect remains a pre-conceptual basic process, or a state of neuro-physiological nature which is reachable to consciousness like a normal non-reflective feeling one might attain: feeling very good or very bad, feeling tired, exhausted or energetic (Russell, 2009). We, in our daily life, perpetually experience and practice core effect: as long as we are awake. The core effect shifts, as seen in Figure 22, giving response to a large variety of both internal (e.g. changes at the hormone level or nourishment problems) and external (e.g. people, weather, objects or events) reasons (Desmet & Hekkert, 2007). Learning the death of someone we love, perusing about injustice in society we live in or thinking about a an environmental danger like global warming for example require cognition (Russell, 2009) could be given as examples. The above-mentioned examples have another particularity in common, which could be defined as conscious attention towards the given information. These emotions we gain are based on the knowledge and experience we have about the events we are faced to. Russell (2009) also gives an example about winning the lottery: if the related news goes ahead to capture consciousness (like congratulatory remarks, shopping or memories), at that moment, it goes on to shape and mould core affect, however, if a person has been distracted through thoughts on the winning, then the win is moved and repelled from consciousness and later the excitement disappears, which means that an aim-oriented approach would reduce the emotional effect.

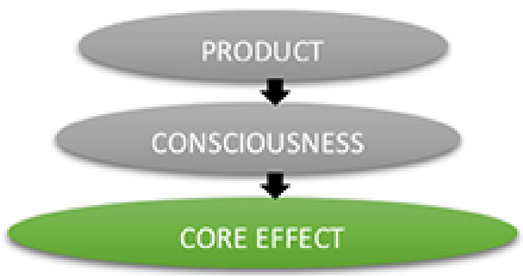

Figure 22. Core effect.

So the important thing here is that people have some knowledge behind (e.g. memory, label, etc.) that a certain product will give pleasure to them for a specific reason. It could be a supportive question for this study to ask if one could gain core effect with a product sound. The answer to this question could be yes, since we are now aware of the aim of engineers and some PhD studies (Cox, 2008) to design solid motor sounds which would enhance pleasantness because it represents the speed and the strong engine of the car. For example, if people have an image about a motor sound of a car (such as the noisier it gets, the stronger it is), they would have the impression that the car is fast and strong when they hear its sound. So people here, consciously predict that a noisy car will give them pleasure that is because it is fast and strong (Figure 23).

Figure 23. Core effect for a car sound.

We have more than one core effect (e.g. being happy, talking to a friend, feeling sad because of loosing in a game) affecting our emotions during the day. We usually go through those changes within core affect without being conscious of the reason behind (Desmet & Hekkert, 2007). Similarly, human-product interaction may be the cause of a change or alteration within core affect. Also, both internal and external factors can remain as the reason of this particular core effect (Desmet & Hekkert, 2007). On the other hand, emotions can be triggered because of small stimuli such as an argument with friends or a failure from an exam. As can be seen in Figure 23, more than one emotion can lead to pleasantness and unpleasantness experiences. The lists also can vary as the studies are currently continuing to analyze and classify emotions for numerous situations people face. For example, if we are to give some comparisons, the joy behind solving a hard task cannot be regarded to be exactly the same as the certain joy of reciprocated love, and the heartbreak caused by a bad partner may not be the same thing as the disillusionment created by a problematic personal computer (McCarthy and Wright, 2004; cited in Ortiz et al., 2014). For these reasons, seemingly, core affect is a unique feeling consisting of more than one feeling. In other words, any two dimensions incorporate into an indispensible fashion to shape a unified feeling as an example, arousal and pleasure blend together to create the sole feeling of extacy (Russell, 2009). This thought is insightful and reasonable, apparently only consisting of the small picture of emotional analysis, that is because amounts of emotions for a specific task may vary. Russell also states that (2009) an analogy remains as the consciousness of a certain color, to be more specific, the maroon autumn leaf that fell from a nearby tree onto the ground, such as the dimensions of saturation, hue and brightness for one particular color.

Multivariable research about affective language, which discovered that the prime variance within emotional meaning and connotation is clarified by dual factors: arousal and pleasure derived (Bradley & Lang, 2000). Pleasantness as well as arousal are solely the two dimensions which have so far caught scholars' attention (Ortiz et al., 2014). Pleasantness portrays the hedonic valence belonging to an emotion and arousal characterizes bodily symptoms of emotion (Barrett, 1998; Desmet, 2002). Hence, emotions we have might be pleasant or unpleasant as well as exciting or calm depending. Almost all emotional states emerge from those two dimensions (Ortiz et al., 2014). Further, arousal and pleasure also contributed to the improvement of measuring affective human responses in emotional studies and user experience (Isbister et al., 2007; cited in Desmet & Hekkert, 2007).

2.10.4. Measuring Emotions

Understanding emotions remain complex to analyze and hence generalize. Having discussed some categorizations of emotions, we also want to discuss the tools measuring emotions. There have been various studies about measuring emotions products may evoke. However, most of them are mostly focused on visual aspects of products.

There are some methods used to analyze emotional responses and some of them are specialized for certain groups of emotions. Desmet et al. (2000) stated that there are some measurement tools based on some certain groups of emotions such as *Emotion Profile Index* made by Plutchik and Kellerman in 1974 and *Differential Emotions Scale* proposed by Izard in 1977 which are focusing to analyze fundamental emotions considering that they consist of complex emotions. More than that, Desmet et al. (2000) proposed a measurement tool called Product Emotion Measure (PrEmo) to analyze 18 emotions evoked by the outlook of products (Figure 24). This is a visual-representative system that every emotion has a short animation where users can rate how they feel. However, this approach is only focused on the appearance of products as Desmet et al. (2000) put forward that it is needed to measure emotions with a low intensity as designed products evoke emotions with low intensity, referring to the study of Desmet and Hekkert (1997).

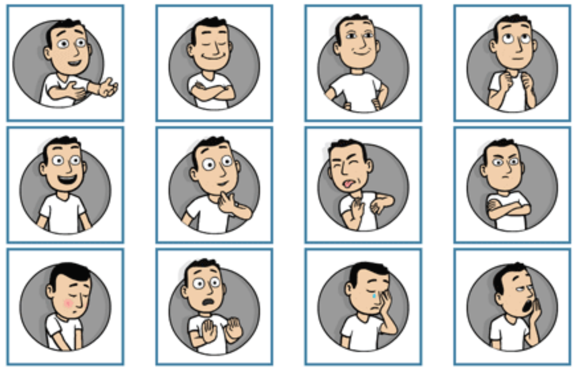

Figure 24. Emotional expressions in PrEmo tool (retrieved from www.premo.com, on 05.08. 2016).

It is crucial to mention that the emotions evoked by senses could be different due to the levels of intensity. It is stated that engine sounds have high levels of arousal by Özcan and Van Egmond (2012) and motor sounds might have high rates of dominance with a high intensity which could be a big difference between emotions evoked by sounds and visuals when they are separately being rated. That is to say, the level of intensity might not be the same among visuals and sounds. It might also vary if sound and visual are given together, so although PrEmo is new and has broad categorizations of emotions, it would not suffice to use it for measuring affective responses to sounds or to multisensory inputs.

There were some approaches though concerning affective pictures and affective sounds for contributing to the studies measuring emotions: *The Self-Assessment Manikin* (SAM) is a non-verbal pictorial assessment technique (Figure 25) that directly measures the pleasure, arousal, and dominance associated with a person's affective reaction to a wide variety of stimuli, which has been used effectively to measure emotional responses in a variety of situations, including reactions to pictures, sounds, advertisement, painful stimuli and more (Bradley & Lang, 1994). Users can rate how they feel according to the visuals stating pleasure, arousal and dominance.

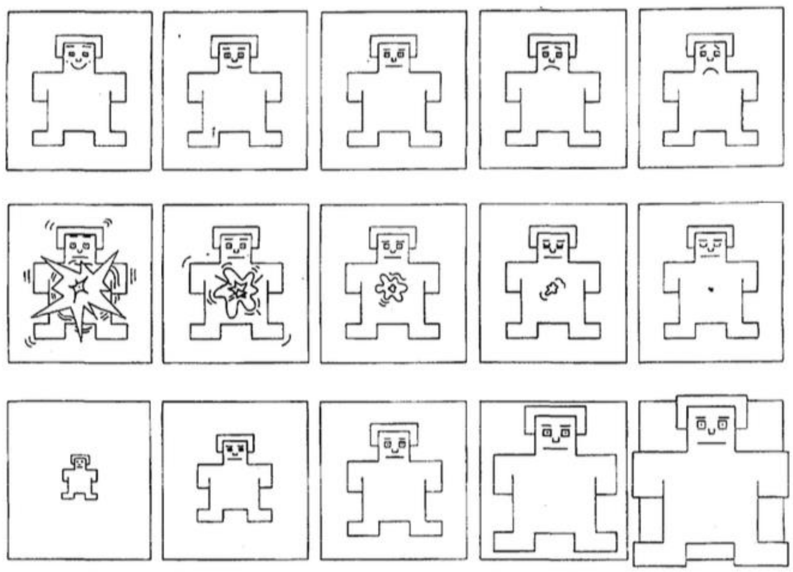

Figure 25. The Self-Assessment Manikin (SAM) used to rate the affective dimensions of valence (top panel), arousal (middle panel), and dominance (bottom panel) by Bradley & Lang (1994, p. 51).

To understand affective reactions to visual and auditory stimuli, two studies were conducted in different times, one for understanding emotional responses to visual input (Lang et al., 1999) and another for understanding emotional responses to auditory stimuli (Bradley and Lang, 1999). To contribute to emotional studies, Lang et al., (1999) suggested *International Affective Picture System* (IAPS) which is an affective visual library consists of 700 semantically classified and colored pictures for measuring emotions in experimental research. Figure 26 shows the results of the experiments of 700 affective pictures where these pictures were classified semantically according to their pleasantness and unpleasantness, as well as their arousal levels combined which refer to appetitive or defensive motivation (it is not permitted to cite the visuals).

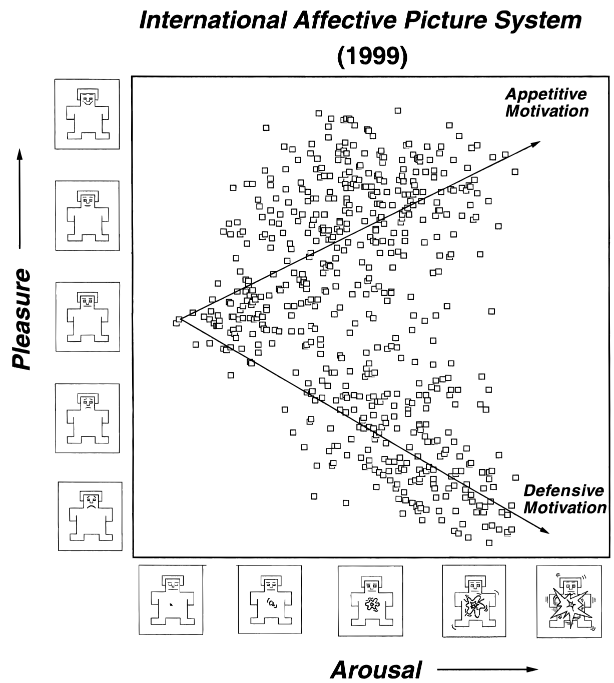

Figure 26. Pleasure and Arousal dimensisons of affective pictures (Bradley and Lang, 2000, p. 205, adapted from Lang et al., 1999).

In another study proposed by Bradley & Lang (1999), 60 affective sounds were semantically classified and measured about how they affect pleasure and arousal, which was called IADS (The International Affective Digitized Sounds) as a sound library to be used for experimental studies. Table 1 is a list of some of the unpleasant sounds and their affective rates given by the participants to IADS. According to the table, these are the sounds which are identifiable by the users, such as yawn, scream, roller coaster which could have some interpretations in mind that users can relate. We can predict that users would not like the sounds like yawning or screaming (depending on the context). As it can be seen from the Table 1 that most of the sounds have low pleasantness ratings with high ratings in arousal or dominancy. However, the sound of a roller coaster seems different with high ratings in terms of pleasure, arousal and dominancy. That is to say, it is pretty clear that people like this sound for some reasons and they thought it was pleasant.

Table 1. Affective means of sounds (adapted from Bradley & Lang, 2007).

Sounds	Pleasure	Arousal	Dominance
Yawn	2.75	6.51	3.46
Scream	2.05	8.16	2.55
Attack3	3.43	7.33	3.52
Attack2	1.80	7.79	2.41
Gunshot	3.08	6.57	3.55
Fight1	1.65	7.61	2.89
Roller Coaster	6.94	7.54	4.73

However, it is not known if it is the sound source or the representation of the source (expectations or experiences) in people's minds that causing positive results about a roller coaster sound. Because it is a loud sound, and it apparently evokes high arousal with its dominancy, which normally would create sensory annoyance due to its psycho-acoustical properties. In terms of most of the sounds having high loudness such as scream were rated low in pleasantness whereas roller coaster had the opposite. In other words, people might have liked it because the sound can be identifiable and represents fun and excitement. For that reason, further study with same types of noisy sounds are needed for product sounds to understand the main reason creating pleasure, even though they are physically unpleasant. Apart from that, when it comes to more abstract sounds where the sound source is not clear, people may not differentiate the engine sounds of a car or a motorcycle. Would we have the same effect on these sounds as well? Or would it differ if we were provided with information regarding the sources of the sounds? The questions remain unclear and need to be studied. Albeit, it is good to have a quick source as a proof for underlying emotional differences on people due to the different types of sounds.

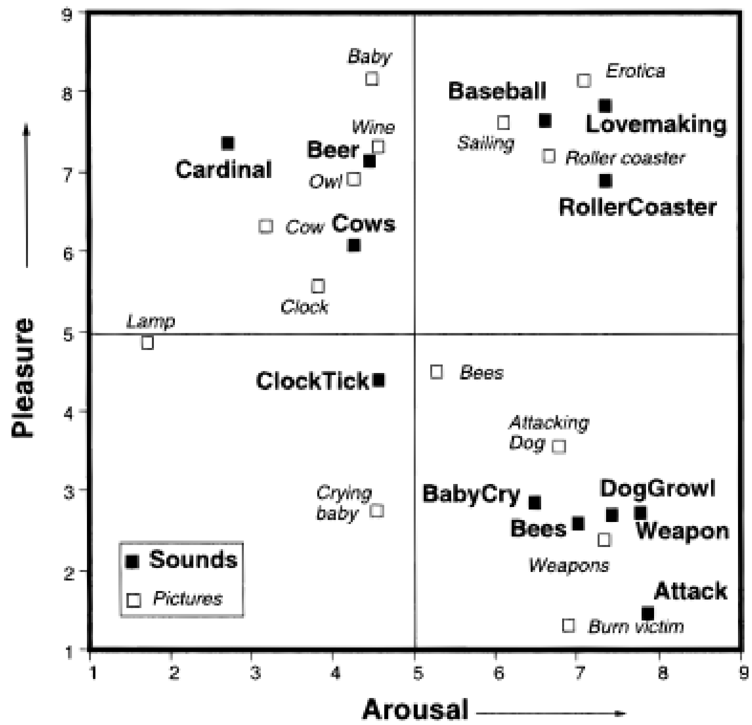

Figure 27. Ratings of pictures (empty squares) and sounds (filled squares) varying in pleasantness and activation (Bradley & Lang, 2000, p. 207).

In Figure 27, sounds were represented by filled squares and the visuals were represented by filled squares and it can be seen how close they are in the pleasure and arousal ratings. The shape of the two-dimensional affective space defined by the mean ratings for each sound was similar to that previously obtained for pictures, and, like memory for pictures, free recall was highest for emotionally arousing stimuli (Bradley & Lang, 2000). Aside from that, it was also found by Ortiz et al. in 2014 that pleasantness was affected positively by high arousal, showing the median and high arousal inputs evoke the most pleasurable emotions. Bradley et al., (1992) stated that while recalling sentimental or touching photos, our memory also acts usually better for materials considered rather sparking regardless of the fact that they are pleasant or not. Thus admittedly, there are some effects on memory.

When it comes to evoking emotions in high arousal, Ortiz et al. (2014) suggested that arousal and pleasure are dependent upon human-product interactions as emotions with high arousal are more noticeable by users which cause excitements.

2.11. Affective Auditory Experience

Despite some studies that profoundly look into the effect issue of the recalled sensations by sounds about image processing of visual nature, the emotional practice of sound and visual stimuli that are connected to each other has not been often worked on (Van Egmond, 2008). However, there were studies concerning the effect of color on product perception where Kueller & Mikellides (1993) conducted a study proving that warm colors evoke arousal and that product users can manipulate colors to evoke arousal.

A reason of having few studies in emotional practice of sound and visual stimuli might be the difficulty in analyzing multisensory interactions as there are many variables in experimental studies that are hard to analyze or classify in a valid way. A secondary reason could be that the combination of auditory and visual stimuli is not easy to design for a reliable experimental research. Further, the field of emotions in psychology has its own difficulties since there are a lot of assumptions on what an emotion is. Bradley & Lang (2000) also stated that embellishing sounds via visual guidance makes it real hard to confine effects from emotional traits of auditory stimulation. Furthermore, the degree of influence of sound and visual to each other also would matter as users might give various reactions. For example, it was found that source visuals when added to their sounds as stimuli, induced the annoyance rate (Cox, 2008).

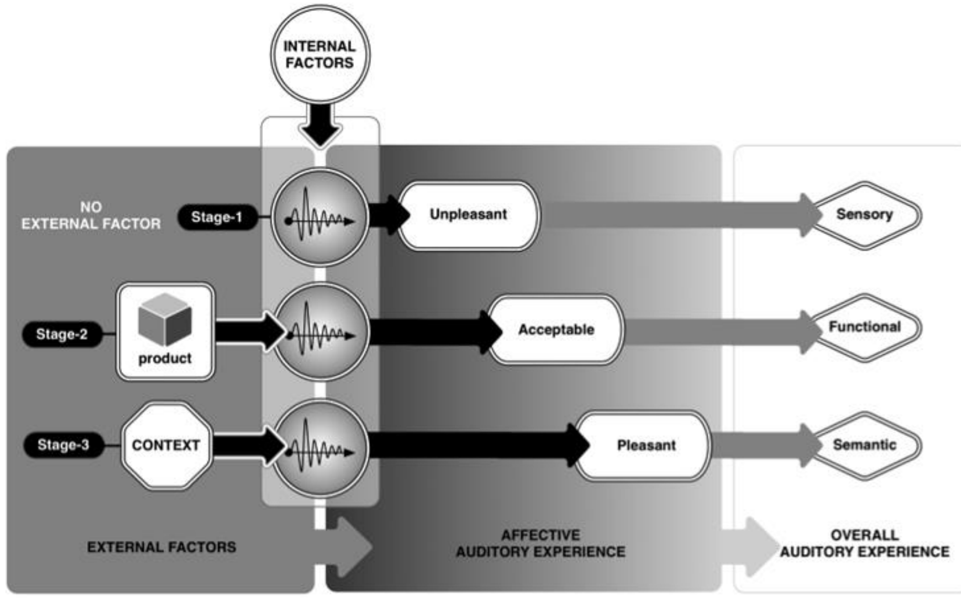

Figure 28. Three stages of overall auditory experience (Ozcan, 2014, p. 7).

Ozcan (2014) provided a framework of affective auditory experience consisting of three stages of product sound perception. According to Figure 28, people use sensory properties to respond to sounds when there is no other stimuli as a reaction to the sound rather than the product itself, whereas Stage 2 deals with the utilitarian side belonging to the product believed to influence sound perception experience (Ozcan, 2014). So, for example, a person hearing a toothbrush sound, will only rate it according to sensory pleasantness if he/she cannot see or interact with the product. However, if he/she uses it, then the auditory experience will change according to the utilitarian aspect of the product. To give an example for this, Parizet et al., (2008) conducted a study with subjects and found that the annoyance of the sound was lower when the subjects themselves are closing the car doors. That is to say, when people used the product, the auditory perception changed and the annoyance level decreased. In Stage 3, a context is introduced, which is proposed to influence the auditory experience in a broader sense by manipulating an emotional quality of the environment wherein the product and a user are in interaction (Ozcan, 2014). Ozcan stated (2014) that every stage in the framework will refer to an improvement of experiences towards positive emotions.

It would be useful to analyze what has been done to change product sound perception so far. From that point of view, it is admissible that we can change emotions by using contexts, if we are able to enhance positive emotions by contexts.

There are attempts to change emotions towards product sounds by manipulating their aspects. Before analyzing the context, it is valuable to take a look into the product sound manipulations to have a broader knowledge.

2.12. Product Sound Manipulation

Product sound design is a new field and currently being developed by designers, engineers and psychologists. As well as the knowledge on the existing data, we also have knowledge about the reasons why sound manipulations are used for enhancing the product experience. We mainly see this need of change in products having noisy sounds because they are loud and sharp and perceived unpleasant by the auditory senses. Being a dominant factor in noisy products, sound might be changed in order to reduce unpleasantness. Subsequently for this reason, it is useful to know which aspect of sound will be changed in order to change affective experiences of product sounds. The quality experience may as well be designed whether a person knows what perceptual characteristics someone is required to have concerning the product sound (Van Egmond, 2008). Cars and motorcycles are the most common examples for this. Not only being noisy and unpleasant, the sounds are also consequential sounds which are the result of the inner components or engines. As we have mentioned in the beginning of the study, normally the dB(A) levels of sounds are reduced in order to decrease the noise and provide a better sensory (less unpleasant) experience. In essence, engineers dealing with acoustics are employed in car production industry for the purpose of fostering increased experience of desired quality (Van Egmond, 2008).

As it is well known, the sound of a car door being shut is a typical example which has been examined and studied on many occasions. When the door sounds of two different cars (one being a lot more expensive than the other) are compared, one can tell which vehicle is more expensive than the other (Lyon, 2003). Similarly, Kuwano et al., (2002) found that people have similar concerns about how the sounds of car doors should be. That is to say, people might have expectations about how the sound should be when a car door is closed. Altinsoy (2011) found that users have certain expectations towards the type of cars by comparing cars belonging to different classes. In another study, Kuwano (2006) stated that there is a strong connection between a car visual and its sound. In the light of the findings from the literature, it is admissible that effects of contexts should be carefully studied and clarified. All in all, to analyze affective responses in product experience, what the context is and how people are engaged with the products should be understood (Desmet & Hekkert, 2007).

2.13. Contextual Factors

It is notable to consider an example from the perspective of sound designers: we perceive differently according to various contexts. For instance, a high quality car in a race should be considerably noisy, which directly refers to its powerful engine. But in a silent street, an example like a silent Honda car would suit the environment better than the race car regarding the sounds. As Russell (2009) sees it, we tend to perceive about how unpleasant or pleasant or rather how soporific or energizing a certain product seems to be. Representation of products also matters, as we have underlined it in the previous parts.

The relation between acoustic stimuli and listeners has been studied and it was found that auditory stimuli evoke emotional responses, which is highly context and meaning attribution dependent (Juslin & Vastfjall, 2008). Within the movie industry business, film producers are fully conscious of the background and accompanying music and sound effects that create emotions on people who are watching or looking on (Van Egmond, 2008). Interestingly enough, in movies, we sometimes can guess what is going to happen from the music itself before seeing the scene. It can either be a melody or a product sound (crashing, rotating so on and forth). On top of that, it was also discovered that people are able to connect some definite sound tracks with clear-cut film scenes quite precisely (Van Egmond, 2008).

Dominic & Gregg (1980) divided context in terms of auditory input into two categories as linguistic and auditory context. They related auditory context with everyday sounds, however they focused on linguistic aspects when it comes to identifying auditory aspects. In their study (1980) how we perceive sounds are dependent on the auditory context and how the form of a sentence is used in a given speech. That is to say, language as an external factor affects auditory perception of words and vowels.

Another study concerning semantic content of spoken sentences was done (Warren, 1970; Warren and Sherman 1974; cited in Bigand & Tillman, 2005). A certain phoneme (speech sound) was either replaced or completely removed by noise bursts within spoken sentences (shown by *). To provide an example, a sentence was used: 'it was discovered that a certain *eel was standing on a fruit' and as a normal function of the sentence surrounding, the listeners have been reported to have heard 'peel', 'meal, or a certain 'wheel' words in these three examples given. Interestingly enough, the study shows that auditory perception could be manipulated in different ways.

On the other hand, Bigand and Tillman (2005) stated that stimuli of environmental nature generally tend to be fragmentary, broken or even unclear and what is more, they keep changing from one certain state to the other perpetually. In other words, environmental stimuli can easily be manipulated. Bigand and Tillman (2005) also gives an example of a spherical orange which would be classified and taken like a tennis ball in the vicinity of a tennis court, further, this particular object would also be identified as a common fruit in a kitchen environment. That is to say the context where objects are perceived is remarkably important. Furthermore, their psychological content and meaning alter as a function of the whole context within which they are involved (Bigand & Tillman, 2005). It goes the same for the auditory experience. It was also put forward that aside from physical characteristics, the listening individual and the context also are considered to be significant factors when it comes to evoking emotional reactions towards auditory information (Vastfjall & Juslin, 2008; cited in Asutay et al., 2012)

We might need confirmation from context to identify the product sound. That is to say, a mechanical sound alone would not mean anything more than a working engine without the context such as an informative input referring to its outlook or at least a verbal input telling what it is. For instance, if we are in a street and hear an engine sound, we might think that it is coming from a motorcycle because we perceive the sound in a defined context. That is to say, one certain sound can evoke a particular affective response for only a listener-context mix while this subject sound is able to activate and prompt totally different affective behaviors and experiences for another listener (Asutay et al., 2012). Ballas & Mullins (1991) stated that, undoubtedly, if the same sound is produced exactly by two events, the only thing that can be employed to identify this certain sound is solely the context itself. For instance, if we hear a mechanical sound, we might not be sure about the source. But if we are informed about what kind of product it is or how it works, we can have a clear identification about the product and its sound then. Bigand & Tilmann (2005) found that perceiving pitch in music depends on the contextual factors. Apparently users need references in order to identify the stimuli according to the given context no matter whether it is auditory or a social context. Identification process has an effect on product sound experience, where knowing the source or not is also leading to an appraisal as mentioned in Section 2.10.2.

Craik (2013) found that people are far more tolerant of noise on a city street than in the privacy of their living room, and even a barely audible sound can be infuriating if it keeps someone from falling asleep. In other words, people who perceive the environment and context are more tolerant to noise. Tolerance can be counted as an internal factor as it is a cognitive process. This is an interesting finding which can be connected to internal factors, for that reason. However, it also has something to do with the sensory perception as people perceive the environment with sensory perception and it includes multisensory perception such as smell, visual aspects of the street. It is stated that overall product experience is related with the human, product and environmental factors within the interaction among users and products (Ozcan, 2014). Suppose that we have a very noisy coffee maker. When we make people listen to its sound, they might evaluate the sound as unpleasurable or noisy. But when we exactly show the source to the people in the preparation process, the feeling they have about the sound might change. Further, we can also add the smell of coffee beans to this context which directly refers to a very relaxing coffee time experience, the perception might completely change too.

There is a framework about context and setting done by Anderson et al., (1983) arguing that (1) the setting can prompt expectations concerning the sounds being heard in that particular setting (2) those expectations can possibly influence patience of noise as well as appreciation towards sounds, however, (3) certain qualities of various sounds -whether listeners expect them or not- are going to affect general evaluations of a certain setting.

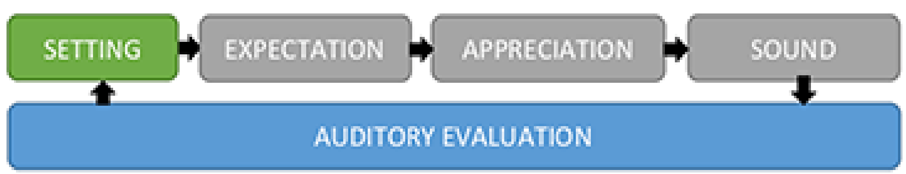

Figure 29. Setting and auditory evaluation.

Figure 29 clarifies the meaning of this model, as it is not clear without examples. The setting is the context given, which leads to the expectations and appreciations regarding the sound. These three together create auditory evaluation. However, auditory evaluation also can change the perception of a setting. Returning to the example of street noise, we perceive its sound by taking into consideration its external aspects, such as the appearance and the smell of the street, which contribute to the auditory evaluation.

2.14. Conclusion

Based on the literature on product sound perception, we confirmed that product sound experience is a step-by-step process where a sound source is perceived psycho-acoustically by evaluating aspects such as loudness and sharpness, which are perceived by using sensory properties. We have explained the internal and external factors which are the determinants of affective process, where it was explained how the emotional perception process is achieved in which mood, memory and other individual factors play a role in evaluation as well as the factors which are not related with sound. As a final part to this, a framework is proposed in which the importance of external factors has been added, referring to the studies concerning contextual factors on sound perception, showing a step-by-step process where a general approach regarding affective product sound experience is explained.

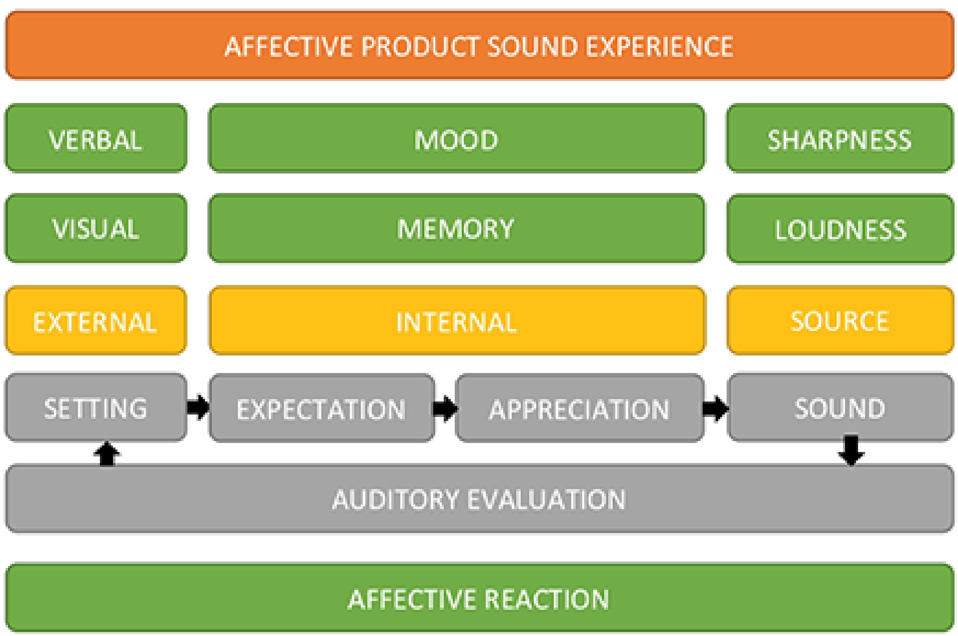

Figure 30. Affective product sound experience.

According to Figure 30, there are three factors that play a role in auditory evaluation: external factors, internal factors and the sound source. External factors are the contextual issues where the product exists, such as the visual, verbal or other environmental stimuli involved in the perceptional process. Internal factors are the cognitive factors, memory, mood or expectations belonging to individuals, which are believed to affect the experience. The third is the sound source, which is perceived by the human senses so it represents the physical aspects of sounds which influence sound perception. These three, altogether affect affective reactions to auditory stimuli. As Anderson et al., (1983) explained, this is a circular process where auditory experience also influences how the context is perceived as well as the other factors are continuously affected by the context.

All in all, these three factors seem to interact with each other as each of them play a remarkable role in affective product sound experience. However, we have also clarified that experimental studies are focused on only the small part of this framework as multisensory inputs is harder to analyze because it is affected by multiple variables. Following that, our study will focus on the visual context manipulations influencing product sound judgements and it will question whether and how contextual factors change product sound perception by conducting an experimental study. The details will be discussed in the next chapter.

CHAPTER 3

METHODOLOGY

Our literature review discussed about how people perceive sounds and focused on analyzing affective responses towards product sounds by discussing the internal and external determinants of auditory perception. In the light of this, we drew a conclusion that non-auditory input (external factors) are as crucial as auditory inputs in affective perception process: setting or environmental issues which are not directly related to sounds but the context were crucial in influencing affective responses. These external factors mentioned in the existing studies were mainly visual inputs or product-related contexts that were proved to influence auditory perception which will be discussed in the next sections in detail. Subsequently, the visual determinants in the existing studies of perception were reviewed and an experimental study was conducted to see the effect of visual input on affective auditory perception.

3.1. Visual Input on Auditory Perception

It is already known that visual input influences auditory quality perception (Hashimoto & Hatano, 2001; cited in Ozcan, 2014). Cox (2008) conducted a study and found that visual input on annoying sounds increased people's negative judgements regarding sounds. That is to say, showing the sources of sounds as visual input increased the intensity of the feelings that sounds evoke on people. Ozcan & Schifferstein (2014) had tested the effect of product visuals on how their sounds are perceived and denoted that visual input has significant effect on auditory perception of products which indicates that showing the products is influential.

Context-related visual information regarding products remain as one of the most crucial parts of products as they affect visual perception. Few studies were done to see the effect of visual input on auditory perception and to see if visual manipulations would create any change on people's feelings towards product sounds. Fenko et al. (2011) tested if visual patterns of products played a role in auditory perception of products by using various noisy patterns on products presented with auditory input; however, the judgements were dependent on the noisiness of sounds but not the noisiness of visual patterns they created.

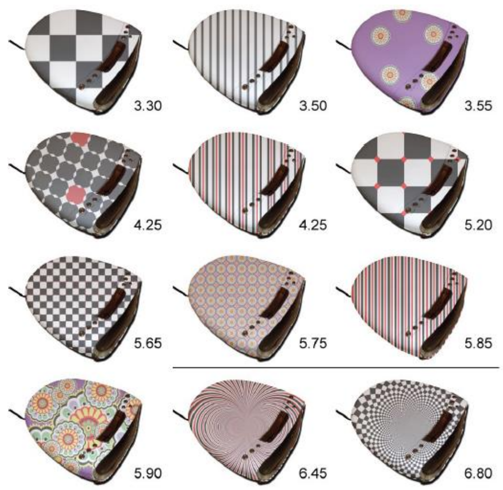

Figure 31. Product visualizations used in the study for alarm clocks (Fenko et al., 2011, p. 4).

Figure 31 Shows the visualizations used in the study: visual pattern apparently had no significant effect on product sound perception, albeit the patterns were not realistic, seemingly, they were intentionally created to be noisy. However, it would remain unclear if the designers would like to create patterns on products as an extra. On the other hand, useful data has been found on the effect of product colors on auditory perception which shows that colors have a significant effect on product sound perception. Thus we have found it reasonable to review the studies regarding colors and used the findings in our study which will be discussed in detail. Following that, valuable data has been collected on the affective perception of colors and how different colors are perceived as calm and warm may differ in terms of perception (Menzel et al., 2009). Previous colour research definitely has denoted that the colour red has been perceived as being tense, physically arousing and negative, whereas blue, as a different colour has been identified as positive, cool and calm (Bellizzi & Hite, 1992). Kaya and Epps (2004) stated that the colour red, which has been symbolically and historically known as dynamic and dominant, is said to have a stimulating and exciting hue effect. It carries not only positive but also negative impressions like passionate, active, warm and strong, and as opposed to expectations: raging, aggressive, intense and bloody. As for the colour green, it has been discovered to have a relaxing and retiring effect on individuals (Kaya and Epps, 2004). That is to say, red is generally perceived as tense and arousing, whereas blue and green are generally perceived as calm and cool. However, the levels of brightness and how salient the colors are, would also be important since they might have some differences in influencing perception. Following that, Menzel et al. (2009) conducted a study on the loudness levels of colors, in other words, the level of "cryingness" of colors referring to their power when compared to other colors. That is to say, colors also have loudness levels. But in order to prevent confusions, cryingness will be used for visual loudness, as auditory perception is referred to by using loudness. Experiments were conducted to understand the cryingness, in other words, loudness levels of sounds to see if there was a difference between crying and non-crying colors on loudness judgements (Menzel et al. 2009).

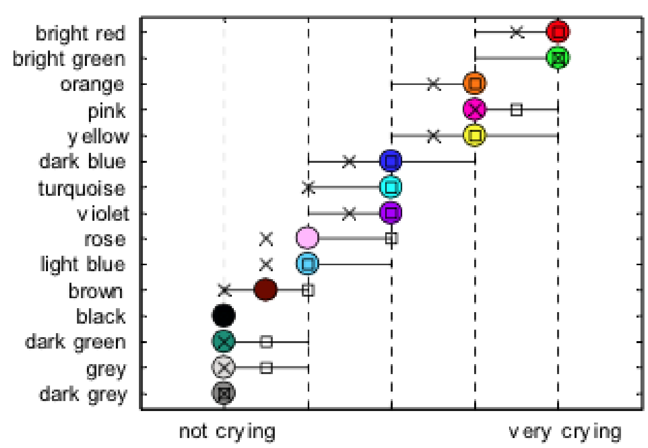

Figure 32. Cryingness ratings of colors (Menzel et al., 2009, p. 2).

The results were interesting: Figure 32 shows the cryingness levels of colors, medians (x) refer to female participants and squares refer to male participants. As it can be seen, red and green were rated as high in cryingness, whereas blue and more neutral colors like dark green and grey were rated low in cryingness in Menzel et al.'s study (2009).

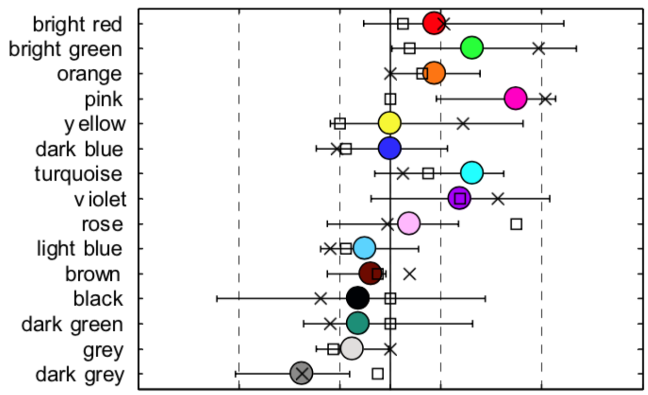

Figure 33. Average loudness (auditory) judgements of colors (Menzel et al., 2009, p. 2).

In the second experiment, Menzel et al. (2009) questioned how loud (in terms of auditory perception) these crying colors were when they were presented with acoustic stimuli and found that loudness judgements increase when people look at the crying colors while judging, whereas non-crying colors lead to induce loudness judgements. In Figure 33, red, green (crying) and magenta were rated high in loudness whereas dark blue, grey and black were rated low in loudness. As it can be seen in Figure 33, there are two types of green colors with differences of hue and brightness where the one who has a high level of crying is also perceived louder. These studies indicate that colors have influence on the physical (loudness) perception of sounds. On the other hand, Patsouras et al. (2002) conducted a study to understand if colors of trains had an effect on loudness perception, referring to the importance of loudness in annoyance judgements belonging to a product sound. That is to say, if auditory perception can be changed with the addition of colors, the annoyance of noisy products could be lessened.

Figure 34. Colors of the trains used in the study (white, red, green, blue) (Patsouras et al., 2002, p. 2).

In the study, images were digitally edited in red, green, blue and white colors (Figure 34), and Patsouras et al. (2002) found that the red train increased the loudness judgement, whereas the green one decreased it. However, in the study, they did not mention any arguments concerning the brightness or hue levels. But it can be seen, at least from the visual they prepared (Figure 34), that the colors did not have high cryingness levels because their brightness levels are low. Figure 35 shows the results of the tests of Patsouras et al. (2002). As it is shown, red leads to higher loudness judgements, whereas blue and green lead to lower loudness ratings compared to the original one.

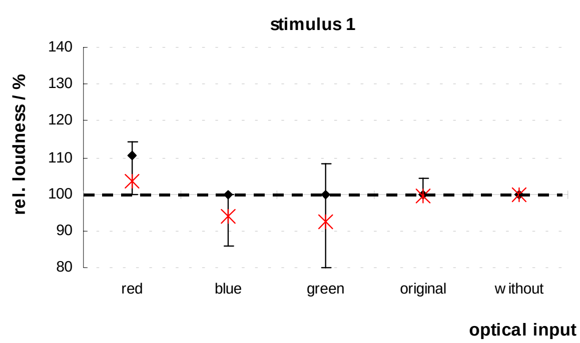

Figure 35. Results of the loudness ratings of colors (Patsouras et al., 2002, p. 2).

Interestingly, Patsouras et al. (2002) examined product (train) colors instead of just colors and found significant effect of product color on the physical (loudness) perception of product sounds. It is notable to mention that what they questioned is the product color as a contextual factor. However, in another study conducted by Menzel et al. (2010) no influence of color was seen in the loudness judgements towards trains. Parizet and Koehl (2011) also tested trains, there was no significant effect of color on the loudness perception, although there were some shifts in the judgements. These findings indicate that more studies should be done to lessen the unclarity of train sounds.

Apart from that, Menzel et al. (2010) went further and conducted a study with videos and visuals of cars with different colors separately in order to understand how color and the type of input change loudness judgements. Figure 36 shows the still car visuals prepared by Menzel et al. (2010) in red, green, blue and dark green, and Figure 37 shows the five moving images of a car in red, green, pink, dark green and white.

Figure 36. Still images of cars: colored in red, green, blue, dark green respectively (Menzel et al., 2010, p. 2).

Figure 37. Images taken from video clips in the experiment: Vehicles colored in red, green, magenta, dark green and white respectively (Menzel et al., 2010, p. 2)

It was found that bright red and bright pink augment the loudness judgements, whereas colors like grey, light green or pale reduce loudness ratings (Menzel et al., 2010). However, not enough information was given about the hue and brightness differences. On the other hand, although individual differences were found, results showed that the change in loudness ratings due to the colors remained the same in moving and still images (Menzel et al 2010).

Nevertheless, the difference among levels of hue of the same color remain unclear in the light of existing studies, as there are not enough studies concerning the difference in auditory perception of color with different hues. On the other hand, it was also found that (Menzel et al., 2009) colors themselves when they were shown to people with sounds did not create any shift in auditory perception (colors only with sounds); however, colored products (such as radio, train, car) were reported to have a significant difference in loudness perception.

All in all, it is clear that colors create a shift in auditory perception when they are presented with sounds. It is notable to mention that the studies we have discussed were questioning the physical perception of sounds which mainly dealt with the loudness levels. There were rather few studies (Bradley and Lang, 1999; Cox, 2008; Fenko et al., 2011; Ozcan & Schifferstein, 2014) questioning the affective responses towards product sounds with the accompaniment of visual input so it is not obvious how colors influence affective auditory perception. However, the existing studies provide empirical evidence that different colors cause shift in the physical perception so this evidence will lead our experiments for questioning the emotional responses towards product sounds. The following sections will discuss the pilot tests and the experiment in detail.

3.2. Experimental Studies

In order to answer the research questions, two pilot studies and a main experiment were conducted. The pilot studies led us to work on for more reliable tests and enabled us to try new set-ups. These pilot studies will be explained in the following sections after discussing the research questions.

3.2.1. Research Questions

The aim was to answer whether product color as an external factor has a significant influence on emotional judgements towards product sounds. It is notable to add that SAM (Self Assessment Manikin) was decided to use for measuring the affective responses towards product sounds for two reasons: it was used in the previous studies measuring affective responses towards visual and auditory inputs separately and together (Bradley and Lang, 1999). The second reason is that it measures three emotions (which were already discussed in the literature review) pleasantness, arousal and dominancy at the same time as affective responses are believed to be consisting of more than one emotion (core effect) which are related with each other. However, it was seen that the existing studies questioning emotions towards product sounds only measured the pleasantness-unpleasantness levels (Ozcan & Schifferstein, 2014) or annoyance levels (Cox, 2008), so we believe that the measurements with SAM would contribute to the studies regarding affective responses which lead to our research questions. Thus we have asked these research questions and sub-questions for our experiment:

- How does color as an external factor affect affective auditory perception of cars?
    - How do different product colors influence affective responses of people towards product sounds in terms of pleasantness?
    - How do different product colors influence affective responses of people towards product sounds in terms of arousal?
    - How do different product colors influence affective responses of people towards product sounds in terms of dominancy?

- How do the emotional judgements of auditory perception change according to the different visual inputs?

Secondary question:
As we had a gender balance in the experiment, gender difference was also tested for all of the research questions mentioned above, being an additional sub-question to our research:

- What are the differences in gender in the affective judgements of people towards product sounds within colors?

3.2.2. Product Selection

The product selection was made due to the findings from literature, as it was noted that noisy consequential sounds were mainly perceived as unpleasant and that is because they are the result sounds of working components of products. It was also discussed in our literature review that product sound manipulations were done in order to lessen the people's unpleasantness judgements towards noisy engine sounds but these attempts were not completely effective as the manipulation remained limited as consequential sounds are not easily changed. However, it was also pointed by us that an affective perception of a product sound could be changed due to the external factors which are not related with sound. Following that, we have decided to conduct an experiment with noisy engine sounds. The existing studies about visual effect on auditory perception were examined since they have tested products with noisy engine sounds of cars, trains, vans. In their studies Patsouras et al. (2002) and Parizet and Koehl (2011) used trains but the results were not convergent with each other, whereas Menzel et al. (2009, 2010) used different types of cars (sports cars and vans) mainly in their studies. For our experiment, we wanted to test how cars are perceived since they are doubtlessly very frequent noises in today's environment belonging to products whose outlook seems to vary due to the numerous design approaches (with color, form) which might influence auditory perception. We have also noted that car sounds also seem to be the main vehicle for travelling having the highest amount of registration with a percentage of 53.2 of total motor vehicles (20 million 350 thousand 893) in Turkey: according to Turkish Statistical Institute(retriewed from http://www.turkstat.gov.tr/PreHaberBultenleri.do?id=21604, in December, 2016).

3.2.3. Pilot Study 1

The first pilot study was conducted to test the sequence of the experiment and see how people experience the test and the survey. As the main question of the study was the 'effect of context' which refers to product color, it was not required to have more than one sound as a variable in the experiments. So the main variables of the study were cars in different colors, to reveal the differences among visual aspects leading the judgements. However, the usage of only one sound with numerous visual inputs would result with memory effect, thus the subjects would easily recognize the sound and would remember that it is the same sound presented with various visual input. In this case, it would not be possible to analyze the shift in auditory perception. So to reduce memory effect and labeling concerning sounds, it was decided to use four different sounds within the visuals in the tests. By comparing various types of engine sounds differing in terms of physical aspects could also be beneficial for checking if different sounds would have the same type of effect or if they differ for any reasons.

3.2.3.1. Auditory Input

Following the above-mentioned arguments, four car engine sounds, named X, Y, Z, T for this study, were retrieved from web-based sound libraries. The three main libraries that were used for the study were: Clyp (https://clyp.it), Soniss (http://www.sonniss.com/sound-effects) and ASoundEffect (http://www.asoundeffect.com/sound-category/vehicles/cars-vehicles/).
Several car engine sounds were taken into consideration and ten sounds were chosen out of them after analyzing their physical aspects in Adobe Audition CC. Then, four sounds that were closein terms of speed (similar) were selected to reduce differences in auditory perception due to rhythm and speed, as sounds were not the main variables in this study.

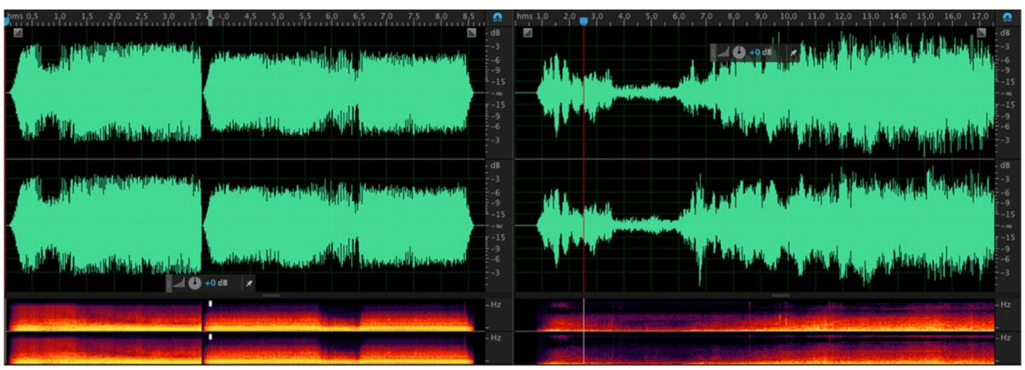

Figure 38. Auditory inputs: Loudness, frequency and pitch graphs of X and Y sounds analyzed in Adobe Audition CC.

Figure 38 illustrates the loudness, waveform (green parts) and pitch (highness or lowness of the tone) graphs of X and Y sounds. Green parts in the chart refer to the waveforms and the panel in the right shows dB(A) levels. Pitch is shown in the yellow and orange-colored parts, where yellow shows higher pitches, compared to orange parts.

Figure 39 illustrates the loudness, waveform and pitch graphs of Z and T sounds. As it can be seen, these sounds are different from each other in terms of pitch but have similar characteristics in terms of loudness levels. That is to say, only the tone between them is different. X and Z sounds have the similar characteristics in terms of frequency, where less interruptions could be heard. Y and T have similar characteristics in a way that a lot of interruptions and ups and downs could be heard, although the waveforms are different. By dividing these sounds into two as the first group (X, Z) having less interruptions and the second group (Y, T) having more interruptions, it was aimed to see whether they would create any memory effect on the ratings given by people to these sounds.

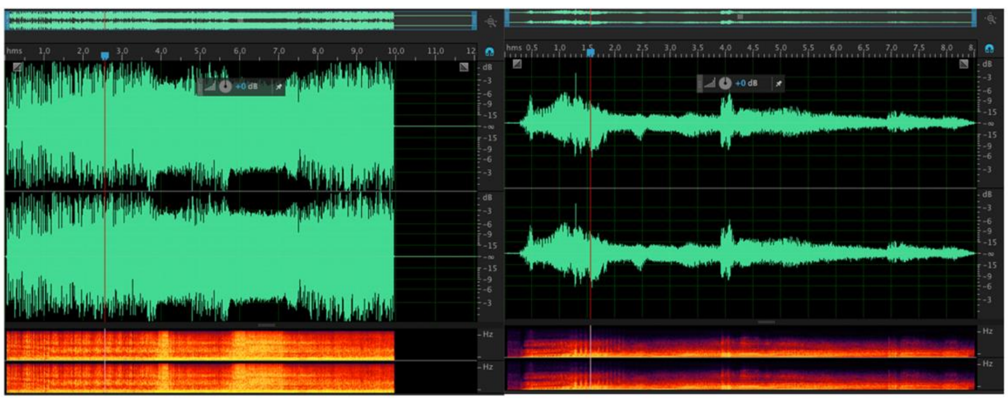

Figure 39. Auditory inputs: Loudness, waveform and pitch graphs of Z and T sounds analyzed in Adobe Audition CC.

3.2.3.2. Visual Input

Four cars were created with different colors in Adobe Photoshop CC, referring to the findings regarding colors from previous sections. Green, magenta, red and black (black might not be described as a color but we use the word here, not to create any confusion) colors were used for the visuals. Black was used because it had neutral ratings on the scales, whereas green was used for its effect on lower loudness ratings, and red as well as magenta were used for their effects on higher loudness ratings based on the studies of Patsouras et al., (2002), Menzel et al. (2009) and Menzel et al. (2010). Figure 40 shows the car images in four different colors used in the pilot study

Figure 40. Car images of Audi A8 used in the study colored in green, magenta, black and red, respectively.

So the point here was to use colors with different results in terms of loudness in previous studies (Patsouras et al., 2002; Menzel et al., 2010) to see how they would or whether they would differ in terms of affective responses. When it comes to the brand, Audi A8 was used as a product with the thought that it would be convenient to use one of the familiar brands. It could also be useful to analyze if colors have an effect on how their sound is perceived in order to contribute to the automotive industry.

3.2.3.3. Design of the Sequence

Within the aim of analyzing each sound-visual combination, the four sounds X, Y, Z and T were matched with each of the four product colors namely red, green, black and magenta, resulting in 16 items consisting of one sound-visual combination. Then, a video of these 16 items was made, one coming after the other. Each item took 15 seconds to watch and listen. The sequence of the video can be seen in Figure 41, where the 16 combinations are shown without overlaps of the same color and sound.

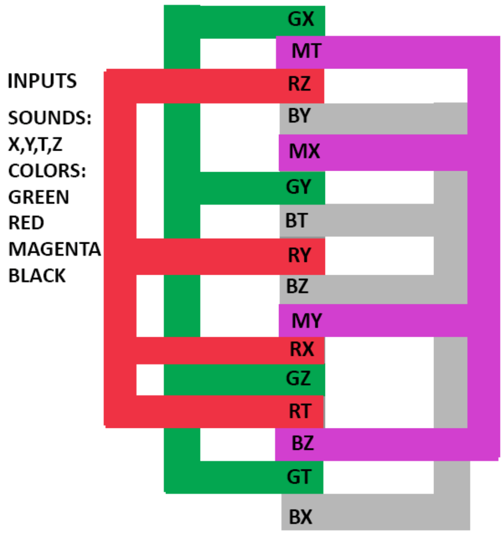

Figure 41. The sequence of the pilot test with the sounds X, Y, Z, and T and the colors green, red, magenta and black.

3.2.3.4. Experiment Set-up

Figure 42 illustrates the experiment set-up for each person at a time in a silent room, seated 30 cm away from the screen with headphones on, provided by the researcher. By doing that, it was aimed to avoid the possible shifts due to the difference in terms of distance to the screen and the possible changes due to technical and performance differences in the types of headphones owned by the participants.

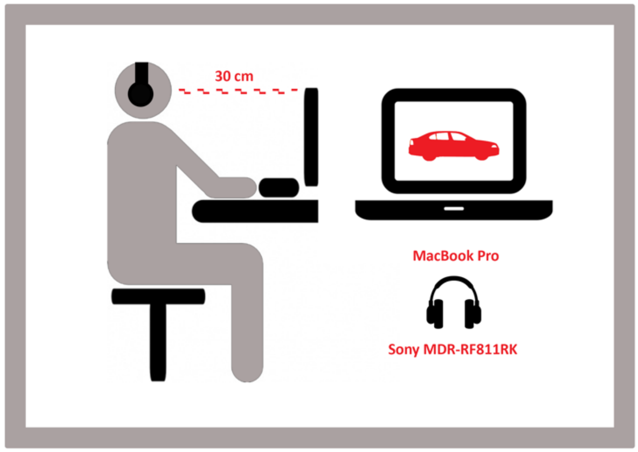

Figure 42. The-set up of the experiment.

Another reason for using headphones was the necessity to keep the sound levels and the hearing levels the same for each participant. Sound levels and volume were adjusted before the study, so that the users were not involved in changing. This was done to prevent possible shifts due to different levels of loudness.

3.2.3.5. The Survey

A survey form consisting of 16 items (one question for each item) was designed for the study. Each question had three sub-questions resulting in 48 sub-questions in total. Participants were asked to rate *pleasantness*, *arousal* and *dominancy* as required by SAM for each of the 16 items (auditory-visual pairs) from 1 to 5, with 1 indicating very low, 2 indicating low, 3 indicating neutral, 4 indicating high, and 5 indicating very high. The survey form was distributed at the experiment setting (see Appendix C).

The participants were given a form to fill in the following questions in the beginning with a consent form (see Appendix A):

- Age;
- Gender;

- Whether they are drivers;
- If so, for how long;

3.2.3.6. The Pilot Test 1

The test was conducted with three subjects as it was a pilot study conducted with the aim of understanding how people would react to the test and whether the time was enough for filling in the form throughout the time the videos were being shown (the duration was 15 seconds for an item). Each participant was located in front of the screen and was provided with headphones, with the researcher joining him/her during the video to check if it was working and whether the sound levels remained the same. The video took around five minutes for each participant, it was possible to stop the video while rating and then continue when the participant asked.

3.2.4. Outcomes of the Pilot Study 1

The outcomes of the pilot test led to change some settings about the experiment. Two of the participants (A and C) said that they could match one sound with one color, that is because the difference among the sounds was identifiable to them, where they could easily spot the difference between the sharp sounds and the smooth ones.

One of the participants (C) told that the brand of the car was identifiable to him, which was one of the models of Audi, which he thought had a unique sound and he had an expectation about it. All of the participants (A, B and C) agreed that the Audi brand has a specific label and seeing this on the car images seemed to affect participants' judgements both positively and negatively.

One of the participants (A) also told that the sequence was very important for her because she judged a present sound with the previous one. Therefore, if the sounds were different in terms of physical aspects, the researcher should be careful about how they are presented to people. This participant also told that she could not label sounds and visuals.

3.2.5. Discussion

In the light of the feedbacks gained from this initial study, it was decided to redesign the sequence, the visuals and the sounds for the below-mentioned reasons:

1. The effect of brand labeling is not something desired, as it can influence judgements.
2. The difference between sounds should not be dominant and easily identifiable as the main study focuses on the effects of visual input and sounds are not the main variables.
3. The memory effect of sounds in the experiment should be reduced in order to obtain reliable results.
4. The sequence would be designed again, but the order of items would not be shuffled each time, in order to avoid comparisons of two different sounds in different sequences. That is to say, for instance, a judgement of a sound with low sharpness after hearing an input with high sharpness would not be the same with the judgement of a sound with high sharpness after hearing an input with low sharpness. Thus, it was decided to have only one sequence for the test.

3.2.6. Redesign of the Test

According to the outcomes obtained from the Pilot Test 1, the sound types, visuals and sound-visual combinations were changed. The sequence of the test was also changed.

3.2.6.1. Visual Input

To begin with, the image of the car was changed as it was decided not to use any brand and thus a car image was chosen, the brand of which could not be recognized. Furthermore, the form should not be salient which makes it easy to spot the brand. Due to that, any brand effect on users could be reduced.

Figure 43. The car visuals used in the main experiment, colored in red, bright blue, white and green, respectively.

The product colors were also changed, where white was used because of it being one of the most popular car colors (white is normally a hue), and it being neutral, with almost no effect on loudness (Menzel et al., 2009). Red, blue and green remained as the main colors of the study. However the colors were made more salient than the car brand and form. Red was used to see how red affects ratings. Green is normally a calm color (Menzel et al., 2009) and the brightness level was not increased to see how users rate a calm color with sound. Blue is a calm color and is rated low in loudness judgements (Menzel et al., 2009) so it was also used in the study to see the effects. As a result, car images with two calm colors (green, blue) one neutral color (white) and one loud (namely crying) color (red) was obtained to investigate. The new version of car images and their colors can be seen in Figure 43.

3.2.6.2. Auditory Input

Two sounds were chosen from among the ten sounds determined for the pilot study, which were psycho-acoustically close to each other with a less salient difference in terms of interrupts to avoid labeling. The less salient interrupts can be seen in Figure 44, where the pitch and loudness levels are shown. As it is also clear from the graphs in Figure 44, the X and Y sounds are similar in terms of loudness and waveforms. So the physical properties were tried to keep as same as possible. However, there is a difference in terms of pitch (the yellow-orange parts); X has a high pitch but Y has a low pitch, referring to a difference in tone. This slight change is important since it is aimed to compare different sounds, limiting the number of variables to one, in order to have a more valid and reliable research. However, as the main idea was to analyze the effect of visual input, it was useful to have more than one auditory input to compare, as it was discussed in the previous sections.

The number of sounds to be analyzed were decreased to two and determined as X and Y, whereas the total number of sounds was increased to five by adding three more sounds 1, 2 and 3, as random sounds to be added among the main sounds to prevent the participants from remembering the main sounds and labeling some sounds on some colors.

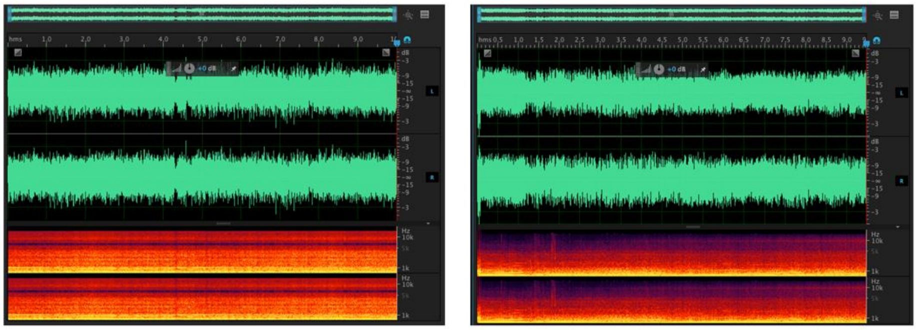

Figure 44. Pitch, waveform and loudness graphs of the main sounds X (left) and Y (right) manipulated in Adobe Audition CC.

The sounds were manipulated in Audacity and the breaks in engine sounds and any other noises that could make these sounds memorable were removed, in order to gain clear sounds. Participants could easily label them if there was a break in these sounds. As it can be seen in Figure 45, these sounds differ in terms of the frequency (the amount of cycles in the waveforms), where each of the sounds 1, 2 and 3 has a unique timing.

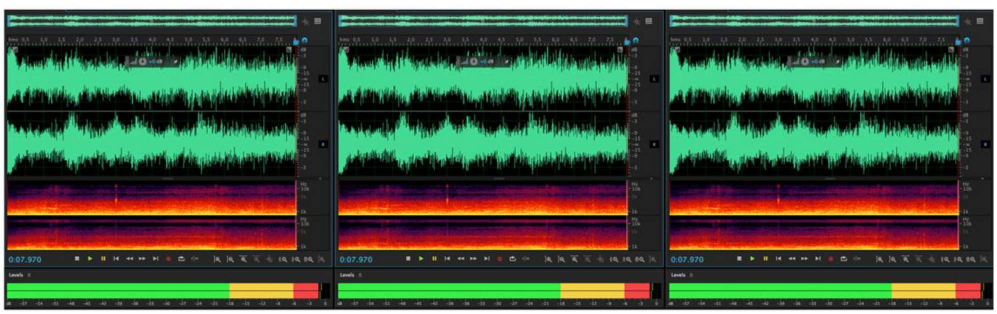

Figure 45. Pitch, frenquency and loudness graphs of sounds 1 (left), 2 (enter) and 3 (right) created in Adobe Audition CC.

Three random sounds were used for the sequence and were put among the main sounds to lessen the labeling effect that could occur hearing the main sounds for times. These sounds (1, 2 and 3) were not distributed in order as will be discussed in the following section. The durations of visual stimuli were set to 10 seconds.

3.2.6.3. The Sequence

The sequence of the test was changed. The two main sounds to be combined with four colors and the three secondary sounds to be used only to prevent memory effect, were specified. So only two sounds would be given with each color, and the other three sounds would not be given with each.

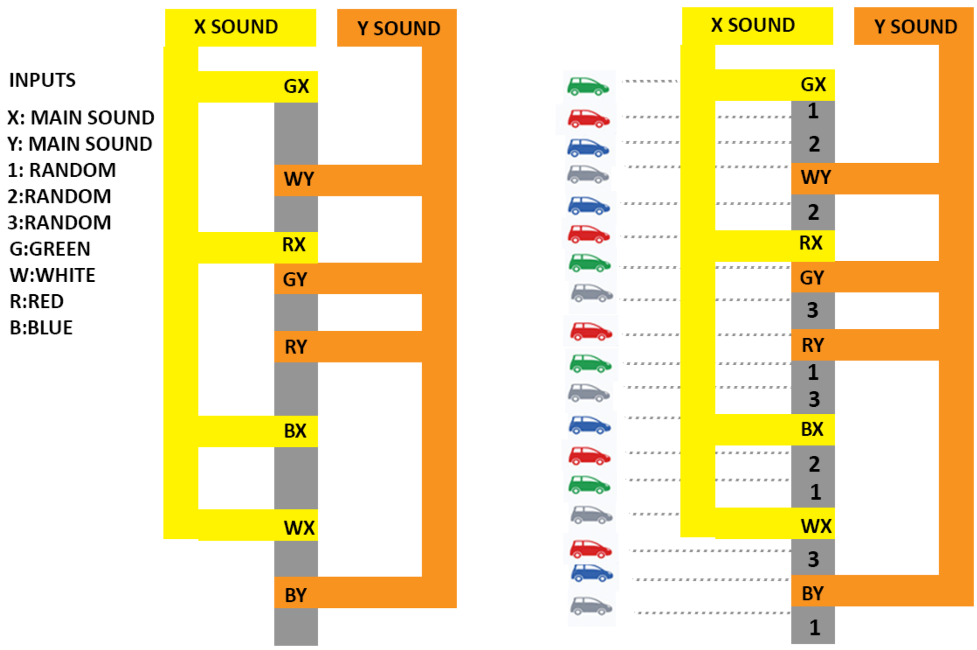

Figure 46. The sequence of the main experiment with the sounds X, Y, 1, 2 and 3, and the colors green, blue, red and white.

Figure 46 illustrates the new combinations for the sequence, where the yellow line represents the sound X sound and the orange line represents the sound Y as the main sounds. X is matched with G (green), R (red), B (blue) and W (white), whereas Y is matched with W (white), G (green), R (red) and B (blue), respectively. 1, 2 and 3 refer to the random sounds that were put to prevent remembrance of sounds and possible audio-visual labeling while listening. 1, 2 and 3 were matched with the colors shown in Figure

46. There were now 18 items instead of 16, and the number of randomized items were more than those aimed to be tested.

3.2.6.4 The Set-up

The test set-up remained the same, where a complete screen was used to show the cars and headphones were used for listening to the sounds. The participants were located at a distance of 30 cm away from the screen.

3.2.6.5. Redesign of the Survey

Some significant questions that could contribute to the analysis were added to the consent form (See Appendix B) These were as follows:

- Age
- Gender
- Education level
- Marital status
- If they have a job
- Monthly income
- The number of cars they have
- The number of cars they have bought
- Duration of driving

3.2.6.6. The Subjects

Fourteen (14) male and sixteen 16 female participants (30 in total) attended the test for an equal distribution of gender. Subject selection in the existing studies concerning color effect on sound perception was taken into consideration. Patsouras et al. (2002) conducted their study concerning color effect on loudness with nine normal hearing subjects (gender was not mentioned). In another study, Menzel et al. (2009) tested fourteen (14) people (6f, 9m) for the first experiment and fourteen (14) people (4f, 10m) for the second experiment, where they found no significant difference in gender. However, there was no explanation given for why there was no equal distribution among men and women. In another study concerning the effect of color on loudness perception, it was stated that eleven (11) subjects were used (Menzel et al. 2010), where no additional information regarding gender or age was given.

As high-quality equipment was not available for the study, and the participants' sensory perception could not be tested, 30 participants were used for this study. The participants were gathered from social media (fifteen (15) participants who were friends/acquaintances of the researcher were personally invited via facebook and e-mail), neighborhood (ten (10) participants were personally invited by the assistant (who was selected by the researcher to contribute to the study) and a pre-school (five (5) participants were gathered from the staff) in İzmir. All the candidates were asked some questions before the test to see if they were eligible for the test. The questions were as follows:

- Whether they had a professional musical education background
- Whether they had hearing-related problems recorded before
- Whether they had any problems in terms of seeing colors (color blindness, etc.)

Candidates were asked whether they had a professional musical education (conservatory or professional schools related with music) to make sure that they did not have a specific auditory education background, as this can lead to high sensitiveness to sounds, which might create differences in evaluating sounds. They were also asked if they have had hearing-related problems before, as sensory differences may create shifts in evaluation. As there were different colors in the study, candidates were asked if they had any problems in terms of seeing colors, to clarify that they are not color-blind and therefore can see each color efficiently.

Each candidate who did not have a musical background and who did not have any hearing-related (auditory) or color-related (visual) problems recorded, was invited to the test as they were thought to have suitable characteristics for the experiment. The level of education was not specified for participation in this study, as whether there is a difference among levels of education was also inquired.

The demographic information of the participants is given in Table 2. Information on the marital status of the participants and whether they were employed are not added, as no relation among these and auditory perception were found. If the participants did not use a car, zero (0) was written as the duration of driving in terms of years.

Table 2. Demographic information of the participants.

Participant no.	**Age**	**Gender**	**Income**	**Education level**	**Duration of driving in terms of years**	**No. of cars they had so far**
Participant 1	35-54	Female	3000+	Bachelor	20+	5
Participant 2	20-24	Female	2000-3000	Bachelor	0	0
Participant 3	25-34	Female	3000+	High School	0	0
Participant 4	15-19	Female	2000-3000	High School	0	0
Participant 5	35-54	Female	2000-3000	High School	0	1
Participant 6	20-24	Female	2000-3000	Bachelor	5-10	0
Participant 7	20-24	Female	2000-3000	Master	1-5	0
Participant 8	20-24	Female	2000-3000	Bachelor	0	0
Participant 9	25-34	Female	1500-2000	Master	0	0
Participant 10	55+	Female	2000-3000	Master	20+	7
Participant 11	20-24	Male	3000+	Bachelor	1-5	0
Participant 12	20-24	Male	1500-2000	Bachelor	1-5	0
Participant 13	20-24	Male	2000-3000	Bachelor	1-5	0

Table 2 continued

Participant 14	20-24	Female	1500-2000	Bachelor	1-5	1
Participant 15	25-34	Female	2000-3000	Master	0	0
Participant 16	25-34	Male	2000-3000	Master	5-10	1
Participant 17	35-54	Male	3000+	Bachelor	20+	3
Participant 18	55+	Male	3000+	Bachelor	20+	6
Participant 19	35-54	Female	3000+	Master	20+	6
Participant 20	20-24	Male	3000+	Bachelor	0	0
Participant 21	20-24	Male	1000-1500	Bachelor	0	0
Participant 22	25-34	Male	2000-3000	Bachelor	5-10	0
Participant 23	25-34	Male	3000+	Bachelor	1-5	1
Participant 24	25-34	Male	1000-1500	Master	1-5	1
Participant 25	20-24	Female	1000-1500	Master	0	0
Participant 26	35-54	Male	3000+	Master	20+	4
Participant 27	15-19	Female	3000+	High School	0	0
Participant 28	35-54	Male	3000+	Bachelor	20+	5
Participant 29	35-54	Female	3000+	Master	0	0
Participant 30	35-54	Female	3000+	Bachelor	0	3

3.2.6.7. The Pilot Test 2

The test was conducted on August 15 and 21, in a total of six days by the researcher or one assistant instructed by the researcher (Assistant A), with a laptop and a headphone, where s/he helped out with the setting and the adjustments of the test. Each experiment was done with one participant and the researcher/assistant in a silent room. Ten (10) participants attended the test with Assistant A and twenty (20) participants attended the test with the researcher. Each participant was firstly given a consent form (Appendix B) to fill in and each survey form (Appendix C) had brief descriptions of how users could rate and what the three sub-questions meant. The researcher/assistant also explained the process and answered questions regarding the process when necessary. It was made sure that everything was clear before the test and time was used for explaining. The experiment procedure was as follows: The participant was given 18 items (audio and visual pairs) in an order, to rate using the survey form. When the participant was ready to begin, s/he stated playing the video to the related sounds while looking at the related car image. Windows Media Player was used for the presentation of the videos one long video was made with all of the items. After each item, the participant rated the pleasantness, arousal and dominancy of the car sound from one (1) to five (5) on the survey form by hand, and then moved on to the next item, until all items were finished. Participants were allowed to ask for stopping the video after each item for rating and they were allowed to ask questions in those breaks. Each experiment took around seven minutes. The survey forms were collected to be processed. Figure 47 shows one of the participants during the test.

Figure 47. Participant 26 during the test.

3.2.7. Results of the Experiment, Findings and Discussions

There were some problems regarding the reliability of our test. The main reasons are as follows:

- The participants were not tested whether they had hearing or visual related problems and that would lessen the validity and the reliability of the test.

- The participants had different educational backgrounds, which could also create differences in controlling our analysis.
- During the test, it was allowed to stop the videos and ask questions where necessary so almost all of the participants wanted to stop at some point and ask questions about what arousal and dominancy are, although it was explained in the survey. Which indicated that the difference between arousal and dominancy was not clearly understood by the participants.
- The tests were conducted from two different computers with two different people at a time.

Subsequently, because of these reasons, the experiment was not found reliable enough to analyse it statistically. It was decided to revise and redesign the experiment by getting additional help from a professional cognitive scientist.

3.2.8. Redesign of the Experiment:

For the redesign of the experiment and the set-up, meetings held at METU School of Informatics, Department of Cognitive Science with Assoc. Prof. Annette Hohenberger in October, 2016. The inputs used in the experiment, the sequence, the set-up and the subjects were discussed in detail and the essential changes for reliability were done due to the advises given. Beneficial feedbacks about statistics and data analysis were also gained and shaped our analysis.

3.2.8.1. Revisions on the Experiment

Due to the outcomes of the pilot tests done, some changes were found essential to be made and some additional tests were included to make it more valid and reliable:

1. In the pilot tests, participants were not tested but asked whether they have normal hearing. As people might not be aware of their hearing problems, hearing test was added to see if the participants had normal hearing.

2. Similarly, participants were not tested for vision, but were only asked whether they had vision-related problems. Although having a driving licence was a proof that they were not color blind, not all of the participants had driving licence. So instead of doing that, a vision test was decided to be done for those who are not aware of their color blindness.
3. The tests could not be conducted in a sound laboratory, which would provide a sensitive venue to sounds. Thus, it was decided to use an empty isolated room for the next test.
4. Two different types of computers were for the test as there were two people who conducted it. Even though headphones were used, there could be the possibility of a difference in sound perception. Thus for the following test, it was decided to use only one and the same computer.
5. In the previous experiment, two people (a researcher and an assistant) conducted the study. However, in order to be more reliable, it was decided that only the researcher would conduct the following experiment.
6. There were numerous age groups considering the range of ages of the participants in the Pilot Test 2, which made it hard to statistically analyse the results. Therefore, it was decided to restrict the age and educational backgrounds of the participants.
7. The survey was given as a fill-in format on paper, which could interrupt the cognitive processes throughout experiencing the test, as participants had to look at the computer and then prepare themselves for filling the paper forms. Thus, it was decided to prepare a new version of a cognitive test on a computer-based program (OpenSesame), so that the subjects would only focus to the computer. By doing that, any types of interruption would be avoided.
8. In order to measure how people judge the sounds and the visuals by themselves only, these visual and auditory inputs were also given in the test separately, besides the sound+visual inputs, which will be discussed in detail in the next sections.

The changes in the light of the advises we decided to make will be discussed in detail in the following sections.

3.2.8.2 Visual and Auditory Inputs

The number and the type of visual input of the cars remained the same as in the Pilot test 2, as it was discussed in Section 3.3.1 Visual Input. However, blank screens in grey (sound-only items) were added to the test for the comparison of sound-only items with sounds+visual inputs. The reason for this was to be able to report if there is a difference between the judgements towards product sounds without product visuals and the product sounds with product visuals (colours). The amount and the type of the auditory input remained the same as in the Pilot Test 2, as it was mentioned in Section 3.3.2 Auditory Input. The durations of each item remain the same as 10 seconds.

3.2.8.3. The Sequence of the Experiment

The sequence of the experiment was changed as the number of the inputs were increased due to the addition of sound-only items. Figure 48 shows the new sequence of the inputs with the sounds X, Y, 1, 2 and 3, and the colors green, blue, red and white, with blank page (for sound-only items).

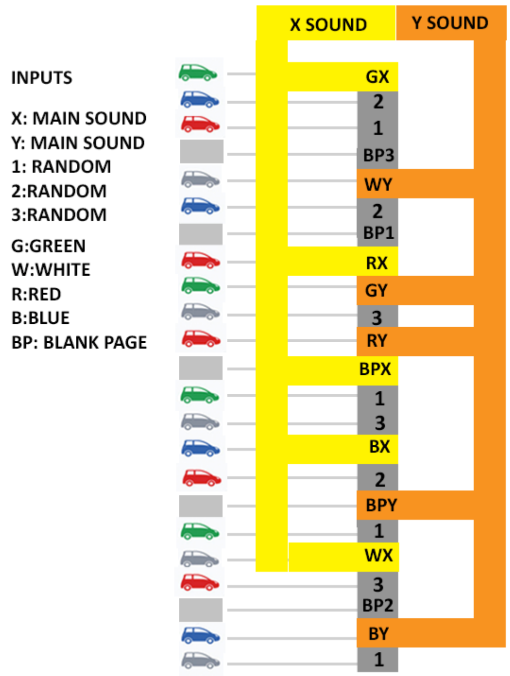

Figure 48. The new sequence with the new sound combinations with blank pages.

The yellow line shows the sound X combined with BP (blank page which is grey), G (green), R (red), B (blue) and W (white), whereas the orange line shows the sound Y combined with BP (blank page), G (green), R (red), B (blue) and W (white). 1, 2 and 3 refer to the random sounds and were matched with the colors shown in Figure 48. There were now 23 items instead of 18, due to the additional items.

3.2.8.4. The Set-up

The test set-up was changed due to the usage of OpenSesame, a cognitive test tool for experimental studies. The consent form and the survey form were added to it so everything would be conducted from computer, with the interaction of the participant.

The physical setting of the test remained the same, where a complete screen was used to show the cars and headphones were used for listening to the sounds (as explained in Section 3.2.3.4 Experiment Set-up). However, a PC laptop was decided to be used because OpenSesame required Windows.

3.2.8.5. Redesign of the Presentation Style

Due to the usage of OpenSesame, the presentation style of the test was changed. The instructions were written on the screen, where participants could interact with it themselves by clicking the buttons or using the keyboard when necessary. A consent form for the test was added to OpenSesame. After the participants read the form and felt ready, they could click on the "agree" button. And then, they were given explanations about Self Assesment Manikin and the three emotions they had to rate: pleasantness, arousal, dominancy respectively in detail by showing the visual form of SAM (The visual was explained in Chapter 2, Figure 25). The explanations were done in Turkish for each emotion: pleasantness, arousal and dominancy were translated into Turkish as "memnuniyet", "uyarilma" and "baskinlik", respectively. After then, the participants were asked to press "enter" and start the experiment when they felt ready.

As it was discussed in Section 3.2.8.3, there were 23 items in the experiment. Subjects were asked three questions after seeing each item in terms of pleasantness, arousal, dominancy, respectively (from 1 to 5). The sequence of the elements for an item on the computer screen was as follows:

1. Fixation screen with a three (3) seconds of duration (for distraction)
2. Item (auditory + visual input) with a ten (10) seconds of duration
3. Explanation of the next step with a three (3) seconds of duration(Figure 49 shows the representation of the fixation, main item and the question on screen).

Figure 49. The representation of the fixation screen, item and question.

4. The first question: How would you rate this product in terms of pleasantness? (switches to the next question when the subject answers it)
5. The second question: How would you rate this product in terms of arousal? (switches to the next question when the subject answers it)
6. The third question: How would you rate this product in terms of dominancy? (switches to the next question when the subject answers it)

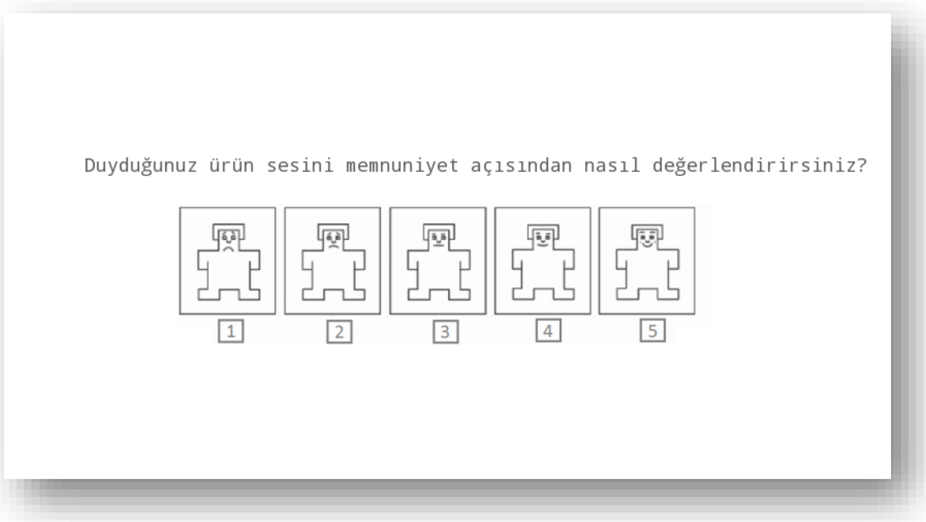

Figure 50. The representation of the first question (pleasantness) in Turkish on screen.

Figure 50 shows the representation of the first question. The three questions for SAM (Self Assessment Manikin) are asked one by one in order to not to confuse subjects. The visuals of each emotion are given with the question as well.

3.2.8.6. The Participants

In order to restrict the age range and educational background of participants, it was decided to carry out the experiment with university students belonging to the same department. Sixteen male (16) and (15) female participants (31 in total) attended the test for an equal distribution of gender (The main reasons of the number and gender balance were discussed in Section 3.2.6.6 The Subjects). The average age of the participants was 21. All of the subjects were from Civil Engineering Department at Ege University, İzmir. They were invited to the test in person by the researcher after introducing herself and her study. One (1) of the participants told that she had a hearing problem reported before. And for that reason, her results were not included in the analysis.

Two questions were asked to the participants before the experiment to track their situation. The questions were as follows:

- Whether they had previously reported hearing-related problems
- Whether they had previously reported any vision-related problems

Candidates were not asked whether they had a professional musical education (conservatory or professional schools related with music) this time, as they all belong to the same educational department at the same university. Each candidate who said he/she did not have any hearing-related (auditory) or color-related (visual) problems recorded, were invited to the further tests.

3.2.8.7. Hearing and Vision Tests

Before starting the experiment, each participant was required to take the hearing and visual-related tests to confirm that they have normal hearing and vision. The existing studies were examined for seeing how they tested their participants for the experiments.

For hearing test, there was not enough information given in the previous studies about the hearing tests which were done to the participants before main experiments: Patsouras et al. (2002) mentioned that their subjects had normal hearing however did not report which test they used. Menzel et al (2008) reported that all participants had normal hearing verified by pure-tone measurements but did not named which specific test they conducted. In other studies, Menzel et al. (2009, 2010) wrote that their participants did not show any signs of hearing problems, however they did not give any information about how they tested them. Thus, it was seen that no specific names of hearing tests were mentioned in the studies. However, it is notable to add that the hearing test should be conducted in the language that participants speak as a mother language because hearing tests have a section where they test "speech recognition" by using words as well. So in our case it needed to be conducted in Turkish, as the participants are Turkish. Thus for this study, Beltone Hearing Test was chosen which is an online hearing test provided in many different languages in the following address: http://www.beltonehearingtest.com/maxtone/. The website is especially designed for online hearing tests, so it starts with checking the type of speakers (the interface can be seen in Figure 51). Our participants were provided headphones so they selected the button on the left in the Figure.

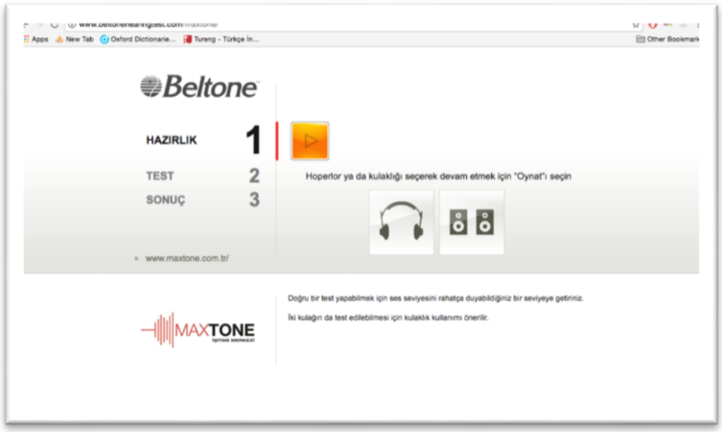

Figure 51. Hearing test speaker check (retrieved from http://www.beltonehearingtest.com/maxtone, in December, 2016).

Then the participants were provided loudness level check by the website for both speakers (left and right) can be seen in Figure 52. Adjusting sound levels are quite crucial for online tests as some of them might be less reliable if they do not have a reliable sound check.

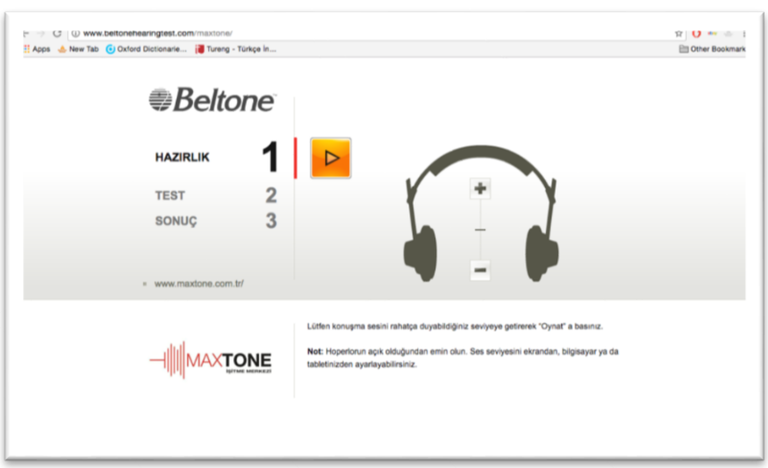

Figure 52. Hearing test sound level check (retrieved from http://www.beltonehearingtest.com/maxtone, in December, 2016).

After the sound check, the main test starts which consists of some auditory input and questions that participants answered online by using the computer and the test took around three to four (3 to 4) minutes. It reported whether the participant had normal hearing or whether he/she needs to see someone professional to check hearing problems. The interface of one of the pages with questions can be seen in Figure 53. The participants whose hearing was reported as normal by the hearing test, were asked to switch to the vision test.

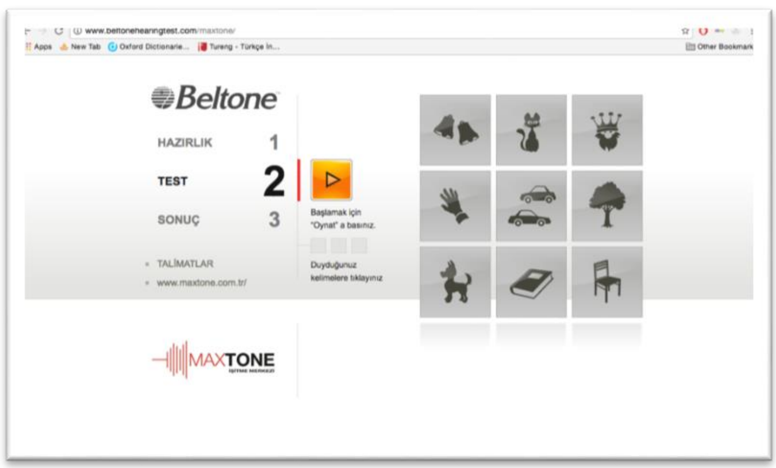

Figure 53. Hearing test questions (retrieved from http://www.beltonehearingtest.com/maxtone, in December, 2016).

When it comes to the vision test, Ishihara vision test is generally used in experimental studies, it was also used by Menzel et al. (2009) and Menzel et al. (2010) in their experiments to check if the subjects had normal color vision. However, in the study by Patsouras et al. (2002), vision tests were not reported so it was not obvious whether and how they tested subjects' vision. Thus, we also used Ishihara test to see if our participants had color-related visual problems or not from the following address: http://www.colour-blindness.com/colour-blindness-tests/ishihara-colour-test-plates/. This test was consisted of 24 colored items, can be seen in Figure 54. Each of the colored items measure different types of color blindness. The participants were asked to name the numbers or the shapes they saw, by the researcher in Turkish, because the website was in English.

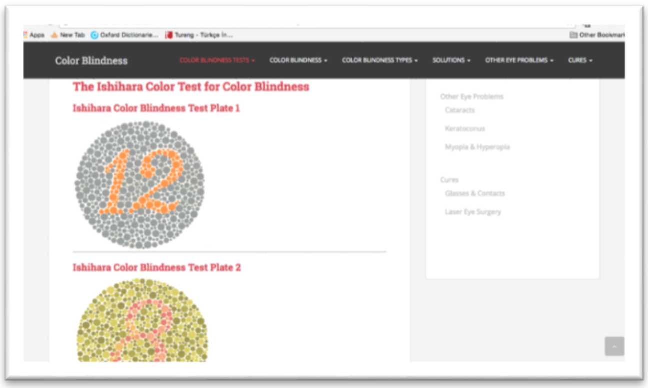

Figure 54. Ishihara colour plates (retrieved from http://www.colour-blindness.com/colour-blindness-tests/ishihara-colour-test-plates, in December, 2016).

The numbers could be seen when clicked on them to check if the participant was right. This action was done by the researcher, so the participants were not allowed to click on the numbers before giving the answers. The first item when clicked on it can be seen in Figure 55. This test took around one to two (1-2) minutes.

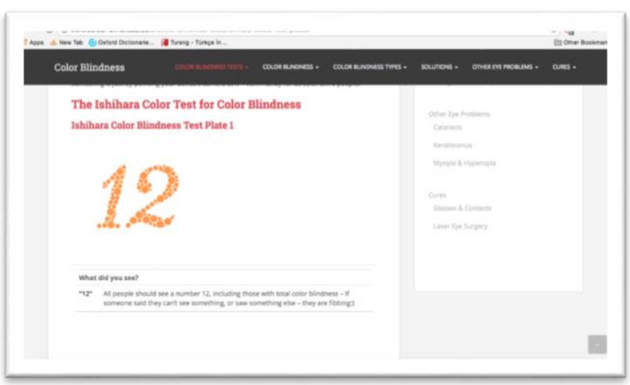

Figure 55. Color plates when clicked on them (retrieved from http://www.colour-blindness.com/colour-blindness-tests/ishihara-colour-test-plates, in December, 2016).

Following these two tests, the participants with normal hearing and vision were allowed to attend to the experiment. Thirty-one (31) participants attended the tests, one of them (1) did not have normal hearing and she got the result from the hearing test that "she needs to see someone professional to check hearing problems" but she had normal vision. Thus her results were not taken into account although she was allowed to continue to the experiment. So we had thirty (30) participants in total to take into account.

3.2.8.9. The Whole Process of the Experiment

The experiments were conducted between October 3 and 6, 2016 in a total of four days. The tests were conducted by the researcher with a laptop and a headphone, as she helped the participant with the preparation and the explanation of the test. Each experiment was done with one participant and the researcher in a silent classroom.

Each participant was firstly given a consent form in paper explaining the whole test (Appendix D). After signing the consent form, the researcher asked the participant some initial questions and recorded the answers by taking notes to paper. The questions were as follow

- Age
- Gender
- Whether they have a car
- If so, what color
- Duration of driving

After that, the researcher explained the sequence and the duration of the tests (as lasting approximately around twenty to twenty-five minutes), where they had to take the hearing and vision tests, and then switched to the main test. All the tests were made by using computer. The sequence of the whole experiment was as follows:

1. Short introduction and signing the consent form (in paper)
2. Hearing test

3. Vision test
4. The experiment
5. Comparison of visuals

The steps of the hearing and vision tests were explained in Section 3.2.8.7. Before the experiment, it was made sure that everything was clear to the participant, because it was not allowed to interrupt the main experiment or the videos for asking questions. None of the participants asked for an additional explanation during the test.

The main experimental procedure was as follows: The participant was explained about the process and SAM (Self Assessment Manikin emotions and how to rate them from the keyboard) after approving the consent form given by OpenSesame. The program itself guided the participants till the end of the experiment. Participants were then shown the visuals without sounds and were asked to rank the car visuals in four colors according to their pleasantness for them. The reason for this was to see if there is a relation between the responses towards the items and the visuals without sounds. Figure 56 and 57 show two of the participants during the test in a silent classroom at the Civil Engineering Building in Ege University.

Figure 56. Participant 19 during the test.

Figure 57. Participant 20 during the test.

The whole experiment, including the hearing and vision tests, took between twenty-four to twenty-nine (24-29) minutes per person.

The participants were given some snacks after attending as a reward. The demographic information of the participants is given in Table 3.

Table 3. Demographic information of the participants of the main experiment.

Participant no	**Age**	**Gender**	**Department**	**Car possession**	**Car color**	**Duration of driving in terms of years**
Participant 1	24	female	Civil En	Yes	White	10
Participant 2	24	female	Civil En	Yes	White	8
Participant 3	24	male	Civil En	Yes	White	6
Participant 4	26	male	Civil En	Yes	Grey	3
Participant 5	20	male	Civil En	Yes	Dark Blu	4
Participant 6	18	female	Civil En	Yes	White	4
Participant 7	24	female	Civil En	Yes	Grey	5
Participant 8	20	female	Civil En	No	None	0
Participant 9	33	male	Civil En	No	None	0
Participant 10	22	male	Civil En	Yes	Black	6
Participant 11	23	male	Civil En	Yes	Green	5
Participant 12	20	female	Civil En	Yes	Grey	1
Participant 13	20	female	Civil En	Yes	White	1
Participant 14	23	male	Civil En	Yes	White	5
Participant 15	19	male	Civil En	No	None	0
Participant 16	19	male	Civil En	Yes	Grey	3

Table 3 continued

Participant 17	20	male	Civil En	No	None	0
Participant 18	26	male	Civil En	Yes	White	4
Participant 19	20	male	Civil En	Yes	Dark Blu	4
Participant 20	21	male	Civil En	Yes	White	3
Participant 21	25	female	Civil En	Yes	Grey	6
Participant 22	21	male	Civil En	Yes	Grey	2
Participant 23	19	male	Civil En	Yes	White	8
Participant 24	22	male	Civil En	No	None	0
Participant 25	20	female	Civil En	Yes	Grey	6
Participant 26	23	female	Civil En	Yes	White	5
Participant 27	19	female	Civil En	Yes	White	4
Participant 28	18	female	Civil En	No	None	0
Participant 29	18	female	Civil En	Yes	Grey	3
Participant 30	18	female	Civil En	No	None	0

3.2.9. Data Collection

The data was collected by OpenSesame automatically where it records the participants' answers (rates from one to five) to a table in Microsoft Excel (one document for each). Then those results were rewritten by the researcher into a table in SPSS software to analyze and calculate the data.

3.2.10. Expectations from the Experiment

Expectations from the conduct of this experiment was to see the possible changes in either of the emotional ratings *pleasure*, *arousal* and *dominance*, while judging product sounds according to the different product colors. The secondary expectation is to analyse whether these three emotions belonging to SAM (Self Assesment Manikin) would have any relation with each other, for instance if there is a relation with pleasantness and arousal for a specific combination, it could be beneficial to report it.

As the literature review gave information on how the colors red, green, blue and white are perceived differently when accompanied by sounds, it was expected that participants would rate red (as a loud color) different from green (which is believed to reduce loudness judgement) and blue (which is a calm color and also reduces loudness judgements). So that is to say, we could expect that different colors which lead to different auditory judgements might lead different affective judgements. Also white was used in our study as a neutral color to see whether it would differ from the other colors that had different loudness shifts in the previous studies, as it remained neutral when compared to other colors (Menzel et al., 2009; Menzel et al., 2010). No differences were expected regarding gender apart from minor ones (in the study by Menzel et al., 2009, women were found to be more sensitive to green and pink, whereas men were found to be more sensitive to red but it was not significant). Similarly no main effect of gender effect was seen in the auditory judgements in the previous studies (Patsouras et al., 2002; Menzel et al. 2009, 2010).

It is also notable that we will be testing the affective judgements which are not physical which may differ from the results regarding loudness judgements that were done in the above-mentioned studies, so our study is not a confirmation of the studies dealing with physical auditory perception, but something new questioning the affective responses towards product sounds. Thus the results might not be convergent with the previous studies.

3.3. Data Analysis & Results

In the previous studies questioning the effect of vehicle color on auditory perception, analysis of variance and T-tests (Menzel et al., 2010) were used to see medians of shifts of the ratings. Menzel et al. (2008) also used repeated measures for analysis of variance using colours as *within-subjects factors* to measure how colors influenced auditory perception. In another study two-way repeated measures (analysis of variance) were used by Menzel et al. in 2009. In the light of these**,** the collected data was analyzed by using SPSS (Statistical Package for the Social Sciences) software by the professional help of Assoc. Prof. Annette Hohenberger (METU School of Informatics). The results were calculated by using Mixed Anova with gender as a *between-subjects factor*, and color and sound as *within-subject factors*. There are two sounds: X and Y and five levels of colors as follows: no color, green, white, red and blue. The data is non-normally distributed, which usually calls for non-parametric tests; but non-parametric tests could not handle multiple variables such as gender, color and sounds (three independent variables) at the same time, thus parametric tests with Anova were done.

To obtain the answers to the research questions, *pleasantness*, *arousal* and *dominancy* rates are analyzed separately for the product sounds (X and Y) and the mixtures of these sounds with five levels of colors. The affective ratings (from one to five) of participants for four cars with different colors (green, white, red, blue) within X and Y sounds were analyzed in terms of pleasantness, arousal and dominancy. Similarly, the affective ratings for sound-only (for X and Y sounds) and visual-only (cars with four colors) were analyzed for having a comparison among the sound-only and visual-only items and the sound+visual combinations.

The main variables were the car visuals varying in colors within the same sound (X) for this study. However, in order to have a more valid analysis, two different sounds were compared to be able to see if there is a same type of effect evoked by colors in both of the sounds. So the two different sounds (X and Y) were analyzed within the combination of cars with four colors. It should be reminded that X and Y sounds are physically very similar to each other, whereas the only difference among them is that the X sound has a higher tone than the Y sound.

Car possession variable was to see if the judgements of participants with cars would differ when compared to the judgements of those without cars. However, it was dismissed from the calculation as the number of participants was not equal: twenty-three (23) participants were using cars whereas seven (7) participants were not; therefore, this distribution was not statistically convenient for the analysis.

3.3.1. Results

In this section, the statistical results of affective judgements towards two product sounds (X and Y) within five (5) color combinations (no color, white, green, red and blue) will be discussed for *pleasantness*, *arousal* and *dominancy*, respectively.

3.3.1.1. Pleasantness Judgements towards Product Sounds (X, Y) within Product Colors

According to the results, there was no main effect of product sound seen on the *pleasantness* judgements of participants towards product sounds within product colors ($p>.05$). This indicates that there was no significant difference in the pleasantness judgements of participants towards the two sounds (X and Y) that are physically different as X having a higher tone than Y, while judging product sounds within product colors. Thus X and Y sounds had the same effect on participants in terms of pleasantness.

There was not any significant influence of product colors on the pleasantness judgements of participants towards product sounds within product colors ($p>.05$). This shows that product colors were not significantly different from each other when accompanied by product sounds in terms of the pleasantness judgements of the participants.

However, there was significancy in terms of the combination of some of the variables: There was significant interaction between product sound and gender, $F(1.28)=4.88$, $p=.036$, $_{p}^{2}=.148$. Males rated the pleasantness of two product sounds similarly (Sound X: M=3.38, SE=0.15; Sound Y M=3.30, SE=0,16). On the other hand, females rated the Y sound more pleasant (M=3.19, SE=0.17), compared to the X sound (M=2.79, SE=0.16). Mean ratings of females and males for both sounds can be seen in Figure 58.

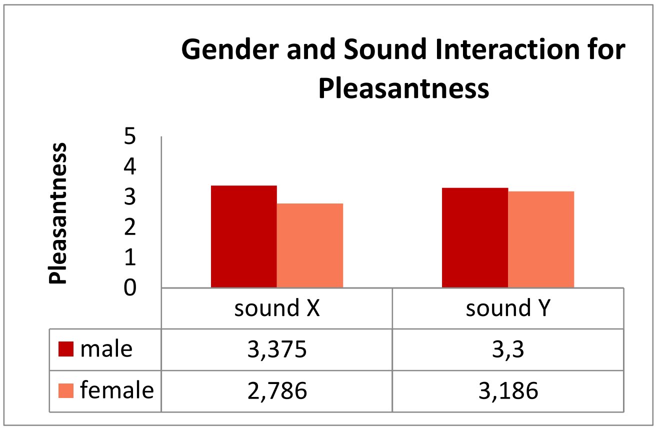

Figure 58. Mean ratings of females and males for both sounds.

According to the results, females' judgements towards the high frequency sound (X) and the low frequency sound (Y) were different, as they found the low frequency sound (Y) significantly more pleasant than the high frequency sound (X). On the other hand, there was no significant difference seen in the pleasantness judgements of males towards the high frequency (X) and low frequency (Y) sounds. All in all, sound and gender interaction is a significant factor on the pleasantness judgements of product sounds. This indicates that sounds having different physical aspects could matter in terms of pleasantness of males and females.

There was no significant interaction found between gender and product color ($p>.05$), likewise, there was no significant interaction found among product sound, product color and gender ($p>.05$) in the pleasantness judgements towards product sounds within product colors.

3.3.1.2. Arousal Judgements towards Product Sounds (X, Y) within Product Colors

According to the results, there was no significant difference among the ratings of males and females in terms of *arousal* judgements on the product sounds within product colors (p>.05). That is to say, both genders responded similarly to the arousal judgements of the product sounds within product colors.

There was a main effect of product sound seen in the arousal judgements of participants towards product sounds within product colors, $F(1,28)=22.5$, $p=.000$, $_{p}^{2}=.446$.

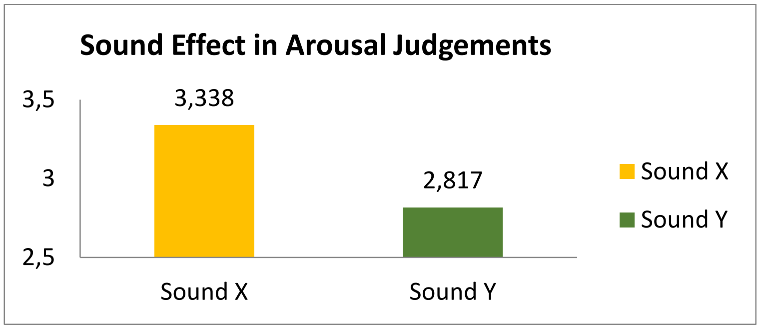

Figure 59. Sound effect in arousal judgements of the participants.

As seen in Figure 59, Sound X, which has a higher tone, was judged higher in arousal than Sound Y, which has a lower tone. This finding indicates that the physical difference in tone was significantly different in terms of the arousal judgements.

There was no main effect of product colors seen on the arousal judgements of participants towards product sounds within product colors (p>.05). This indicates that product colors were not significantly different from each other when accompanied by product sounds in terms of the arousal judgements of the participants.

There was a significant influence of the interaction of product color and product sound seen in the arousal judgements of participants towards product sounds within product colors, $F(4,11)=6$, $p=.000$, $_{p}^{2}=.178$. The degrees of freedom are 4 and 112.

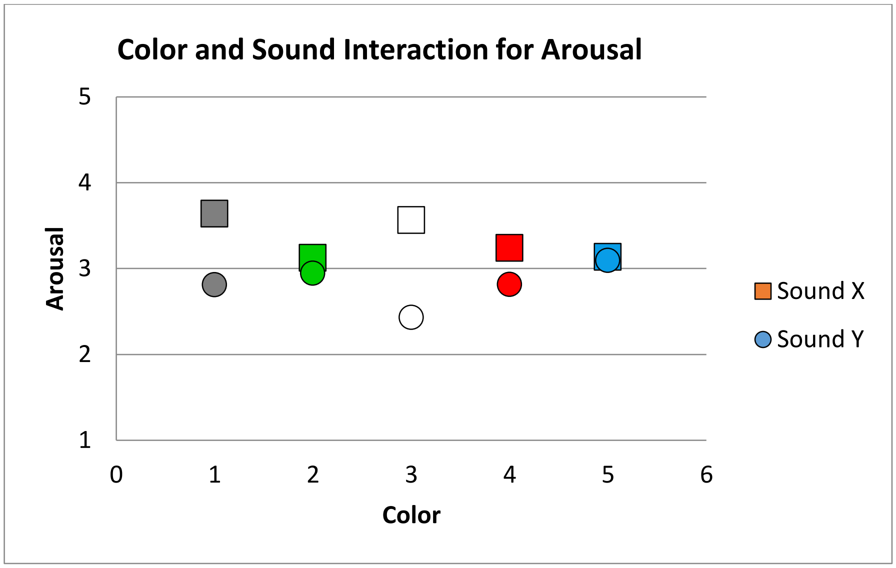

Figure 60. Color and sound interaction for arousal.

Figure 60 shows the color and sound interaction for arousal. The squares represent the mean ratings for Sound X and the circles represent the mean ratings for Sound Y from one (1) to five (5). The grey shapes represent the grey screen (blank page, no color accompanied by sounds X and Y) whereas the other colored shapes are representing the product colors (car) green, white, red and blue, accompanied by product (engine) sounds X and Y respectively. As it can be seen in the figure, arousal judgements towards product sounds changed significantly for both sounds (X and Y) due to the addition of the different product colors. Especially for green and blue, the difference among the ratings of sounds in arousal seem to approach zero, which indicates that the difference in the ratings of the sounds (see item number 1, Figure 60) were decreased significantly due to the usage of green and blue (see items number 2 and 4, Figure 60) product colors. However, the difference in the arousal ratings for white (see item number 3, Figure 60) product color accompanied by X and Y sounds was not decreased whereas red product color (see item 4, Figure 60) also lead to a decrease in the difference between the arousal judgements of two product sounds (X and Y). Interestingly, the addition of product colors seems to cause a decrease in the arousal judgements towards Sound X, whereas the same effect seems to cause an increase in the arousal judgements towards Sound Y. That is to say, this particular interaction among product colors and product sounds shows that the addition of product colors had a significant effect in terms of the arousal judgements but differed for both product sounds that are physically different (X being higher in tone than Y). Thus it is obvious that product sounds and product colors both play significant role in a combination. And the affective results may vary significantly when different combinations are made. On the other hand, only the affective ratings of white color with both sounds (X,Y) did not get closer to each other, which indicates that white color (which is a neutral color) did not have a significant effect on product sound judgements regarding arousal as the ratings for sound-only item (see number 1, Figure 60) and white color with product sound (see number 3,Figure 60) are close to each other. However, red, green and blue colors had the same pattern and effect on the product sound judgements in terms of arousal.

There was no significant interaction found between product color and gender ($p>.05$), also no significant interaction was found among product sound, product color and gender ($p>.05$) in the arousal judgements towards product sounds within product colors.

3.3.1.3. Dominancy Judgements towards Product Sounds (X, Y) within Product Colors

In parallel to the arousal ratings, there was no significant difference among the ratings of males and females in terms of dominancy judgements towards the product sounds within product colors. That is to say, both genders responded similarly to the dominancy judgements of the product sounds within product colors ($p>.05$).

There was a main effect of product sound seen in the dominancy judgements of participants towards product sounds within product colors, $F(1,28)=16$, $p=.000$, p2=.363.

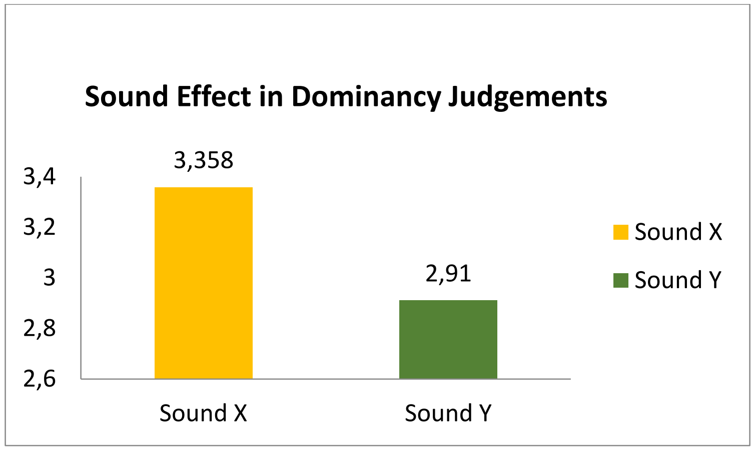

Figure 61. Sound effect in dominancy judgements of the participants.

As it can be seen in Figure 61, Sound X, which has a higher tone, was judged higher in dominancy than Sound Y, which has a lower tone. This result shows that the physical difference in sounds X and Y (in terms of tone) was significantly different in terms of the dominancy judgements.

There was no main effect of product color seen on the dominancy judgements of participants towards product sounds within product colors ($p>.05$). This particular result verifies that product colors were not significantly different from each other when accompanied by product sounds in terms of the dominancy judgements of the participants.

There was a significant effect of the interaction of product color and product sound seen in the dominancy judgements of participants towards product sounds within product colors, $F(4,11)=3.2$, $p=.016$, $_{p}^{2}=.103$.

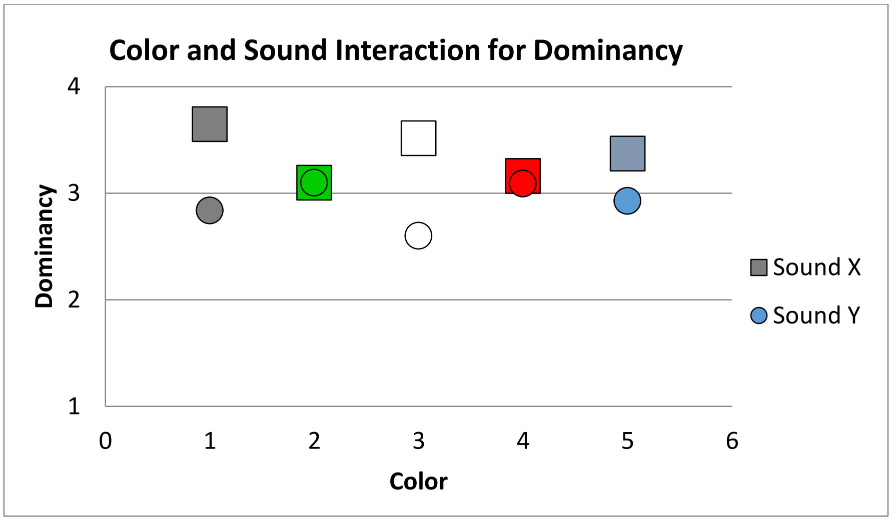

Figure 62. Color and sound interaction for dominancy.

Figure 62 shows the color and sound interaction for dominancy. The squares represent the mean ratings for Sound X and the circles represent the mean ratings for Sound Y from one (1) to five (5). The grey shapes represent the grey screen (blank page, no color accompanied by sounds X and Y) whereas the other colored shapes are representing the product colors (car) green, white, red and blue, accompanied by product (engine) sounds X and Y respectively. As it is shown in the Figure 62, dominancy judgements towards product sounds had a significant change for both sounds (X and Y) due to the addition of the different product colors. The pattern is similar with the arousal ratings (in Figure 60) as the difference among the ratings of sounds in arousal seem to approach zero, which shows that the difference in sounds (see item number 1, Figure 62) were decreased significantly due to the usage of green and blue (see items number 2 and 4, Figure 62) product colors. Nevertheless, the difference in the arousal ratings of white (see item number 3, Figure 62) product color was not decreased whereas red product color (see item 4, Figure 62) caused a decrease in the difference between dominancy judgements of two product sounds (X, Y). Similar to the arousal judgements, the addition of product colors seems to cause a decrease in the dominancy judgements towards Sound X, whereas the same effect seems to lead an increase in the dominancy judgements towards Sound Y.

Similarly, the interaction among product colors and product sounds indicates that the addition of product colors had a significant effect regarding the dominancy judgements but was different for both product sounds that are physically different (X being higher in tone than Y). Thus, white as a neutral product color did not have the same effect that red, green and blue product colors had in terms of dominancy. This finding also confirms that product sounds and product colors both play significant role in a combination parallel to the arousal ratings.

There was no significant interaction found between product color and gender ($p>.05$), also no significant interaction was found among product sound, product color and gender ($p>.05$) in the dominancy judgements towards product sounds within product colors.

3.3.1.4. Pleasantness Judgements towards Product Colors

Friedman's one-way analysis of variance was used to calculate how participants ranked the colors of cars (visual only). It was to question whether there is a relation among people's visual preferences and the affective ratings towards product sounds within product colors.

Overall the difference among the colors on pleasantness judgements was found significant, $H(3)=18.930$, $p< 0.001$. White > red >blue> green (Mean rank of white=2.03, red=1.97, blue=1.69.31, green=0.31), shows that green was ranked significantly lower than the other colors together.

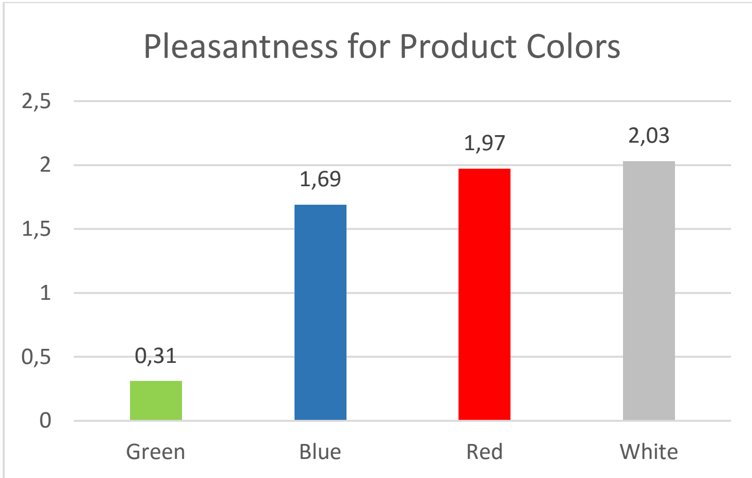

Figure 63. Pleasantness judgments for product colors

Figure 63 shows the preferences of the participants in terms of pleasantness. White was the most pleasant color according to the participants' responses regarding the product colors, whereas the green was the most unpleasant one (The rating system was calculated from one (most pleasant) to four (least pleasant) according to the judgements of participants). However, there was no significant relation among participants' pleasantness judgements towards the product colors and their judgements towards the product sounds within product colors. That is to say, participants did not necessarily judge the any of the product sounds within colored cars significantly more pleasant due to their visual preferences towards product colors (visuals-only). Subsequently, there was no color effect of visual pleasantness in the pleasantness judgements of participants towards product color within product sounds. This indicates that the affective judgements of product colors and product colors within product sounds were independent from each other.

CHAPTER 4

DISCUSSION

According to the findings of the experiment, arousal and dominancy judgements have yielded the same pattern with similar results and were quite different than pleasantness judgements. Thus they will be examined and discussed in different sections by revisiting the research questions for the experimental study.

4.1. How Do Different Product Colors Influence Affective Responses of Participants towards Product Sounds in Terms of Pleasantness?

Due to the results of the experiment, there was no main effect of product color on the affective judgements in terms of pleasantness towards product sounds within product colors; that is to say, product colors did not affect how product sounds were perceived. This was surprising and unexpected since it was expected that there would be a significant change or a shift in the pleasantness judgements evoked by different product colors on product sounds, having had the point that colors did have significant difference in auditory perception in the literature review (Patsouras et al., 2002; Menzel et al., 2008; 2009; 2010). Subsequently, there was a significant difference in the pleasantness ratings of different color visuals of cars in the experiment, where the most pleasant product visual was the white car and the green car was rated as the most unpleasant (significantly lower than the other colors). However, there was not any significant difference of the white car within any of the product sounds in terms of pleasantness when compared to other product colors within product sounds. This shows that there was no relation among the affective judgements of the participants towards product colors and product colors within product sounds, as colors and color-visual combinations were judged independently. That is to say, the components (visual, and sound separately) of the combinations (visual + sound) had different pleasantness ratings due to their presentation with or without each other.

4.2. How Do Different Product Colors Influence Affective Responses of Participants towards Product Sounds in Terms of Arousal and Dominancy?

As arousal and dominancy ratings yielded the same pattern due to the results, these will be answered together in the same section. It is also important to report that in terms of SAM (Self Assessment Manikin) the pleasantness judgements varied significantly compared to arousal and dominancy, whereas these two had the same pattern in terms of the judgements towards product sounds within product colors. In other words, it is admissible that the responses towards audiovisual (sound + visual) items created parallel changes in terms of arousal and dominancy but not in terms of pleasantness while judging product sound within product colors. Nevertheless, this point of view is not yet comparable with the previous studies as they were not questioning emotions that sound evoke so SAM (Self Assessment Manikin) was not used for them to see the effect of color in auditory judgements. Nonetheless, it would be useful to have this record for further studies with SAM for examining the emotional responses.

Returning to the ratings of arousal and dominancy, there was a main effect of sound for both, in which the participants judged Sound X (higher in tone) higher in arousal and dominancy than Sound Y (lower in tone). This means that a physical difference caused a significant change in the arousal and dominancy judgements, whereas it did not in the pleasantness judgements. Which indicates that a physical difference might cause a change or not depending on the type of emotion we test.

There was a significant interaction between sound and color in terms of affecting arousal and dominancy judgements towards product sounds. This means that although color and sound seemed independent from each other, their combination became statistically significant in terms of the judgements towards both sounds. More interestingly, it was noted that the physical difference in product sounds X and Y caused a significant difference in the arousal and dominancy judgements of participants, whereas when the sounds were accompanied with product colors, this difference seems to decrease and the ratings for the sounds X and Y became quite close for arousal and dominancy (the differences were close to zero for green and blue for both sounds). That is to say, the results for product sounds were quite different from the results for the product sounds within product colors. That confirms that product colors do have an effect on how product sounds are perceived in terms of arousal and dominancy. However, it is crucially important to add that the sounds were not the main variables, they had main effect on influencing affective responses. But this significant effect reached to zero when these two sounds were accompanied with product colors and further, the pattern for each color was the same for arousal and dominancy.

4.3. What are the Differences in Gender in the Affective Judgements of Participants towards Product Sounds within Colors?

There was a significant interaction with product sound and gender in terms of pleasantness judgements towards product sounds. This finding was not expected, because there was no gender difference noted in the earlier experiments concerning sound perception (as discussed in Section 3.2.10).

Interestingly, gender difference was noted in the studies concerning color and loudness, where females and males were found to be sensitive in judging different colors as well as judging colors accompanied by sounds. That is to say, differences were found in either color variety or colors with sounds. Those previous results suggested that auditory shifts would occur with the main effect of visuals (colors) as gender had difference in judging visuals and visual+sound combinations. Nevertheless in this study, no color effect was seen in terms of gender, but females judged two sounds (which were different in tone) significantly different than males. A difference in auditory perception (a difference in the physical aspects of sounds) was seen in this study, which indicates the opposite to the earlier studies. It is also worth mentioning that the reveiwed studies were questioning loudness, which is a physical property in terms of auditory perception. However, this study questioned the affective responses evoked by auditory perception, which could also be one of the reasons why the results were quite different than the results of earlier studies.

There was no effect or any interaction of gender seen in the arousal and dominancy judgements of participants towards product sounds within product colors. That is to say, males and females responded similarly.

CHAPTER 5

CONCLUSION

The main aim of this study was to analyze how people perceive product sounds emotionally in the light of the internal and the external determinants of sound perception and to demonstrate that contextual factors that are not related to sound can have a significant influence on product sound perception.

This chapter begins with the overall summary of the literature review, methodology and results, and continues with revisiting the research questions in regard of the overall insights gained from the study. Then it explains the limitations of the study and suggests ideas for further research.

In the literature review, the human perception systems and how people perceive and evaluate sounds were discussed by asking the sub-question*: How do people perceive and react to product sounds?* That being the case, how people react to sounds has been discussed and the affective responses towards sounds were explained. The main question was asked as *how do internal and external factors affect product sound perception*, in order to analyze internal and external determinants of auditory experience and
a general framework out of the findings was created. *How the affective responses towards product sounds can be manipulated* was asked and subsequently, the current attempts for manipulating components of the products to change affective product sound perception were discussed as well as the new suggestions about manipulating the contextual (external) aspects of products that might influence sound perception. It was then asked *how product contexts influence product sound perception* to review the current studies questioning visual effect on product sound perception. With the aim of answering the research questions, the existing studies from literature review were combined and a small

experimental study concerning the *product color effect on affective product sound perception* was conducted in order to support the argument that psycho-acoustical measurements are not enough to understand affective product sound perception as contextual factors should also be analyzed within the product sounds. The research questions will be discussed in the next sections.

5.1. How Do People Perceive and React to Product Sounds?

This sub-question was answered based on the literature review. People firstly perceive sounds with their senses and they process them in their cognitive systems dealing with the psycho-acoustical factors of sounds as a first step in sensory perception. This refers to the physical perception that requires no consciousness, and might lead to affective responses as pleasant or unpleasant depending on the tonality, sharpness and loudness of product sounds. However, cognition process for sounds is supported by internal factors (those belonging to individuals) and external factors (contextual factors that are not related with sounds), which altogether, influence affective auditory perception. Affective responses are mainly pleasantness or unpleasantness towards product sounds. However, they might change due to internal and external factors (which will be discussed in the next parts in detail). Further, more than one emotion can contribute to how people react to these sounds: such as a highly noisy and a dominant engine sound leading to a feeling of irritation due to the core effect, which suggests that more than one emotion is created towards an event.

5.2. How Do Internal and External Factors Influence Affective Product Sound Perception?

This was the main question of the study and a framework to answer this question was already proposed in the literature review. And then, it was reframed according to the results of the experiment. The first version of the framework explained (can be seen in

Figure 64) the three determinants of affective product sound experience. These were namely the external factors, the internal factors and the sound source which contribute to the auditory evaluation. External factors are the factors of a product or its representation (context) that are not related with the sounds. The environment where products are shown or the other multi-sensory properties, such as tactile properties or the smell of the product/environment, could be examples for external factors. Internal factors were the individual factors influencing auditory perception such as mood, memory or the emotions that influence expectations and appreciations regarding product sounds.

And, the third one was the sound source where physical input contributes to the sensory perception. These three main factors contribute to affective product sound experience.

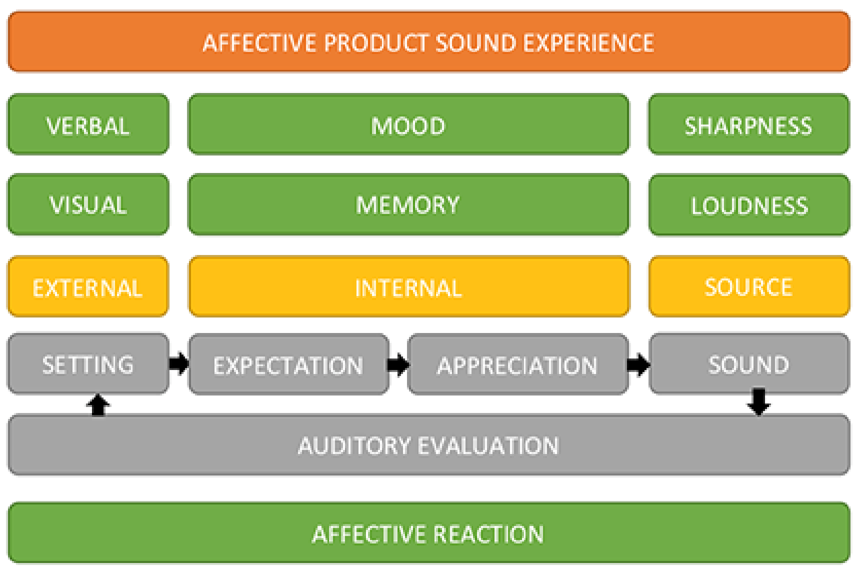

Figure 64. Framework for affective product experience.

5.3. How Can Affective Responses towards Product Sounds Be Manipulated?

It was discussed in the literature review that product sound designers are focusing on manipulating physical aspects of sounds for changing the affective responses towards noisy sounds (to make them less unpleasant). There already are remarkable studies on manipulating the sound sources, as car companies are focusing on the manipulations of car sounds (Van Egmond, 2008), evaluating car door sounds (Parizet et al., 2008) or analyzing the physical components of cars (Bezat et al., 2014). However, it was also underlined that psycho-acoustical measurements and changes do not suffice to have a remarkable change in the affective responses towards product sounds since their components that cause noisy and unpleasant sounds cannot be changed. The existing studies questioning the internal and external factors suggest that these factors might contribute to the manipulating of affective responses. Internal factors are mainly individual dependent thus hard to change, but product contexts are promising to change affective responses (Ozcan, 2014); if we are to give any information regarding the product, such as visual or verbal input, those might influence or change the affective responses.

As the next steps to this research question mentioned above, existing studies suggesting that context has a valuable effect on product sound perception were reviewed (this will be discussed in the following heading) and to confirm the influence of context on affective responses towards product sounds, the effect of color was questioned (this will be discussed in the following sections).

5.4. What is the Effect of Product Context on Product Sound Perception?

Based on the findings from the literature, it can be said that visual stimuli have significant influence on auditory perception, both negatively (Cox, 2008) and positively, as visual and auditory input separately (Ozcan and Schifferstein, 2014) contribute to the overall perception. Visual input or verbal input, as they are the components of product contexts (Ozcan, 2014), can lessen the unpleasantness and might cause pleasantness in the affective auditory judgements when they are added to product sounds.Visual input also increases the intensity of the feelings towards product sounds (Cox, 2008). As an addition to those mentioned, there are several studies (Patsouras et al., 2002; Menzel et al., 2008; Menzel et al., 2009; Menzel et al., 2010) demonstrating how color affects auditory perception in terms of loudness; some colors lead to higher loudness ratings whereas some lead to the opposite when they are added to sounds. The findings of these studies indicate that visual contexts (mainly product colors) have a significant effect on creating a shift in auditory perception. To support these arguments, a small experiment was conducted with 30 participants to see how product colors influence affective auditory perception when they are presented with product sounds. According to the results, it was shown that product colors had an effect on the affective responses of participants when added to product sounds. In other words, emotional responses towards product sounds changed by adding product contexts. Moreover, Ozcan (2014) found that adding contexts lessens the unpleasantness of product sounds. However, there were shifts in the arousal and dominancy judgements of people in this experiment, whereas no significant changes were seen in the pleasantness judgements towards product sounds when accompanied by product colors.

5.5. What is the Effect of Product Color on Product Sound Perception?

In the methodology of this particular research, how product color as a contextual factor influences affective responses towards product sounds was tested. To explain what was done, the framework suggested based on the literature review (Figure 64) was adjusted according to the inputs used in the experiment (Figure 65). Green parts (on the left in Figure 65) refer to the variables used: product colors were used as external factors, whereas engine sounds X and Y which had a difference in tone (pitch) were used as the secondary variables (discussed in detail in the methodology), referring to the sound source (on the right in Figure 65). A gender balance was maintained in the study to have equal numbers of females and males; however, it was not expected to see anything regarding gender, as no gender effect was noted in the previous studies concerning auditory perception (so gender as an internal factor is not on the visual). Subsequently, whether or not internal determinants such as memory or mood had an effect on product sound perception were not tested so these parts have been left grey in Figure 65.

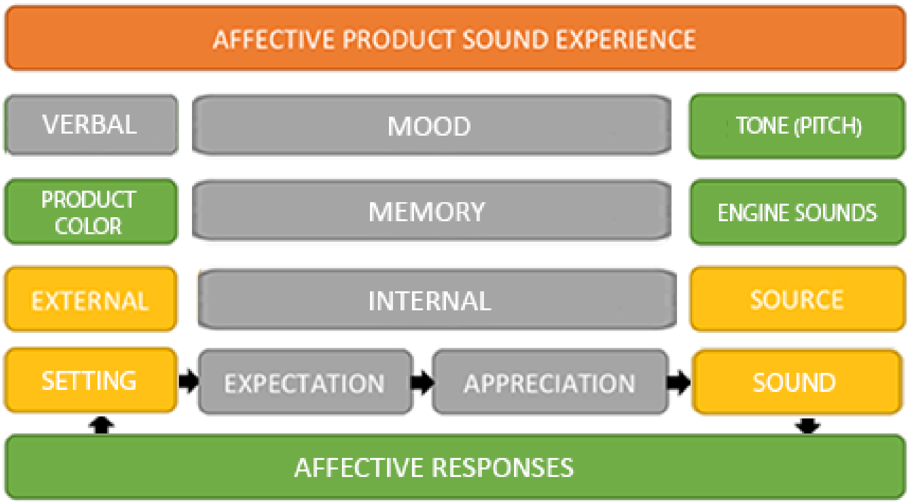

Figure 65. Adjustment of the framework to the experiment.

According to the results obtained from the experiment, there were different patterns for pleasantness compared to dominancy and arousal, whereas dominancy and arousal yielded the same pattern with each other in terms of the judgements: there was a significant interaction of product colors and product sounds for arousal and dominancy. It was discussed in the results section that product colors led to lower arousal and dominancy judgements for the sound X (higher tone), whereas the same product colors led to higher arousal and dominancy judgements for the sound Y (lower tone). Only white was an exception where the difference among the mean ratings of X and Y sounds were not decreased, they remained almost the same for arousal and dominancy. Aside from that, product colors when added to product sounds reduced the difference among the ratings of two physically different product sounds towards zero. This finding indicates that product color as a contextual factor had a significant effect on the affective judgements towards product sounds in terms of arousal and dominancy where it seems to break and change the affective judgements evoked by the physical auditory perception (affective responses evoked by sensory perception). That is to say, what was measured in terms of sensory perception (sounds-only) was changed due to the cognition induced by product colors.

Moreover, the pattern was the same for green, red, and blue with one another for arousal and dominancy. This particular effect induced the relevancy of our findings regarding the influence of colors.

However, there was not the same influence for both sounds, as product colors influenced the judgements in the opposite way by increasing the ratings for the X sound and decreasing the ratings for the Y sound. This shows that the effect of product colors are in a two-way interaction with product sounds in influencing affective auditory perception and each combination might differ from each other significantly. All in all, it is admissible that product colors changed the affective judgements according to their interaction with product sounds.

When it comes to pleasantness, there was no main effect of product color seen on the affective judgements towards product sounds within product colors. This indicates that the results of this study are not similar to the previous studies concerning color influence on auditory judgements where significant differences in red, green, blue, and white were found in terms of loudness. Due to this, it can be admitted that the studies concerning the physical perception of sounds (namely auditory perception) do not have similarity with the results regarding affective responses towards product sounds within product colors. All in all, product colors did not influence the pleasantness judgements whereas they influenced the arousal and dominancy judgements in the same way for three colors: red, green and blue except for white.

5.6. Gender Difference as an Internal Determinant

Finally, as another important aspect of the study, it was found that there was a gender difference in terms of pleasantness judgements towards the sounds X and Y, where females and males rated the product sounds differently. Gender as an internal determinant was not reviewed in the literature; however, gender had a significant influence on auditory judgements of people in this experiment. So, the framework was reframed and *gender* as an internal factor was added as a determinant of affective product sound experience (Figure 66). On the other hand, it was not clarified whether gender has to do with expectation or appreciation or other issues related to cultural factors, as we did not have any information about gender in the previous studies. The question remains unclear. As the framework (Figure 66) was to show the determinants of product sound perception and was revised after the methodology of this study, further studies can contribute to it with a lot more experimental studies. And more elements regarding external (product smell, product tactility), internal (psychological situations) or source factors could be added to it.

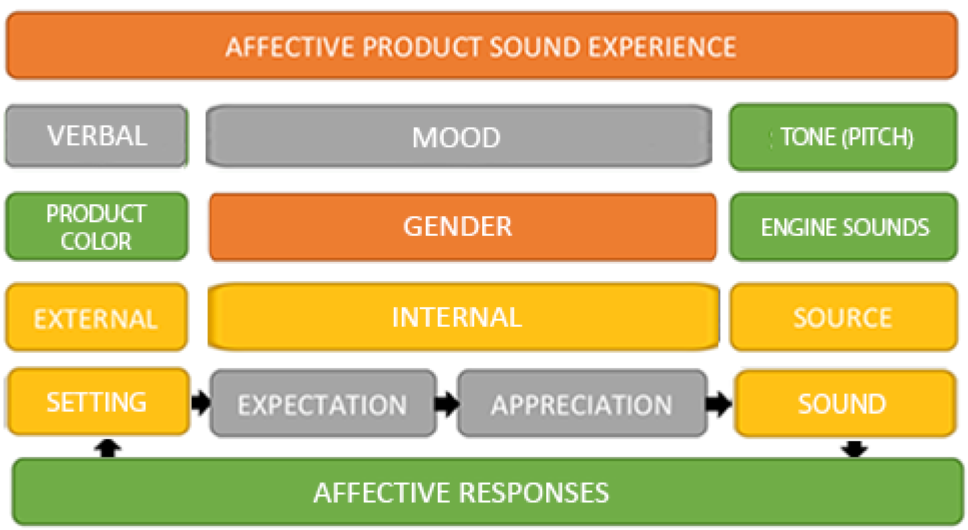

Figure 66. Adjustment to the framework based on the results of the experiment.

Our overall findings indicate that external and internal factors are in an interaction with each other in a way that every combination is unique and needs to be analyzed step by step as the combination differs from its determinants significantly. Similar to what Ozcan and Schifferstein (2014) suggested in their study, visual and auditory inputs separately contributed to each other, as visual judgements did not have any relation with the affective judgements towards product sounds within product colors in the experiment.

5.7. Outcomes of the Research and Suggestions for Further Studies

All in all, our study aimed to show that psycho-acoustical factors were not sufficient in analyzing auditory perception towards product sounds and that the product contexts played a remarkable role in affective sound experience. In the light of our experiment with car colors and engine sounds, we have found that product color as a contextual factor had a significant effect on the affective judgements towards product sounds in terms of arousal and dominancy by showing that the product colors were able to change emotional shifts evoked by the physical aspects of sounds. That is to say, we would not be able to understand how people exactly felt towards these product sounds and product colors together if we would only focus on analyzing the emotional responses towards the physical aspects of sounds as the findings from the literature and the experiment showed that whether internal or external, each addition might have a potential to cause a significant difference in terms of the affective responses towards product sounds.

It is admissible that the studies regarding product sound perception are new and thus very few. And most of the studies have mainly focused on the physical aspects of product sounds by questioning the auditory elements of the product separately. For instance, they only take the auditory aspects of products to measure how people perceive product sounds (Blauert and Jekosch, 2012; Bezat et al., 2014) and do not test sounds with the other sensory inputs. We hope that our study will trigger people to broaden their research from auditory oriented analysis to a multi-sensory oriented level as products could better be analyzed as multi-sensory objects, meaning that the context, or the elements that products have, are in a significant interaction with their sounds which might have a multi-sensorial effect on auditory perception. This type of interaction, as can be seen from the frameworks (Figures 64, 65, 66), introduces a multi-sensory level of analyzing product sound perception. Hopefully, by the help of multi-sensory analysis, designers might focus on designing products in a multi-sensory level where they can test their products by changing their multi-sensorial aspects (product color, contexts, external factors) to manipulate affective judgements towards their products. In this way, by manipulating different aspects of products, they can lessen the unpleasantness of an auditory aspect belonging to products. On the other hand, there is a suggestion by Ozcan (2014) that positive emotions towards product sound experience could be created by adding product contexts. However, as we did not report any significant effect on the pleasantness judgements towards car sounds with car colours in our experiment (changes were seen in arousal and dominancy judgements), it is not clear how those affective judgements might influence people's preferences towards products with sounds, more studies would be needed for clarifying this particular issue.

5.8. Limitations of the Study

There are few studies concerning the contextual effects on sound perception and they were mainly questioning the physical aspects (loudness) of product sounds. There are studies that question the influence of visual input on auditory judgements (Cox, 2008; Ozcan, 2014) but these do not test the addition of product colors. Therefore, more studies concerning the affective responses towards product sounds are needed.

Further tests with different types of sounds are required to compare more sounds and see whether or not colors have the same kinds of effects on the auditory perception of these sounds.

There is a limitation in terms of measuring the affective responses towards product sounds as the measuring tools for product visuals do not seem to have valid results. SAM (Self Assessment Manikin) was the only affective measurement system used for measuring affective judgements towards sounds and visuals. However, it was not used for analyzing the affective judgements especially towards product sounds before, it was used for random sounds including some products as well.

REFERENCES

Altinsoy, M. E. (2011). The Role of Expectation on the Judgment of Vehicle Sound Quality.

Altinsoy, M. E. (2012, August). Knocking sound as quality sign for household appliances and the evaluation of the audio-haptic interaction. In International Conference on Haptic and Audio Interaction Design (pp. 121-130). Springer Berlin Heidelberg.

Anderson, L. M., Mulligan, B. E., Goodman, L. S., & Regen, H. Z. (1983). Effects of sounds on preferences for outdoor settings. Environment and Behavior, 15(5), 539-566.

Asutay, E., & Västfjäll, D. (2012). Perception of loudness is influenced by emotion. PloS one, 7(6), e38660.

Asutay, E., Västfjäll, D., Tajadura-Jiménez, A., Genell, A., Bergman, P., & Kleiner, M. (2012). Emoacoustics: A study of the psychoacoustical and psychological dimensions of emotional sound design. Journal of the Audio Engineering Society, 60(1/2), 21-28.

Ballas, J. A., & Howard, J. H. (1987). Interpreting the language of environmental sounds. Environment and behavior, 19(1), 91-114.

Ballas, J. A., & Mullins, T. (1991). Effects of context on the identification of everyday sounds. Human performance, 4(3), 199-219.

Barrett, L. F. (1998). Discrete emotions or dimensions? The role of valence focus and arousal focus. Cognition & Emotion, 12(4), 579-599.

Bellizzi, J. A., & Hite, R. E. (1992). Environmental color, consumer feelings, and purchase likelihood. *Psychology & marketing*, *9*(5), 347-363.

Bezat, M. C., Kronland-Martinet, R., Roussarie, V., & Ystad, S. (2014). From acoustic descriptors to evoked quality of car door sounds. The Journal of the Acoustical Society of America, 136(1), 226-241.

Blauert, J., & Jekosch, U. (1997). Sound-quality evaluation–a multi-layered problem. Acta acustica united with acustica, 83(5), 747-753.

Blauert, J. (Ed.). (2005). Communication acoustics (Vol. 2). Springer.

Blauert, J., & Jekosch, U. (2012). A layer model of sound quality. Journal of the Audio Engineering Society, 60(1/2), 4-12.

Bigand, E., & Tillmann, B. (2005). Effect of context on the perception of pitch structures. In Pitch (pp. 306-351). Springer New York.

Bodden, M. (1997). Instrumentation for sound quality evaluation. Acta Acustica united with Acustica, 83(5), 775-783.

Bodden, M., & Iglseder, H. (2002). Active sound design: Vacuum cleaner. In Revista de Acustica (special issue Forum Acusticum, Sevilla, Spain) (Vol. 33).

Bradley, M. M., Greenwald, M. K., Petry, M. C., & Lang, P. J. (1992). Remembering pictures: pleasure and arousal in memory. Journal of experimental psychology: Learning, Memory, and Cognition, 18(2), 379.

Bradley, M. M., & Lang, P. J. (1999). International Affective Digitized Sounds (IADS): Stimuli, instruction manual and affective ratings. Gainesville, FL: The Center for Research in Psychophysiology, University of Florida

Bradley, M. M., & Lang, P. J. (2000). Affective reactions to acoustic stimuli. Psychophysiology, 37(02), 204-215.

Bradley, M. M. & Lang, P. J. (2007). The International Affective Digitized Sounds (2nd Edition; IADS-2): Affective ratings of sounds and instruction manual. Technical report B-3. University of Florida, Gainesville, Fl.

Bradley, M., & Lang, P. J. (1999). The International affective digitized sounds (IADS): stimuli, instruction manual and affective ratings. NIMH Center for the Study of Emotion and Attention.

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: the self-assessment manikin and the semantic differential. Journal of behavior therapy and experimental psychiatry, 25(1), 49-59.

Cessford, G. R. (2000). Noise impact issues on the Great Walks of New Zealand.

Cox, T. J. (2008). The effect of visual stimuli on the horribleness of awful sounds. Applied acoustics, 69(8), 691-703.

Craik, K. (Ed.). (2013). Perceiving environmental quality: Research and applications (Vol. 9). Springer Science & Business Media.

Desmet, P. M., Hekkert, P., & Jacobs, J. J. (2000). When a car makes you smile: Development and application of an instrument to measure product emotions. *NA-* Advances in Consumer Research Volume 27.

Desmet, P. M. (2002). Designing emotion. TU Delft, Delft University of Technology.

Desmet, P. M. (2012). Faces of product pleasure: 25 positive emotions in human-product interactions. International Journal of Design, 6 (2), 2012.

Desmet, P., & Hekkert, P. (2007). Framework of product experience. International journal of design, 1(1).

Dominic, W. M., & Gregg, C. (1980). Speech Perception: A Framework for Research and Theory. Speech and Language: Advances in Basic Research and Practice, 129.

Fenko, A., Schifferstein, H. N., & Hekkert, P. (2011). Noisy products: Does appearance matter? International Journal of Design, 5(3).

Frank, E., Engels, B., Naimipour, B., & Rinaldi, G. (2015). Consumer's Demand for Better Sound and Vibration Quality. SOUND AND VIBRATION, 49(12), 12-15.

Gaver, W. W. (1993a). How do we hear in the world? Explorations in ecological acoustics. Ecological psychology, 5(4), 285-313.

Gaver, W. W. (1993b). What in the world do we hear? An ecological approach to auditory event perception. Ecological psychology, 5(1), 1-29.

Genuit, K. (1997). Background and practical examples of sound design. Acta Acustica united with Acustica, 83(5), 805-812.

Guski, R. (1997). Psychological methods for evaluating sound quality and assessing acoustic information. Acta Acustica united with Acustica, 83(5), 765-774.

Juslin, P. N., & Vastfjall, D. (2008). Emotional responses to music: The need to consider underlying mechanisms. Behavioral and brain sciences, 31(05), 559-575.

Kaya, N., & Epps, H. H. (2004). Relationship between color and emotion: A study of college students. *College student journal*, *38*(3), 396.

Kueller, R., & Mikellides, B. (1993). Simulated studies of color, arousal, and comfort. In Environmental Simulation (pp. 163-190). Springer US.

Kuwano, S., Fastl, H., Namba, S., Nakamura, S., & Uchida, H. (2002). Subjective evaluation of car door sound. Proc. Sound-Quality Sym., Dearborn MI.

Kuwano, S., Fastl, H., Namba, S., Nakamura, S., & Uchida, H. (2006). Quality of door sounds of passenger cars. Acoustical science and technology, 27(5), 309-312.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1999). International affective picture system (IAPS): Technical manual and affective ratings. Gainesville, FL: The Center for Research in Psychophysiology, University of Florida.

Langeveld, L. H., Van Egmond, R., Jansen, R. J., & Özcan Vieira, E. (2013)

Lyon, R. H. (2003). Product sound quality-From perception to design. Sound and vibration, 37(3), 18-23.

Menzel, D., Dauenhauer, T., & Fastl, H. (2009). Crying Colours and their influence on loudness judgments. *NAG/DAGA 2009*, 1528-1531.

Menzel, D., Fastl, H., Graf, R., & Hellbrück, J. (2008). Influence of vehicle color on loudness judgments. The Journal of the Acoustical Society of America, 123(5), 2477-2479.

Menzel, D., Haufe, N., & Fastl, H. (2010). Colour-influences on loudness judgements. *Proc. 20th ICA Sydney*.

Namba, S. (1994, September). Noise-quantity and quality. In INTER-NOISE and NOISE-CON Congress and Conference Proceedings (Vol. 1994, No. 6, pp. 3-22). Institute of Noise Control Engineering.

Ortíz Nicolás, J. C., Aurisicchio, M., & Desmet, P. M. (2014, October). Pleasantness and arousal in twenty-five positive emotions elicited by durable products. In Proceedings of the Colors of Care: The 9th International Conference on Design & Emotion, Bogotá, Colombia, 6-10 October 2014. Ediciones Uniandes.

Ouis, D. (2001). Annoyance from road traffic noise: a review. Journal of environmental psychology, 21(1), 101-120.

Ozcan, Vieira, E. (2008). Product sounds: fundamentals and application. TU Delft, Delft University of Technology.

Ozcan Vieira, E. (2014). The Harley effect: Internal and external factors that facilitate positive experiences with product sounds. Journal of Sonic Studies 6 (1), 1-16.(2014) http://journal. sonicstudies. org/vol06/nr01/a07.

Ozcan, E., & Van Egmond, R. (2005). Characterizing descriptions of product sounds. In Proceedings of the 11th International Conference on Auditory Display (pp. 55-60)

Ozcan, E. & Van Egmond, R. (2008). Product sound design: An interdisciplinary approach. In Proceedings of the 4th International Conference on Design Research. Sheffield, UK: Sheffield Hallam University. Retrieved October 20, 2014, from http://shura.shu.ac.uk/drs2008

Ozcan, E., & Van Egmond, R. (2012). Basic semantics of product sounds. International Journal of Design, 6(2).

Ozcan Vieira, E., & Schifferstein, H. N. (2014, October). The effect of (un)pleasant sounds on the visual and overall pleasantness of products. In Proceedings of the colors of care: The 9th international conference on design and emotion, 6-7 October 2014, Bogota, Colombia. Ediciones Uniandes

Parizet, E., Guyader, E., & Nosulenko, V. (2008). Analysis of car door closing sound quality. Applied Acoustics, 69(1), 12-22.

Parizet, E., & Koehl, V. (2011). Influence of train colour on loudness judgments. Acta Acustica united with Acustica, 97(2), 347-349.

Payne, S. R., Davies, W. J., & Adams, M. D. (2009). Research into the practical and policy applications of soundscape concepts and techniques in urban areas.

Patsouras, C., Filippou, T. G., & Fastl, H. (2002, June). Influences of color on the loudness judgement. In *Proc. Forum Acusticum* (Vol. 2).

Russell, J. A. (2009). Emotion, core affect, and psychological construction. *Cognition and Emotion*, *23*(7), 1259-1283

Schafer, R. M. (1977). The tuning of the world. Alfred A. Knopf.

Siegel, E. H., & Stefanucci, J. K. (2011). A little bit louder now: Negative affect increases perceived loudness.Emotion, 11(4), 1006.

Smith, C. A., & Lazarus, R. S. (1990). Emotion and adaptation.

Van Egmond, R. (2008, February). Impact of sound on image-evoked emotions. In Electronic Imaging 2008 (pp. 68060G-68060G). International Society for Optics and Photonics.

Vastfjall, D., & Kleiner, M. (2002). Emotion in product sound design. Proceedings of Journées Design Sonore.

Vastfjall, D., Gulbol, M. A., & Kleiner, M. (2003). "Wow, what car is that?": Perception of exterior vehicle sound quality. Noise Control Engineering Journal, 51(4), 253-261.

Viollon, S., Lavandier, C., & Drake, C. (2002). Influence of visual setting on sound ratings in an urban environment. Applied acoustics, 63(5), 493-511.

Zwicker, E., & Fastl, H. (1990). Psychoacoustics: Facts and models. Vienna: Springer.

APPENDICES

APPENDIX A

CONSENT FORM

Değerli Katılımcı,

Bu çalışma Orta Doğu Teknik Üniversitesi, Endüstri Ürünleri Tasarımı Bölümü yüksek lisans öğrencisi tarafından yürütülen yüksek lisans tezi için bir araştırma niteliğinde olup, bağlamsal faktörlerin ürün seslerinin duyusal algısı üzerindeki etkisini araştırmayı amaçlamaktadır. Yapılacak olan anket 18 soru içermekte olup, yaklaşık 5 dakika sürecektir. Katılımcılara kulaklık sunulacak ve bilgisayar üzerinden ürünler ve seslerinin olduğu bir video klip izletilecektir ve bunları oylamaları istenecektir. Bunun dışında hiçbir kimliksel bilgi gerektirmeksizin, istatistiksel sınıflandırılma yapmak amacıyla yaşınız, cinsiyetiniz, eğitim ve gelir aralığınız sorulacaktır ve bu bilgiler saklı tutularak sadece tez kapsamında kullanılacaktır.

Çalışmama verdiğiniz katkı ve desteğiniz için şimdiden teşekkür ederim. Çalışmam ve sonuçları ile ilgili bilgi almak isterseniz, aşağıdaki iletişim adresinden irtibata geçebilirsiniz.

Araştırmayı yürüten kişi

Çisem Özkul — Katılımcı imza

cisemozkul@metu.edu.tr — ……………………..

LÜTFEN SORULARI SİZE UYGUN OLACAK ŞEKİLDE YANITLANDIRINIZ:

Yaşınız:	15-19	20-24	25-34	35-54	55 +
Cinsiyetiniz:	Bay	Bayan			
Araba kullanıyor musunuz?:	Evet	Hayır			
Evet ise, kaç senedir?:	1-5	5-10	15-20	20+	

APPENDIX B

CONSENT FORM

Değerli Katılımcı,

Bu çalışma Orta Doğu Teknik Üniversitesi, Endüstri Ürünleri Tasarımı Bölümü yüksek lisans öğrencisi tarafından yürütülen yüksek lisans tezi için bir araştırma niteliğinde olup, bağlamsal faktörlerin ürün seslerinin duyusal algısı üzerindeki etkisini araştırmayı amaçlamaktadır. Yapılacak olan anket 18 soru içermekte olup, yaklaşık 5 dakika sürecektir. Katılımcılara kulaklık sunulacak ve bilgisayar üzerinden ürünler ve seslerinin olduğu bir video klip izletilecektir ve bunları oylamaları istenecektir. Bunun dışında hiçbir kimliksel bilgi gerektirmeksizin, istatistiksel sınıflandırılma yapmak amacıyla yaşınız, cinsiyetiniz, eğitim ve gelir aralığınız sorulacaktır ve bu bilgiler saklı tutularak sadece tez kapsamında kullanılacaktır.

Çalışmama verdiğiniz katkı ve desteğiniz için şimdiden teşekkür ederim. Çalışmam ve sonuçları ile ilgili bilgi almak isterseniz, aşağıdaki iletişim adresinden irtibata geçebilirsiniz.

Araştırmayı yürüten kişi

Çisem Özkul	Katılımcı imza
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LÜTFEN SORULARI SİZE UYGUN OLACAK ŞEKİLDE YANITLANDIRINIZ:

Yaşınız:	15-19 20-24 25-34 35-54 55 +
Cinsiyetiniz:	Bay Bayan
Eğitim durumunuz:	Lise Üniversite Lisansüstü Lisansüstü +
Medeni durumunuz:	Bekar Evli
İş durumunuz:	Var Yok
Aylık ortalama gelir aralığınız:	1000-1500 1500-2000 2000-3000 3000+
Araba kullanıyor musunuz?:	Evet Hayır
Evet ise, kaç senedir?:	1-5 5-10 15-20 20+
Araba satın aldınız mı?	Evet Hayır
Şimdiye kadar kaç tane arabanız oldu?	____ (Olduysa lütfen sayı belirtiniz)

APPENDIX C

SURVEY FORM

BU BÖLÜMDE VİDEODAN İZLEYECEĞİNİZ ÜRÜNLERİ OYLAMANIZ BEKLENMEKTEDİR, SİZİ ANKET BOYUNCA YÖNLENDİRECEĞİM. LÜTFEN AŞAĞIDAKİ SORULARI YANITLAYINIZ VE HER ARABA İÇİN BİR BLOK KULLANINIZ.

Açıklamalar:

Memnuniyet: Bir ürünün sesinin sizde yarattığı hoşa gitme ve beğenilme derecesini oylamanız beklenmektedir.

Duygusal uyarılma: Bir ürün sesinin sizde yarattığı uyarılma etkisinin derecesini oylamanız beklenmektedir.

Baskınlık: Bir ürün sesinin size ne kadar baskın duyulduğunu oylamanız beklenmektedir.

1. VIDEODAKİ ARABA SESLERİNİ MEMNUNİYET, UYARMA, BASKINLIK AÇISINDAN NASIL DEĞERLENDİRİRSİNİZ?

1	Çok Yüksek	Yüksek	Orta	Düşük	Çok Düşük
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

2					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

3					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

4					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

5					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

6					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

7					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

8					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

9	Çok Yüksek	Yüksek	Orta	Düşük	Çok Düşük
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

10					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

11					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

12					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

13					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

14					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

15					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

16					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

17					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

18					
Memnuniyet					
Duygusal Uyarılma					
Baskınlık					

KATKILARINIZ İÇİN ÇOK TEŞEKKÜR EDERİM!

APPENDIX D

CONSENT FORM

Değerli Katılımcı,

Bu çalışma Orta Doğu Teknik Üniversitesi, Endüstri Ürünleri Tasarımı Bölümü yüksek lisans öğrencisi tarafından yürütülen yüksek lisans tezi için bir araştırma niteliğinde olup, bağlamsal faktörlerin ürün seslerinin duyusal algısı üzerindeki etkisini araştırmayı amaçlamaktadır.

Bu testin öncesinde kullanıcıların renk ve sesleri normal şartlarda algıladığını konfirme etmek amacıyla 1-2 dakika süreli renk algı testi ve 3-4 dakika süreli işitme algı testi uygulanacaktır.
Yapılacak olan ana test 23 soru içermekte olup yaklaşık 20 dakika sürecektir. Bu testte kullanıcılara ürün sesleri ve görüntüleri sunularak bunları belirli özelliklere göre oylamaları istenecektir. Detaylı açıklamalar testin başında araştırmacımız tarafından sunulacaktır.
Bunun dışında hiçbir kimliksel bilgi gerektirmeksizin, istatistiksel sınıflandırma yapmak amacıyla yaşınız, cinsiyetiniz ve diğer bilgiler saklı tutlarak sadece tez kapsamında kullanılacaktır.

Çalışmama verdiğiniz katkı ve desteğiniz için şimdiden teşekkür ederim. Çalışmam ve sonuçları ile ilgili bilgi almak isterseniz, aşağıdaki iletişim adresinden irtibata geçebilirsiniz.

Araştırmayı yürüten kişi

Çisem Özkul	Katılımcı imza
cisemozkul@metu.edu.tr	…………………..