THE INFLUENCE OF SOUND PROPERTIES ON THE SEMANTIC ASSOCIATIONS OF PRODUCT SOUNDS

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THE INFLUENCE OF SOUND PROPERTIES ON THE SEMANTIC ASSOCIATIONS OF PRODUCT SOUNDS

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ABSTRACT

THE INFLUENCE OF SOUND PROPERTIES ON THE SEMANTIC ASSOCIATIONS OF PRODUCT SOUNDS

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To be able to design product sounds that elicit a predetermined expression a study was performed to find how sound properties influence the experience of their expression. Two explorative studies using figurative against abstract visual stimuli were performed to create insight in how people experience sounds and to create a list of usable semantic associations. This list was ordered in 25 expression categories each under one descriptive semantic association. A third study using mind mapping was conducted to examine what sound properties were considered as influences on a few of these categories and to optimize the categorization. The sound properties that were considered as most influential were sharpness and noisiness. The final descriptive semantic associations were placed on a scale with the axes unpleasant-pleasant and calm-active. From these the following were considered to be most usable: activated, angry, boring, calm, chaotic, cheerful, eerie, energetic, pleasant, relaxed, trustworthy and unpleasant. In a fourth study the sounds of six domestic appliances were chosen and adjusted for sharpness, noisiness and their combination. They were evaluated for their valued expression on the 12 semantic associations by 30 participants. The results showed that increased sharpness elicited a more unpleasant and activated expression and decreased sharpness elicited a more pleasant and calm expression. This indicates that a general influence of sound properties can be established to design sounds for expression.

Keywords: Sound design, Semantic associations, Sound properties

ÖZ

SES ÖZELLİKLERİNİN ÜRÜN SESLERİNİN YOL AÇTIĞI SEMANTİK ÇAĞRIŞIMLARA ETKİSİ

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Bu tez, sahip oldukları sesler aracılığıyla önceden belirlenen ürün ifadelerini ortaya çıkartmak üzere, sese ait özelliklerin ürünlere ait ses deneyimini nasıl etkileyeceğini anlamaya yöneliktir. Buna bağlı olarak, dört ayrı çalışma gerçekleştirilmiştir. İlk iki çalışma, biri temsili bir diğeri ise soyut görsel uyarıcıları kullananarak, insanların sesi nasıl deneyimlediklerine ve bu seslerin ne tür anlambilimsel (semantik) çağrışımlar yaptıklarına dair bir liste meydana getirmeyi amaçlamaktadır. Elde edilen liste, her biri farklı semantic bir çağrışıma yönelik tanımı içeren 25 ayrı kategoriden oluşmaktadır. Zihin haritaları kullanılarak gerçekleştirilen üçüncü çalışma, bu kategorilerde yer alan hangi ses özelliklerinin daha önemli olduğunu anlamak ve kategorileri daha iyi tanımlayabilmeyi amaçlamaktadır. Bulunan en önemli ses özellikleri tizlik ve gürültü seviyesidir. Semantik çağrışımlar grafik üzerinde biri 'hoşa giden/gitmeyen' bir diğeri ise 'sakin/aktif' olarak etiketlenmiş akslara yerleştirilerek değerlendirildiler. Bunun sonucunda bulunan ürün seslerini tanımlamak üzere kullanılabilecek olan en uygun sıfatlar: etkinleştirilmiş; kızgın; sıkıcı; sakin; kaotik; neşeli; tuhaf; enerjik; hoşa giden; rahat; güvenilir; ve hoşa gitmeyendir. Dördüncü çalışmada, altı elektronik ev eşyasına ait sesler tizlik, gürültü seviyesi, ve tizlik/gürültü seviyelerine bağlı olarak farklı ayarlar yapılarak değiştirildi. Ardından, 30 katılımcı tarafından 12 sıfata göre değerlendirildiler. Sonuçlara göre, fazla tiz sesin ürünlerde hoşa gitmeyen ve etkinleştirilmiş ifadeye yol açtığı, tizliği azaltmanın ise ürünlerde daha hoşa giden ve sakin ifadeye yol açtığı tespit edildi. Bu sonuçlar, ürünlerin verdikleri sesler aracılığıyla belli ifadeler yaratmak üzere tasarlanabilmeleri için ses özelliklerinin ayarlanmasının mümkün olduğunu göstermektedir.

Anahtar Kelimeler: Ses tasarımı, Semantik çağrışımlar, Ses özellikleri

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CHAPTER 1

SUBJECT AND ARGUMENTS

1.1 Thesis subject

When a new product is designed it always needs to add something compared to already existing products. This can either be done by adding new product functions or by creating a different product expression. In the conceptual design phase of a design project an industrial designer therefore not only tries to get a clear picture of the product functions (the concrete product features) but also of the core concept that is envisioned for the new product expression (abstract product features) (Özcan & Sonneveld, 2009). This affective expression is most often described by using semantic associations (sportive, elegant, friendly, etc.) which are then translated into a physical design (Baxter, 1995). Because users prefer objects with a consistent relation among the different sensory features (Ludden, 2008; Schifferstein & Desmet, 2008) every aspect of the new design ideally needs to elicit the same semantic associations.

Visual features have been linked to product expression in the past (Kobayashi, 1981; Govers, Hekkert & Schoormans, 2002) but other features, like auditory features, have been neglected for a long time. Jekosch (1999) already concluded that the opinion a listener has about a product sound is very dependent on the meaning they associate with it. Västfjäll and Kleiner (2002) also stated that product sounds provide the user with information rather than just being a nuisance factor. These statements show that the sound of a product definitely has influence on the associated product expression.

So how can designers create these product sounds that enhance their envisioned product expression? For example, when a new washing machine is designed that should express cuteness, it cannot simply sound like a cute kitten because this would have a very strange effect on the interpretation of the product. It is necessary to copy the properties of the cute sound and paste them on the washing machine sound, without loosing its identity. In other words, the sound of the washing machine needs to be changed in such a way that it still sounds like a washing machine but elicits the same experience as a cute kitten.

1.2 Literary arguments

To do research on sound design for envisioned product expression it is necessary to review previous literature about the use of semantic associations because these are commonly used to explain interpreted product expression. Secondly a short investigation in color semantics was done to see how their influence on product expression was studied and what similarities there are for sounds. The conclusions on existing sound properties were studied to be able to find out how to influence a sound to change its expression and finally the latest progress within the field of sound design was reviewed.

1.2.1 Semantic associations

The use of semantic associations originally comes from psychology where it was used as explanation of someone's personality (Eysenck, 1947; Norman, 1963; Ash, 1964; Cattell, Eber & Tatsuoka, 1977; Anderson & Klatzky, 1987). In time, personality characteristics became applied to objects using the same semantic associations to describe those objects experienced expressions (Malhotra, 1981; Aaker, 1997; Schiffman, Reynolds & Young, 1981; Jordan, 2002). Finally, semantic associations were used to describe sounds (Von Bismarck, 1974; Björk, 1985; Kendall and Carterette, 1993).

Researchers that worked with semantic associations made lists of what they thought were the most important ones (Norman, 1963; Ash, 1964; Cattell, Eber & Tatsuoka, 1977; Malhotra, 1981; Anderson & Klatzky, 1987; Aaker, 1997; Jordan, 2002). But the lists that were established were very subjective to the type of research and the considered use of the results. This means that for every study that uses semantic associations as descriptions for product expression a new list of words needs to be created to suite the specific purpose of that study. It seems that studies on semantic associations have mostly been done to serve evaluative purposes of specific personal or product features and the studies that were done on general semantic associations were difficult to use for general purposes.

Previous studies on information prosessing within the brain suggest that object information is organised into perceptual and semantic systems (Paivo, 1971; Schooler & Engstler-Schooler, 1990; Melcher & Schooler, 1996). Pavio (1971) states that semantic information has an additive effect, while Schooler and Engstler-Schooler (1990) found that verbalisation of the semantic information might actually hamper recognition. Other studies have suggested that people's vocabulary to express their sound experience is rich, but very scattered and unorganized (Van Egmond, 2004; Özcan, 2008) which leads to unstructured and often inconclusive results.

1.2.2 Color semantics

Up to now, semantic associations that were used to describe product expressions were mostly applied to evaluate the visual aspects of the product. Specifically for the visual aspect color researchers have tried and succeeded to find patterns of the influence of this feature on the interpreted experience, creating more generally applicable semantic properties (Kobayashi, 1981; Valdez and Mehrabian, 1994). This gives reason to believe that general patterns can also be found for other product features influence on the evaluation of product expression.

Field (1841) already wrote a book about how colors affect a viewer, therefore combining a specific sensory feature to emotional impact. Munsell (1921) then identified three basic properties of color which allowed other researchers like Valdez and Mehrabian (1994) to identify the influence of each property on the emotional impact. Kobayashi (1981) was one of the first to try and identify the influence of these basic properties on color semantics. This process could be applied for a different sensory feature to find similar results.

In his book (1841) Field already mentioned an analogy between expression of colors and the expressions of musical sounds, comparing the mutual experiences between two senses (Linders, 2009). In addition, many methods in conceptual design and design research use visualization to create a more tangible description of an interpretation, experience or associated meaning (collages for interpretation, story boards for experience, mind maps for associated meaning, etc.). The application of visual stimuli makes, combined with the knowledge on color semantics, a useful aid in research on semantic associations of sound.

Garfield (2007) tried to find coherences between the basic properties of both sensory features. He found that the waves creating light (color) are similar to the waves that create sound. He argued that the wavelength of each color in the visible spectrum can be halved repeatedly until the rate of its vibration falls within the audible spectrum, giving a table of musical tones that correspond to each color (Figure 1). He also suggested a similarity between visual harmony as mapped by the circle of complementary colors and auditory harmony as mapped by the circle of fifths (Figure 2). Garfields conclusion was that pleasant sounds and pleasant sights were for these reasons geometrically identical. But his research raises many questions on the validity of the similarities between visible and auditable waves because they are constructed out of different dimensions and measures. In spite of this, the research does show an indication of correspondence between color and sound which could benefit the expression of sound experience.

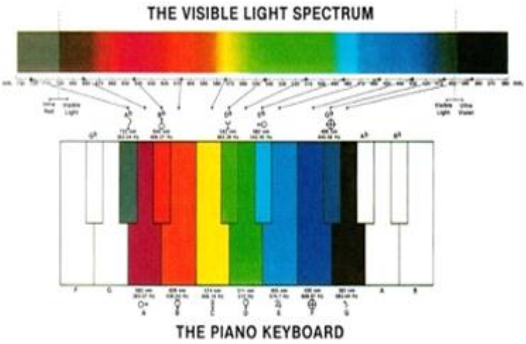

Figure 1: Similarity in wavelength between sounds and colors (Garfield, 2007)

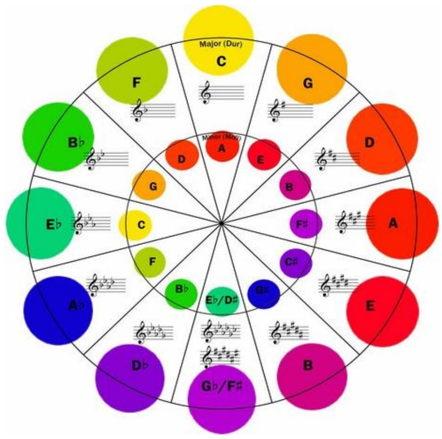

Figure 2: Similarity in visual harmony between colors and fifths (Garfield, 2007)

1.2.3 Sound properties

Research on sound properties has been done especially in the field of music. Olson (1967) has written one of the first musical engineering books, considering all the sensory aspects of sound. He found two kinds of musical characteristics: physical (vibration, growth/decay, duration, waveform, intensity, frequency) and psychological (pitch, loudness, timbre). Psychological characteristics are sound interpretations that can be explained as the interpreted effect of a combination of physical characteristic. They can therefore only be changed by changing their influencing physical properties. For example, the physical properties modulation frequency and modulation depth are both determinant factors of the psychological sound characteristic roughness (Zwicker and Fastl, 1990). The psychological values sharpness, roughness, tonality and loudness that Zwicker and Fastl (1990) concluded to be influential on the pleasantness of sound are used frequently in research on sound design to evaluate and categorize product sounds. These and other influences will be explored further in Chapter 3.

Samson, Zatorre and Ramsay (1997) found in their studies that single tones gave similar results as short melodies. This basically excludes duration of having a major influence on the interpretation of sound. Jekosch (1999) stated that to ask the subject to just concentrate on the form and disregard the meaning means to simplify and reduce matters, because a sound can neither be understood without its listener nor without the meaning the listener associates with it. In this line of thought we can say that intensity will be associated with the proximity and growth or decay with movement of the product. Both are therefore expected not to have significant influence on the interpretation of the sound itself.

Finally Olson (1967) stated that human hearing is normally limited to frequencies between 12 Hz and 20,000 Hz (20 kHz). Within these limits frequencies between 200 Hz and 1000 Hz are considered most pleasant (Vitz, 1973). It was also found that low frequencies are more pleasant below 60dB, but high frequencies are more pleasant for intensities above this level. These values are valuable bases for any hypothesis on sound interpretation.

1.2.4 Sound design

Sound design has become a more active part of industrial design research in recent years (Özcan, 2008; Özcan & Sonneveld, 2009). Most of the research on sound experience in the past has been done in the field of Human Computer Interaction, alarm sounds and the automotive industry. The design of these sounds is mostly done experimentally which means that for each new design or evaluation a new explorative study needs to be done on the effect of the products sounds. Research has also been done on matching product design to music (Smets & Overbeeke, 1989; Beerends & Stemerdink, 1992) but these kinds of studies only resulted in the confirmation of a general objective mind frame and not in how this mind frame should be addressed by designers.

Lately the environment on which Human Computer Interaction was primarily based (work) is extending slowly into other environments (home, mobile). Because the environment is shifting and extending the relationships that influence the interpretation of the products become more powerful and complex (Benyon, 2001). Coleman, Macaulay and Newell (2008) stated that considering sound as a potential means for mediating (instead of supporting) such relationships open up significant opportunities for sound designers.

Within the field of sound design a distinction has been made between consequential and intentional sounds (van Egmond, 2008). Consequential sounds occur as a result of a product's functioning and its moving mechanical parts. Intentional sounds occur because they are chosen (often by a designer) to be part of the products functionality or a user interface. This separation does however exclude the option to redesign mechanical parts to make a more pleasant sound during functioning.

In recent research it became clear that translating the abstract interpretation of sounds to the concrete differences between the sounds, is a process that needs to be explored and experienced on both the concrete and the abstract level (Özcan & Sonneveld, 2009). Several indications have been given that link semantic associations to one sound characteristic through experimental research for this reason (von Bismark 1974; Daniel & Weber 1997; Zwicker & Fastl 1999; Bienvienue, Nobile & Barker, 1991). However; all these researches consider only one sound characteristic at the time. Ali and Peynircioglu (2006) found that lyrics enhanced negative feelings, but contributed little to positive feelings, indicating that the properties that make a sound pleasant are not necessarily the opposites of the properties that make a sound unpleasant.

Van Egmond (2004) has done much research on basic sound design in general and used scales on pleasantness (vs. unpleasantness) and activation (vs. calmness) as proposed by Russell (1980). These scales were also used by Larsen and Diener (1992) and by Desmet (2007) to map ratings on product emotions. To help people express their emotional assessment an instrument was created to measure emotional responses to products (Desmet, 2002; Desmet, 2003). However, since the emotional response to an impression is twice as subjective as just the impression, it is much harder to find general patterns of influence on emotional response than on interpretation of expression.

The sounds of domestic appliances have only been considered for product expression in recent years (Özcan, 2008). However, the reasons why different products elicited different semantic associations were not made concrete enough to identify adjustable sound properties. Since domestic products are encountered daily and come in many different forms, this range of products is recognizable to many people and therefore usable for general evaluation of sound expression. Özcan (2008) found six categories of domestic appliances: air, alarm, cyclic, impact, liquid and mechanical. These categories were establish by grouping similarly perceived sounds of domestic appliances together. The sounds that most clearly elicit meaning are alarm sounds. This type of sounds has been investigated for their interpretation and emotional assessment (Stanton & Edworthy, 1998; Edworthy & Stanton, 1995; van Egmond, 2004). It was indicated that the interpretation of meaning was most important for these sounds, so only a general emotional assessment should be considered. For this reason this category is very different from the other categories when looking at interpretations of the sound expression.

1.2.5 Conclusions

The evoked emotional response to a product is considered to be even more subjective to personal interpretation than the interpretation of the elicited product expression. Therefore evaluating the product expression will give a more noticeable consistency between peoples evaluations and a better structure for influence of sound properties. That is why emotional responses were not further examined within this research and semantic association needed to be used instead of tools to evaluate emotional responses.

A list of general semantic associations for sounds is missing because they are very subjective to the type of research and the considered use of the results. Therefore new studies in the area of sound semantics are likely to need to generate a new usable list as a preliminary part of the investigation.

Studies have suggested that people's vocabulary to express their sound experience is very unstructured and often inconclusive. Therefore it appears useful to consider different techniques that help people describe their sound experience. Since several studies confirmed relationships between auditory and visual features they are a good indication that the use of visual stimuli can help to express and structure the experience of sound.

In terms of sound properties the relative values of sharpness, roughness, tonality and loudness were used frequently in sound design research to evaluate and categorize product sounds. Because these four properties are psychological characteristics they can be explained as the interpreted effect of a combination of physical characteristics. To be able to use them to change the interpreted sound expression their influencing physical properties need to be determined.

From the sound design literature it can be concluded that the domestic appliances are a useful group of products to use for evaluation of the interpreted sound expression. In addition the pleasantness-activation scale proved to be of use in previous research and were therefore kept in mind for ordering, categorizing and evaluating information.

1.3 Research methodology

1.3.1 Problem definition

What is missing in previous sound design literature is that although several tools and measurements exist to evaluate the associations and interpretation of sounds, there is no tool or guideline yet to help designers properly construct, adjust or manipulate sounds by changing one or more sound properties in order to elicit the intended product expression (Özcan & Sonneveld, 2009). To create a tool that can help designers create appropriate sounds that fit their envisioned product expression, research needed to be done on how to adjust sound properties in such a way that the perceived semantic association changes, without changing the product identity of the sound. This was investigated by trying to discover the influence of sound properties on the semantic associations that the product sound elicited.

1.3.2 Aim

The aim of this research was to find out how to adjust sounds in such a way that their perceived semantic associations change. This was done by linking semantic associations to different auditory features like noisiness and sharpness. In other words, this thesis is about the influence of sound properties on the semantic associations of product sounds.

1.3.3 Research questions

1.3.3.1 Main question

"How do sound properties influence the semantic associations of product sounds?"

1.3.3.2 Sub-questions

- How to assign semantic associations to sounds?
    - What semantic associations have been used in previous research? E.g. sportive, elegant, friendly, etc. (i.e. literature based)
    - Do visual attributes help to understand and express the interpretation of a sound?
- Does the semantic association of a sound change when its combination of sound properties changes?
    - What are the intrinsic properties of sounds that have potential to influence their semantic association? E.g. volume, frequency, timbre, etc. (i.e. literature based)
    - Can adjusting sound properties lead to a change in semantic association without changing the nature of the sounds (their associated origin)?

1.3.4 Approach

1.3.4.1 Methods

The first part of this thesis was set up to investigate how semantic associations of sounds were composed and was done by conducting three different studies. The first study investigated whether sound semantics could be found by describing the sound of a domestic appliance in a poetic way, as if it was a person, to elicit associations with figurative visual stimuli. The second study investigated whether sounds semantics could be found by relating the sound of a domestic appliance to abstract visual stimuli and verbalize their similarity. These studies resulted in a list of general semantic associations. In the third study a few of the found semantic associations were chosen to create mind maps of their main characteristics and the sound properties that were associated with them, so the most mentioned and most influencing sound properties could be found. In the second part of this project, a large study was conducted to investigate the presence of possible influences of changes in sound properties on changes in semantic associations. For this study sounds of domestic appliances were altered so one sound property was different to find similar changes in semantic association assessments for the sound with the same changed sound property. Finally, a conclusion was made defining how the investigated sound properties could best be influenced in order to have it elicit the designed product expression. With these influences a guideline can be established for further research necessary to create a design tool that enables a product designer to design sounds that fit the envisioned semantic product properties.

1.3.4.2 Participants

The participants for all of the suggested studies need to have experience with and be able to express associations of sounds and/or products and be open minded in their associations. Specially targeted groups are musicians because they have skill in linking semantic descriptions of sounds with physical sound properties, and industrial design students because they have skill in designing and evaluating product expression.

1.3.4.3 Planning

The way the studies, required preparations, evaluations, meetings, finalization and deliverables are scheduled within the available project time can be seen in Figure 3. The blocks represent the division of the project in the different studies. After completing the studies, some time is scheduled for writing the thesis report and preparing the examination, presentation and other deliverables.

The grey deliverables in Figure 3 show the finished documents that were send to the whole supervisory team for review and commentary through email. In addition the whole supervisory team was informed by email of the progress of the project and of gathered results every other week. All emails were sent to all team members at once so they could read each others commentary. The meetings that can be seen in Figure 3 were held with the whole supervisory team using a video conference call on the internet application Skype. These meetings were scheduled on important moments throughout the research to keep the supervisory team updated, erase differences in opinions, answer difficult questions and have a discussion about important decisions, findings and evaluations.

Finally it can be seen that the project itself was performed within exactly five months including the writing of the report, starting on the first of February and ending on the first of July. After this date the examination took place, only small adjustments were made in the report, some final deliverables were created and a presentation was held. This period of examination and finalizing took two months, starting on the first of July and ending on the twenty seventh of August. Study 1 was initially done as a part of the explorative literature study but the results appeared to have so much resemblance to the results of Study 2 that they were considered for evaluation as well, see Chapter 2.

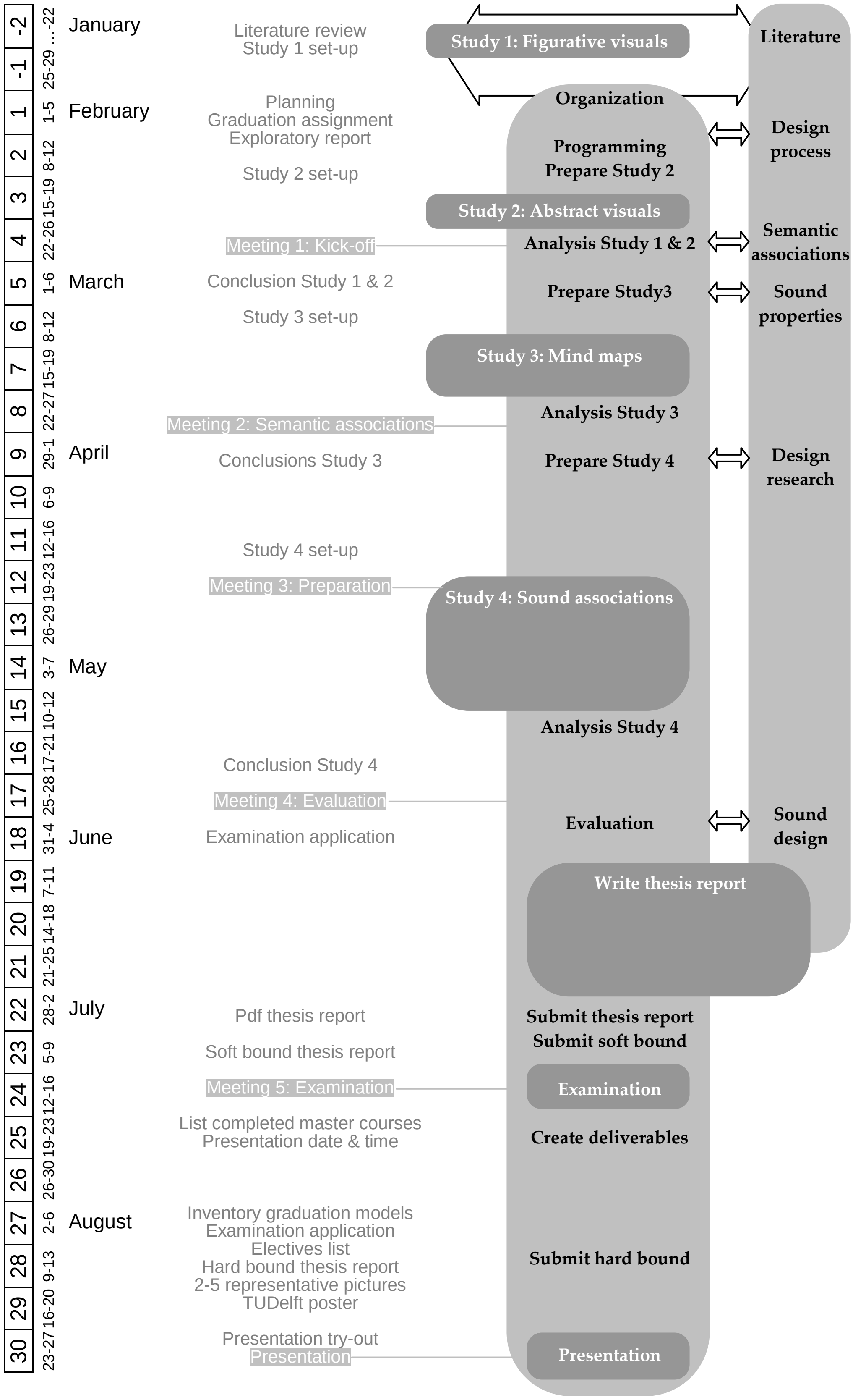

Figure 3: Project planning

CHAPTER 2

SEMANTIC ASSOCIATIONS OF PRODUCT SOUNDS

The meaning that is found in a sound is an associative meaning that arises from a mental relationship between at least two sensory memories (Kendall & Carterette, 1991; Garfield, 2007). This is because the semantic memory is used to fit physical matter in to an affective mindframe. In other words if you want to know how to adjust physical matter to fit into an affective mindframe you need semantic associations as a translator.

Examples of researchers that created lists of semantic associations are: Norman (1963), Ash (1964), Cattell, Eber & Tatsuoka (1977), Malhotra (1981), Anderson & Klatzky (1987), Aaker (1997) and Jordan (2002). The lists resulting from these researches contained between twenty-one and fifty-eight semantic descriptions and were found to be very subjective to the type of research and the considered use of the results. Care should therefore be taken before using earlier produced lists of semantic associations for new studies. Since few studies have been conducted on the semantic associations of sounds of domestic appliances, it seems wise to conduct one or more pre-studies to arrive at a list of semantic associations that are specific for research on the experience of sounds and for use in identifying changes in experience resulting from changes in sound properties.

Previous studies (Paivo, 1971; Schooler & Engstler-Schooler, 1990; Melcher & Schooler, 1996) suggest that object information is organised into perceptual and semantic systems within the cognitive system. Therefore it appears that the research methods should not only address the semantic memory of the participants, but should consult their perceptual memory as well to help them verbalize their associations. An argument can be made to use figurative visualisation of the product that makes the sound to help the participant understand the sound before interpreting it. On the other hand, abstract visualisation without figurative meaning can help the participant judge the sound without any bias or expectation. In this research both kinds of visual stimuli were used to determine their influence on verbalising semantic associations of product sounds.

So to find the influences of sound properties on the semantic associations that product sounds elicit, research needed to be done on how people experience and evaluate a product sound. In addition a list of general sound semantics had to be established that could be applied for this type of research and their use in evaluating changes in semantic associations for changes in sound properties. To create this list of useable semantic associations, two studies were conducted; one using figurative perception as a way to verbalize sound stimuli (Study 1) and one using abstract visualization (Study 2). The tests were performed separately to see whether the different methods had different influences on interpretation or on the kinds of semantic associations that were evoked.

2.1 Study 1

The first study was based on an experimental method that tries to evaluate product sounds using figurative perception by first evaluating the visual appearance of the product and then evaluating the product sound by considering both as if they were a person. This forces the participant to think in metaphors to discover new associations and interpretations of products. In previous studies, metaphors have already been used to bridge the gap between concrete and abstract product features (Lakoff & Johnson, 1980; Steen, 1994; Baxter, 1995). A metaphor is defined as a linguistic style that is used to simplify and also embody abstract thoughts and ideas in order to make them relatively more imaginable to explore, understand and communicate. This makes metaphors a very applicable tool to verbalize sound experience. In addition a metaphor helps people associate figurative meaning to a concept which indicates that it can help to enhance figurative visual associations as well. The method used for Study 1 can be applied in the beginning of the design process to get inspiration for possible product experiences.

2.1.1 Method

2.1.1.1 Participants

Students between the ages of 19 and 25 (in their second to fifth year) enrolled at the Industrial Design Engineering faculty of Delft University of Technology were asked to participate. This group was chosen because Industrial Design Engineering students are familiar with analyzing and describing products using metaphors.

Twenty five people were contacted to participate in this research of which only seven responded. This number of participants was small enough to keep the amount of data that would be gathered within manageable limits, but large enough to get a good idea on the effectiveness of the method and gather a substantial list of semantic associations.

2.1.1.2 Stimuli

The participants were asked to choose one of the domestic appliances that they use in their own home. The only requirement was that the product needed to make a sound.

2.1.1.3 Apparatus

For this study a question sheet was produced. Two pilot tests were carried out to discover what kind of questions would be understood the best and therefore give the best results. The first pilot was given as one single question to describe the products visual appearance, the product sound and the interaction between them. In the second pilot one question was asked to describe the products visual appearance and one question to describe only the product sound. The first pilot evoked a greater number of distinct semantic associations, but the second pilot gave more associations specifically on the sound. Therefore the second pilot was chosen as basis for this study.

In the final question sheet the participants were asked to select a domestic appliance in their home that makes a noise. Then they were required to place the appliance in front of them and describe the way that it looked in a poetic way, as if it was a person. Thirdly they were asked to turn the appliance on and describe its operating sound in a poetic way, as if it was a person. This separation was added to see if there was any difference in judgment between auditory and visual product features. For both descriptions it was specifically requested that the participant did not mention what kind of appliance they chose or what its function was, thereby steering the participants to give answers that would involve metaphors instead of direct descriptions. Finally the participants were asked to include a photograph and a sound recording of the product as a reference to what kind of appliance was described and send everything back via e-mail. The question sheet as sent to the participants can be seen in Appendix A.

2.1.1.4 Procedure

The question sheet was sent to 25 people via e-mail with the request to participate in a research on domestic appliances by returning their answers via e-mail. Only seven people responded to this request. The test duration was approximately 45 minutes.

2,.1.2 Results

The participants chose their own domestic appliances. The pictures they took can be seen in Appendix B. Only two people were able to record the sounds of their chosen appliance so the sound recordings were not taken into further account. The chosen appliances were a computer, a washing machine, a mixer, a vacuum cleaner and three coffee makers.

The results of this study were seven poetical descriptions, the first part describing the products appearance and the second part describing the product sounds (Appendix C). Exemplary quotations can be seen below. From the poems it was possible to deduce descriptive semantic associations for the visual stimuli (75 different words, 79 times mentioned) and the auditory stimuli (74 different words, 81 times mentioned) see Table 1. The semantic associations that were derived from the quotes are underlined.

Quotations: *About a computer:* "I still remember, the first time I met her, she was very <u>interesting</u>, yet <u>annoying</u>. I hardly understood what she truly could. She was <u>difficult</u> to communicate with and I <u>spoiled</u> her like a kid."

About a hand mixer: "As so many women she also has two sides. When she gets going I have to hold her tight to prevent her going <u>wild</u>."

About a washing machine: "I imagine many will find you a <u>nuisance</u>, but I don't mind. In fact, you're <u>calming</u> when I actually listen to you."

Table 1: List of semantic associations resulting from Study 1

Visual			**Auditory**		
Adopted	Expected	Providing	Agitated	Human	Relaxing
Annoying	Familiar	Punctual	Angry	Humming	Reminding
Arousing	Familiar	Ready	Annoying	Hyperventilating	Rewarding
Asset	Female	Refreshing	Blushing	Important	Ruthless
Big	Frantic	Reminding	Bored	Inconsiderate	Safe
Blessed	Friendly	Safe	Breathing	Inviting	Screaming
Capable	Functional	Satisfied	Calm	Lazy	Screaming
Caring	Gratifying	Silly	Calming	Mechanical	Secluded
Caring	Grown	Slim	Childish	Mellow	Sinister
Changed	Habitual	Small	Choking	Motherly	Slow
Cheerful	Helpful	Smiling	Common	Mumbling	Slow
Clear	Homely	Speaking	Complex	Mumbling	Stable
Comfortable	Homely	Spoiled	Cozy	Necessary	Steady
Comforting	Important	Straightforward	Crushing	Notifying	Striking
Committed	Indicating	Strong	Crying	Nuisance	Structured
Complaining	Initiating	Struggling	Cute	Obtrusive	Talking
Controlling	Insisting	Successful	Detached	Obtrusive	Tempting
Cooperating	Interesting	Sweet	Desired	Peaceful	Trustworthy
Crying	Light	Systematic	Distant	Powerful	Trustworthy
Demanding	Listening	Trustworthy	Disturbing	Present	Uneasy
Dependable	Motherly	Unstable	Eerie	Protesting	Unpleasant
Destructive	Natural	Valuable	Favorable	Protesting	Useless
Determined	Needed	Wanted	Fighting	Punctual	Useless
Difficult	Needed	Wild	Forcing	Punishing	Venomous
Dying	Noticeable	Young	Frigid	Purring	Wild
Elegant	Pleasant		Fulfilling	Quiet	Worthwhile
Energetic	Pretty		Growling	Ready	Yelling

2.1.2.1 Limitations

By having the participants choose their own stimulus they might have been biased in their opinion on the product and its sound. Predefining the different stimuli would possibly have given a larger diversity in semantic associations.

Asking the participants to only describe the product in a poetic way, and not mention the type or function, proved to be too vague. Many participants still described the chosen product and found it hard to come up with appropriate metaphors themselves. Possibly personal guidance in verbalizing metaphors and semantic associations or using a target group even more familiar with using these attributes would have resulted in a greater diversity of semantic associations. However, the study did result in a large list of usable semantic associations and the results were applicable for the continuation of the research.

2.1.3 Conclusions

Study 1 has shown that metaphors are a good tool to help people describe their sound experience. The method resulted in many semantic associations even though there was no guidance during the tests. When using metaphors it is very important to keep the goal of the research and the use of the results in mind. Asking the participants to describe the visual features and auditory features separately revealed significant differences in semantic associations. This indicates that visual and auditory features were not eliciting the same experience (e.g. quotation about a hand mixer, pg. 14) and could be aligned better to elicit a more consistent experience (Ludden, 2008; Schifferstein & Desmet, 2008).

However, even though there was a difference in experience between visual and auditory features, ten of the gathered semantic associations featured for both stimuli. This indicates that visual and auditory features are both described using the same semantic memory. Therefore both lists of words could be used for the continuing of this research.

2.2 Study 2

The second study was based on an uncommon and experimental method using abstract visual stimuli to describe the associations a product elicits. By comparing the product to an abstract visual stimulus and verbalizing the similarities, the less obvious associations would also be addressed. This method can be used to describe the interpretation of a product on deeper levels of consciousness and can be applied in the beginning of the design process to get inspiration for possible product experiences or at the end of the design process to evaluate the experience which a specific product elicits.

The inspiration of using abstract visual stimuli to express a product impression came from working on a design for personality project during the bachelor research course ID3701 Onderzoeksleer (Research learning) at Delft University of Technology under supervision of Prof. Dr. Ir. C.C.M. Hummels.

2.2.1 Method

2.2.1.1 Participants

Students between the ages of 19 and 25 from the Industrial Design Engineering faculty of Delft University of Technology were asked to participate. This group was chosen because Industrial Design Engineering students are familiar with analyzing and describing products.

For this study ten participants were gathered. The number of participants was kept small to keep the amount of data within manageable limits, but large enough to get a good idea on the effectiveness of the method and gather a substantial list of semantic associations.

2.2.1.2 Stimuli

Unlike Study 1, Study 2 used preselected product sounds gathered from Sounddogs.com (Rob Nokes, 1997). The sounds were all cut to last around 3 seconds and were all digitally stored as wave files. They are on the attached CD in the folder E:Sound Semantics/Sounds/Study 2/. The sounds originated from the following products:

- vacuum cleaner
- centrifuge
- drill
- refrigerator
- hair dryer

2.2.1.3 Apparatus

A stack of 100 cards depicting abstract visual impressions was used. All the cards varied in color, sharpness and general appearance. The visuals on the cards were not clearly of one specific product or impression but were open to different interpretations. The complete stack of cards, as can be seen in Appendix D, was adopted from the bachelor research course ID3701 Onderzoeksleer (Research learning) at Delft University of Technology under the supervision of Prof. Dr. Ir. C.C.M. Hummels. A general description form was created (Appendix E) and supplied for each sound to place the four chosen abstract visual impression cards on and note down the mentioned semantic associations.

The sounds were played using Windows Media Player on a HP xp4600 workstation PC using Philips SHE2550 earphones.

2.2.1.4 Procedure

Students were asked to participate in the research at the Faculty of Industrial Design Engineering at TUDelft. Each participant was invited to come to a private room with a computer and desk and listen to the first sound by clicking play in the media player application. Then they were asked to pick four cards from the stack of visual impression cards that they thought described the sound. The participants could replay the sound as many times as they wanted. When four cards were chosen they were placed on the description form and the participant was asked to explain for each card why it was similar or dissimilar to the sound. If an answer was still open for more than one interpretation the participant was asked to elaborate on their answer until at least one concrete semantic association was given. After all the chosen cards were explained the participants were asked what they missed in the cards and why, or if they had any additional remarks. Then the cards were put back into the stack at random places and the procedure was repeated for the next sound. The test duration was approximately 30 minutes.

2.2.2 Results

The results of this study were 10 descriptive forms for each of the 5 sounds. The 40 chosen cards for each sound were pasted together to create a sound experience collage and the mentioned words were put into a lists for each sound, see Appendix F. Many of the in total 467 words were used multiple times, such that only 279 different words were mentioned. A list could be deduced containing the redundant associations (Table 2). These were unusable words because they were not described with semantic associations and described aspects that are not characteristics of the sound but more associations resulting from comparison (e.g. wind, city, etc). The redundant list included associated sound properties (46 different words, 110 times mentioned) and associated sources (69 different words, 104 times mentioned). However, many usable semantic associations were also gathered (164 different words, 253 times mentioned) (Table 3).

2.2.2.1 Limitations

By not informing the participants about the source of the sound which they were listening to the participants started associating the sounds with different possible sources. This resulted in some of them having source associations that were incorrect, thereby influencing their experience of the sound and creating different semantic associations. For example, one participant thought one of the sounds was a thunderstorm so it sounded eerie, but it could also be a waterfall which made it sound calming. For this reason explaining the kind of sounds more clearly to test participants by telling them they were made by domestic appliances could have given the participants a clearer direction and could have helped them create more specified associations.

Table 2: List of redundant associations resulting from Study 2

Associated sound properties		**Associated sources**		
Alternating	Not tight	Accelerating	Evening	Passing
Average speed	Nuances	Advanced	Falling	Process
Changing	Patterned	Air	Far	Rotating
Circular	Quick	Alarming	Field	Rubbing
Constant	Quiet	Automatic	Flying	Running
Continuous	Repeating	Autumn	Grey	Rush
Decreasing	Repetition	Beware	Grinding	Signals
Diverging	Resonating	Blowing	Ground	Stormy
Fast	Returning	Bowing	Heavy	Suction
Frequency	Rumbling	Building	High Tech	Submarine
High	Sharp	Bulging	Holliday	Summer
High frequency	Small differences	Buzzing	Hot	Sunny
Increasing	Soft	Cell	Insect	Technical
Irregular	Speed	City	Machine	Tool
Lengthy	Straight	Cleaning	Machine room	Travelling
Long	Structured	Close	Mechanical	Turning
Low	Tight	Combined	Metallic	Under water
Monotonous	Unchanging	Crowded	Movement	Unnatural
Multiple	Uniform	Cutting	Movie	Vacuum
No changes	Up-down	Echo	Neon	Vehicle
Noisy	Variation	Electrical	Not organic	Water
Not constant	Variety	Equal	Organic	Waves
Not noisy	Vibrating	Equipment	Part	Wind

2.2.3 Conclusions

Study 2 showed that multi interpretable visual stimuli are a good tool to translate auditory experience into semantic associations. It appeared easy for the participants to link a sound to different abstract visual stimuli. Two of the ten participants even complained that they could not find the exact visual impressions they were looking for in the given stack of 100 cards indicating that their intuitive visual interpretation of the sound was very distinct. By having them choose the cards intuitively and ask them to think about and verbalize their thoughts later, it was possible to find many subconscious associations for any given sound. This led to a very detailed view on the sound experience. Therefore, using abstract visual stimuli for comparison proved to be a useful method in evaluating sound experience.

Because the sources of the sounds were not clear to the participants some of the associations that were made cannot be regarded as semantic descriptions but instead were related to the source or the experienced properties of the sound. Therefore the redundant words in Table 2 were discarded for further use in this research, instead focusing only on the semantic associations compiled in Table 3.

Table 3: List of usable semantic associations resulting from Study 2

Semantic associations					
Activated	Convincible	Homely	Not dull	Regular	Supporting
Active	Correct	Homely	Not harmonious	Regular	Symmetrical
Agitated	Cursing	Homely	Not interesting	Rigid	Tolerated
Aggressive	Dangerous	Hostile	Not irritating	Rough	Tranquil
Angular	Dark	Impersonal	Not playful	Round	Trustworthy
Angular	Dark	Important	Not pushing	Round	Trustworthy
Annoying	Dark	Impure	Not relaxed	Round	Trustworthy
Annoying	Dark	Inconspicuous	Not relaxed	Rounded	Unclear
Annoying	Dark	Incontrollable	Not relaxed	Sad	Uncomfortable
Annoying	Dark	Interesting	Not relaxed	Scary	Uncontrolled
Background	Difficult	Irritating	Not relaxing	Scary	Uneasy
Background	Dingy	Irritating	Not relaxing	Searching	Uneasy
Background	Direction	Irritating	Not serious	Searching	Uneasy
Background	Dirty	Irritating	Not sharp	Serious	Unending
Big	Dirty	Large	Not sharp	Serious	Unhappy
Big	Dismal	Less sharp	Not soft	Shrill	Unmoving
Big	Dismal	Light	Not sparkling	Simple	Unpleasant
Big	Disturbing	Light	Not striking	Sinister	Unpleasant
Big	Diverse	Light	Not unpleasant	Sinister	Unpredictable
Boring	Earthly	Light	Obscure	Sinister	Unsafe
Boring	Earthly	Little contrast	Obstinate	Small	Unstructured
Boring	Easing	Lonely	Open	Small	Usable
Broken	Easy	Lonely	Open	Smell	Vague
Busy	Easy	Lonely	Open	Smooth	Vague
Calm	Easy	Lonely	Open	Smooth	Vague
Calming	Empty	Maintaining	Organized	Smooth	Violent
Capricious	Existing	Meaningful	Outdoors	Solid	Waiting
Chaotic	Familiar	Memory	Outdoors	Somber	Warm
Cheerful	Fierce	Misfit	Outside	Spacious	Warm
Clashing	Flat	Modern	Playful	Spacious	Warm
Coarse	Flowing	Mossy	Pleasant	Spacious	Warm
Coarse	Flowing	Moving	Pleasant	Spacious	Warm
Coarse	Forbidden	Nagging	Pleasing	Spacious	Warm
Coarse	Foreground	Nagging	Pointed	Special	Warning
Cold	Freedom	Natural	Pointed	Spiked	Weird
Cold	Friendly	Natural	Powerful	Spiked	Whining
Cold	Friendly	Not airy	Precise	Sportive	Wide
Colorful	Friendly	Not annoying	Prickly	Stinging	Working
Comfortable	Fun	Not busy	Prickly	Stinging	
Communicative	Functional	Not cheerful	Productive	Strengthened	
Complementing	Happy	Not cheerful	Qui vive	Stressful	
Confusing	Harmonious	Not disturbing	Reflecting	Strong	
Confusing	Hazy	Not disturbing	Regular	Subtle	

2.3 Discussion

Looking at the lists of semantic associations for visible and auditory features resulting from Study 1 and the list of usable semantic associations resulting from Study 2 the words “annoying”, “important” and “trustworthy” were mentioned in all three cases, and many words were very similar to each other. In addition Study 2 had fourteen similarities with only the visual stimuli list from Study 1 and seven with the auditory stimuli list. This indicated that similar semantic associations were used for all three lists. Therefore the three lists could be combined for further use in this research.

The compiled list of all gathered semantic associations comprises 277 different words across 413 mentions. As presented in the introduction of this Chapter, previous literature shows that lists between twenty-one and fifty-eight semantic descriptions were reported. Therefore a list of 277 words was considered too extensive to work with. For this reason the complete list of words was categorized, grouping semantic associations with similar meanings under a general descriptive semantic association.

2.3.0.1 Categorization

The grouping of the semantic associations was performed with the assistance of two other Industrial Design Engineering students. The complete list was rearranged by placing semantic associations that described similar expressions together and create groups. The outcome was a collection of 25 groups of words, each eliciting a different product expression. For each of the groups, one of the semantic associations in that group was picked to represent it. This was done by choosing the semantic association that seemed to represent the group expression best and which could easily be understood by none-native English speakers. The list with all the expression categories (spaces), their descriptive semantic associations (bold) and whether each semantic association was mentioned more than once in the studies (digits) can be found in Table 4. The 25 groups were:

- Agitated
- Annoying
- Boring
- Chaotic
- Cheerful
- Comforting
- Complex
- Cozy
- Cute
- Distant
- Elegant
- Energetic
- Familiar
- Hostile
- Interesting
- Lazy
- Pleasant
- Rewarding
- Simple
- Sinister
- Sportive
- Systematic
- Trustworthy
- Unpleasant
- Useless

Table 4: Semantic categories

Semantic associations

Agitated 2	Calming 2	Cold 3	Adopted	Calm 2	Angular 2
Capricious	Caring 2	Detached	Breathing	Background 4	Busy
Cursing	**Comforting**	**Distant**	Communicative	Earthly 2	Controlling
Fierce	Easing	Frigid	**Familiar** 3	Existing	Determined
Frantic	Less sharp	Hazy	Female	Flowing 2	Direction
Not airy	Mellow	Impersonal	Habitual	**Lazy**	Functional 2
Not harmonious	Not irritating	Inconsiderate	Homely 5	Little contrast	Mechanical
Not relaxed 4	Relaxing	Lonely 4	Human	Not busy	Necessary
Not relaxing 2		Misfit	Memory	Not playful	Needed 2
Not soft	Changed	Quiet	Motherly 2	Not pushing	Organized
Pointed 2	**Complex**	Secluded	Natural 3	Not sparkling	Precise
Stressful	Confusing 2	Tolerated	Noticeable	Slow 2	Productive
Struggling	Searching 2	Vague 3	Reflecting		Regular 3
Tight	Unpredictable	Weird	Reminding 2	Complementing	Straightforward
	Diverse		Smell	Cooperating	Structured
Annoying 6		Big 6	Speaking	Favorable	Symmetrical
Choking	**Chaotic**	Coarse 4	Talking	Gratifying	**Systematic**
Complaining	Clashing	Crying 2		Not unpleasant	Unending
Difficult 2	Hyperventilating	Dangerous	Aggressive	**Pleasant** 3	
Irritating 4	Incontrollable	Dark 6	Angry	Pleasing	Capable
Nagging 2	Unclear	Dingy	Crushing	Pretty	Committed
Nuisance	Uncontrolled	Dismal 2	Demanding	Satisfied	Convincible
Obstinate	Unstable	Disturbing 2	Destructive	Spacious 5	Correct
Protesting 2	Unstructured	Eerie	Fighting	Special	Dependable
Shrill		Forbidden	Forcing		Expected
Spoiled	Comfortable 2	Large	Growling	Asset	Maintaining
Whining	**Cozy**	Obscure	**Hostile**	Blessed	Punctual 2
	Easy 3	Scary 2	Not cheerful 2	Fulfilling	Ready 2
Bored	Harmonious	**Sinister** 4	Obtrusive 2	Helpful	Safe 2
Boring 3	Inviting	Somber	Punishing	Initiating	Serious 2
Common	Listening	Uneasy 4	Rough	Present	Solid
Empty	Not annoying	Unhappy	Ruthless	Providing	Stable
Flat	Not disturbing 2	Unsafe	Screaming 2	**Rewarding** 2	Steady
Mossy	Not sharp 2		Stinging 2	Successful	Strengthened
Mumbling 2	Purring	Blushing	Striking	Valuable	Strong 2
Not interesting	Smooth 3	**Elegant**	Venomous	Worthwhile	Supporting
Not striking	Tranquil	Grown	Violent		**Trustworthy** 6
Waiting		Modern	Yelling	Clear	Unmoving
	Childish	Peaceful		Freedom	Usable
Cheerful 2	**Cute**	Slim	Desired	Inconspicuous	Working
Colorful	Not serious		Important 3	Open 4	
Friendly 4	Playful	Activated	Indicating	**Simple**	Dirty 2
Fun	Round 3	Active	**Interesting** 2	Subtle	Impure
Happy	Rounded	Arousing	Meaningful		Rigid
Humming	Small 3	**Energetic**	Not dull		Sad
Light 5	Sweet	Foreground	Notifying	Moving	Uncomfortable
Qui vive	Young	Insisting	Prickly 2	Outdoors 2	**Unpleasant** 3
Silly		Powerful	Tempting	Outside	
Smiling		Refreshing	Wanted	**Sportive**	Broken
Warm 6		Spiked 2	Warning		Dying
		Wild 2	Wide		**Useless** 2

CHAPTER 3

CHARACTERISTICS OF SEMANTIC ASSOCIATIONS

To get an idea of why certain semantic associations are linked to certain sounds a study was done on what the characteristics of the semantic associations are and how they are translated into sound properties. In preparation for this third study some literature about sound properties was consulted more thoroughly to get an idea of the different possible sound properties that could influence sound semantics.

Bodden (1997) found that perception of sound quality is not only based on the pure physical signal, but also depends on other factors. Sound evaluation methods can therefore not restrict themselves to the acoustical signal. However to be able to change a sound in order to elicit a certain expression, it is necessary to understand what physical sound properties influence these other factors.

A sound property that has been the cause of contradictions in music literature is timbre (defined as the sound “color”). For pitch (dominant frequencies) and loudness (volume and frequency area) it is relatively clear which physical sound properties influence them. However, the third of Olsons (1967) psychological characteristic is not that easy to define in terms of physical sound properties. Researchers tried to find a definition for timbre using verbal attributes (Von Bismarck, 1974) or neural responses (Kobayashi, 1981). These concluded that timbre was indeed measurable, but gave no conclusion on what physical sound properties are influencing it. Samson, Zatorre and Ramsay (1997) found that pitch, loudness and duration (timespan) could remain identical when timbre was judged differently. This suggests excludes all the physical sound properties that influence pitch, loudness and duration. And although Helmholtz (1868) found evidence that timbre depends mainly upon the amplitudes of spectral components, Berger (1964) already established that the timbre of a recorded piano tone was perceived as completely different when it was played backward, even though the spectra stayed the same. Contradictions like these within research on timbre were the cause of much doubt.

Kendall and Carterette (1993) tried to find semantic differentials among ten timbres. They found that four main factors accounted for 91% of the variance: dull-sharp (44%), compact-scattered, empty-full, colorless-colorful. Piston's (1955) performed a similar study for orchestration and found that the interpretations on power, strident, plangent and reed counted for almost 86% of the variance. But these semantic associations still don't explain how to influence timbre. The sound property timbre was therefore too elusive to use in this research and was discarded as an option.

Research has also been done on the influence of tonalness on sound associations (Vormann et al, 2000). It was concluded that sounds become more annoying when they are composed of more tonal components. Because domestic appliances do not elicit tonal sounds tonalness cannot be used in this study besides being an indication of the effect of using more frequencies in a sound.

For links made between sound properties and semantic associations, Bonebright (2001) concluded that three dimensions of sound existed that could be explained using both acoustic measures and perceptual variables. Dimension 1 was defined by the perceptual variables "compact/scattered", "dull/sharp", "uninteresting/interesting" and "rough/smooth" and the acoustic measures amplitude, intensity and change in frequency. Dimension 2 was defined by the perceptual variable "low/high" and the acoustic measure change in time. Dimension 3 was defined by the perceptual variables "relaxed/tense", "unpleasant/pleasant" and "soft/loud" and the acoustic measures amplitude and peak frequency. These dimensions offer a starting point for finding the influence of sound properties on semantic associations and indicate that there is a connection between them.

In the research of Özcan and Van Egmond (2006) the perceptual variables of roughness, sharpness, loudness and noisiness (presence of unnecessary frequencies) were considered to be influences on sound interpretation which partly confirms the study of Bonebright. Because it is difficult to define the variable roughness into acoustic measures and loudness is associated with proximity, the remaining perceptual variables of sharpness and noisiness were regarded as most important for this research. To get an idea of how these sound properties influence the semantic associations a sound evokes, a third study was conducted to find out what sound properties are considered to have the most influence on the interpretation of semantic associations.

Finally the semantic associations were be placed on the pleasantness-activation scale of Russell (1980) introduced in Chapter 1 to see how they would be judged.

3.1 Study 3

This third study was performed to get an idea of how and why people assign certain sound property values to semantic associations in order to understand what sound properties values need to be strived for to elicit a desired expression. In addition, the division of the semantic associations in to 25 categories that was made in Chapter 2 was discussed and the placing of semantic associations on the pleasantness-activation scale was evaluated.

3.1.1 Method

3.1.1.1 Participants

Students between the ages of 19 and 25 (in their second to fifth year) in the Industrial Design Engineering faculty of Delft University of Technology, and who had played a musical instrument for more than five years, were asked to participate. This group was chosen because Industrial Design Engineering students are familiar with analyzing and describing products and musicians are capable of linking sound properties to their interpretation of the sound.

Nine people were contacted to participate in this study of which four replied. The number of participants was small enough to organize a controllable brainstorm around one table and large enough to have enough different viewpoints to create informative mind maps.

3.1.1.2 Stimuli

The stimuli for this study were 11 of the 25 categories of semantic associations of sounds, determined in Chapter 1. This selection was random and the study continued with creating mind maps for each of the categories until the participants requested to end the session. The eleven categories for which a mind map was completed are:

- Chaotic
- Complex
- Cozy
- Cute
- Elegant
- Hostile
- Lazy
- Simple
- Sinister
- Sportive
- Trustworthy

3.1.1.3 Apparatus

Sheets of A1 format were used, with each side marked with one semantic association. A standard marker was used for the notation.

3.1.1.4 Procedure

Nine Industrial Design Engineering students that were musicians were asked to participate. Four of them agreed and were invited to a private table at the Industrial Design

Engineering faculty of the TUDelft. After a short introduction one of the A1 sheets was placed on the table. The participants were asked to think about a car, a person and a vacuum cleaner that could be described using this semantic association and to explain what main characteristics they had in common. When the characteristics were written down the question was how each of them could be translated into sound property values. Then they were asked to place the semantic association on the pleasantness-activation scale. This concluded the mind map and the next semantic association was shown for which the procedure was repeated. When the participants wished to stop creating mind maps a short discussion of all categories of semantic associations took place to get feedback on the categorization and the choice of descriptive associations. The test duration was approximately two hours.

3.1.2 Results

The results of this study were eleven mind maps of semantic association containing their characteristics and sound properties. These mind maps can be found in Appendix G. The mentioned characteristics and associated sound properties (italic) for each semantic association can be seen in Table 5. The locations on the pleasantness-activation scale where the semantic associations were placed can be seen in Figure 4.

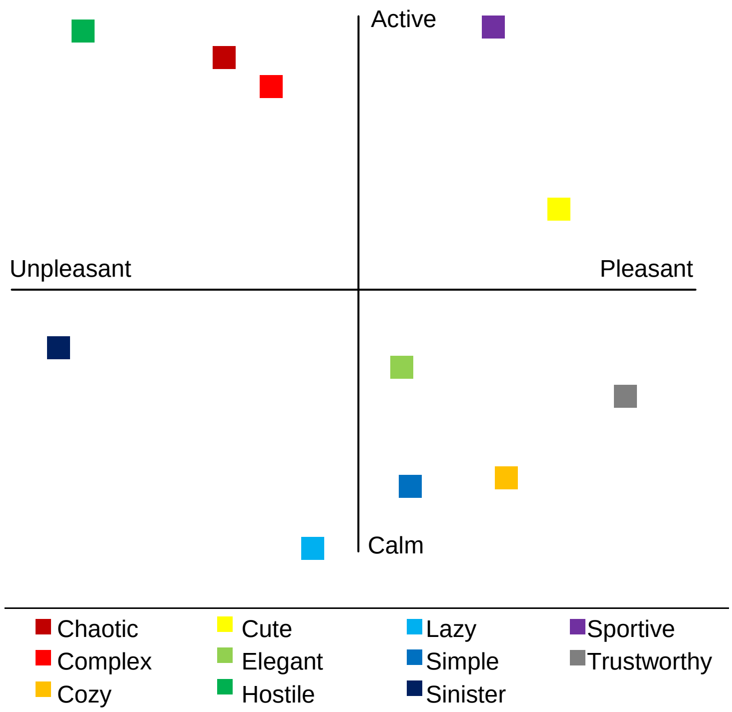

Figure 4: Evaluation of semantic associations on pleasantness-activation scale

Table 5: Results of mind maps from Study 3

Characteristics and sound properties

Chaotic	**Complex**	**Cozy**	**Cute**	**Elegant**	**Hostile**
Annoying	Changing	Associations	Cheerful	Balanced	Aggressive
Dissonant	*Contrast*	Closed	*Fade in*	Classy	Building
Goalless	Difficult	Easy	*Fade out*	Floating	Clashing
Irregular	*Fast*	Familiar	Fragile	Fluently	Consequences
Messy	Interesting	*Full*	Harmless	Gradually	*Dissonant*
Much	Layered	*Harmonic*	*High*	*Increasing*	Force
Noisy	*Multiple*	Homely	Incomplete	*Long*	Foreboding
No rhythm	Network	*Increasing*	Inviting	*No noise*	*Hard*
No pattern	Parts	*Low freq*	*Melodious*	*Pauses*	Hostile
Not Scary	Patterned	Memories	Rounded	Round	Illogical
Understandable	Random	Not disturbing	Small	Simple	Immediate
Unpredictable	*Rhythmic*	Safe	Softening	*Slow*	*Increasing*
Unclear	Square	Shielded	*Soft*	Subtle	*Loud*
Wild	Unpredictable	*Slow*	Uneven	Sweeping	*Low high freq*
		Small	United	Thin	*Noise*
		Soft	Warm	Whole	Scary
		Together			Screeching
		Touchable			*Sharp*
		Trustworthy			Shrill
		Warm			Surprising
					Threatening
					Unknown
					Weird

Lazy	**Simple**	**Sinister**	**Sportive**	**Trustworthy**
Aimless	Boring	Building	Attention	Balanced
Bended	Bright	Calm	Bombastic	Bright
Calm	Clear	Changing	Clear	*Building*
Easy	Forceful	Dark	Distinct	Clear
Empty	*Harmonious*	Distortion	*Fast*	Decent
Goalless	*High*	Layered	Firm	Familiar
Hanging	*Loud*	*Low*	Force	Honest
Indifferent	Little content	*Not harmonious*	Foreground	*Medium loud*
Low	*Low*	Opaque	Full	No secrets
No rhythm	*Monotonous*	Plotting	*High*	No surprises
Round	*Noise*	Secret	*Loud*	*Not many freq*
Slow	No meaning	*Silence*	*Low freq*	Open
Stretching	Not complex	*Slow*	Macho	*Pauses*
Stuttering	*Not vibrating*	Sneaky	*Outliers*	Quality
Tired	Open	*Soft*	Powerful	*Repetition*
Weak	*Short*	*Sudden*	Repetition	Round
	Understandable	Suggestive	*Rhythmic*	Solid
	Unity	Surprising	*Simple*	Transparent
		Unpredictable	Tight	Understandable
		Unreliable		Whole

3.1.2.1 Categorization

Looking at the proposed list of the gathered semantic associations, several adjustments were made to arrive at the final list of categories. The categories “elegant” and “sportive” appeared to be more like characteristics than descriptions of an expression. An elegant object could be experienced as either “proud” or “subtle” and sportive could be “flashy” or “healthy”. Therefore these two categories were not seen as equal to other categories and were discarded from the list.

Most of the other categories were altered during the discussion with the participants at the end of this study. The categories “complex” and “chaotic” were considered to be built from more or less the same characteristics and were therefore combined into the category “chaotic’. The category “cozy” became “comfortable” to point out the dissimilarity with the category “comforting”. To differentiate “cute” from “cheerful” the category descriptive was changed into “childish” to bring out the slightly more negative expression of the combined semantic associations. “Hostile” became “angry” because it was associated with the product initiating unwanted actions, which a product cannot do without interference of the user. The category “lazy” became “calm” to make it less negative than “boring”. Since “simple” did not capture the categories expression clearly enough this description was changed into “relaxed”. Finally, “sinister’ was changed into “eerie” because this word was believed to be more understandable. In the end, the only descriptive semantic associations that remained unchanged were “chaotic” and “trustworthy”.

3.1.2.2 Limitations

Only four people were gathered for this study which does not represent the target group. To get a complete view on the sound characteristics and properties that influence semantic associations it would be better to make mind maps with more people or groups and combine them. However, since the requirements for the participants of this study were only chosen for an easy process and understanding of the assignment, they do not define a specific target group that has to be represented in the results.

The participants might have had certain views on sound properties and common ideas of sound expression as they were all Dutch jazz musicians and already knew each other before this study. Therefore the results might be biased. Their musical background also indicates that their assumed elevated ability to evaluate sounds is mostly true for tonal sound. Therefore they were considering harmony and chord progressions as important sound properties. These attributes of sound are not very applicable for the sounds of domestic appliances because they are not composed out of tonal sounds.

3.1.3 Conclusions

In the results of the mind maps several sound properties are mentioned. Loudness and harmony were omitted from this list because of their associations with proximity and tonality. Without these, the sound properties noisiness, low/high frequencies, sharpness and vibration were most mentioned supporting the decision in the introduction of this chapter to focus on sharpness and noisiness as influencing sound properties.

The changes that were made during the discussion of the categorization resulted in a new list of 22 descriptive semantic associations to represent the 277 different semantic associations gathered in Study 1, Study 2 and Study 3. The final categories are:

- Agitated
- Angry
- Annoying
- Boring
- Calm
- Chaotic
- Cheerful
- Childish
- Comfortable
- Comforting
- Distant
- Eerie
- Energetic
- Familiar
- Interesting
- Pleasant
- Relaxed
- Rewarding
- Systematic
- Trustworthy
- Unpleasant
- Useless

The placing of the semantic associations used in this research on the pleasantness-activation scale showed similarities to the circumplex model of core affect with product relevant emotions, as defined by Desmet (2007) (Figure 5). This supports the usefulness of the pleasantness-activation scale in further categorizing the semantic associations.

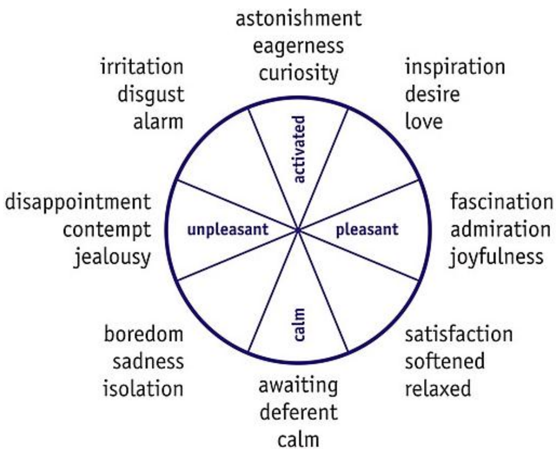

Figure 5: Circomplex model of core affect with product relevant emotions
(Desmet, 2007; adapted from Russell, 1980)

CHAPTER 4

SOUND PROPERTY INFLUENCE

Västfjäll and Kleiner (2002) stated that the need for a general theory of human responses to sounds is great. It has been proven that auditory sensations arouse profound and deep emotional reactions (Büchel & Dolan, 2000; Scott et al, 1997; Ghika-Schmid et al, 1997). However, systematic studies of emotional reactions to auditory impulses only recently have gained some interest. Vastfjäll and Kleiner find this surprising, since a primary goal of product sound design development is to elicit positive user reactions which indicates that designing product sounds is also about designing experiences. They therefore tried to link everyday sounds to fundamental emotions using semantic associations. The results of their self-report study show three affect dimensions: valence (positive/negative) arousal (calm/excited) dominance/potency (powerfulness/powerlessness). These dimensions have an overlap with the semantic dimensions of Osgood, Suci and Tannenbaum (1957) and the already used pleasantness-activation scale, which can be considered an extra affirmation.

Özcan (2008) is one of the few researchers that did research on the sounds of domestic appliances. Özcan found 6 relevant product sound catagories within the soundscape of domestic appliences as described in Chapter 1: impact, alarm, mechanical, liquid, cyclic and air. For the current research on how to design sounds of domestic appliances, three of these catagories are excluded. Alarm sounds need to convey a very specific meaning and therefore need to be understood instead of experienced. Impact sounds have a too small temporal domain to create reasonable semantic associations. Liquid sounds are very unpredictable and associated with an action of the user which will elicit associations on the interaction instead of on the sound itself. In conclusion, this research on the influence of basic sound properties on semantic association can best be done using sounds in the categories mechanical, cyclic and air because these are quite similar in timing and association, but still have many differences in sound properties to consider.

In modern psychophysics, 4 basic types of measurement scales for sensations have been defined: nominal, ordinal, interval and ratio (Ou, 2010). A nominal scale reflects qualitative differences (such as the identification between red and green objects) rather than quantitative ones. An ordinal scale includes a set of measurements in which the amount of a property can be ranked. An interval scale indicates differences between amounts of the property measured, as represented by intervals between values. A ratio scale is an interval scale with a zero point that represents the zero amount of a property.

4.1 Study 4

4.1.1 Preparation

For the fourth study within this research the pleasantness-activation scale was used to categorize the sounds and semantic associations and evaluate the results. To get a good impression of minor differences in ratings for each of the semantic associations per sound a ratio scale was to be used. This scale had a zero point for when the sound did not express the semantic association at all and seven steps for low to high expression of the semantic association. Since literature has proven that negative experiences could be influenced by different sound properties than positive experiences, a negative rating was not applied.

4.1.1.1 Sounds

The sounds that were used as basis for this final study were adopted from previous research on sounds of domestic appliances (Özcan, 2008) and cut to a duration of five seconds. From each of the usable categories of domestic appliances (air, mechanical and cyclic) the sounds of two domestic appliances were chosen that were judged as part of this group in Özcans studies. The resulting six sounds were:

- Dustbuster (air)
- Epilator (mechanical)
- Microwave (cyclic)
- Mixer (air)
- Toothbrush (mechanical)
- Washing machine (cyclic)

The previous studies and related literature confirms the possibility to use the pleasantness-activation scale for placement of the semantic associations. To get an idea of how the sounds would be experienced according to pleasantness and activation the six chosen sounds were placed on this scale intuitively. This placement is shown in Figure 6.

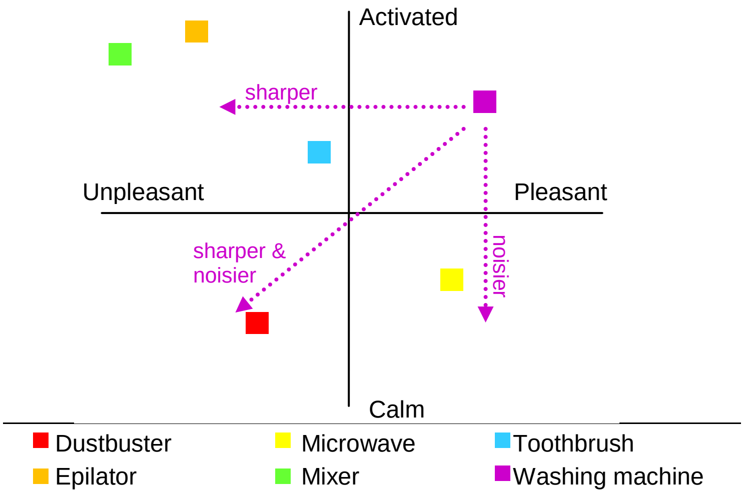

Figure 6: Placement of sounds on pleasantness-activation scale

The four sounds that were considered to be unpleasant (placed on the left part of Figure 6) were interpreted to be sharper than the others. Therefore it was assumed that sharpness (definition: maximum clarity or distinctness that makes perception easy) would influence the pleasantness assessment. In the same way the sounds that were placed in the calm part of the scale (lower part of Figure 6) were interpreted to be noisier and louder than the sounds in the activated part of the scale. Because loudness was considered to be associated with proximity in Chapter 1, noisiness (definition: full of loud and nonmusical sounds) was taken as the main influence on the activation assessment of the sounds.

To understand how sharpness and noisiness influenced sound assessment, they were altered in such a way that the sounds were expected to end up in different quadrants of the pleasantness-activation scale. See for example the expected shift for the three adjustments of the washing machine sound in Figure 6. To create a sound in the horizontally opposite quadrant, the sharpness was increased by finding the characterizing frequency area (frequencies that are necessary to be able to identify the eliciting product) and increasing the intensity of this area with a peak in the frequency equalizer. To create a sound in the vertically opposite quadrant the noisy frequencies (frequencies that had no influence on the identification of the eliciting product) were increased. For this alteration it was taken into account that the sound would not become a computer sound or a bad recording. Finally the changes in sharpness and noisiness were combined to create a sound for the complete opposite quadrant. The sounds were altered using a free trial version of the audio recording and editing software program Sound Studio 3.6 on a Mac computer in the sound lab of the Industrial Design Engineering faculty of the TUDelft.

The difference in frequencies between the altered sounds and the original can be seen in the frequency domain graphs in Appendix H made by the computer program Praat. These graphs sometimes show only small differences when larger alterations would make the sound appear to be a computer sounds or a bad recording. The original sounds and their alterations can be found on the attached CD in Appendix L in the folder E:Sound Semantics/Sounds/Study 4/. The sounds were named using this information:

- Domestic appliance
- Kind of alteration
- Hypothesized quadrant on the pleasantness-activation scale (UA/PA/UC/PC)
- Number in the sequence as used during the test

The quadrants were shortened to the first letter of extremes of the two axes that enclose it. The test sequence was composed in such a way that equal domestic appliances, equal altered properties and equal expected quadrants were all furthest apart.

4.1.1.2 Semantic associations

The results of this fourth study would become too extensive if all 22 final semantic association categories were used for evaluation. That is why the categories were placed on the pleasantness-activation scale to see if a selection could be made, see Figure 7.

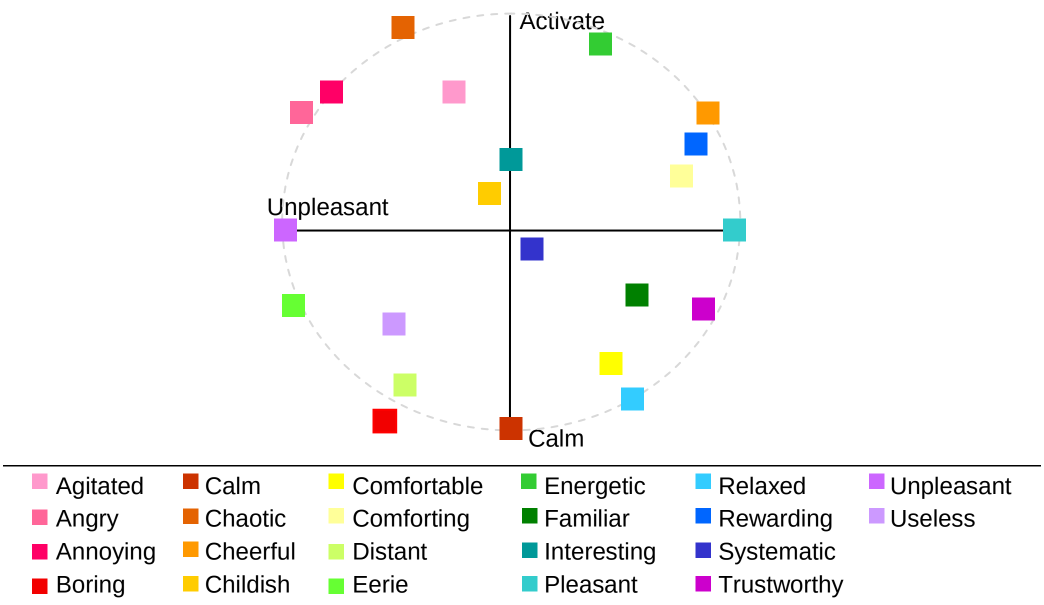

Figure 7: Placement of semantic associations on pleasantness-activation scale

When the placement of the semantic associations was considered, several semantic associations could be excluded for use in this research. The semantic associations that are placed near the origin were considered to be less extreme and therefore result in less extreme results during sound evaluation. For this reason the semantic associations that lie at a large distance from the origin were chosen as stimuli for the Study 4. To get an equal division of extremes over the four quadrants, an equal amount of semantic associations was chosen per quadrant that had an equally large distance between them. This means the extremes of the pleasantness-activation axes and two outlying semantic associations in every quadrant (the 12 semantic associations that lie closest to the grey circle in Figure 7). The final list of semantic associations therefore became:

- Activated
- Angry
- Boring
- Calm
- Chaotic
- Cheerful
- Eerie
- Energetic
- Pleasant
- Relaxed
- Trustworthy
- Unpleasant

4.1.2 Method

4.1.2.1 Participants

Students between the ages of 19 and 25 (in their second to last year) on the Industrial Design Engineering faculty of Delft University of Technology were asked to participate. This group was chosen because Industrial Design Engineering students are familiar with analyzing and describing product expression and using semantic associations.

Thirty participants were gathered for this study. The number of participants was kept small to keep the amount of data that would be gathered within manageable limits, but large enough to get a scientifically appropriate population and a good general impression.

4.1.2.2 Stimuli

The stimuli for this study are the 6 adopted and 18 adjusted sounds as discussed in the preparation (on attached CD in Appendix L in folder E:Sound Semantics/Sounds/Study 4/). The rating attributes are the 12 semantic associations that were chosen in the preparation.

4.1.2.3 Apparatus

The stimuli were put into a test program that was designed for the purpose of this study using Microsoft Visual Basic 2010 Express. The design and programming code of this test program can be found in Appendix I. The program contained a Form1 that let the participant evaluate the sound expression for each semantic association on a scale from 0 to 7. A play sound button was added to replay the current sound. The next button would automatically save the data, reload the form for the next sound, and shuffle the semantic associations so the order of words would not influence judgment. If no information was entered the next button would give a warning that input should be given first. When Form1 was completed for all sounds Form2 would automatically open to evaluate whether the sounds sounded like their original sources. It consisted only out of a yes or no checkbox and the same sequence of sounds was used. After this form was completed for all sounds the program would automatically inform the user and shut down.

The test program was played on a HP EliteBook 8530w using Microsoft Visual Basic 2010 Express and Philips SHE2550 earphones.

4.1.2.4 Procedure

Students were asked to participate in the research at the Industrial Design Engineering faculty of the TUDelft. The participant was invited to come to a private room with a table, chair and laptop with the test program. It was explained that the sound could be played as many times as necessary. The participants were told to judge with care whether they believed each semantic association to be a characteristic of the sound (and not of their own emotional reaction). Then they were informed of the sliders neutral point on the left side and an explanation of the semantic associations was given. When the procedure of the test was explained they began and were guided through the program automatically. When the test automatically shut down, their final questions, interest in the project or remarks about the test were discussed. The estimated time for this test was 20 minutes.

4.1.3 Results

The results of the test were 30 rows of numbers between 0 and 7 assessing each of the 12 semantic associations for all 24 sounds (288 numbers per row) and between 0 and 1 for the identification question (24 numbers per row). The results were sorted on domestic appliance and the identification results were colored (green for positive identification, red for negative identification). These complete tables of data can be seen in Appendix J.

To see the general difference between all sounds of one domestic appliance for all assessed semantic associations the mean of all 30 participants for each semantic association was placed on a pleasantness-activation scale (Figure 8). In this figure you can see the enclosed area of the pleasantness-activation scale that the standard sound of each domestic appliance was generally placed on and how this enclosed area shifted for each alteration. It also shows the placement of the standard sound of the domestic appliance as was hypothesized in the preparation (see also Figure 6).

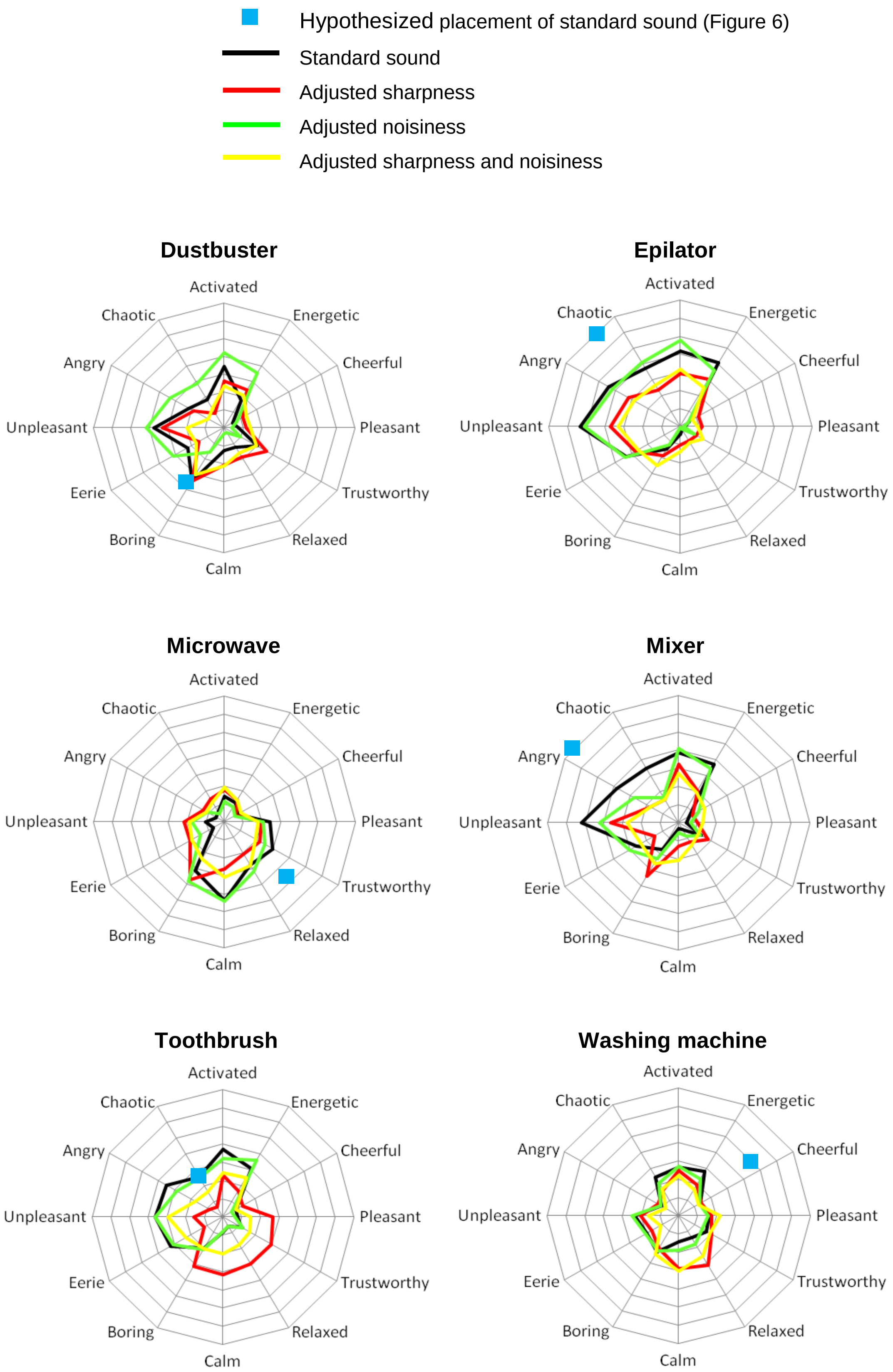

Figure 8: Spider web diagrams of resulting mean values per domestic appliance

4.1.3.1 Limitations

The test sequence of the 24 sounds could have slightly influenced the judgment of the participant. The duration of the test was considered long for the repetition of actions that was required so the participants got bored and a little less concentrated towards the end.

The sounds were not always identified as their original source. Considering not even the standard recorded sounds were always assessed as belonging to their original domestic appliance these results should be considered when looking at the general test results.

Not all the resulting data were significant enough to draw scientifically founded conclusions. This can be seen in the mean value diagrams that show the standard deviation of the mean in Appendix K. The low significance might be due to a too small number of participants, a too large number of possible slider values or the one sided scale starting at the neutral point instead of a two sided scale with a neutral midpoint.

Because a one sided scale was used the resulting values were not gathered in a normal distribution but cut off at values 0 and 7, as is illustrated by the example histograms in Figure 9. This figure shows the number of participants that chose each slider value as the amount that the given sound expressed that specific semantic association. The examples demonstrate that without a normal distribution the mean values (and corresponding standard deviations of the means) become useless because they no longer represent the peak values (mode). For this reason the mode for each semantic association was also calculated to see which values were chosen most. The differences between the diagrams of the mean values, the mode values and the mean and mode values of only the identified sounds for each domestic appliance can be seen in Appendix K.

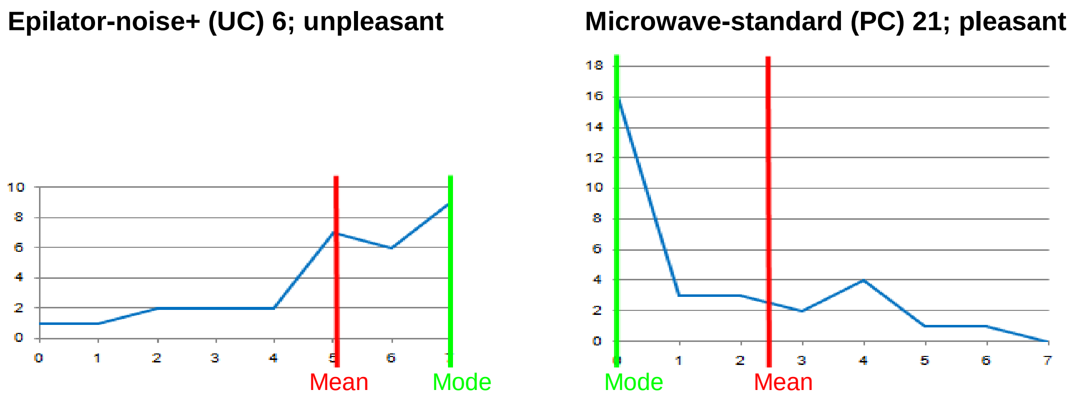

Figure 9: Histograms of two sounds showing difference between mean and mode

4.1.4 Conclusions

Even though using mode values results in a better representation of the general results when a normal distribution is absent, the calculated mode values were not usable to create scientific conclusions because their significance could not be measured. They do however give a better indication of what values were mostly assigned to the sound and can therefore be used as a better foundation for new hypotheses in following studies.

Secondly, the modes show that the most commonly assigned semantic association differs per each alteration (Appendix K). Unfortunately the different domestic appliances do not show similar peaks for one semantic association or a general shift for one sound property.

The identification question did not have much influence on the evaluation of the sounds. This can be concluded from the equality between the mean and mode diagrams of the complete results and those of only the results of the identified sounds (Appendix K). The results of the identification question were therefore not very useful for the evaluation of the sound property influence. However, the identification question did result in some conclusions of its own. First of all, not all participants recognized the original domestic appliances in the standard sounds, even though the sounds were direct recordings. The most remarkable about this was that some alterations of these sounds were identified as their corresponding domestic appliance where their original standard was not.

Secondly it was interesting that the washing machine sounds were almost always identified, and the mixer sounds were identified the least. Especially the less sharp mixer was only identified by two participants, indicating that the sharpness of a mixer is a very important characteristic of the sound. Finally it can be deduced that in most cases the standard sound was identified mostly, either sharpness or noisiness was considerably less identified and the sharpness and noisiness sounds were over all identified least. These results are interesting for further research on sound identification.

When the resulting enclosed areas of the mean values are compared to the hypothesized placement of the sounds on the pleasantness-activation scale in the mean diagrams in Figure 8, it can be concluded that the majority of the areas enclosed by the lines generally point in the direction of the hypothesized placement. This shows that the hypothesized placements were relatively accurate which indicates that a general hypothesized placement of sounds on the pleasantness-activation scale can be representative for general judgment on sound expression. However by using many semantic associations and only one sided scales the data got scattered which makes the outcome of the evaluated sound placement area on the pleasantness-activation scale less precise.

Secondly, one of the noticeable conclusions following from the resulting means is that the mean values appeared to be very balanced. This can be concluded from the central placement of the enclosed areas in Figure 8 which indicates that the participants often had contradicting opinions on two opposite semantic associations. The mean values for each semantic association are also moderate (between three and four) which shows that there was a large difference between participants evaluation per semantic association as well. The conclusion that can be drawn from this is that using one sided scales from 0 to 7 might have confused the participants during their evaluation of the sound expression.

The proximity of the green lines (adjusted noisiness) to the black lines (standard) in Figure 8 indicates that noisiness does not have an effect on the semantic associations of a sound. This is confirmed by the proximity of the yellow lines (adjusted sharpness and noisiness) to the red lines (adjusted sharpness) in which noisiness is also the only different factor. However this does not necessarily conclude that the sound property noisiness has no influence on the assessment of a product sound. In the frequency graphs in Appendix H. the changes in frequency distribution for the adjusted noisiness and the adjusted sharpness and noisiness sounds are sometimes very small. This means that these sounds did not sound very different than the others. Therefore no general shift could be expected and no conclusion can be drawn on the influence of noisiness.

The main conclusion that can be drawn from the results of this study is that a definite general shift can be noticed for altered sharpness. When the red lines (adjusted sharpness) in Figure 8 are compared to the black lines (standard) the hypothesized shift on the horizontal axis can be seen (Figure 6), but also a shift on the vertical axis. This indicates that sharpness does not only influence the sound on the horizontal axis but more on the downward facing diagonal between unpleasant-activated and pleasant-calm. This conclusion shows that the influence of sharpness can be generalized for the evaluation of sounds of domestic appliances using semantic associations.

The appearing shift for sharpness shows that the basic theory of this research was verified. The influence of sound properties on the semantic associations of product sounds can indeed be generalized for the property sharpness. But because this can only be concluded for one sound property and the results had a very low significance it is necessary to do more research before any general definition can be given.

CHAPTER 5

EVALUATION

5.1 Discussion

5.1.1 Research questions

The four studies that were done in this research were sufficient to get answers to the research questions that were set up in Chapter 1. To get a short overview of this research and final conclusions to the research questions are stated below.

5.1.1.1 Sub-question 1

- How to assign semantic associations to sounds?
  - What semantic associations have been used in previous research? E.g. sportive, elegant, friendly, etc. (i.e. literature based)

Research showed that many studies with different subjects use semantic associations to describe personalities, characteristics, expressions and even emotions. Yet it was not possible to find a common set of semantic associations within these studies or even within studies on the same subject. Because the ultimate use of the semantic associations is of great influence on which semantic associations are important and not many studies has been done on their use for describing sound expression it was necessary to create a new set of semantic associations for specific use in this research.

- How to assign semantic associations to sounds?
  - Do visual attributes help to understand and express the interpretation of a sound?

This was investigated by conducting two studies to gather semantic associations using visual attributes. Study 1 showed that the appearance of a product (figurative visual stimuli) was considered to have a different expression than the product sound. The sounds were considered to be much more negative than the appearance, but they were still described with the same kind of semantic associations. This implied that although the same semantic memory is used to describe auditory and visual stimuli, their expressions are not the same and they could influence each other during the evaluation of the whole product expression. Study 2 showed that abstract instead of figurative visual stimuli did not influence the experience of the sound but enhanced the possibility for the participant to express themselves more clearly so that their interpretation of the sound expression could be understood in much more detail. This proved that visual stimuli help to understand and express the interpretation of sound.

5.1.1.2 Sub-question 2

- Does the semantic association of a sound change when its combination of sound properties changes?
    - What are the intrinsic properties of sounds that have potential to influence their semantic association? E.g. volume, frequency, timbre, etc. (i.e. literature based)

Literature showed that sound properties were divided into physical and psychological properties in which the psychological properties were built up from combinations of physical property values. For evaluation reasons the psychological properties were chosen to work with, for adjustment reasons the psychological properties were chosen that could be clearly explained in adjustable physical sound properties. To find the most influential of these properties a study was performed on the characteristics of several semantic associations and what values of sound properties could express these characteristics. This study gave an indication that sharpness and noisiness were most likely to be of influence on interpretations using semantic associations.

- Does the semantic association of a sound change when its combination of sound properties changes?
    - Can adjusting sound properties lead to a change in semantic association without changing the nature of the sounds (their associated origin)?

By creating sounds that differed from each other on only one sound property, the influence of this property on the evaluated sound expression could be investigated. Six sounds of domestic appliances were altered for sharpness, noisiness and both sharpness and noisiness. Then they were evaluated using a selection of the resulting semantic associations from sub-question 1. The results showed that one of the two studied sound properties had a general influence on the interpretation of the sound expression. Even though not all the sounds were associated with the original domestic appliance that emitted it, viewing only the positively identified sounds did not have any influence on the results of the study, meaning that adjusting sound properties does lead to a general change in sound experience regardless whether it was associated with its original source.

5.1.1.3 Main research question

- How do sound properties influence the semantic associations of product sounds?

Of the two sound properties that were adjusted in the final study, only sharpness showed a general influence on the interpretation of sound expression. The influence of the sound property noisiness could not be evaluated because no general change in experience was seen for this property. The conclusion of the main research question is therefore that sharpness influences the semantic associations of product sounds in such a way that more sharpness is experienced as more active and unpleasant, where less sharpness is experienced as more calm and pleasant. But most importantly this result proves that changes in sound properties can have a general effect on the semantic assessment of sound expression, which is a starting point for designing the expression of product sounds.

5.1.2 Research process

By creating inspirational studies to find out how people would evaluate product sounds, how they could be stimulated to verbalize their associations, how they would judge sound characteristics and categorize product expressions it was possible to get a better understanding of sound experience and create more insights in the possible influence of sound properties on this experience. The performed studies gave much information on how to help people verbalize their interpretations, which was very insightful for use in future research about sound experience.

The gathered semantic associations did result in a list of usable words. However, the sounds that were used for this research were sounds of domestic appliances which were in general not often associated as being pleasant. In addition the used semantic associations were not always understood by the participants. This means that the categorization of the semantic associations was probably done with a too small and too specified group of participants.

In advance the sub-question concerning the final study was kept very broad because the first few studies needed to be finalized to know which sound properties and semantic associations to use for investigation. Even though only one of the two properties appeared to have influence on the evaluation of the sounds, this influence did show a clear consistency throughout the results. Therefore the results gave a clear indication that general influences of sound properties on the evaluation of sound expression can be found in order to create well founded guidelines for designing for experience of sound.

5.2 Recommendations

5.2.1 Future studies

For designing for experience of sound a few remarks can be given with the knowledge gathered from this research. In general the research showed that it is possible to alter specific sound properties in order to alter the experienced sound expression in a specific way. But practically the influence of sharpness on sound expression was only an indication because the results were not statistically significant. Therefore the indication needs to be verified in future research to do a definite test of influence. The influence of noisiness can also be reconsidered by creating more difference between the frequency distribution of the sound with adjusted noisiness and the frequency distribution of the standard sound so a larger difference for that sound property can be noticed. In addition other sound properties can be investigated, for example low or high frequency areas and amplitude. Also the sound property change in time was not taken into account in this research, which appears to have influence on the identification of the domestic appliance since the changing sounds of microwave and washing machine were identified most.

5.2.1.1 Preparation

The placement of sounds on the pleasantness-activation scale and the sound manipulations were done quickly and intuitively in this research. To get more systematic and scientifically founded placements and alterations these actions could be conducted together with a test group to get more general and verified hypotheses. In addition, the alterations can be verified by asking a control group whether the sounds are really perceived as being altered for a specific sound property. The use of participants for hypothesized sound placement and sound manipulation, control groups next to the experiment groups and pre-determined reference sounds are therefore recommended to create more systematic and scientifically founded hypotheses and results.

The chosen semantic associations raised questions with the participants and therefore need to be reconsidered in a separate study about the placement of semantic associations on the pleasantness-activation scale. To get more precise results in future studies it is also recommended to use fewer semantic associations for evaluation. It can be argued to first use only the pleasantness-activation scale and only use more semantic association diagonals to evaluate expressions in more detail.

Within Study 4 it seemed hard for the participants to consider the pleasant half of the pleasantness-activation scale for the used sounds of domestic appliances. Therefore the use of the pleasantness-activation scale can be seen as only half effective.

5.2.1.2 Testing

For future research on the influence of sound properties on product expression and to validate the current research a study needs to be done on the influence of the sound sequence in Study 4. This can be done by using only standard sounds in the same sequence. The resulting difference in evaluated expression can then be used to calculate the sequence influence on the results of this study. If new studies will be performed on the influence of sound properties on sound expression that are based on this research it is recommended to either randomize the starting point of the sequence for each participant or play all used sounds multiple times to reduce the sequence influence.

Using sliders to evaluate the semantic associations resulted in two problems. First of all the results were hard to evaluate because the spreading of the chosen values was large due to the large number of values. To reduce this spreading, a slider with fewer values could be used. Secondly almost all participants had trouble with the neutral starting point of the scale that was defined as “no influence at all” and expected a negative value as well. In addition two opposite semantic associations on the pleasantness-activation scale (calm-active, boring-energetic, eerie-cheerful, etc.) could both be ranked positively and thus neutralize each other. For example, a rating of 3 for “calm” and 3 for “activated” gives a total rating of 0 on the calm-activated axis. Therefore it is advised for future studies using ratio scales to use two dimensional scales with a neutral midpoint for the diagonals on the pleasantness-activation scale.

To create a more accurate and statistically significant study on the influence of sound properties on the semantic associations of product sounds it is necessary to gather more participants. This adjustment can be combined with less extensive ratio scales that have a neutral midpoint, a random sequence of sounds, fewer product sounds and fewer semantic associations to evaluate. When all these adjustments are considered the research probably have a more adequate statistical significance, resulting in more accurate and reliable conclusions.

5.2.1.3 Cultural differences

Finally it could be interesting to consider people from different cultures than the west European culture for these kinds of studies. These people are used to different kinds of music and sound which could have an influence on the associations they have when they evaluate sound expression. This factor in the evaluation of sound expression should also be considered in future research during the selection of the participants. By applying the studies to more cultures it will be possible to find more widespread general experiences for changes in sound properties.

5.2.2 Application of results

To better understand the influence of certain sound attributes the results of this research can be applied to more specified product sectors. For example, if the resulting shift in sharpness for only washing machines is investigated, a more general hypothesis and evaluation can be made on the expected characterizing frequencies and acceptable noise levels. In addition, the general expectations that people have for the sound of that specific domestic appliance can be investigated to try to find the borders of the sounds identification in between which the sound properties can be altered. This will create more concrete and applicable generalizations.

Secondly, this research considered sounds of domestic appliances without reference to the original product or its context. Therefore, a comparative analysis on the influence of context should be done because the sound expression is in real life always associated in correspondence with the appearance, handling and environment of the eliciting product. Since it is important to align the expressions of all the sensory features to create a clearer product expression, the influences of other sensory features on sound expression and the influence of sound expression on the interpreted product expression should be investigated.

For the influence of sensory features on product expression the connection between the influence of auditory and visual features should be investigated, because this research has proven that visual and auditory stimuli can easily be combined to express the same association, but can also have very contradicting expressions. A practical example could be to use the method of Study 2 (abstract visual impression cards) to embed the product appearance into the evaluation of the sound experience. By using the product appearance as visual stimulus it is possible to go deeper into the experienced product expression. If several very different designs of the original domestic appliance would be chosen as visual stimuli and the sound needed to be matched with one of these designs, a more detailed description could be recorded of the connection between appearance and sound.

Another combination of sensory features that influence the interpreted product expression is the connection between product sound and product handling (vibration, texture, weight, etc). These sensory features seem related because most domestic appliances have to be turned on or handled before they start making sounds. This connection might even be more influential than the connection to product appearance, which can be experienced without using the product. Aligning the expression of the auditory and tactile features of a product therefore seems a necessary step in creating a more general product expression.

Finally, this research has been about trying to influence consequential sounds of mechanical products to create a product expression instead of trying to influence synthesized sounds. Influencing the consequential sound of a product presents the complicated design problem of (re)designing mechanical parts of products in order to make them sound a certain way. This design problem not only creates a new category of product sounds (designed consequential sounds) but also creates a new level of consideration during the mechanical design of a product. Therefore it is necessary to investigate whether it is possible to (re)design mechanical parts of a product to create different sounds. When a future applied research shows that it is possible to (re)design mechanical parts to make a sound containing the hypothesized frequency distribution, that is still identified as the eliciting product and aligns with a consistent product expression, only then can it be really confirmed that it is possible to design (consequential) sounds for expression.

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APPENDIX A

STUDY 1: QUESTION SHEET *(PG. 13+52)*

This information was send to 25 people without further explanation for the purpose of gathering poetic descriptions of domestic appliances for Study 1.

Dear participant,

Thank you for your interest in this project! This research is about your interpretation of a product, its properties and its sound. Find an electrical domestic appliance at your home that makes a sound (e.g., a vacuum cleaner, shaver, washing machine, microwave, etc), put it in front of you and follow the instructions below.

A **Describe your product in a poetic way**, e.g. as if it was a person. What's the effect of the product on you? *Do not mention the appliance or its function*. The answer should be between 200 and 500 words.

Now turn on the product and follow the instructions below.

B **Describe the sound that your product make**s in a poetic way, e.g. as if it was a person. What's the effect of the sound on you? *Do not mention the appliance or its function*. The answer should be between 200 and 500 words.

Please provide a photo of your product and also the recording of its sound.

Send your descriptions to
cjverviers@gmail.com
before the 18th of December

Thank you for participating!

APPENDIX B

STUDY 1: CHOSEN DOMESTIC APPLIANCES *(PG. 13+52)*

Figure 10: Poetically described domestic appliances in Study 1

APPENDIX C

STUDY 1: POETICAL DESCRIPTIONS *(PG. 14)*

These are the poetical descriptions of the chosen domestic appliances (Appendix B) that were handed in as answers to the question sheet (Appendix A) of Study 1.

Poem 1 Washing machine

Appearance

You're big, you're strong and dependable. I trust you to punctually take care of a lot of work that I would normally break myself over to perform and you listen to me. Actually, I have no idea what it would be like to live without you. I hardly ever realize the gratitude I hold for you. But now it is noticeable that something is wrong. Is that a foreboding that you are dying? Even if so, I will do everything to keep you here. I don't want things to change.

Sound

I imagine many will find you a nuisance, but I don't mind. In fact, you're calming when I actually listen to you. I think it reminds me of long ago, when you were there while those whom I hold dear were close to me, and I felt safe. Your sound might be common, but it is cute and trustworthy to me and I desire you to be favorably present in my life for a long time to come and your sinister fate will wait a while.

Poem 2 Computer

Appearance

I still remember, the first time I met her, she was very interesting, yet annoying. I hardly understood what she truly could. She was difficult to communicate with and I spoiled her like a kid. I used a lot of money, to buy her accessories but she was never satisfied. She would break and we cried. She changed my live totally and without me she will look silly. Fortunately, I have grown as well, and as I got to know her more she also changed, I can tell. She will listen to me and cooperate. She gets my job done with determination. She's not complaining or demanding and that makes me happy. I will be needing her my whole life, therefore, she will always be my second wife. Until death do us part.

Sound

She screams and yells when I wake her up. I literally hear her yawn when she needs to work until dawn. She is hyperventilating and will burp and this will not stop until she sleeps again. I tried to clean her, so the annoying sounds will stop and bought expensive gears, hoping she will be more quiet. But still, everyday and every time I will hear her even if she doesn't do anything fine. She never knows the time and at night she will produce the same obtrusive loudness as if we are having a fight. Sometimes that will punish other people and most of the time me. But, there are also times when I can relax on her voice, when she is breathing slowly and secluded. I hear she is at peace and stable and I can enjoy the moment of mellow. After a day long work, I can put her to sleep. She will make the last loud voices to tell me she is getting ready and when her voices finally are calm I can hear nothing but myself.

Poem 3 Vacuum cleaner

Appearance

The product is a small and sweet product to see. It has some organic round shapes and has a shiny red color. If I would compare it with a person I would say a young, pretty and energetic female. It is a natural and clear thing for me.

Sound

However the sound is loud (with some high tones) and unpleasant to listen at for a long time and makes me uneasy. It is more like an angry child who is screaming. The son is lazy and doesn't want to listen to his mother. His mother is angry about her son and want to bring him to his bedroom through holding him on the arm. By doing this, the boy is protesting by screaming and crying.

Poem 4 Hand mixer

Appearance

She looks like a slim dancer. Elegant and light of feat when she stands before me with her back straight. When I see her I remember the summer, because it was a beautiful summer when we first met. That first smoothy together… delicious. I wanted something that gratifying at home. Her appearance and character are very different. As so many women she also has two sides. When she gets going I have to hold her tight to prevent her going wild. Starting easily is out of the question, she is functional and controlling and goes frantic right from the start. She initiates a struggle and insists that I try to tame her. And when she is this way she becomes unstable and destructive! Everything that will cross her path will be crushed with her sharp heals.

Sound

She sounds like a venomous mumbling. Something that gets really agitated an then strikes wildly. But it gives a sense of forcing power. She sounds frigid and mechanical, but also kind of tempting when you feel like crushing something which can be very rewarding. Everything she aims for will perish and you can aim her anywhere you want easily. But you can also feel the distance and when you hold her an inconsiderate ruthlessness.

Poem 5 Coffee maker

Appearance

When I see you standing in your usual corner of the kitchen, I realize how homely you feel and familiar you are to me. So many years I have been watching those creamy white curves and the shimmers on your surface that have a different shape and shine on the glass than on your opaque top and bottom. You have been helpful to me for so many years now, speaking to me and giving me comfort that I can also give to others. Not just to one person like your modern sisters, but whole buckets of comfort for ten people at a time. You are needed and I don't want to miss you, without your motherly commitment or the scent and taste you spread life would be a lot less pleasant.

Sound

Suddenly you come to life to meet your destiny; the time of waiting is over. Once you are filled with precious gifts you will make the right connection at the right time. You are blushing and become a little red. For a moment you seem bored, but then I hear a sound that is familiar to me and that I have been looking forward to. Mumbling, humming and dripping you make yourself known. Your scent fills kitchen and living room. Your voice brings us in the mood, less pressing than that of your younger sisters; slow and steady, but in such a way that you invite everybody and make them drool. I hope to hear your voice my entire life.

Poem 6 Coffee maker

Appearance

It has a refreshing effect with the smell of the coffee. It reminds me of familiar things every time I hear the smell. It is like my mom waking me up before school days. It is expected in some ways. When I put the exact amount of water I need to make a cup of coffee, I feel like I know the machine so weel because it is so straightforward. The warmth of the coffee indicates that we both are comfortable and at home; I can feel the safety. It is the habit of morning ritual to prepare the machine for my morning coffee before visiting the bathroom. I hear the voice of coffee getting ready inside and it arouses me so I don't want to miss the freshness, so I feel that I should be ready when the coffee is ready so that I can enjoy it.

Sound

The sound of the product when it's preparing the coffee is rather disturbing. I do not enjoy much the sound it makes. It feels like someone choking. But I feel like the sound is necessary and important to reach a fresh coffee. Even though the sound is not so cozy the coffee makes it worthwile. When the sound ends I know that my coffee is ready, the sound is part of the process. I try to ignore the sound and do not wait in front of the machine while the coffee is getting ready and try to do some other stuff. It is like listening to someone talking about some useless stuff but you keep on listening to what they are saying because you know that at the end of this conversation you will learn something important. You know that the protesting at the beginning is just worth listening to. I wish that it took less time to have the coffee with the same taste.

Poem 7 Coffee maker

Appearance

Dear domestic appliance,

You've been in my home for some years now and you are a blessed asset. We've adopted you and took you into our family. Of course you cost us something but it was worth every penny considering what you provide. You look friendly and cheerful. You are capable of many things and everything has its own color, button or slider. You are caring. Soft foaming milk, strong coffee, hot chocolate, soup or thee, its all possible with you. A smiling mouth receives the contents for one or two people. What a success when you systematically cleaned yourself the other day. I could kiss you!!! That's how important and valuable I think you are!

Sound

To warm up, you start to growl slightly like the purring of a kitten. I can trust you to do what I want you to do with structure. You are punctual and immediately answer when I ask a question, but I cannot ask it until you're ready. You notify me clearly when you are. You fulfill a complex need. So is there nothing less perfect about you? Well, you make a little too much useless noise that seem detached from your purpose and what I want from you. It is quite obtrusive and eerie, but I have my peace with that. It just makes you a little more human.

APPENDIX D

STUDY 2: ABSTRACT VISUAL IMPRESSION CARDS *(PG. 16+58)*

Each rectangle shows one of the used cards with an abstract visual impression. These 100 cards were adopted from the bachelor research course ID3701 Onderzoeksleer (Research learning) at Delft University of Technology under the supervision of Prof. Dr. Ir. C.C.M. Hummels. They were used in Study 2 to help the participants verbalize their impression of the sound expression.

Figure 11: The first 35 abstract visual impression cards used in Study 2

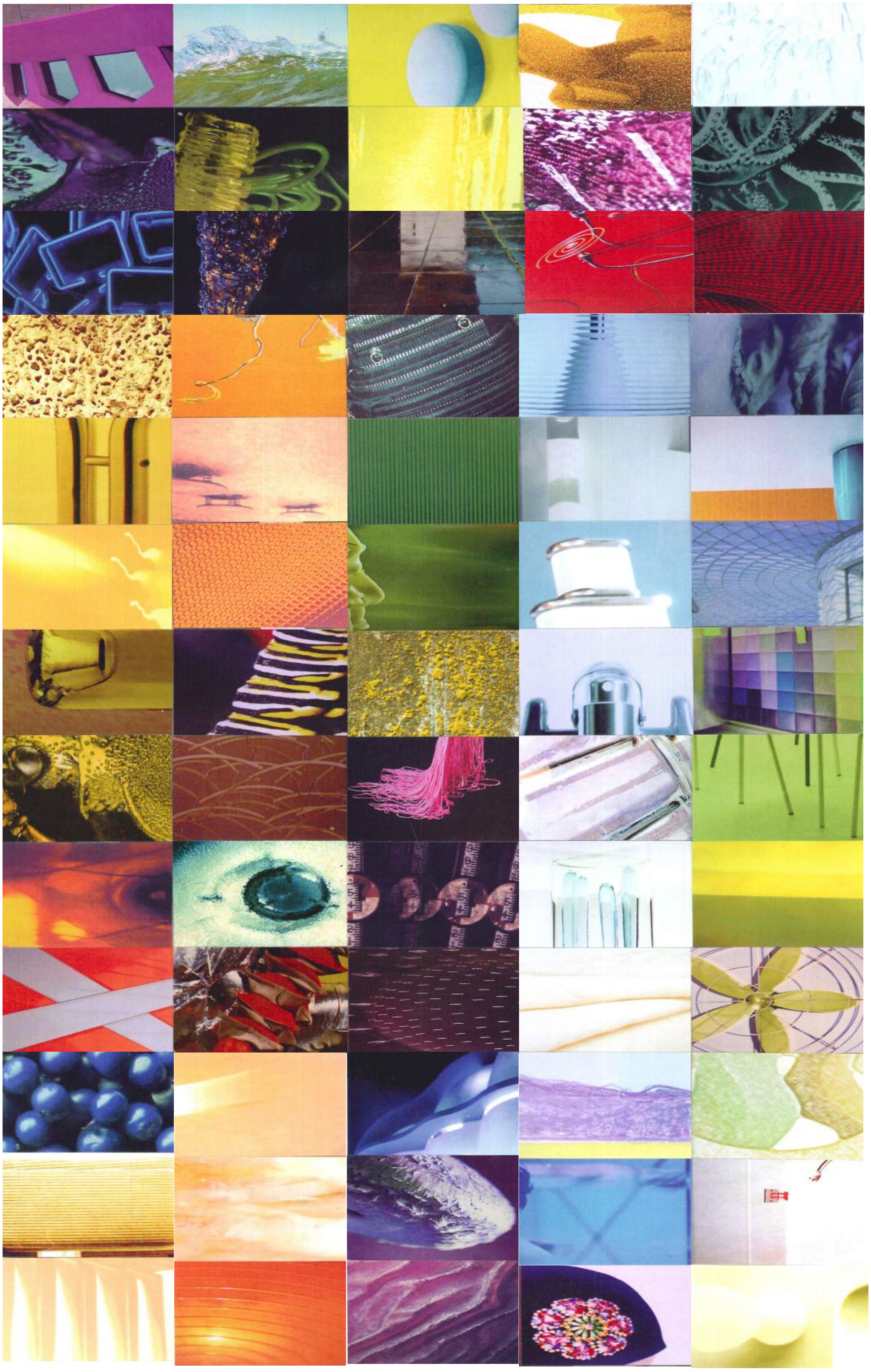


Figure 12: The other 65 abstract visual impression cards used in Study 2

APPENDIX E

STUDY 2: DESCRIPTION FORM *(PG. 16)*

The general description form was created for use during testing in Study 2. The four cards that were chosen from the stack of 100 abstract visual impression cards (Appendix D) to describe the sound were placed in the top boxes. In the description boxes the semantic associations could be noted that were mentioned during the explanation of why each chosen card was similar to the sound.

SOUND 1 Card 1	SOUND 1 Card 2	SOUND 1 Card 3	SOUND 1 Card 4
Description:	**Description:**	**Description:**	**Description:**

Figure 13: The general description form used in Study 2

APPENDIX F

STUDY 2: SOUND COLLAGES AND ASSOCIATIONS *(PG. 17)*

Here the resulting cards and semantic associations for Study 2 can be seen for each of the 5 used sounds (Appendix L; E:Sound Semantics/Sounds/Study 2/). The semantic associations that were mentioned for each sound by all participants are listed in the tables and the pictures show the four cards that each of the ten participants chose.

Sound 1 *(E:Sound Semantics/Sounds/Study 2/Sound 1.wav)*

Table 6: The resulting semantic associations for sound 1 in Study 2

Semantic associations for sound 1

Accelerating	Diverging	Incontrollable	Noisy	Rotating	Structured
Agitated	Easy	Increasing	Noisy	Rough	Unclear
Autumn	Echo	Irritating	Noisy	Rush	Uncomfortable
Big	Electrical	Irritating	Not relaxed	Sad	Uncontrolled
Big	Empty	Lonely	Not sparkling	Scary	Uneasy
Boring	Evening	Lonely	Obscure	Sharp	Uniform
City	Far	Low	Open	Sinister	Unsafe
Coarse	Fast Fast	Mechanical	Open	Sinister	Vibrating
Cold	Flat	Mechanical	Part	Somber	Weird
Combined	Flowing	Monotonous	Patterned	Spacious	Whining
Crowded	Freedom	Monotonous	Process	Speed	Wide
Dark	Grinding	Monotonous	Quick	Stinging	Wind
Dark	High	Movement	Repeating	Stormy	Wind
Dark	Hostile	Movement	Regular	Stormy	
Dingy	Impure	Nagging	Rigid	Stormy	

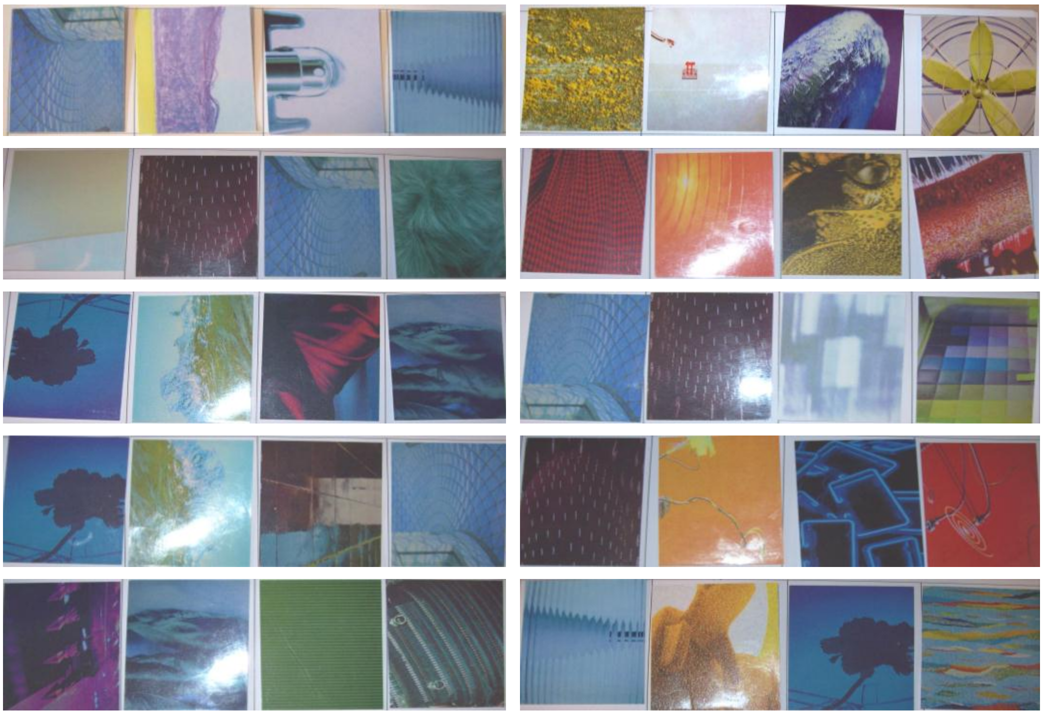


Figure 14: The chosen abstract visual impression cards for sound 1 in Study 2

Sound 2 *(E:Sound Semantics/Sounds/Study 2/Sound 2.wav)*

Table 7: The resulting semantic associations for sound 2 in Study 2

Semantic associations for sound 2

Advanced	Correct	Large	Multiple	Rumbling	Technical
Air	Dark	Low	Neon	Serious	Tight
Automatic	Dark	Low	No changes	Simple	Tool
Average speed	Direction	Machine	Not busy	Smell	Trustworthy
Background	Dirty	Machine room	Not disturbing	Smooth	Unchanging
Background	Easy	Machine room	Not interesting	Soft	Vague
Big	Easy	Mechanical	Not irritating	Solid	Vibrating
Blowing	Equal	Mechanical	Not noisy	Spacious	Vibrating
Boring	Equipment	Modern	Not playful	Spacious	Warm
Building	Frequency	Monotonous	Not unpleasant	Speed	Warm
Buzzing	Friendly	Monotonous	Outdoors	Straight	Water
Buzzing	Ground	Monotonous	Precise	Straight	Waves
Coarse	Heavy	Monotonous	Productive	Structured	Waves
Colorful	Impersonal	Monotonous	Regular	Submarine	
Continuous	Important	Mossy	Resonating	Technical	
Continuous	Insect	Moving	Rotating	Technical	

Figure 15: The chosen abstract visual impression cards for sound 2 in Study 2

Sound 3 *(E:Sound Semantics/Sounds/Study 2/Sound 3.wav)*

Table 8: The resulting semantic associations for sound 3 in Study 2

Semantic associations for sound 3

Active	Coarse	Hazy	Noisy	Pointed	Smooth
Aggressive	Cold	High	Noisy	Powerful	Spiked
Air	Cold	High	Noisy	Prickly	Stressful
Alarming	Communicative	High	Noisy	Qui vive	Strong
Alternating	Continuous	High	Noisy	Rotating	Subtle
Annoying	Convincible	High	Noisy	Round	Suction
Annoying	Cursing	High frequency	Not cheerful	Rubbing	Sunny
Annoying	Cutting	Irritating	Not harmonious	Scary	Uneasy
Beware	Dangerous	Light	Not relaxed	Searching	Unhappy
Big	Dismal	Light	Not relaxing	Sharp	Unnatural
Bowing	Disturbing	Little contrast	Not sharp	Sharp	Unpleasant
Broken	Falling	Meaningful	Not tight	Sharp	Unpleasant
Chaotic	Fast	Metallic	Obstinate	Shrill	Vacuum
Clashing	Fierce	Misfit	Open	Signals	Violent
Cleaning	Forbidden	Monotonous	Patterned	Small	Warning
Close	Frequency	Monotonous	Playful	Small	Waves
Cheerful	Grey	Movement	Pointed	Smooth	Working

Figure 16: The chosen abstract visual impression cards for sound 3 in Study 2

Sound 4 *(E:Sound Semantics/Sounds/Study 2/Sound 4.wav)*

Table 9: The resulting semantic associations for sound 4 in Study 2

Semantic associations for sound 4

Air	Continuous	Heavy	Not airy	Rumbling	Tranquil
Air	Dark	High	Not disturbing	Running	Travelling
Air	Difficult	High Tech	Not sharp	Searching	Trustworthy
Air	Earthly	Holliday	Not striking	Serious	Trustworthy
Background	Earthly	Hot	Not tight	Small differences	Turning
Big	Easing	Light	Nuances	Soft	Under water
Blowing	Equal	Lonely	Open	Soft	Unending
Boring	Far	Lonely	Outside	Soft	Unmoving
Busy	Fast	Long	Passing	Spacious	Vague
Calm	Field	Maintaining	Passing	Spacious	Vehicle
Calming	Flowing	Memory	Patterned	Special	Vehicle
Coarse	Friendly	Metallic	Pleasant	Sportive	Waiting
Combined	Fun	Monotonous	Process	Strengthened	Warm
Complementing	Functional	Movie	Quiet	Summer	Warm
Confusing	Happy	Noisy	Reflecting	Supporting	Warm
Constant	Harmonious	Noisy	Rounded	Symmetrical	

Figure 17: The chosen abstract visual impression cards for sound 4 in Study 2

Sound 5 ***(E:Sound Semantics/Sounds/Study 2/Sound 5.wav)***

Table 10: The resulting semantic associations for sound 5 in Study 2

Semantic associations for sound 5

Activated	Confusing	Inconspicuous	Not dull	Pleasant	Tolerated
Air	Constant	Increasing	Not cheerful	Pleasing	Turning
Angular	Decreasing	Interesting	Not constant	Prickly	Uneasy
Angular	Dirty	Irregular	Not organic	Regular	Unpredictable
Annoying	Dismal	Irregular	Not pushing	Repeating	Unstructured
Background	Diverse	Irritating	Not relaxed	Repeating	Up-down
Beware	Existing	Lengthy	Not relaxed	Repeating	Up-down
Bulging	Familiar	Less sharp	Not relaxing	Repetition	Usable
Buzzing	Fast	Light	Not serious	Returning	Vague
Capricious	Friendly	Monotonous	Not soft	Round	Variation
Cell	Flying	Movement	Not tight	Round	Variety
Changing	Foreground	Nagging	Organic	Sharp	Warm
Circular	High	Natural	Organized	Sinister	
Cleaning	Homely	Natural	Outdoors	Soft	
Cleaning	Homely	Noisy	Patterned	Spiked	
Comfortable	Homely	Not annoying	Patterned	Stinging	

Figure 18: The chosen abstract visual impression cards for sound 5 in Study 2

APPENDIX G

STUDY 3: MIND MAPS OF SEMANTIC ASSOCIATIONS *(PG. 25)*

These are the mind maps of semantic associations resulting from Study 3. The four participants in this study were asked to think about a car, a person and a vacuum cleaner that could be described using this semantic association, to explain what main characteristics they had in common and how each of these characteristics could be translated into sound property values. The mind maps therefore contain the associated characteristics and sound properties for 11 semantic associations according to the four participants.

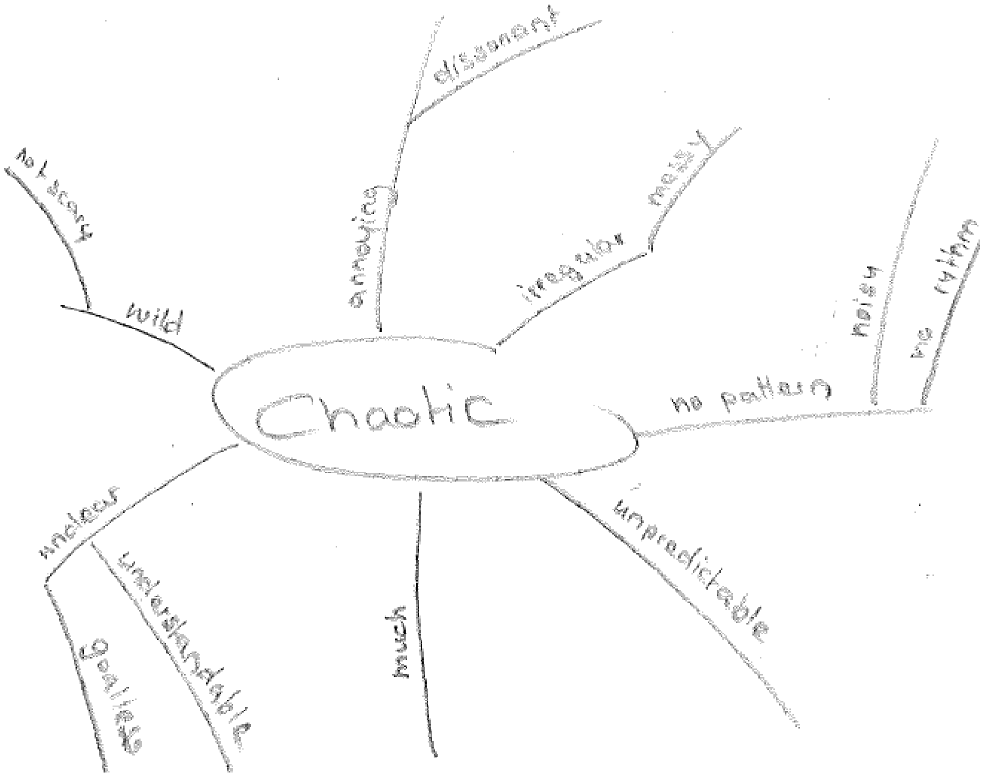


Figure 19: Main characteristics of " chaotic" resulting from Study 3

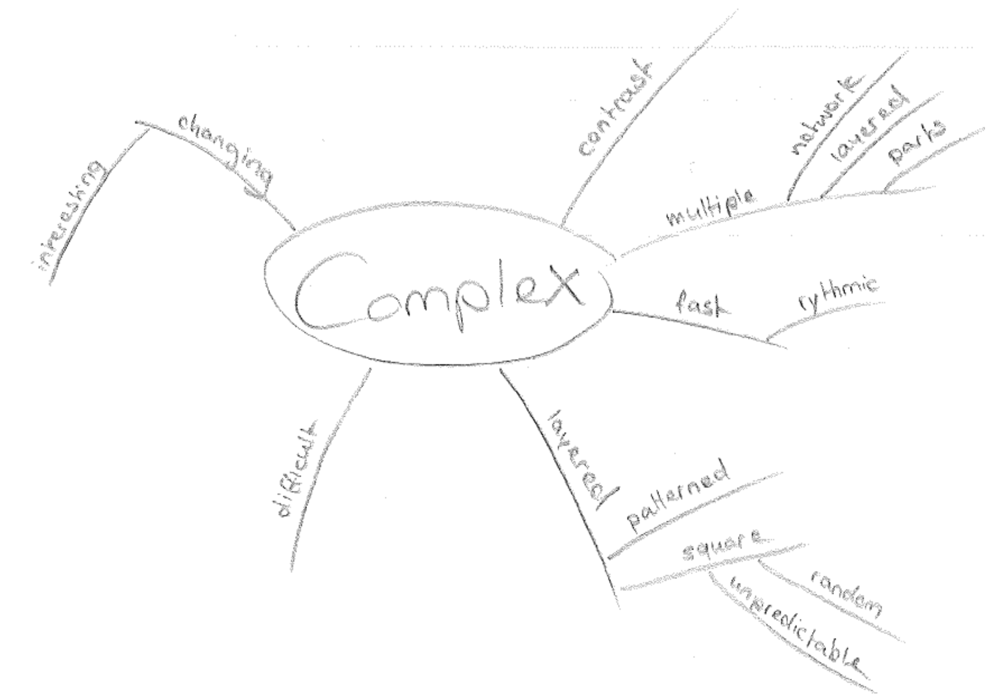


Figure 20: Main characteristics of " complex" resulting from Study 3

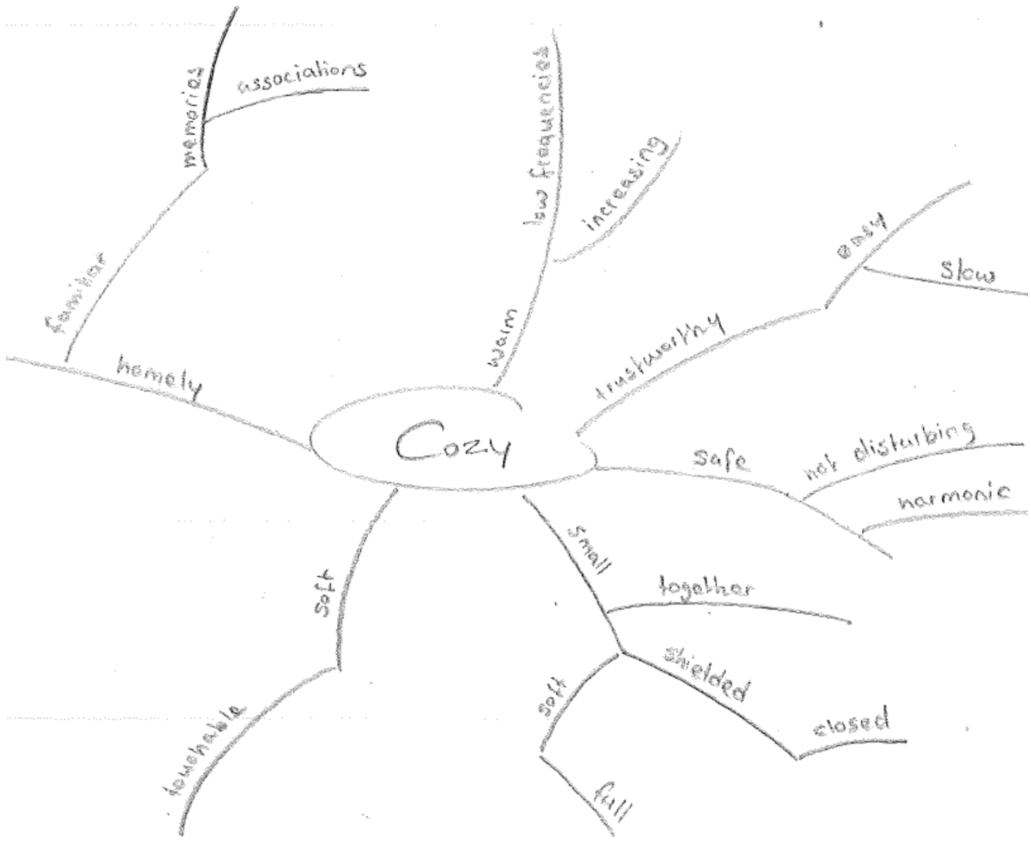


Figure 21: Main characteristics of " cozy" resulting from Study 3

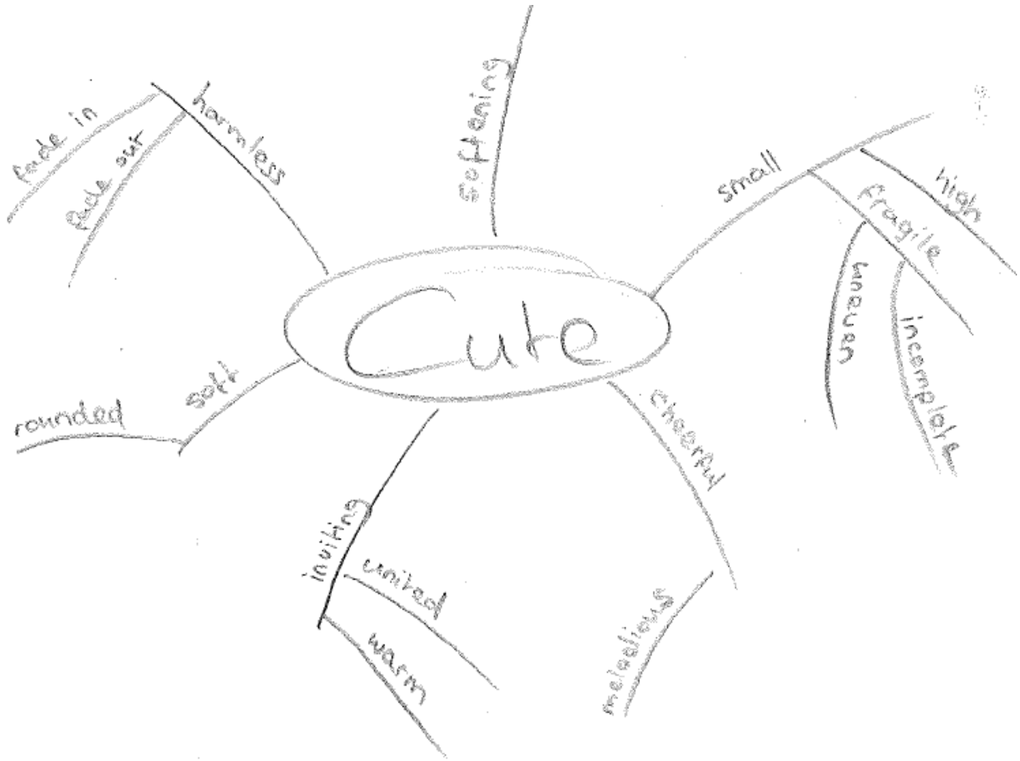


Figure 22: Main characteristics of " cute" resulting from Study 3

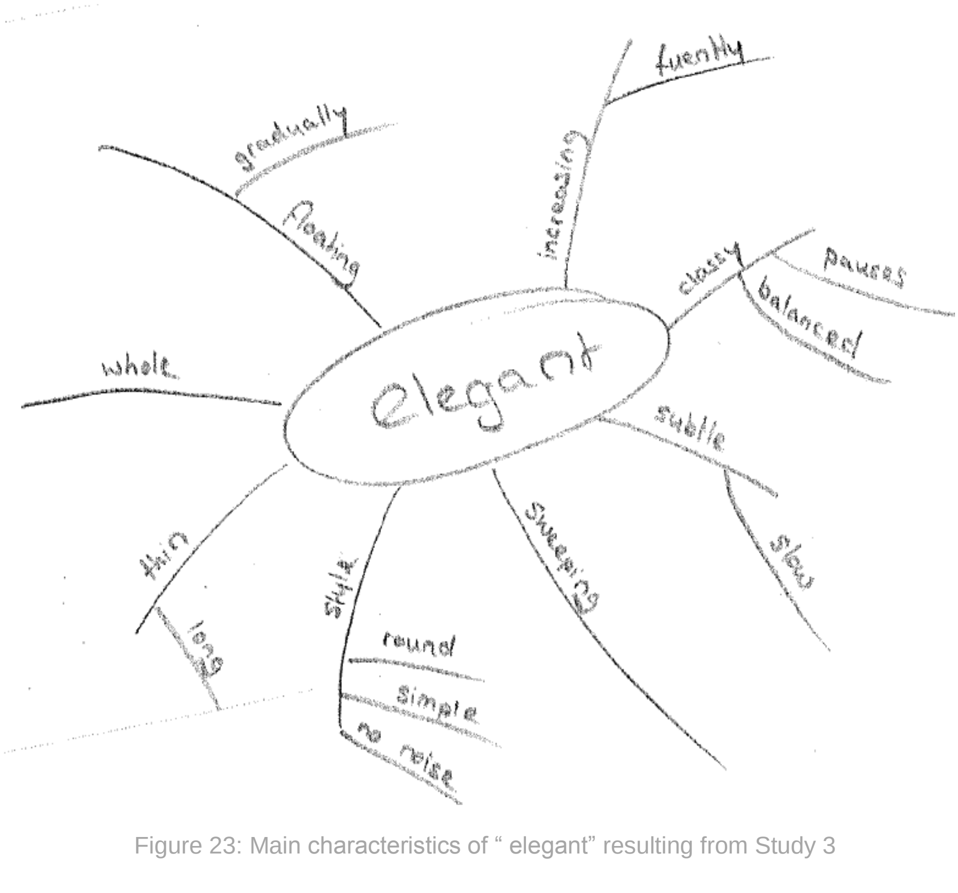


Figure 23: Main characteristics of " elegant" resulting from Study 3

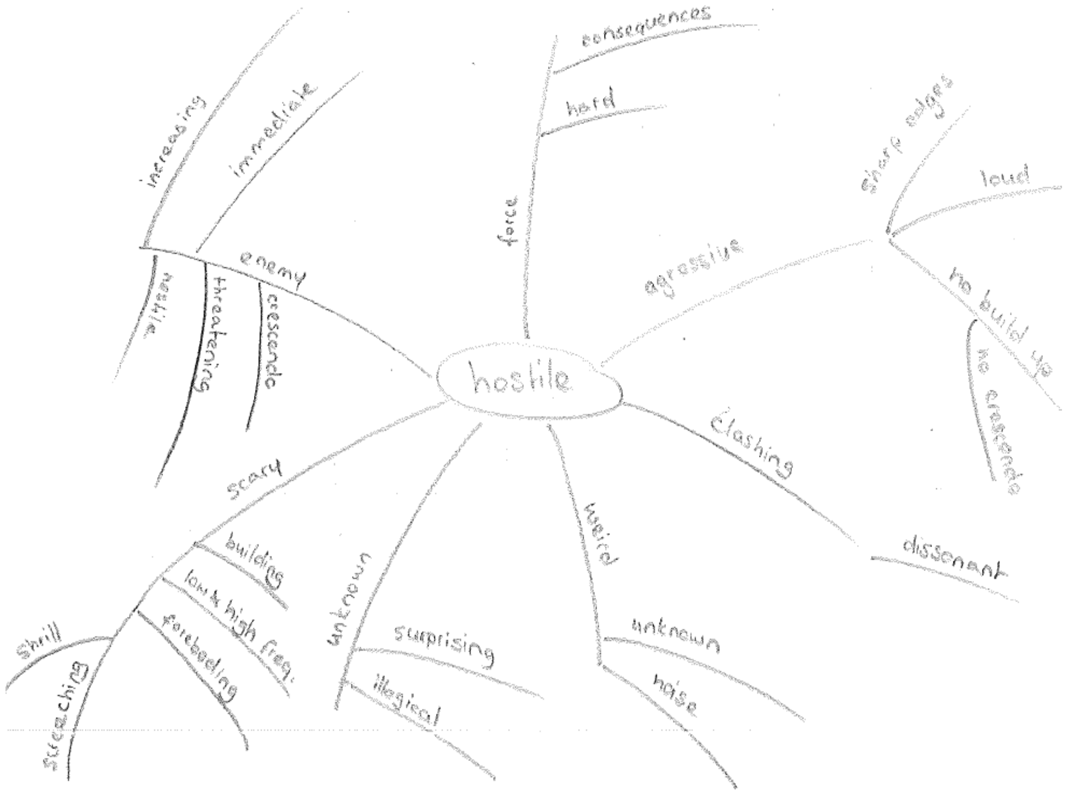


Figure 24: Main characteristics of " hostile" resulting from Study 3

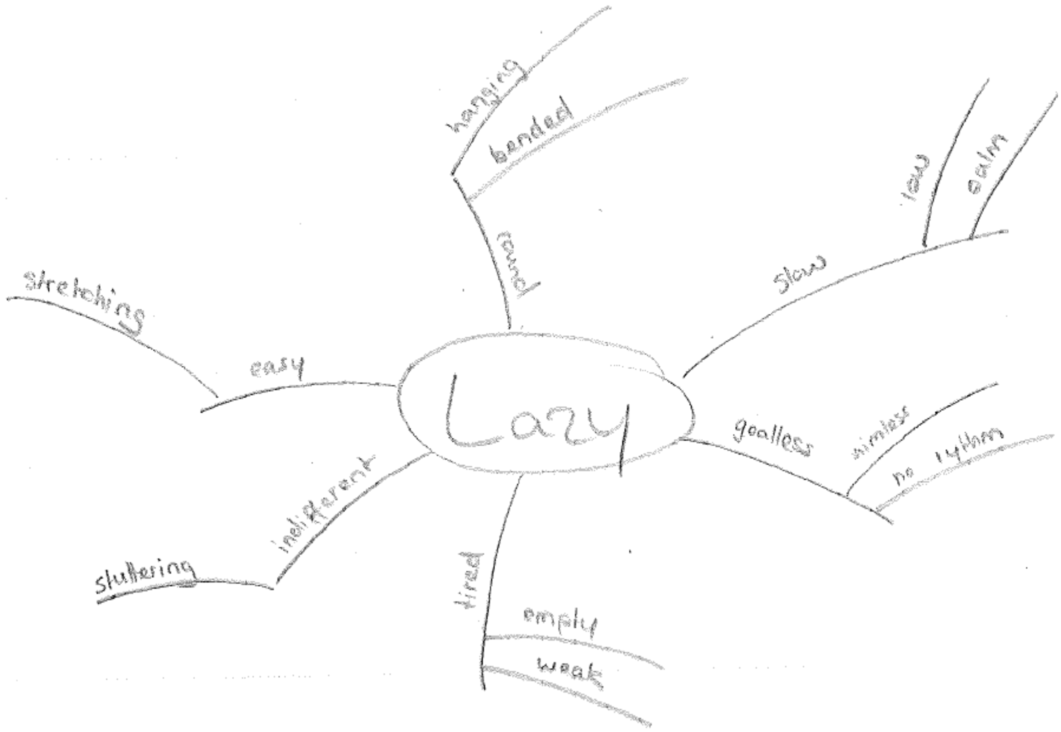


Figure 25: Main characteristics of " lazy" resulting from Study 3

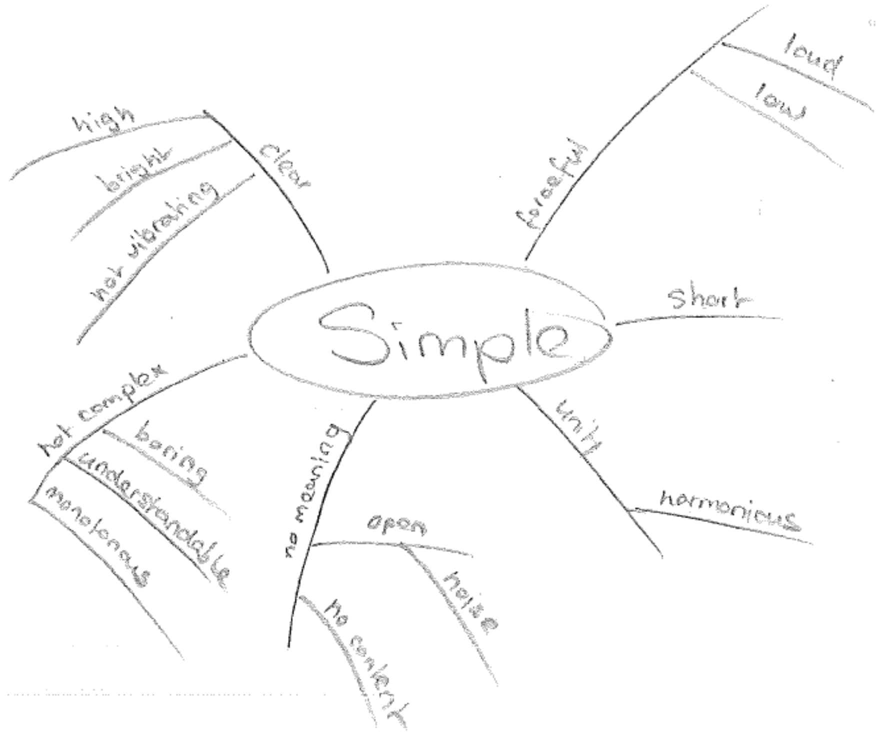


Figure 26: Main characteristics of " simple" resulting from Study 3

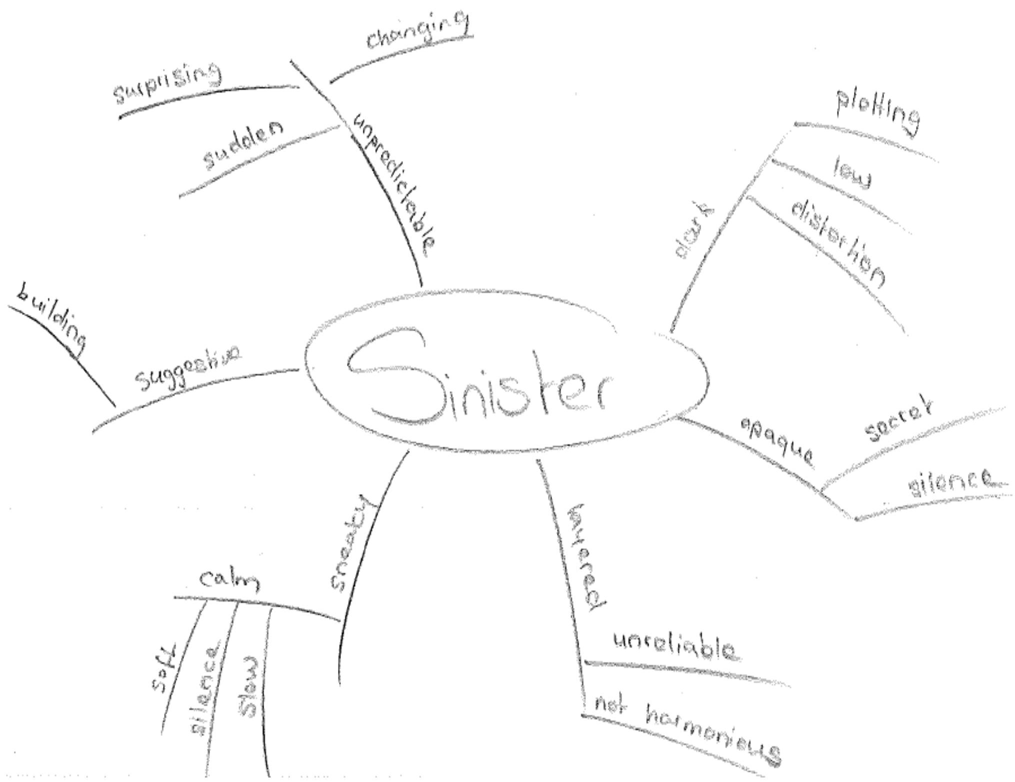


Figure 27: Main characteristics of " sinister" resulting from Study 3

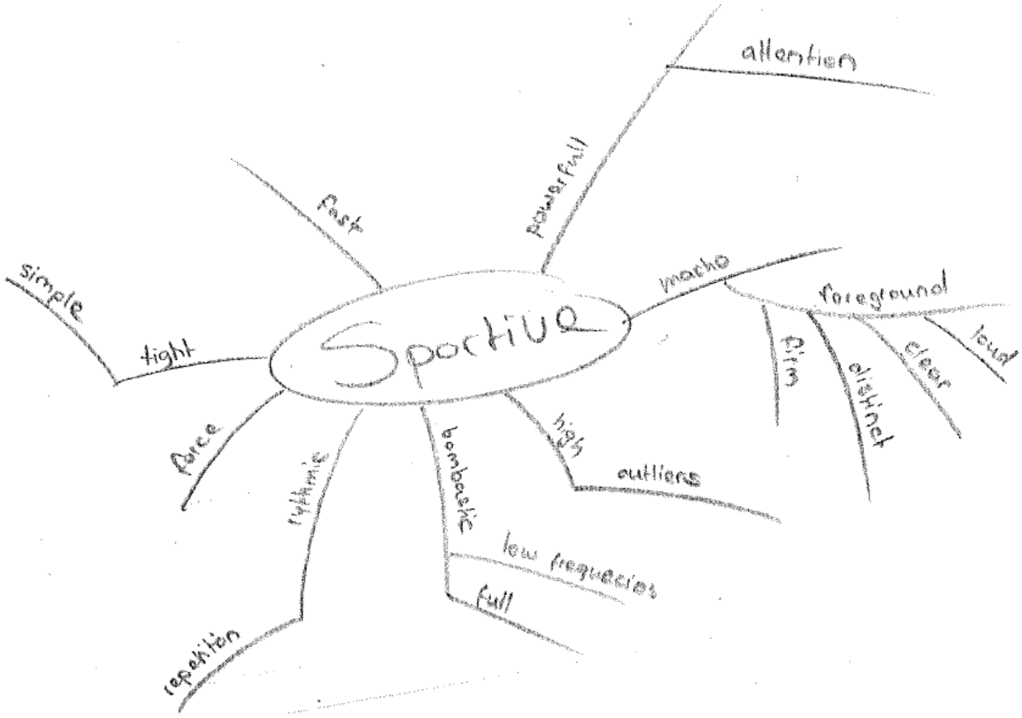


Figure 28: Main characteristics of " sportive" resulting from Study 3

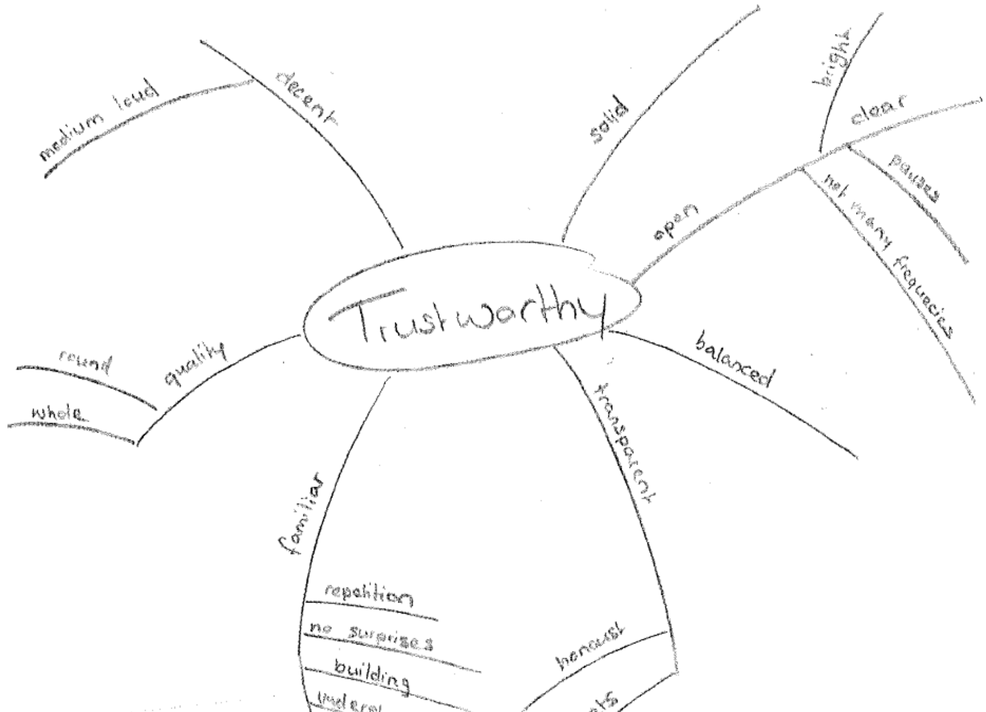


Figure 29: Main characteristics of " trustworthy" resulting from Study 3

APPENDIX H

STUDY 4: SOUND FREQUENCY ADJUSTMENTS *(PG. 32+38)*

The graphs show the frequency distribution of the standard recorded sound and the three adjusted sound per domestic appliance as calculated by the sound program PRAAT. The sounds that belong to these frequency distributions can be found on the attached CD in Appendix L in the folder E:Sound Semantics/Sounds/Study 4/. On the CD the sounds are named according to the following information:

- Domestic appliance
- Kind of alteration
- Hypothesized quadrant on the pleasantness-activation scale (UA/PA/UC/PC)
- Number in the sequence as used during the test

The graphs sometimes show only small differences when larger alterations would make the sound appear to be a computer sounds or a bad recording.

Dust buster

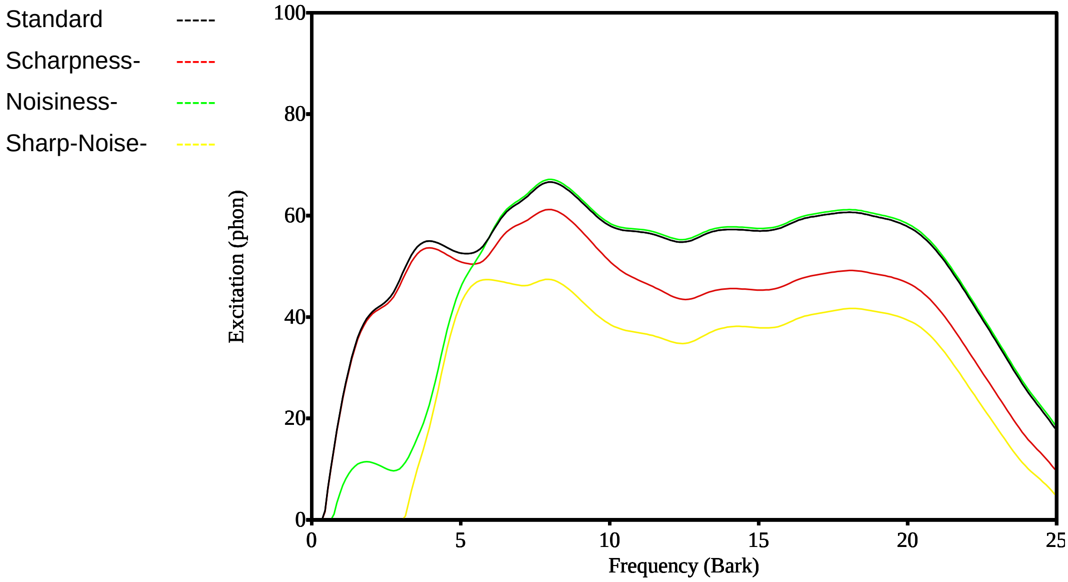


Figure 30: Frequency distribution of dustbuster sounds for preparation Study 4

Epilator

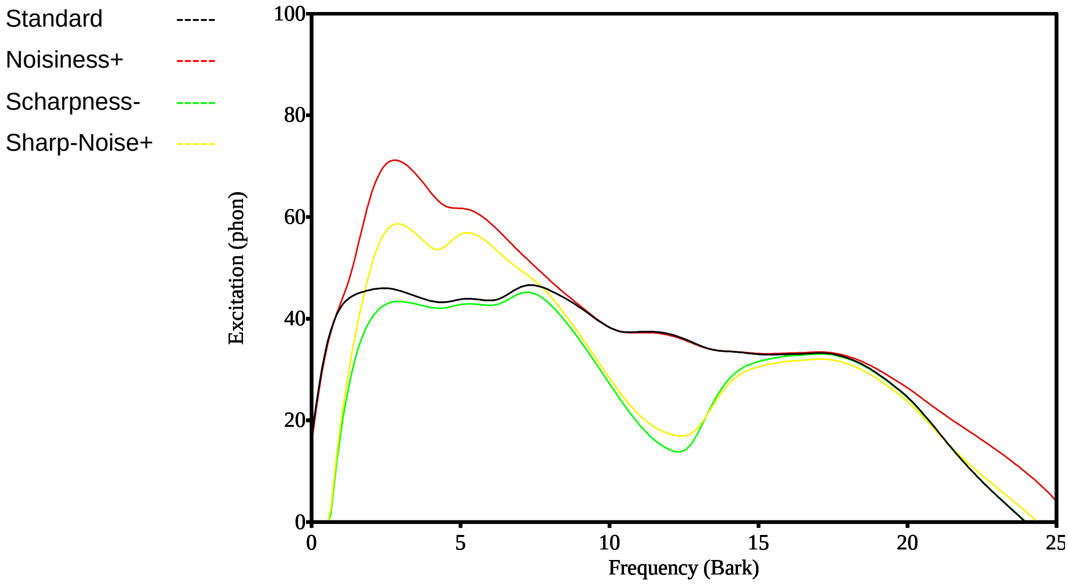


Figure 31: Frequency distribution of epilator sounds for preparation Study 4

Microwave

Standard -----
Noisiness- -----
Scharpness+ -----
Sharp+Noise- -----

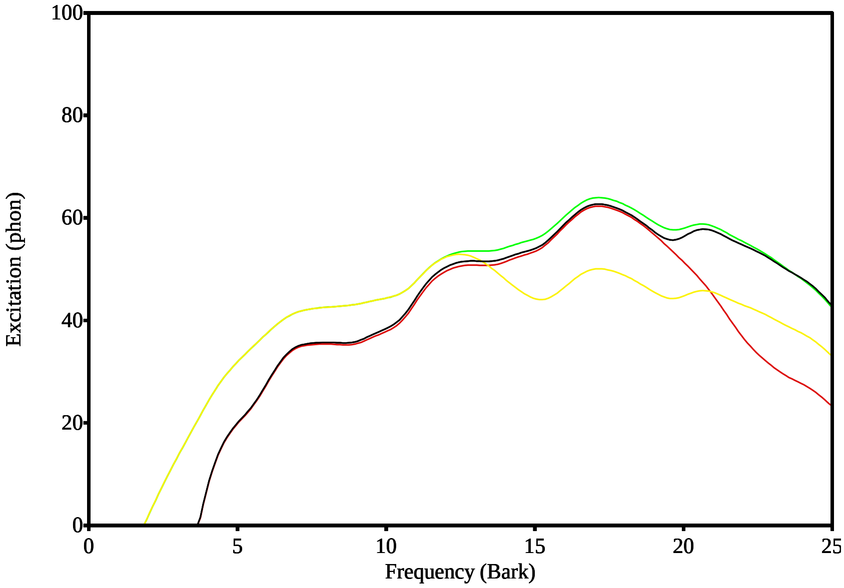


Figure 32: Frequency distribution of microwave sounds for preparation Study 4

Mixer

Standard -----
Scharpness- -----
Noisiness- -----
Sharp-Noise- -----

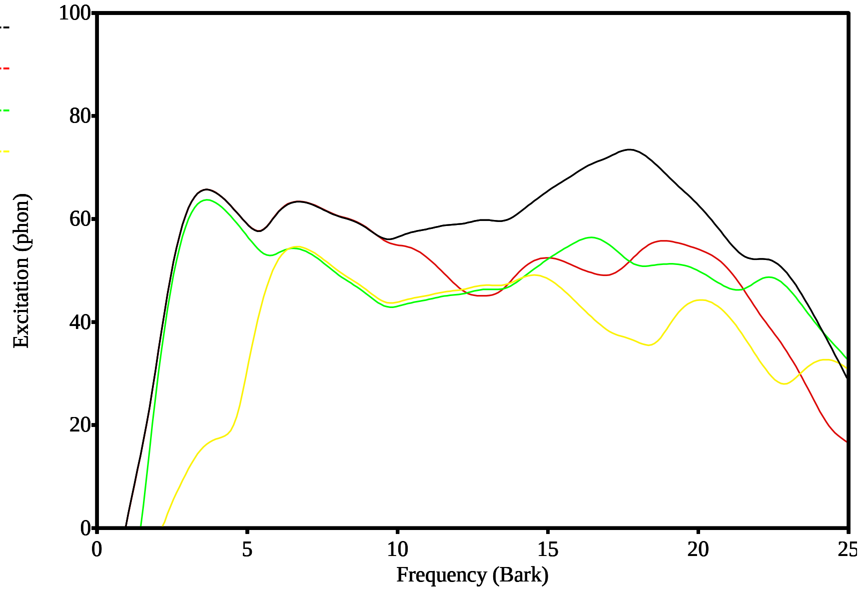


Figure 33: Frequency distribution of mixer sounds for preparation Study 4

Toothbrush

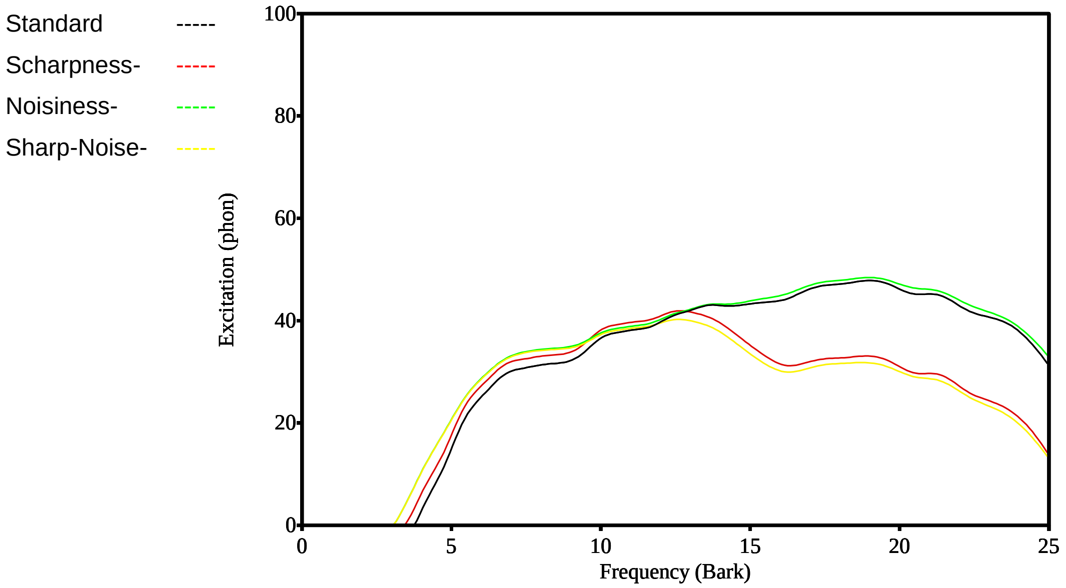


Figure 34: Frequency distribution of toothbrush sounds for preparation Study 4

Washing machine

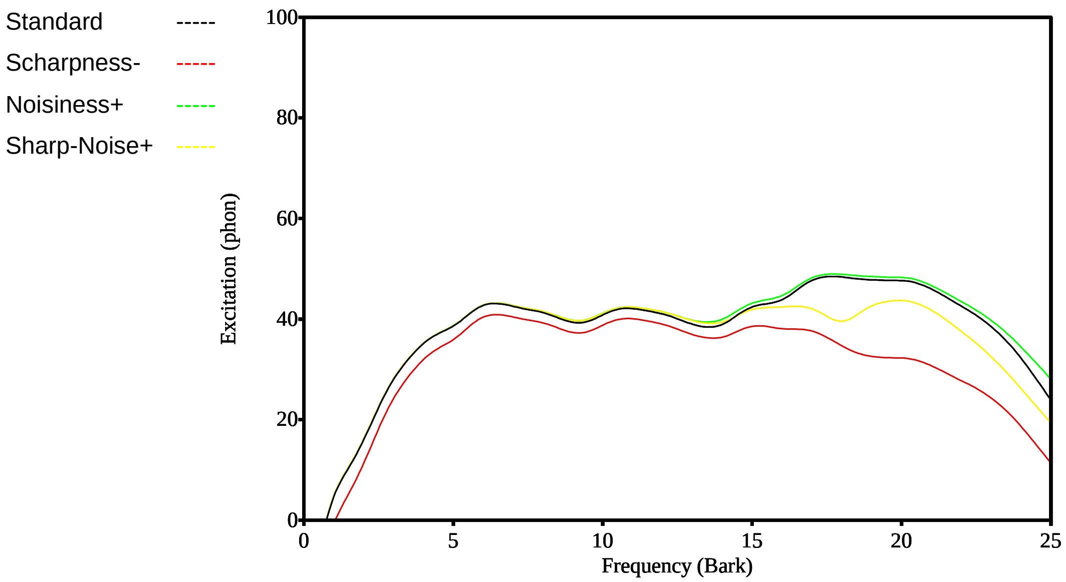


Figure 35: Frequency distribution of washing machine sounds for preparation Study 4

APPENDIX I

STUDY 4: VISUAL BASIC CODE OF TEST PROGRAM *(PG. 33+80+87)*

With these designs and programming codes a test program was created to conduct Study 4 using Microsoft Visual Basic 2010 Express. Form1 let the participant evaluate the sound expression for each semantic association on a scale from 0 to 7. Form2 would let the participant evaluate whether the sounds sounded like their original sources. The program functioned and saved the data automatically.

Design Form1

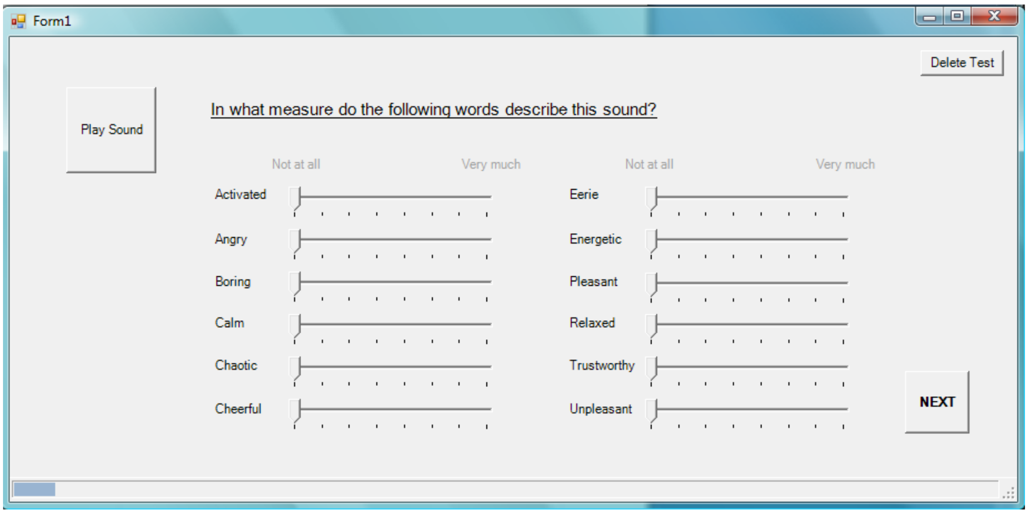


Figure 36: Lay-out of Form1 of the test program as used in Study 4

```
Public Class Form1
```

```
Dim counter As Integer = 1
Dim strWords(0 To 11) As String
Dim interim(0 To 11) As Integer
Dim final(0 To 11) As Integer
Dim resultvalue(0 To 11) As Integer
Dim i As Integer = 1
Dim mainpath As String = "C:/Users/Claire/Desktop/TEST/"
Dim resultpath As String = mainpath & "results/"
Dim soundpath As String = mainpath & "sounds/"
Dim resultfile As String = resultpath & "results.csv"
```

```
Private Sub Form1_Load(ByVal sender As Object, ByVal e As System.EventArgs)
                                                            Handles Me.Load
    For j As Integer = 0 To 11
        interim(j) = j
        final(j) = j
    Next
    strWords(0) = "Activated"
    strWords(1) = "Angry"
    strWords(2) = "Boring"
    strWords(3) = "Calm"
    strWords(4) = "Chaotic"
    strWords(5) = "Cheerful"
    strWords(6) = "Eerie"
    strWords(7) = "Energetic"
    strWords(8) = "Pleasant"
    strWords(9) = "Relaxed"
    strWords(10) = "Trustworthy"
    strWords(11) = "Unpleasant"
    ToolStripProgressBar1.Value = 37
End Sub
```

```
Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As
                                    System.EventArgs) Handles ButtonNext.Click
     If TrackBar1.Value =0 And TrackBar2.Value = 0 And TrackBar3.Value = 0 And
                               TrackBar4.Value = 0 And TrackBar5.Value = 0 And
                               TrackBar6.Value = 0 And TrackBar7.Value = 0 And
                               TrackBar8.Value = 0 And TrackBar9.Value = 0 And
                               TrackBar10.Value = 0 And TrackBar11.Value = 0 And
                               TrackBar12.Value = 0 Then
            MessageBox.Show("You have to enter at least one value!")
    Else
        REM: Opslaan
        resultvalue(final(0)) = TrackBar1.Value
        resultvalue(final(1)) = TrackBar2.Value
        resultvalue(final(2)) = TrackBar3.Value
        resultvalue(final(3)) = TrackBar4.Value
        resultvalue(final(4)) = TrackBar5.Value
        resultvalue(final(5)) = TrackBar6.Value
        resultvalue(final(6)) = TrackBar7.Value
        resultvalue(final(7)) = TrackBar8.Value
        resultvalue(final(8)) = TrackBar9.Value
        resultvalue(final(9)) = TrackBar10.Value
        resultvalue(final(10)) = TrackBar11.Value
        resultvalue(final(11)) = TrackBar12.Value
        My.Computer.FileSystem.WriteAllText(resultfile, resultvalue(0) & "," &
                              resultvalue(1) & "," & resultvalue(2) & "," &
                              resultvalue(3) & "," & resultvalue(4) & "," &
                              resultvalue(5) & "," & resultvalue(6) & "," &
                              resultvalue(7) & "," & resultvalue(8) & "," &
                              resultvalue(9) & "," & resultvalue(10) & "," &
                              resultvalue(11) & ",", True)
        counter = counter + 1
        REM: Recet values
        TrackBar1.Value = 0
        TrackBar2.Value = 0
        TrackBar3.Value = 0
        TrackBar4.Value = 0
        TrackBar5.Value = 0
        TrackBar6.Value = 0
        TrackBar7.Value = 0
        TrackBar8.Value = 0
```

```
            TrackBar9.Value = 0
            TrackBar10.Value = 0
            TrackBar11.Value = 0
            TrackBar12.Value = 0
            REM: Woorden shuffle
            For j As Integer = 0 To 11
                interim(j) = j
            Next
            For j As Integer = 0 To 11
                i = Int(Rnd() * 11)
                Do While interim(i) = -1
                    If i = 11 Then
                        i = 0
                    Else
                        i = i + 1
                    End If
                Loop
                final(j) = interim(i)
                interim(i) = -1
            Next
            Word1.Text = strWords(final(0))
            Word2.Text = strWords(final(1))
            Word3.Text = strWords(final(2))
            Word4.Text = strWords(final(3))
            Word5.Text = strWords(final(4))
            Word6.Text = strWords(final(5))
            Word7.Text = strWords(final(6))
            Word8.Text = strWords(final(7))
            Word9.Text = strWords(final(8))
            Word10.Text = strWords(final(9))
            Word11.Text = strWords(final(10))
            Word12.Text = strWords(final(11))
            If counter < 25 Then
                REM: Progressbar
                ToolStripProgressBar1.Value = counter * 37
                My.Computer.Audio.Play(soundpath & counter & ".wav",
                                                AudioPlayMode.Background)
            ElseIf counter = 25 Then
                REM: Laatste x NEXT button +\= END
                MessageBox.Show("Well done! On to the second half")
                Form2.Show()
                Me.Hide()
            End If
        End If
    End Sub
```

```
    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As
                                    System.EventArgs) Handles ButtonEnd.Click
        REM: Recet button = new participant line
        My.Computer.FileSystem.WriteAllText(resultfile, Chr(13), True)
        End
    End Sub
```

```
    Private Sub Button4_Click(ByVal sender As System.Object, ByVal e As
                                   System.EventArgs) Handles ButtonPlay.Click
        REM: Play new sound
        My.Computer.Audio.Play(soundpath & counter & ".wav",
    End Sub                                          AudioPlayMode.Background)
```

```
End Class
```

Design Form2

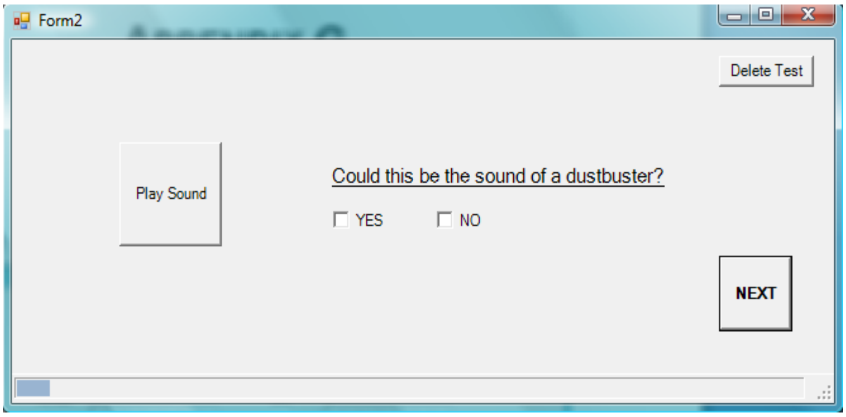


Figure 37: Lay-out of Form2 of the test program as used in Study 4

```
Public Class Form2
```

```
Dim counter As Integer = 1
Dim mainpath As String = "C:/Users/Claire/Desktop/TEST/"
Dim resultpath As String = mainpath & "results/"
Dim soundpath As String = mainpath & "sounds/"
Dim resultfile As String = resultpath & "results.csv"
```

```
Private Sub Form2_Load(ByVal sender As System.Object, ByVal e As
                                          System.EventArgs) Handles MyBase.Load
    ToolStripProgressBar1.Value = 26
     My.Computer.Audio.Play(soundpath & counter & ".wav",
                                                     AudioPlayMode.Background)
End Sub
```

```
Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As
                                    System.EventArgs) Handles ButtonNext.Click
    If CheckBox1.CheckState = 0 And CheckBox2.CheckState = 0 Then
        MessageBox.Show("You have to check one of the boxes!")
    Else
        REM: Save
        My.Computer.FileSystem.WriteAllText(resultfile, CheckBox1.CheckState &
               "," & CheckBox2.CheckState & ",", True)
        REM: Recet values
        CheckBox1.CheckState = 0
        CheckBox2.CheckState = 0
        REM: Lable 14 change
        counter = counter + 1
        If counter = 8 Or counter = 16 Or counter = 22 Then
            Label14.Text = "Could this be the sound of a dustbuster?"
        ElseIf counter = 6 Or counter = 11 Or counter = 17 Or counter = 24 Then
            Label14.Text = "Could this be the sound of a epilator?"
        ElseIf counter = 4 Or counter = 9 Or counter = 15 Or counter = 21 Then
            Label14.Text = "Could this be the sound of a microwave?"
        ElseIf counter = 2 Or counter = 10 Or counter = 14 Or counter = 19 Then
            Label14.Text = "Could this be the sound of a mixer?"
        ElseIf counter = 5 Or counter = 13 Or counter = 18 Or counter = 23 Then
            Label14.Text = "Could this be the sound of a toothbrush?"
        ElseIf counter = 3 Or counter = 7 Or counter = 12 Or counter = 20 Then
            Label14.Text = "Could this be the sound of a washing machine?"
```

```
        End If
        If counter < 25 Then
           REM: Progressbar
           ToolStripProgressBar1.Value = counter * 26
           My.Computer.Audio.Play(soundpath & counter & ".wav",
                                                    AudioPlayMode.Background)
        ElseIf counter = 25 Then
           REM: END
           My.Computer.FileSystem.WriteAllText(resultfile, Chr(13), True)
           MessageBox.Show("You successfully finished the test!")
           Form1.Close()
        End If
    End If
End Sub
```

```
Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As
                                     System.EventArgs) Handles ButtonEnd.Click
    REM: Recet button = new participant line
    My.Computer.FileSystem.WriteAllText(resultfile, Chr(13), True)
    End
End Sub
```

```
Private Sub Button4_Click(ByVal sender As System.Object, ByVal e As
                                   System.EventArgs) Handles ButtonPlay.Click
    REM: Play new sound
    My.Computer.Audio.Play(soundpath & counter & ".wav",
                                                    AudioPlayMode.Background)
End Sub
```

```
Private Sub CheckBox1_CheckedChanged(ByVal sender As System.Object, ByVal e As
                        System.EventArgs) Handles CheckBox1.CheckedChanged
    REM: YES
    If CheckBox1.CheckState = 1 Then
        CheckBox2.CheckState = 0
    End If
End Sub
```

```
Private Sub CheckBox2_CheckedChanged(ByVal sender As System.Object, ByVal e As
                       System.EventArgs) Handles CheckBox2.CheckedChanged
    REM: NO
    If CheckBox2.CheckState = 1 Then
        CheckBox1.CheckState = 0
    End If
End Sub
```

```
End Class
```

APPENDIX J

STUDY 4: TEST RESULTS *(PG. 34+88)*

The six tables tables in this appendix show the values (0-7) that were entered using the slider bars in Form1 of the test program (Appendix I) of Study 4. This was done according to the perceived value of expression for each semantic association per sound.

The sounds that belong to the columns can be found on the attached CD in Appendix L in the folder E:Sound Semantics/Sounds/Study 4/. The sounds are named according to the following information:

- Domestic appliance
- Kind of alteration
- Hypothesized quadrant on the pleasantness-activation scale (UA/PA/UC/PC)
- Number in the sequence as used during the test in Study 4

Quadrants of expected placement on pleasantness-activation scale

PA = Pleasant-Activated

UA = Unpleasant-Activated

PC = Pleasant-Calm

UC = Unpleasant-Calm

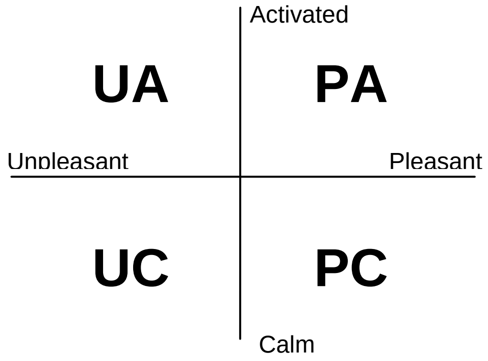


Figure 38: Explanation of quadrants on pleasantness-activation scale

Table 11: Resulting evaluated values for the dustbuster sounds in Study 4

Resulting values for dustbuster sounds

	Dustbuster-standard (UC) 1											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	4	2	0	0	4	0	0	2	0	0	0	4
P 2	0	0	0	2	0	0	0	0	1	3	1	0
P 3	0	4	5	0	1	0	3	1	0	0	1	4
P 4	6	0	6	3	0	0	0	0	0	0	5	6
P 5	6	1	5	0	2	0	0	2	0	0	0	1
P 6	6	1	0	1	2	2	1	3	4	5	5	1
P 7	2	1	7	5	1	0	0	2	1	3	6	2
P 8	2	5	4	2	1	0	5	1	0	1	2	5
P 9	5	6	7	0	5	3	3	0	0	0	3	5
P 10	1	0	4	7	0	0	0	0	5	6	7	0
P 11	5	3	0	0	3	1	1	5	0	0	0	3
P 12	1	0	5	0	0	0	4	0	0	0	0	3
P 13	3	6	6	0	5	1	3	2	1	0	0	6
P 14	4	1	5	2	1	2	1	2	1	1	3	2
P 15	4	3	1	0	2	0	2	3	0	0	1	6
P 16	0	0	4	0	0	0	6	0	0	0	2	6
P 17	3	1	6	1	0	3	1	4	1	2	3	2
P 18	7	3	2	2	2	2	1	4	2	3	3	1
P 19	6	0	0	0	0	0	1	4	0	0	0	5
P 20	6	6	5	0	2	0	5	2	1	1	2	3
P 21	5	5	5	0	1	0	4	3	1	0	1	6
P 22	3	2	7	4	0	0	1	2	0	4	5	4
P 23	4	3	1	0	5	0	6	1	0	0	2	7
P 24	5	2	2	0	4	0	2	3	0	0	0	3
P 25	6	0	0	0	1	0	0	0	0	0	2	6
P 26	1	5	4	4	0	0	5	1	0	2	2	4
P 27	5	5	6	0	3	1	5	4	0	0	0	6
P 28	0	0	1	0	6	0	1	0	0	0	0	6
P 29	0	0	4	0	4	0	7	0	0	0	0	5
P 30	3	0	2	5	0	1	0	3	5	6	5	0

	Dustbuster-sharp- (PC) 8											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	0	0	0	1	0	6	0	0	3	2	1	0
P 2	0	0	0	2	0	4	0	3	0	1	1	0
P 3	2	4	5	0	1	0	4	2	0	0	2	5
P 4	2	0	4	1	0	0	0	1	0	0	1	5
P 5	1	0	2	2	0	0	0	4	1	0	1	0
P 6	5	1	4	4	1	2	0	5	2	5	4	4
P 7	3	0	7	6	0	2	1	2	0	3	7	1
P 8	2	5	6	2	4	1	4	2	1	2	4	6
P 9	2	2	7	3	1	0	4	1	0	1	3	5
P 10	1	1	4	6	0	0	1	0	7	6	7	2
P 11	4	2	2	0	0	0	1	3	0	1	2	1
P 12	0	3	0	2	0	0	0	0	0	3	0	1
P 13	5	4	4	5	1	3	0	7	4	4	5	1
P 14	2	2	3	1	0	1	0	3	2	4	4	1
P 15	6	4	5	0	1	0	1	6	0	4	0	4
P 16	0	0	2	0	0	0	0	0	0	0	2	0
P 17	4	5	5	1	0	0	0	2	0	3	3	6
P 18	6	5	4	5	1	2	5	4	2	4	5	4
P 19	0	0	2	0	1	0	2	0	0	0	0	3
P 20	2	1	5	5	1	2	0	1	5	6	6	5
P 21	5	1	4	1	1	2	4	5	2	0	2	5
P 22	3	2	7	3	1	2	1	3	0	0	3	6
P 23	2	4	1	2	1	1	5	3	1	2	3	4
P 24	4	3	4	0	3	0	3	3	0	0	0	4
P 25	4	1	4	0	0	0	0	3	0	0	4	5
P 26	6	2	3	6	0	0	1	0	0	1	5	5
P 27	4	2	1	5	4	3	3	3	4	4	2	2
P 28	0	2	0	0	2	0	0	2	0	0	0	3
P 29	0	0	6	0	3	0	6	0	0	0	0	7
P 30	4	0	2	0	2	3	1	5	2	1	2	4

	Dustbuster-noise- (UA) 16											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	3	2	0	0	4	0	1	1	0	0	0	0
P 2	6	0	0	0	5	0	0	3	0	0	0	4
P 3	5	4	1	0	0	0	4	3	0	0	0	2
P 4	5	5	0	0	2	0	1	2	0	0	0	7
P 5	1	1	2	0	2	0	1	1	0	0	0	5
P 6	5	4	2	0	4	3	2	4	1	1	3	5
P 7	6	2	0	0	3	0	7	6	0	0	2	5
P 8	6	5	2	0	2	2	7	6	0	0	2	7
P 9	5	4	0	0	0	0	4	5	0	0	0	7
P 10	7	4	0	0	5	1	3	6	0	0	1	6
P 11	4	3	1	1	2	0	2	4	0	1	0	2
P 12	4	0	0	0	3	0	5	0	0	0	0	0
P 13	4	0	0	0	0	4	0	4	0	0	0	0
P 14	4	5	7	0	5	0	3	2	1	0	0	6
P 15	6	6	0	0	6	0	0	5	0	0	0	5
P 16	3	3	0	0	0	0	0	0	0	0	0	0
P 17	3	2	3	0	5	0	4	3	0	0	1	5
P 18	4	7	5	1	5	1	5	5	1	1	2	6
P 19	0	5	0	0	3	0	1	0	0	0	0	5
P 20	6	6	6	1	2	0	4	5	1	0	0	6
P 21	6	4	2	2	1	0	4	5	0	1	2	5
P 22	5	2	4	1	5	3	0	3	2	1	2	7
P 23	4	6	3	1	6	1	7	4	0	0	4	6
P 24	3	2	3	0	3	0	4	2	0	0	0	3
P 25	3	0	0	0	2	1	1	6	0	0	4	2
P 26	4	6	3	0	0	1	6	7	1	0	3	7
P 27	4	3	2	2	3	2	4	4	3	3	2	2
P 28	2	2	0	0	3	0	0	3	0	0	0	6
P 29	3	7	0	0	0	0	7	2	0	0	0	0
P 30	6	0	1	0	5	4	7	6	2	1	2	4

	Dustbuster-sharp-noise- (PA) 22											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	0	0	5	0	0	0	0	0	0	0	0	0
P 2	0	0	7	0	0	0	0	0	0	3	0	0
P 3	3	0	4	4	0	2	0	1	2	4	1	0
P 4	0	0	1	0	2	0	2	0	0	0	0	2
P 5	3	0	3	1	0	0	1	2	0	0	0	3
P 6	5	0	6	5	1	1	1	3	5	6	4	2
P 7	4	2	6	1	0	4	3	5	0	2	5	0
P 8	5	3	5	2	5	4	5	5	1	2	2	5
P 9	0	0	7	1	0	0	0	2	0	0	1	5
P 10	4	0	0	7	0	5	0	0	6	6	7	0
P 11	3	0	1	3	3	0	1	3	0	2	1	1
P 12	2	0	0	4	0	0	0	0	1	0	2	0
P 13	0	0	0	0	0	0	5	0	0	0	0	0
P 14	2	1	5	5	2	1	2	3	4	4	6	1
P 15	2	4	0	0	0	0	1	4	0	0	1	5
P 16	2	0	3	0	2	0	0	0	0	0	0	0
P 17	5	0	0	4	0	2	0	5	3	3	3	0
P 18	3	1	5	7	3	1	4	1	5	5	5	1
P 19	0	0	1	2	0	0	0	0	1	1	0	0
P 20	2	0	5	3	1	4	1	5	2	2	1	4
P 21	2	3	6	2	1	2	5	2	1	1	3	5
P 22	4	3	6	2	6	4	2	4	0	2	1	6
P 23	2	5	2	2	4	2	5	3	1	1	3	5
P 24	2	0	1	1	2	0	0	2	0	0	0	1
P 25	3	0	2	2	1	0	1	1	0	0	1	0
P 26	4	4	1	0	1	2	4	3	2	0	3	4
P 27	4	2	4	3	3	3	4	4	4	4	3	2
P 28	0	0	0	1	0	0	0	1	0	0	2	2
P 29	0	0	4	0	0	0	2	0	1	0	3	2
P 30	4	2	1	2	0	4	2	3	3	1	2	3

Table 12: Resulting evaluated values for the epilator sounds in Study 4

Resulting values for epilator sounds

	Epilator-standard (UA) 24											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	4	2	0	0	4	0	1	5	0	0	0	6
P 2	7	4	0	0	6	0	0	6	0	0	0	5
P 3	4	3	0	3	1	0	1	5	1	2	0	1
P 4	4	5	0	0	0	0	0	2	0	0	0	4
P 5	1	2	2	0	3	0	0	1	0	0	0	5
P 6	6	4	1	0	3	2	3	5	1	0	0	5
P 7	6	7	0	0	6	0	5	6	0	0	2	6
P 8	6	6	2	1	6	4	5	6	1	0	2	6
P 9	0	1	7	0	0	0	0	0	1	0	0	3
P 10	7	6	0	0	5	0	5	6	0	0	0	6
P 11	3	3	0	0	2	0	2	3	0	0	0	4
P 12	2	4	0	3	1	0	5	0	0	0	0	5
P 13	5	7	6	0	7	2	7	7	0	0	0	7
P 14	5	5	2	1	5	1	4	4	0	1	2	6
P 15	5	5	0	0	3	0	2	6	0	0	0	5
P 16	5	0	0	0	0	0	0	5	1	0	0	0
P 17	3	6	4	0	7	0	6	2	0	0	0	7
P 18	7	7	1	1	5	1	5	7	0	0	1	7
P 19	0	4	0	0	1	0	1	1	0	0	0	4
P 20	5	5	0	0	2	0	3	5	0	0	0	7
P 21	5	5	3	0	4	0	3	6	0	0	3	7
P 22	6	6	2	0	7	0	4	5	0	0	1	7
P 23	3	2	3	0	5	1	7	1	0	0	1	7
P 24	4	4	3	0	5	0	5	4	0	0	0	5
P 25	4	2	0	0	3	0	2	4	0	0	0	2
P 26	5	5	0	1	3	0	7	5	0	0	2	7
P 27	4	6	6	2	5	2	3	4	2	2	1	6
P 28	2	4	0	0	2	0	0	1	0	0	0	7
P 29	0	5	0	0	5	0	7	3	0	0	0	7
P 30	7	7	1	0	6	3	7	7	0	0	0	5

	Epilator-sharp- (PA) 11											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	4	5	0	0	2	0	3	4	0	0	0	2
P 2	6	7	0	0	0	0	3	5	0	0	0	2
P 3	2	1	1	5	0	2	0	2	3	1	0	0
P 4	4	2	0	0	0	0	1	0	0	0	0	5
P 5	1	1	3	0	2	0	0	1	0	0	0	4
P 6	5	5	2	1	4	1	2	4	1	1	1	6
P 7	6	5	2	0	6	0	6	4	0	0	1	5
P 8	4	2	4	5	1	2	2	5	2	5	5	2
P 9	0	3	7	0	0	0	0	0	0	0	0	6
P 10	4	0	2	6	5	7	1	6	7	6	3	0
P 11	5	3	0	0	3	0	2	2	0	0	0	5
P 12	0	3	0	0	0	0	6	0	0	0	0	3
P 13	4	4	5	1	6	4	2	3	3	2	0	4
P 14	3	4	3	1	2	2	2	3	1	1	2	1
P 15	2	5	0	0	0	0	3	4	0	0	0	2
P 16	0	0	0	0	0	0	2	2	0	0	0	2
P 17	4	6	6	0	5	0	6	5	0	0	0	5
P 18	5	5	3	1	4	4	2	5	1	1	5	5
P 19	0	1	2	0	0	0	0	0	0	0	0	4
P 20	5	6	0	1	5	1	4	5	2	1	1	5
P 21	4	1	2	3	1	2	1	3	4	4	4	1
P 22	0	0	0	0	5	2	0	4	2	2	2	6
P 23	2	3	3	3	4	1	4	3	1	1	1	5
P 24	2	3	3	0	3	0	4	1	0	0	0	4
P 25	2	0	0	0	1	3	3	5	5	0	1	2
P 26	1	6	5	3	0	0	6	4	0	0	1	7
P 27	3	5	1	0	6	2	5	4	2	2	2	4
P 28	2	0	0	0	1	0	0	2	0	0	0	3
P 29	3	3	0	0	0	0	7	1	0	0	0	6
P 30	5	6	2	0	4	0	5	3	0	0	0	6

	Epilator-noise+ (UC) 6											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	5	6	0	0	4	0	1	0	0	0	0	4
P 2	7	0	0	0	4	0	0	0	0	0	0	5
P 3	5	3	1	0	2	0	2	3	0	0	3	2
P 4	6	2	0	0	0	0	3	3	0	0	1	3
P 5	4	0	2	0	1	0	0	2	0	0	0	5
P 6	6	6	1	0	5	0	4	5	0	0	1	7
P 7	7	5	0	0	5	0	6	5	0	0	1	7
P 8	6	7	2	0	5	2	5	6	0	1	2	6
P 9	4	1	1	0	3	5	0	4	2	2	0	2
P 10	7	7	0	0	4	0	4	5	0	0	2	7
P 11	3	6	0	0	5	0	2	0	0	0	0	4
P 12	3	0	0	0	0	0	2	2	0	0	0	3
P 13	6	7	1	0	7	4	4	5	0	0	0	7
P 14	2	5	1	0	4	0	2	3	1	1	2	1
P 15	6	6	3	0	6	0	2	6	0	0	0	5
P 16	0	0	0	0	7	0	0	6	0	0	0	0
P 17	5	6	5	0	0	0	6	3	0	0	0	6
P 18	6	7	2	0	5	1	6	6	1	1	2	5
P 19	0	2	5	0	2	0	2	0	0	0	0	5
P 20	5	5	0	0	4	1	5	6	0	0	2	6
P 21	7	4	0	0	5	0	2	6	0	0	1	6
P 22	6	6	2	0	2	0	4	1	0	0	0	7
P 23	2	5	1	0	7	0	7	1	0	0	2	7
P 24	4	3	1	0	5	0	5	4	0	0	0	5
P 25	6	3	0	0	4	0	2	4	0	0	0	5
P 26	6	7	4	0	6	0	7	3	0	0	4	7
P 27	5	5	2	1	6	2	5	5	1	0	2	6
P 28	4	2	0	0	6	0	0	5	0	0	0	6
P 29	5	3	0	0	5	0	7	3	0	0	0	7
P 30	5	6	1	0	4	0	7	6	0	0	1	7

	Epilator-sharp-noise+ (PC) 17											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	3	1	0	0	5	0	3	1	0	0	0	1
P 2	1	6	1	0	0	0	0	3	0	0	0	4
P 3	2	0	3	4	1	2	0	3	2	3	2	0
P 4	1	3	0	0	1	0	1	1	0	0	0	3
P 5	2	3	2	0	1	0	1	1	0	0	0	4
P 6	5	4	5	4	6	2	2	6	2	3	1	5
P 7	6	1	2	0	4	0	6	3	0	0	3	2
P 8	5	5	6	5	2	1	4	5	2	5	3	3
P 9	1	0	7	0	0	0	0	1	0	0	1	5
P 10	7	0	0	6	2	4	6	2	3	3	2	4
P 11	3	2	1	2	2	0	4	2	0	0	0	3
P 12	2	4	0	0	2	0	4	0	0	0	0	2
P 13	6	5	1	0	7	2	5	6	0	0	1	7
P 14	4	3	4	2	3	2	1	2	0	0	1	5
P 15	1	1	4	0	1	0	0	2	2	3	0	1
P 16	0	1	0	1	2	0	0	0	0	0	0	0
P 17	4	3	3	1	2	0	0	3	0	1	2	3
P 18	5	5	2	2	2	1	5	1	2	2	7	4
P 19	0	1	2	0	2	0	1	0	0	0	0	2
P 20	5	0	1	5	1	2	1	5	4	4	4	1
P 21	5	5	6	3	2	2	3	3	1	1	2	5
P 22	4	7	2	0	2	0	0	1	0	0	0	7
P 23	4	4	5	3	6	1	4	4	1	1	3	4
P 24	2	2	3	0	3	0	4	2	0	0	0	3
P 25	4	2	1	0	0	0	0	3	1	1	3	0
P 26	4	4	5	1	4	1	7	3	1	0	3	6
P 27	3	4	6	2	5	2	3	4	3	3	1	4
P 28	0	2	1	0	1	0	0	0	0	0	0	2
P 29	4	1	0	0	5	0	7	4	0	0	0	7
P 30	2	7	2	0	5	0	5	3	4	0	2	2

Table 13: Resulting evaluated values for the microwave sounds in Study 4

Resulting values for microwave sounds

	Microwave-standard (PC) 21											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	0	0	0	3	0	0	0	0	2	2	1	0
P 2	0	0	3	0	0	0	6	0	0	0	0	3
P 3	0	0	3	5	0	3	0	0	1	4	4	0
P 4	0	0	2	6	0	0	0	0	0	2	2	1
P 5	0	1	3	0	2	0	0	1	0	0	0	4
P 6	6	1	5	5	0	3	1	5	4	4	4	1
P 7	0	0	7	5	0	0	0	1	0	6	4	0
P 8	2	4	5	5	4	1	4	2	2	2	5	4
P 9	0	0	7	4	1	0	0	1	0	0	4	0
P 10	0	0	4	7	0	0	0	0	7	7	7	0
P 11	3	0	2	2	1	0	0	3	1	2	1	0
P 12	0	0	1	6	0	0	0	0	2	4	3	0
P 13	5	0	2	7	0	4	0	2	6	6	7	0
P 14	2	2	4	5	2	1	2	2	5	5	5	2
P 15	0	0	1	6	0	0	0	0	3	5	4	0
P 16	0	0	4	1	3	0	2	0	0	0	0	0
P 17	4	0	0	4	1	0	0	3	5	4	5	0
P 18	4	0	0	7	1	3	0	2	0	0	0	1
P 19	0	0	2	3	0	0	0	0	2	0	1	0
P 20	1	0	6	6	0	0	0	0	7	7	6	1
P 21	1	0	4	5	0	2	0	2	4	6	5	1
P 22	4	1	7	6	0	2	0	5	4	1	2	6
P 23	2	1	5	5	2	1	1	2	3	1	3	1
P 24	3	0	2	2	2	0	0	1	0	1	1	0
P 25	1	0	0	3	0	0	1	0	1	1	2	0
P 26	0	3	4	5	0	0	0	0	4	3	5	1
P 27	4	2	4	5	1	3	3	4	4	4	2	3
P 28	0	0	1	3	0	0	0	0	1	2	0	0
P 29	0	0	3	3	0	0	0	0	0	0	3	1
P 30	0	0	3	7	0	2	0	1	5	4	4	0

	Microwave-sharp+ (UC) 15											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	0	0	5	1	0	0	0	0	0	2	0	1
P 2	0	0	7	1	0	0	2	0	0	0	0	0
P 3	0	0	5	4	6	1	0	4	1	0	5	0
P 4	1	0	2	0	1	0	0	0	0	0	2	2
P 5	2	0	3	0	0	0	1	0	3	0	0	1
P 6	3	4	5	5	1	2	4	3	2	2	2	3
P 7	0	6	0	6	4	0	5	0	0	0	0	5
P 8	5	4	5	2	6	2	6	6	1	1	5	6
P 9	0	0	7	0	0	0	0	1	2	0	4	3
P 10	0	3	6	7	0	0	3	0	5	6	7	2
P 11	3	0	2	1	1	0	2	0	0	1	1	1
P 12	0	3	2	2	0	0	0	0	0	3	0	0
P 13	5	1	0	0	1	2	4	0	6	5	5	1
P 14	3	5	2	1	4	1	5	2	1	1	1	4
P 15	0	0	5	6	0	0	0	0	3	6	2	0
P 16	0	0	2	0	1	0	0	0	0	2	0	0
P 17	4	1	4	0	0	0	1	3	0	2	1	2
P 18	6	1	6	7	1	1	5	1	6	6	6	1
P 19	1	0	2	1	0	0	0	0	0	0	0	3
P 20	2	0	4	4	2	1	4	1	3	4	5	4
P 21	4	1	4	4	1	2	3	3	5	4	2	2
P 22	1	3	7	2	5	4	0	4	2	2	3	6
P 23	4	1	2	5	2	2	3	2	4	5	3	2
P 24	2	2	3	0	3	0	3	2	0	0	0	2
P 25	1	0	1	2	1	0	0	0	5	2	2	0
P 26	0	0	7	7	0	1	0	4	4	0	6	1
P 27	4	4	2	4	4	2	4	3	3	4	2	2
P 28	0	0	1	1	1	0	1	0	0	0	0	2
P 29	0	0	6	2	0	0	5	0	0	0	0	6
P 30	2	0	4	3	0	0	3	2	3	4	2	3

	Microwave-noise- (PA) 4											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	0	0	5	4	0	0	0	0	0	4	2	0
P 2	0	0	0	3	0	0	0	0	3	4	0	0
P 3	1	0	1	3	0	1	0	0	4	3	0	0
P 4	0	0	7	3	0	0	0	0	0	1	0	0
P 5	0	0	2	5	0	0	0	0	3	2	1	0
P 6	4	1	2	6	0	1	0	3	6	5	5	0
P 7	2	0	7	6	0	0	1	1	0	7	6	0
P 8	1	4	5	5	3	0	2	1	1	3	4	5
P 9	0	2	7	1	0	0	0	0	0	0	2	7
P 10	0	0	5	7	0	0	0	0	5	6	7	1
P 11	2	0	2	5	0	0	0	1	1	3	1	0
P 12	0	0	1	5	0	0	0	0	0	0	1	0
P 13	1	1	6	6	0	1	4	2	5	6	6	1
P 14	2	0	5	3	0	1	3	2	1	1	3	1
P 15	0	3	5	6	1	0	3	0	0	5	3	5
P 16	0	0	5	3	0	0	0	0	0	0	0	0
P 17	3	0	0	7	0	6	0	2	6	7	5	0
P 18	4	5	4	6	4	1	5	6	2	5	2	2
P 19	0	0	2	3	0	0	0	0	0	2	0	0
P 20	0	0	5	6	0	2	0	0	5	6	5	1
P 21	4	2	1	4	1	3	5	2	3	4	3	4
P 22	2	5	5	2	1	0	6	2	1	0	2	5
P 23	1	3	4	5	2	0	2	1	5	6	4	1
P 24	3	2	2	1	3	0	0	1	2	0	0	0
P 25	0	0	6	5	0	0	1	0	0	1	3	4
P 26	0	1	7	7	0	0	3	0	0	0	5	6
P 27	3	1	2	5	1	3	3	4	4	5	3	2
P 28	0	0	0	4	0	0	0	0	2	4	1	0
P 29	0	0	4	2	0	0	5	0	0	0	0	5
P 30	1	2	7	4	0	0	2	0	3	5	1	2

	Microwave-sharp+noise- (UA) 9											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	0	0	0	5	0	0	1	1	0	0	0	0
P 2	0	0	0	3	0	5	0	0	4	7	0	0
P 3	1	0	1	6	0	0	0	2	3	4	4	0
P 4	2	1	2	0	0	0	0	0	0	0	0	5
P 5	1	0	2	3	0	0	0	0	1	2	1	0
P 6	1	0	5	5	3	0	4	1	1	2	1	3
P 7	0	2	2	0	2	0	4	0	0	5	0	0
P 8	2	5	6	6	1	0	3	1	2	6	3	2
P 9	3	1	0	3	0	0	0	1	3	3	3	3
P 10	0	5	4	7	1	0	7	1	0	0	3	7
P 11	2	0	5	2	0	0	3	0	0	1	1	1
P 12	3	3	0	0	0	0	0	2	0	1	4	0
P 13	4	1	5	6	1	2	5	1	4	6	4	1
P 14	2	0	5	4	1	2	4	2	3	2	4	2
P 15	0	0	4	5	0	1	0	0	3	4	4	1
P 16	0	0	0	0	3	0	0	0	0	3	0	0
P 17	4	0	0	5	0	2	0	4	4	5	2	0
P 18	5	1	5	5	5	1	7	5	1	3	1	4
P 19	0	0	1	1	0	0	0	1	1	0	1	0
P 20	4	1	1	5	2	4	1	1	4	4	4	0
P 21	5	1	2	4	1	1	2	4	5	4	3	2
P 22	5	0	0	2	6	2	0	3	3	4	1	5
P 23	1	1	3	5	1	2	2	2	3	6	3	2
P 24	2	2	3	0	3	0	2	2	0	0	0	3
P 25	2	0	2	0	2	0	0	0	0	2	2	3
P 26	0	4	5	2	0	1	3	0	2	5	5	3
P 27	3	3	2	6	3	4	3	4	5	3	1	2
P 28	1	0	2	0	0	0	0	0	1	1	0	0
P 29	0	0	4	2	1	0	6	0	0	1	0	6
P 30	5	2	0	0	2	3	3	4	1	0	2	1

Table 14: Resulting evaluated values for the mixer sounds in Study 4

Resulting values for mixer sounds

	Mixer-standard (UA) 19												Mixer-sharp- (PA) 14												Mixer-noise+ (UC) 10												Mixer-sharp-noise+ (PC) 2											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	5	1	0	0	3	0	1	6	0	0	0	6	3	3	0	0	5	0	0	2	0	0	0	5	4	0	1	1	0	0	0	1	2	5	0	0	1	0	0	1	0	3	0	1	3	0	0	0
P 2	0	0	0	0	0	0	1	0	0	0	0	6	0	6	0	0	1	0	0	1	0	0	0	3	5	0	0	0	0	0	0	0	2	4	0	0	0	0	0	1	0	0	5	0	0	0	0	1
P 3	3	2	0	0	2	1	2	4	0	0	2	4	3	2	4	0	1	1	1	2	0	0	0	1	5	3	0	0	1	0	4	1	0	0	1	3	2	0	0	0	1	1	3	4	2	0	1	2
P 4	5	0	2	0	2	0	0	3	0	0	0	5	4	0	0	1	0	0	0	2	0	0	2	7	5	0	1	0	0	0	0	3	0	0	1	1	4	0	6	6	0	0	2	0	0	3	3	3
P 5	2	0	0	0	1	0	0	3	0	0	0	3	4	0	3	0	1	0	0	2	0	0	0	3	2	0	3	0	0	0	0	3	0	0	0	4	0	0	4	4	0	0	1	0	1	2	3	0
P 6	7	5	0	1	2	1	0	3	0	0	1	6	5	3	6	2	2	2	1	2	1	4	5	4	5	5	1	1	6	4	3	5	1	1	2	5	4	0	3	4	2	1	2	2	4	2	2	1
P 7	5	0	0	0	6	3	6	7	0	0	5	5	5	0	6	2	3	2	2	2	0	0	5	3	6	0	6	0	1	3	4	5	0	3	3	2	6	5	1	0	7	4	4	5	2	0	2	4
P 8	5	6	5	1	4	2	7	6	0	1	5	6	5	2	6	1	1	2	5	5	1	0	4	6	5	2	5	3	2	6	4	5	2	1	2	6	5	1	2	1	1	3	2	2	4	1	1	2
P 9	6	3	7	0	5	2	1	3	0	0	1	7	3	0	7	0	0	1	0	0	0	0	0	6	3	4	6	0	0	2	2	3	1	0	1	4	0	3	6	3	2	0	0	1	1	0	0	5
P 10	7	6	5	1	0	0	0	7	4	1	7	4	0	0	6	5	0	0	0	1	5	6	6	0	7	2	1	1	2	1	5	7	2	0	6	5	6	2	2	5	4	3	2	4	1	1	1	5
P 11	3	2	0	0	4	0	2	5	0	0	0	2	3	3	2	1	3	0	2	4	0	1	0	2	2	2	0	1	0	1	1	3	0	1	0	3	2	0	2	0	0	0	0	2	0	1	0	1
P 12	2	4	0	0	3	0	0	0	0	0	0	3	2	2	3	0	1	0	0	0	0	0	0	0	3	2	0	0	1	0	5	0	0	0	0	1	1	4	1	0	2	0	4	0	0	0	0	2
P 13	5	6	5	0	7	1	3	5	0	0	0	7	4	3	3	4	3	4	1	3	3	3	4	3	5	6	6	0	5	3	3	6	1	1	1	6	2	4	4	4	2	4	4	1	1	4	0	4
P 14	3	5	1	2	5	1	3	4	1	1	3	5	2	1	2	2	3	1	2	2	1	2	1	3	3	2	4	1	1	2	5	2	2	1	2	2	1	4	3	1	1	2	4	1	1	1	1	4
P 15	1	6	2	0	5	0	0	5	0	0	0	6	5	3	0	0	0	0	0	3	0	0	0	4	6	6	4	0	4	0	0	5	0	0	0	5	2	1	2	2	2	1	4	0	1	1	0	4
P 16	7	4	0	0	0	0	0	4	0	0	0	0	3	0	0	0	0	0	2	0	0	0	0	3	3	0	0	0	0	0	0	5	0	0	0	0	3	0	0	0	0	3	0	4	0	0	0	0
P 17	5	6	4	0	6	0	5	0	0	0	0	6	5	0	5	2	0	0	3	3	0	0	2	3	5	5	5	0	0	0	4	4	0	0	0	6	4	0	3	6	0	4	0	4	2	5	5	0
P 18	6	7	2	1	6	1	5	2	1	0	1	6	5	0	5	6	1	1	1	3	4	5	5	1	5	7	1	1	5	0	5	5	1	1	1	6	5	4	4	4	2	4	2	4	2	5	5	2
P 19	0	6	0	0	1	0	1	2	0	0	0	6	0	5	5	0	0	0	1	0	0	0	0	5	0	3	2	0	0	0	2	1	0	0	0	5	1	0	4	0	0	0	0	2	0	0	1	2
P 20	5	4	1	0	3	1	4	5	1	2	1	5	1	0	2	4	1	2	1	1	5	5	6	1	5	5	1	1	2	1	5	6	1	0	1	5	4	1	3	5	1	4	2	4	3	1	2	4
P 21	5	4	1	1	3	0	2	4	0	0	4	7	5	2	2	1	1	1	2	3	1	1	1	3	6	6	2	1	4	2	5	6	1	1	1	7	5	3	4	1	0	3	2	4	2	5	2	3
P 22	2	6	4	0	4	0	0	2	2	0	2	6	2	0	5	1	3	1	0	5	1	0	3	5	3	0	3	4	0	2	0	2	0	2	4	7	4	4	5	1	0	3	1	2	0	0	2	6
P 23	4	5	2	1	5	1	5	4	1	5	3	6	4	3	5	2	2	2	2	2	2	4	3	6	5	3	4	1	1	1	6	4	1	1	3	5	4	4	2	2	4	1	5	2	1	1	2	7
P 24	3	3	2	0	5	0	4	3	0	0	0	4	4	2	3	0	4	0	4	3	0	0	0	4	3	3	2	0	3	0	5	3	0	0	0	4	3	0	3	1	4	0	4	2	0	0	0	2
P 25	5	2	0	0	2	0	1	4	0	0	1	5	6	0	2	0	0	0	0	2	0	0	2	3	6	2	0	0	0	0	1	5	0	0	3	6	4	0	5	0	0	1	0	0	0	0	1	2
P 26	4	7	0	0	4	2	7	7	0	0	3	7	6	5	7	1	0	0	3	3	3	1	4	5	4	2	5	0	0	1	5	0	0	1	5	6	0	2	3	7	0	1	0	0	6	7	2	0
P 27	4	3	6	2	4	2	4	4	2	2	2	4	4	3	5	4	4	4	4	2	4	4	2	2	4	4	0	1	5	3	4	4	2	2	2	5	5	4	1	2	3	2	4	5	2	3	1	3
P 28	2	2	0	0	2	0	0	2	0	0	0	6	0	0	2	0	2	0	1	0	0	0	0	4	0	3	0	0	3	0	0	1	0	0	0	6	0	3	0	1	1	0	0	0	0	0	0	4
P 29	0	3	0	0	4	0	6	3	0	0	0	7	2	0	3	0	0	0	0	0	0	0	0	6	0	2	5	0	0	0	5	2	0	0	1	7	0	0	5	0	4	0	6	0	0	0	0	3
P 30	5	6	2	0	5	2	7	5	0	0	0	6	2	5	2	0	2	2	7	3	0	0	0	7	7	4	0	0	2	4	7	6	1	0	0	5	3	3	0	0	2	0	6	1	0	0	0	6

Table 15: Resulting evaluated values for the toothbrush sounds in Study 4

Resulting values for toothbrush sounds

	Toothbrush-standard (UA) 13											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	3	3	0	0	4	0	0	5	0	0	0	2
P 2	5	0	0	0	0	0	1	6	1	0	2	0
P 3	3	2	0	0	1	0	2	4	0	0	1	1
P 4	2	1	1	1	1	0	0	0	0	0	0	5
P 5	1	2	2	0	1	0	0	1	0	0	0	3
P 6	6	4	1	5	1	4	1	6	4	4	6	2
P 7	7	6	7	0	5	0	5	6	0	0	3	6
P 8	6	5	2	4	2	1	5	5	1	1	2	5
P 9	1	0	7	1	2	0	0	0	1	0	0	2
P 10	1	6	1	1	5	0	6	1	1	0	2	6
P 11	4	3	0	1	2	0	2	3	0	1	1	2
P 12	3	0	0	0	3	0	5	3	0	0	0	0
P 13	5	4	5	1	5	2	7	4	1	0	1	1
P 14	2	4	1	3	2	2	3	1	2	2	3	2
P 15	6	7	0	0	3	0	0	6	0	0	0	6
P 16	0	5	0	0	0	0	0	0	0	0	0	2
P 17	7	5	7	0	5	0	6	0	0	0	0	6
P 18	6	5	4	3	1	5	1	5	4	4	5	1
P 19	0	0	2	0	0	0	0	0	0	0	0	2
P 20	4	5	0	1	4	0	5	5	1	0	0	6
P 21	6	5	3	0	2	1	5	5	0	0	0	6
P 22	5	6	3	0	2	0	5	5	0	0	0	7
P 23	5	4	2	1	4	1	5	3	3	1	4	5
P 24	3	4	2	0	3	0	4	1	0	0	0	3
P 25	4	2	3	0	3	1	1	5	0	0	0	2
P 26	3	5	0	1	4	0	7	5	1	2	2	6
P 27	4	5	1	2	6	2	5	2	2	2	1	5
P 28	1	0	0	0	0	0	2	0	0	0	0	3
P 29	4	4	0	0	0	0	7	0	0	1	0	7
P 30	4	3	5	0	5	5	6	5	1	0	1	5

	Toothbrush-sharp- (PA) 18											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	0	0	0	2	0	0	0	0	3	6	1	0
P 2	0	0	7	1	0	0	2	0	4	0	0	0
P 3	2	0	5	4	1	0	1	1	2	3	0	0
P 4	5	1	3	1	0	0	0	1	0	0	1	1
P 5	0	3	1	0	2	0	1	0	0	0	0	4
P 6	5	1	4	5	1	2	1	3	4	4	5	2
P 7	3	1	6	2	0	0	4	0	0	2	3	4
P 8	1	2	5	6	2	4	1	3	5	5	5	1
P 9	1	0	7	1	0	0	0	0	0	0	0	7
P 10	0	0	2	5	0	6	3	2	6	5	7	0
P 11	3	0	1	3	0	1	1	2	1	1	2	0
P 12	0	0	3	3	0	0	0	0	1	2	3	0
P 13	3	0	4	7	0	3	4	4	7	7	7	0
P 14	3	2	4	5	0	0	0	5	4	5	6	1
P 15	2	1	2	4	0	0	0	1	2	4	4	0
P 16	0	2	0	0	1	0	0	0	0	0	0	2
P 17	5	0	0	6	0	4	0	3	5	5	5	0
P 18	6	1	2	7	1	4	1	2	6	7	7	0
P 19	0	0	2	0	1	0	0	0	0	0	0	2
P 20	1	1	5	5	0	1	0	4	5	6	6	0
P 21	4	2	5	0	1	1	2	1	0	0	1	6
P 22	5	0	5	6	0	2	0	2	6	7	6	0
P 23	3	3	2	2	4	1	4	4	4	3	3	3
P 24	2	1	1	1	1	0	0	1	1	2	0	0
P 25	4	0	2	2	0	1	0	2	3	2	3	0
P 26	4	0	2	6	0	2	0	0	4	7	7	2
P 27	4	4	6	3	4	3	4	4	2	2	1	5
P 28	0	0	3	2	0	0	1	1	0	0	0	1
P 29	0	0	3	0	0	0	4	1	0	0	1	6
P 30	3	0	2	6	0	2	0	2	5	4	6	0

	Toothbrush-noise+ (UC) 23											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	3	0	1	1	0	0	4	3	0	0	0	3
P 2	0	3	0	0	0	0	0	5	0	0	0	6
P 3	3	2	4	0	0	0	2	3	1	0	2	1
P 4	0	0	0	3	1	0	0	0	0	4	1	0
P 5	1	3	3	0	0	0	0	1	0	0	0	2
P 6	5	3	4	0	5	3	4	5	1	1	2	3
P 7	7	4	6	0	4	0	6	6	0	0	2	4
P 8	5	5	1	3	5	5	4	5	2	2	4	3
P 9	1	1	7	0	0	0	0	1	0	0	0	4
P 10	7	6	0	0	0	0	6	2	2	0	2	6
P 11	2	1	2	1	2	0	1	3	0	2	0	1
P 12	2	2	0	0	0	0	6	1	0	0	0	2
P 13	5	6	3	0	6	0	7	7	0	0	0	6
P 14	4	1	3	3	2	1	2	4	3	2	4	3
P 15	4	6	0	0	3	0	4	6	0	0	0	4
P 16	0	0	0	0	0	0	0	3	1	0	0	0
P 17	3	4	3	0	4	0	5	3	0	0	0	6
P 18	4	5	2	5	5	0	5	6	2	3	6	5
P 19	0	2	2	0	0	0	0	0	0	0	0	2
P 20	5	3	0	0	1	1	4	5	1	1	1	5
P 21	5	4	1	1	5	1	4	6	1	0	1	5
P 22	5	2	3	3	6	0	3	5	0	0	0	7
P 23	4	3	2	2	3	2	3	3	3	1	3	3
P 24	3	3	3	0	4	0	3	3	0	0	0	4
P 25	4	1	0	0	1	0	1	4	0	0	1	1
P 26	3	7	3	0	4	0	4	5	0	0	1	4
P 27	3	4	5	2	5	2	4	4	1	2	2	5
P 28	0	0	0	0	3	0	1	1	0	0	0	6
P 29	3	0	1	0	0	0	4	3	2	0	4	2
P 30	6	5	3	0	6	1	5	5	0	0	1	5

	Toothbrush-sharp-noise+ (PC) 5											
	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	0	0	5	3	0	0	0	0	3	1	0	0
P 2	0	0	1	3	0	0	0	0	4	6	0	0
P 3	0	0	2	5	0	0	1	4	3	1	1	1
P 4	2	1	0	1	0	0	1	1	0	0	0	4
P 5	1	1	4	0	3	0	2	2	0	0	0	5
P 6	4	1	1	3	2	1	1	3	1	2	2	3
P 7	3	3	1	5	0	0	4	3	0	2	2	5
P 8	5	2	2	5	1	4	1	5	7	5	5	2
P 9	0	0	7	0	0	0	0	0	2	5	2	3
P 10	5	0	0	1	3	4	5	1	1	0	5	4
P 11	4	4	0	2	0	0	1	2	0	0	0	1
P 12	0	0	3	1	0	0	0	0	0	1	0	0
P 13	1	6	1	0	6	0	7	5	0	0	0	7
P 14	2	1	5	3	1	2	1	3	4	3	4	3
P 15	4	6	2	1	3	0	4	0	0	0	0	6
P 16	2	0	0	0	4	0	0	0	0	0	0	0
P 17	3	0	1	3	0	0	2	2	0	2	3	3
P 18	6	5	2	4	2	2	5	6	2	3	4	5
P 19	0	0	4	1	0	0	0	0	0	1	0	2
P 20	6	4	1	1	5	2	5	5	2	2	1	5
P 21	6	5	1	3	2	3	4	4	3	2	2	6
P 22	0	0	6	1	0	2	2	5	1	4	3	3
P 23	4	1	2	1	3	3	5	3	3	3	4	3
P 24	1	0	3	0	3	0	3	0	0	0	0	4
P 25	3	1	1	1	0	0	0	3	2	0	3	0
P 26	0	2	0	5	0	0	2	0	2	6	5	2
P 27	4	5	2	0	7	1	5	7	2	2	2	4
P 28	2	0	0	3	0	0	0	5	0	2	0	0
P 29	0	0	1	4	0	0	1	0	1	0	0	0
P 30	5	3	3	1	3	0	6	5	1	0	2	7

Table 16: Resulting evaluated values for the washing machine sounds in Study 4

Resulting values for washing machine sounds

Wasching machine-standard (PA) 7	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	4	0	0	1	0	0	5	0	0	0	0	3
P 2	3	0	5	0	3	0	0	2	0	0	0	2
P 3	1	0	3	0	2	0	1	2	0	0	2	3
P 4	2	1	3	0	1	0	2	1	0	0	0	2
P 5	1	1	3	0	2	0	1	0	0	0	0	4
P 6	3	3	1	1	5	2	3	4	1	1	2	5
P 7	2	1	6	3	3	2	4	2	0	3	5	2
P 8	6	6	1	1	6	4	5	6	1	0	1	5
P 9	3	1	0	0	6	1	0	4	0	0	0	5
P 10	2	0	3	5	4	5	1	1	6	6	5	0
P 11	0	0	4	2	0	0	1	3	0	1	2	1
P 12	0	0	3	0	0	0	0	0	0	4	3	0
P 13	5	0	3	6	0	2	1	1	6	1	5	1
P 14	3	0	2	5	1	2	0	3	4	1	2	0
P 15	4	2	2	1	3	0	4	4	0	1	1	4
P 16	0	0	0	0	0	0	4	5	0	0	0	0
P 17	4	5	4	0	5	0	5	4	0	0	0	5
P 18	5	2	2	2	5	3	2	5	2	2	4	1
P 19	1	0	2	0	0	0	0	1	0	0	0	3
P 20	1	1	2	6	3	3	1	1	6	5	5	0
P 21	3	1	5	2	4	4	1	4	4	5	4	2
P 22	4	1	3	2	3	4	0	7	6	2	2	2
P 23	1	1	3	1	5	0	4	1	1	1	2	5
P 24	3	0	0	1	3	0	0	2	3	2	1	0
P 25	1	0	3	0	2	0	0	1	0	1	0	0
P 26	7	4	2	0	4	0	7	5	0	0	1	7
P 27	2	1	3	2	2	3	3	4	4	5	1	2
P 28	2	0	0	0	0	1	0	0	1	0	0	0
P 29	2	1	0	0	0	0	2	4	0	0	0	5
P 30	5	0	1	2	1	4	1	7	3	1	3	1

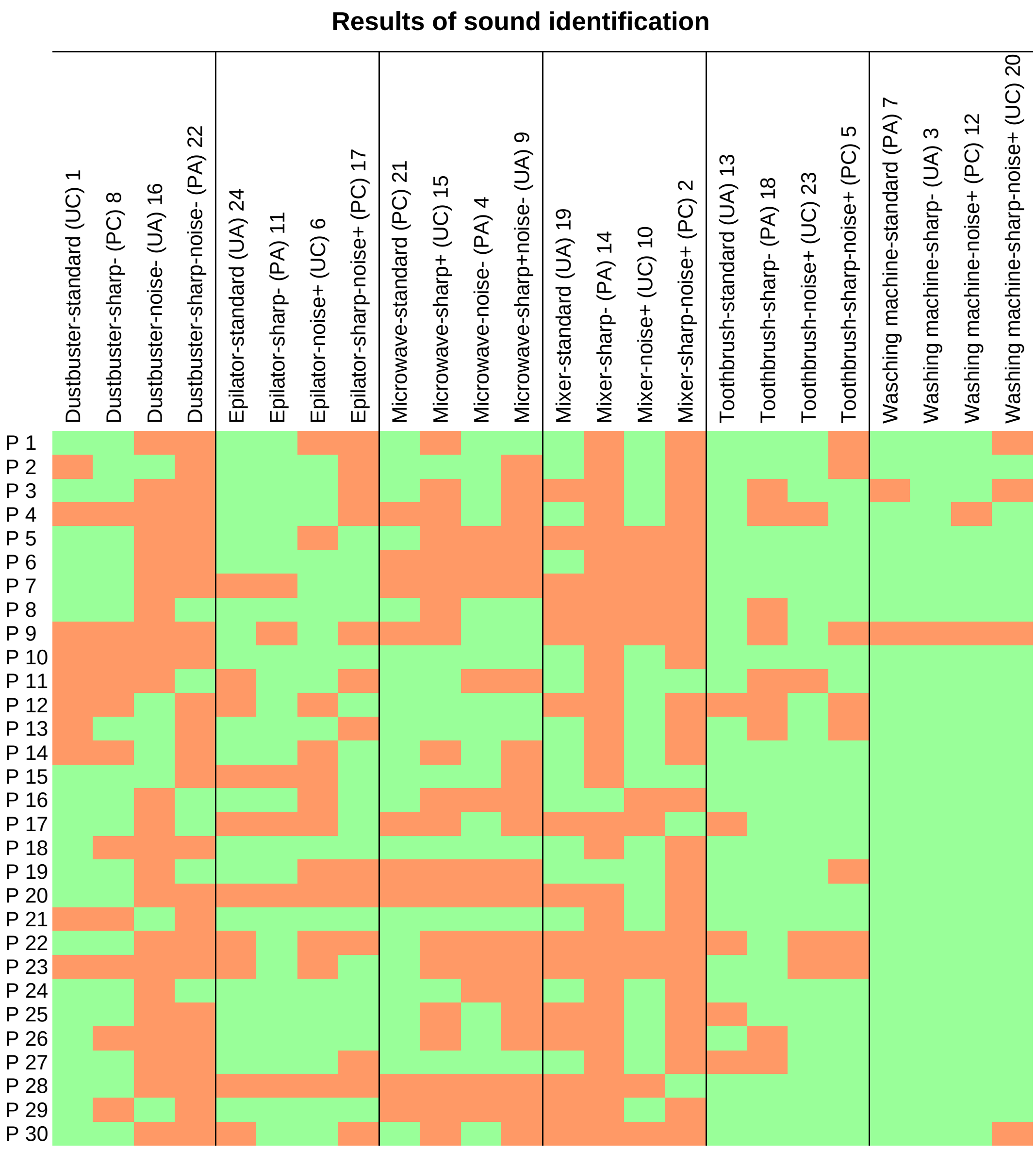
Washing machine-sharp- (UA) 3	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	3	0	0	4	0	1	0	0	1	2	5	0
P 2	3	1	0	0	1	0	0	4	0	0	0	0
P 3	1	0	0	1	2	2	1	2	1	0	4	0
P 4	0	0	0	7	0	0	0	0	4	7	2	0
P 5	0	1	0	0	4	0	4	0	0	0	0	3
P 6	4	3	2	1	3	2	5	3	1	1	1	5
P 7	1	1	6	5	0	0	0	0	3	7	2	3
P 8	6	2	2	1	5	4	6	5	1	1	1	4
P 9	4	5	0	0	4	0	0	3	0	0	1	5
P 10	2	0	5	6	1	2	0	1	4	7	4	1
P 11	2	0	3	4	0	1	0	2	0	2	2	1
P 12	3	0	1	3	0	1	0	0	0	5	2	0
P 13	3	1	2	6	0	4	4	2	3	5	2	4
P 14	4	1	3	3	4	2	0	5	1	2	2	1
P 15	0	3	4	3	2	1	6	0	0	4	0	6
P 16	0	2	0	0	0	0	6	5	0	0	0	5
P 17	1	0	0	7	0	5	0	4	6	6	5	0
P 18	5	5	2	1	6	2	2	5	1	2	2	4
P 19	2	0	0	2	0	0	0	0	0	1	2	0
P 20	5	1	5	2	2	2	1	3	4	5	4	3
P 21	5	0	2	5	1	4	1	1	3	6	3	1
P 22	5	3	2	5	3	2	0	3	4	6	1	2
P 23	1	4	2	4	2	1	3	1	2	5	4	3
P 24	3	1	0	0	2	0	0	2	1	0	0	0
P 25	1	0	7	2	2	0	2	0	0	0	0	5
P 26	3	3	3	6	0	0	2	3	5	7	3	1
P 27	3	1	1	5	3	2	3	3	4	5	2	3
P 28	2	0	0	0	0	2	0	0	0	1	0	1
P 29	1	0	4	0	2	0	3	0	0	0	0	0
P 30	2	0	6	4	0	1	0	2	4	6	6	0

Washing machine-noise+ (PC) 12	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	4	0	0	0	2	0	0	2	0	0	0	1
P 2	5	1	0	0	2	0	1	0	0	0	0	2
P 3	1	0	6	5	1	0	2	4	0	0	1	3
P 4	4	2	0	0	4	0	3	1	0	0	0	3
P 5	2	0	3	0	2	0	0	1	0	0	0	4
P 6	5	4	4	1	5	2	4	4	3	1	1	4
P 7	3	2	5	1	3	1	5	3	1	3	3	1
P 8	5	5	2	0	7	5	4	6	2	1	2	5
P 9	0	0	7	1	0	0	3	0	0	0	0	6
P 10	3	0	2	5	0	2	1	0	6	6	4	1
P 11	3	0	3	2	0	1	1	3	0	2	2	1
P 12	0	0	0	4	0	0	0	0	2	4	3	0
P 13	2	0	0	6	0	3	0	2	4	7	4	2
P 14	2	1	2	1	2	3	2	2	3	3	2	1
P 15	2	3	1	4	0	0	1	2	3	2	0	1
P 16	0	0	0	0	0	0	4	0	0	0	0	3
P 17	5	2	3	0	5	0	5	4	0	0	0	6
P 18	5	2	2	1	6	2	5	5	1	2	2	4
P 19	0	0	1	2	1	0	0	0	1	1	0	2
P 20	3	0	1	5	1	3	0	2	5	3	6	1
P 21	5	0	4	4	1	2	2	5	3	4	3	1
P 22	5	0	3	5	5	3	0	6	4	2	3	3
P 23	2	2	1	2	4	1	3	1	1	2	0	4
P 24	2	0	1	0	3	0	0	3	0	0	0	1
P 25	1	0	6	0	1	0	0	1	2	3	0	2
P 26	5	3	4	1	4	2	5	5	0	1	1	6
P 27	3	2	1	5	1	3	3	3	4	5	2	2
P 28	0	0	0	1	0	1	1	0	1	2	0	0
P 29	0	0	2	0	0	0	1	0	0	0	3	1
P 30	4	4	3	0	2	4	4	5	1	0	1	3

Washing machine-sharp-noise+ (UC) 20	Activated	Angry	Boring	Calm	Chaotic	Cheerful	Eerie	Energetic	Pleasant	Relaxed	Trustworthy	Unpleasant
P 1	0	0	0	2	1	0	1	3	0	0	0	1
P 2	2	0	0	2	0	0	0	0	5	3	0	0
P 3	1	0	5	4	0	1	0	1	2	4	0	0
P 4	1	1	1	0	3	0	1	0	0	0	0	2
P 5	1	0	2	0	3	0	2	0	0	0	0	3
P 6	5	2	1	1	4	3	0	4	3	2	1	4
P 7	2	1	6	3	2	0	4	1	0	2	3	5
P 8	5	5	2	2	6	4	3	5	5	2	2	3
P 9	0	0	7	2	4	0	2	3	0	0	0	0
P 10	0	0	5	7	0	0	4	0	5	6	2	3
P 11	3	0	1	2	0	0	1	2	0	1	2	1
P 12	0	0	2	3	0	0	0	0	0	3	4	0
P 13	2	0	4	7	0	2	0	2	5	6	2	1
P 14	4	1	4	4	1	1	1	2	3	2	4	1
P 15	0	0	3	6	0	0	0	0	2	3	3	0
P 16	3	2	0	0	3	0	0	0	0	0	0	0
P 17	3	5	3	2	4	0	2	1	0	0	0	4
P 18	5	1	2	5	1	4	2	3	5	6	6	1
P 19	0	0	1	2	0	0	0	0	1	1	1	0
P 20	4	0	1	5	2	5	0	4	6	5	5	1
P 21	3	0	4	5	0	4	0	2	4	6	5	1
P 22	5	0	1	7	1	5	0	5	5	6	7	1
P 23	2	1	1	3	5	0	1	1	4	4	2	5
P 24	2	0	1	1	2	0	0	2	1	0	1	0
P 25	1	0	2	2	1	0	0	0	1	1	0	0
P 26	5	3	3	0	5	1	4	3	1	3	2	5
P 27	3	2	4	6	2	3	3	3	4	5	2	2
P 28	0	0	0	2	0	0	0	0	0	1	0	1
P 29	2	0	4	2	0	0	0	0	0	0	0	2
P 30	2	0	3	4	1	3	2	2	4	5	3	1

This table shows the results of Form2 of the test program (Appendix I) of Study 4; whether the sounds were identified as belonging to their original domestic appliance. The red blocks show when a sound was not regarded as possibly originating from their original domestic appliance. For example, Participant 1 thought that the first sound could indeed be the sound of a dustbuster, where participant two thought that it could not.

Table 17: Results of sound identification in Study 4



APPENDIX K

STUDY 4: MEAN, MODE AND IDENTIFIED RESULTS *(PG. 36+37)*

These graphs show the mean distributions with their standard deviations (95%) for all test results of Study 4 (Appendix J) and for only the results for the positively identified sounds per domestic appliance. The mode distributions are also shown for all the test results and only the results of the positively identified sound.

Dustbuster

Mean

Complete results

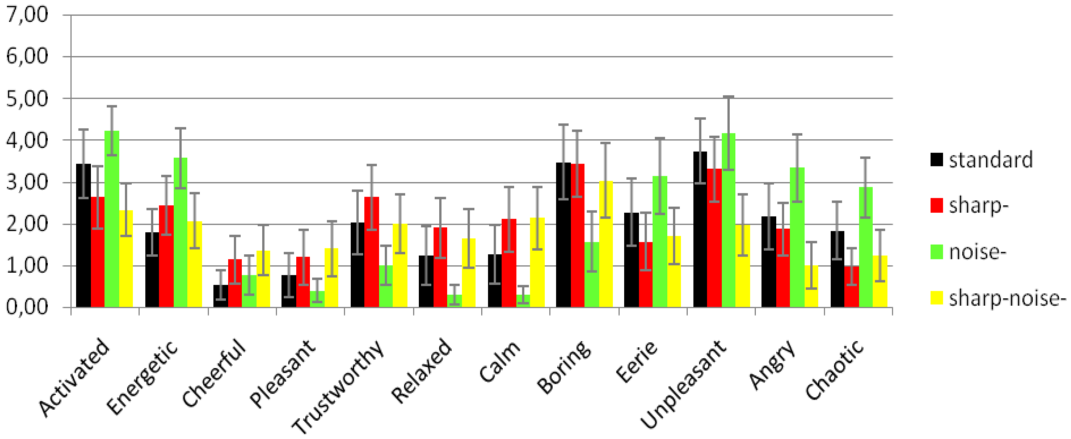


Figure 39: Mean distribution for complete results of dustbuster sounds Study 4

Results of identified sounds

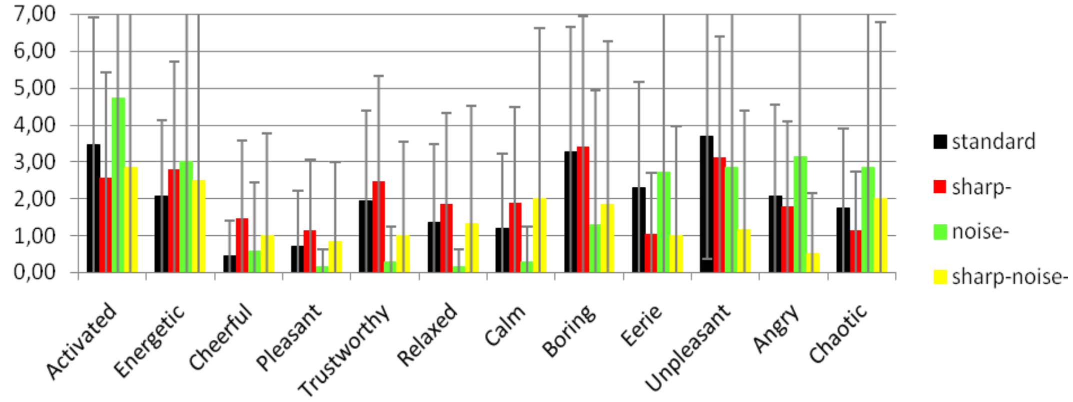


Figure 40: Mean distribution for identified results of dustbuster sounds Study 4

Mode

Complete results

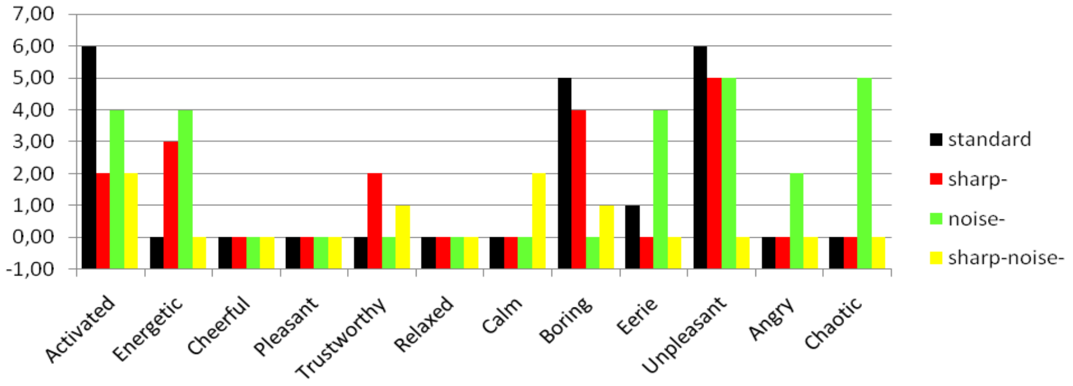


Figure 41: Mode distribution for complete results of dustbuster sounds Study 4

Results of identified sounds

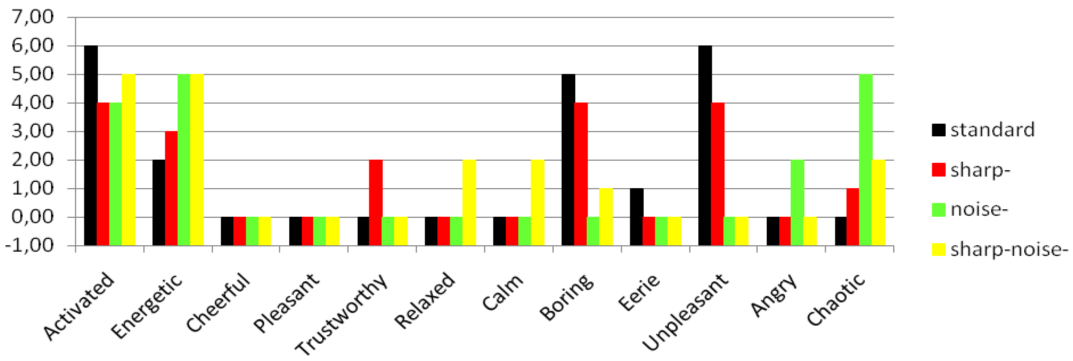


Figure 42: Mode distribution for identified results of dustbuster sounds Study 4

Epilator

Mean

Complete results

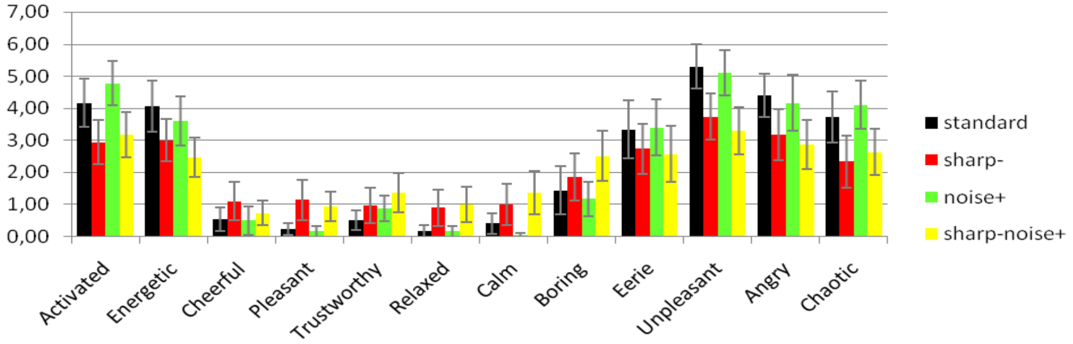


Figure 43: Mean distribution for complete results of epilator sounds Study 4

Results of identified sounds

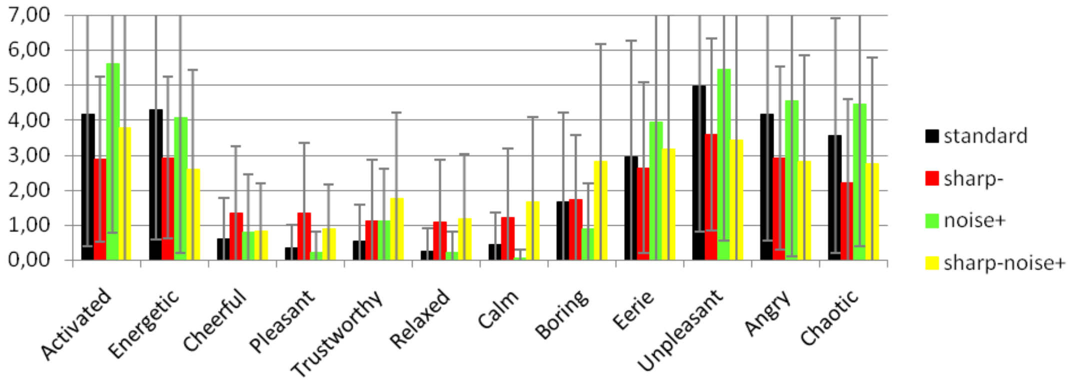


Figure 44: Mean distribution for identified results of epilator sounds Study 4

Mode

Complete results

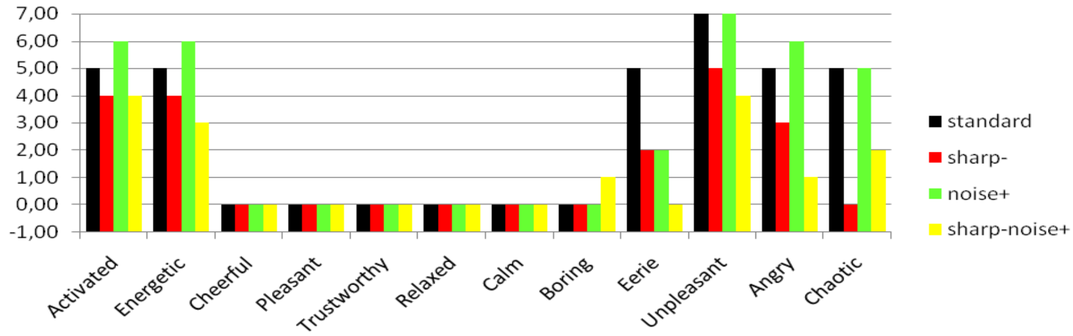


Figure 45: Mode distribution for complete results of epilator sounds Study 4

Results of identified sounds

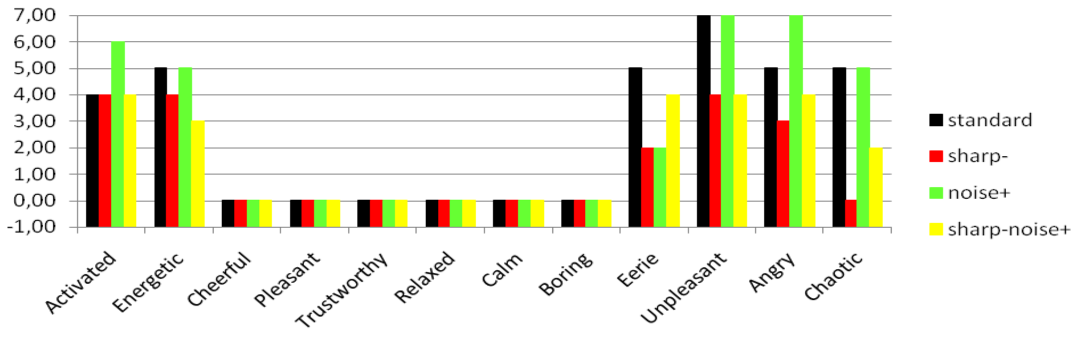


Figure 46: Mode distribution for identified results of epilator sounds Study 4

Microwave

Mean

Complete results

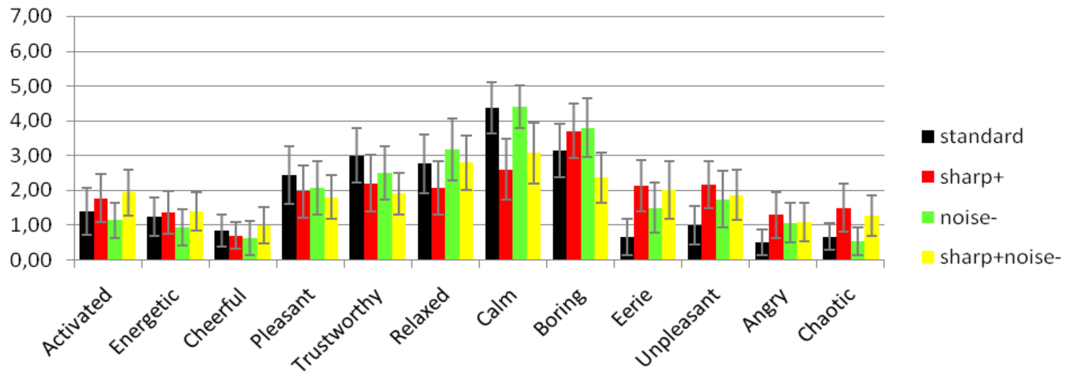


Figure 47: Mean distribution for complete results of microwave sounds Study 4

Results of identified sounds

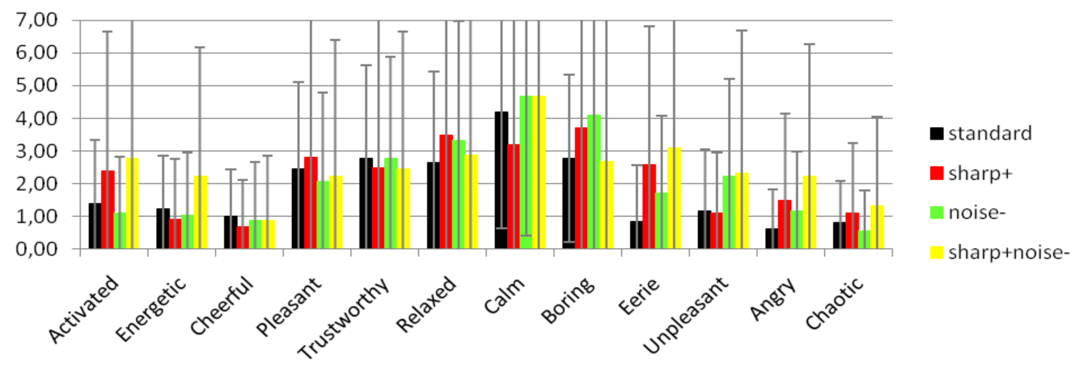


Figure 48: Mean distribution for identified results of microwave sounds Study 4

Mode

Complete results

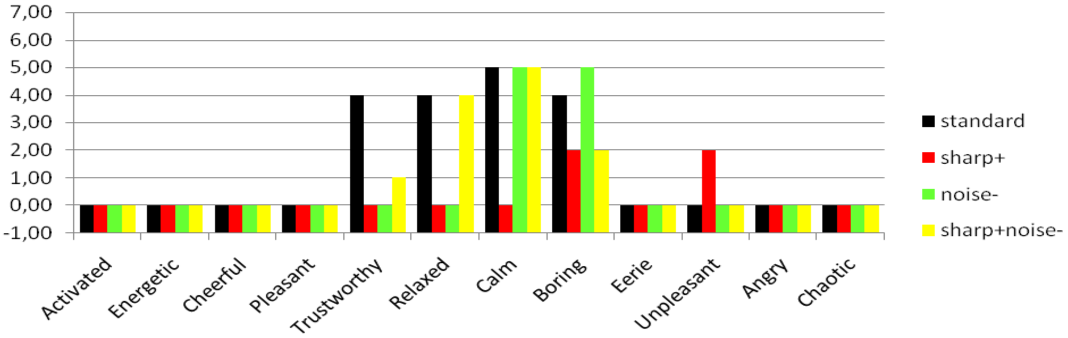


Figure 49: Mode distribution for complete results of microwave sounds Study 4

Results of identified sounds

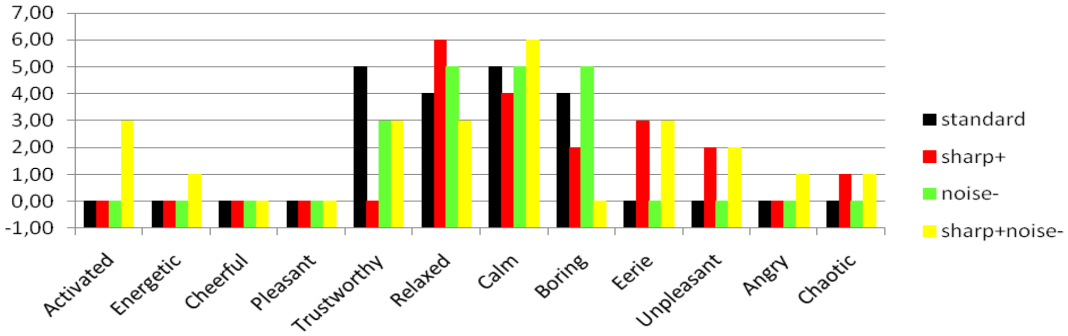


Figure 50: Mode distribution for identified results of microwave sounds Study 4

Mixer

Mean

Complete results

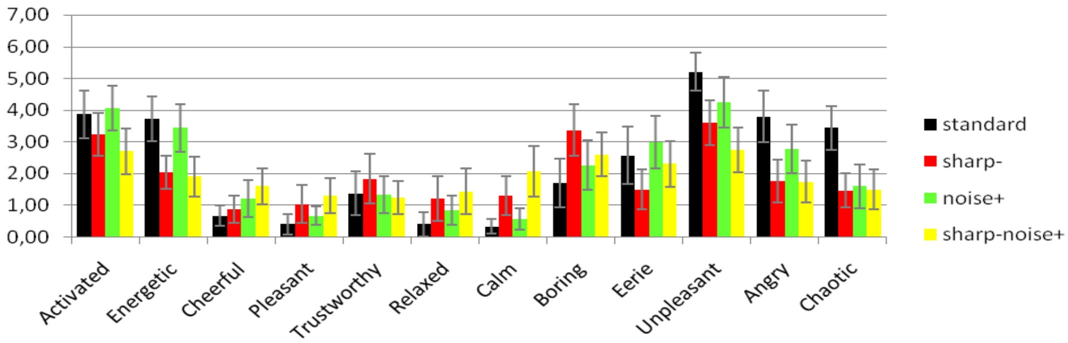


Figure 51: Mean distribution for complete results of mixer sounds Study 4

Results of identified sounds

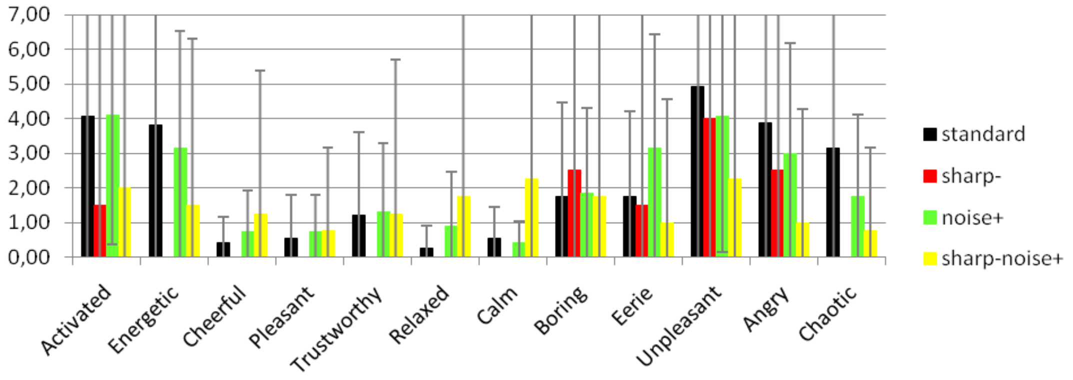


Figure 52: Mean distribution for identified results of mixer sounds Study 4

Mode

Complete results

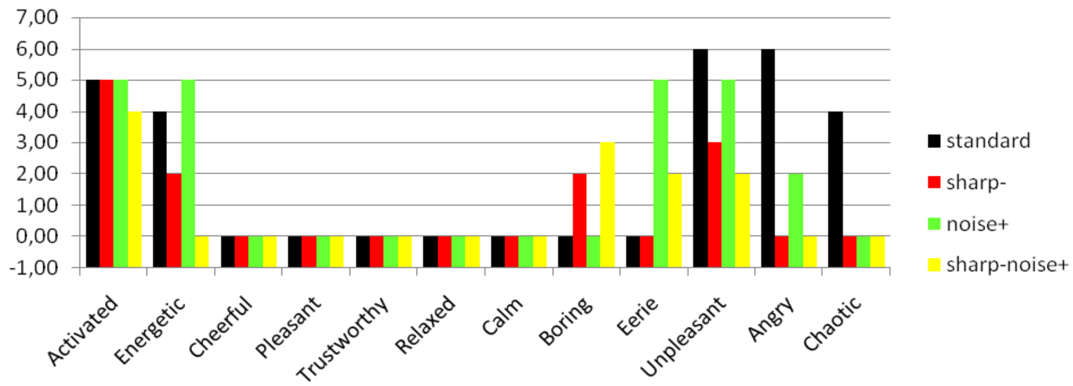


Figure 53: Mode distribution for complete results of mixer sounds Study 4

Results of identified sounds

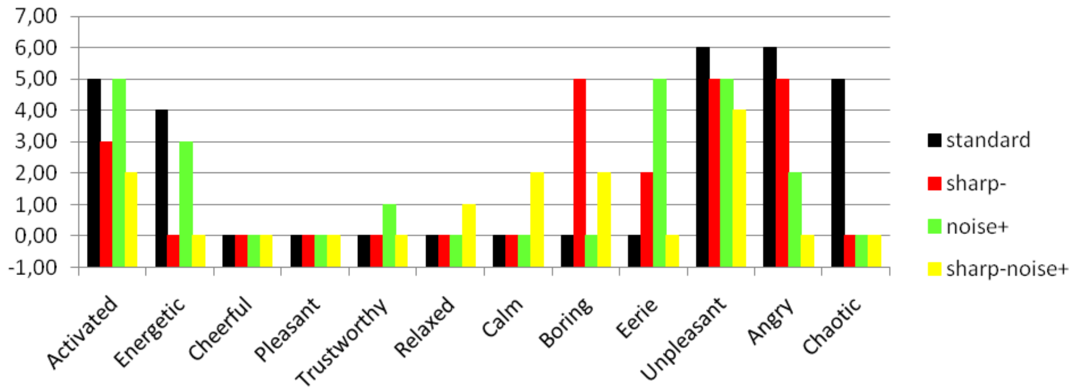


Figure 54: Mode distribution for identified results of mixer sounds Study 4

Toothbrush

Mean

Complete results

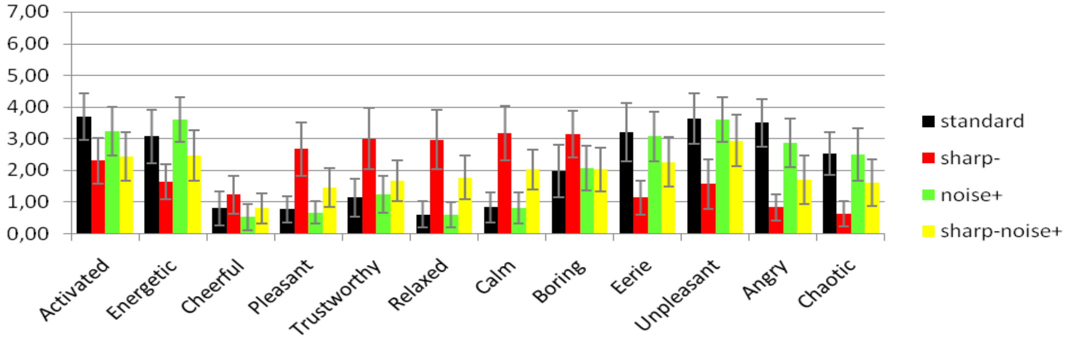


Figure 55: Mean distribution for complete results
of toothbrush sounds Study 4

Results of identified sounds

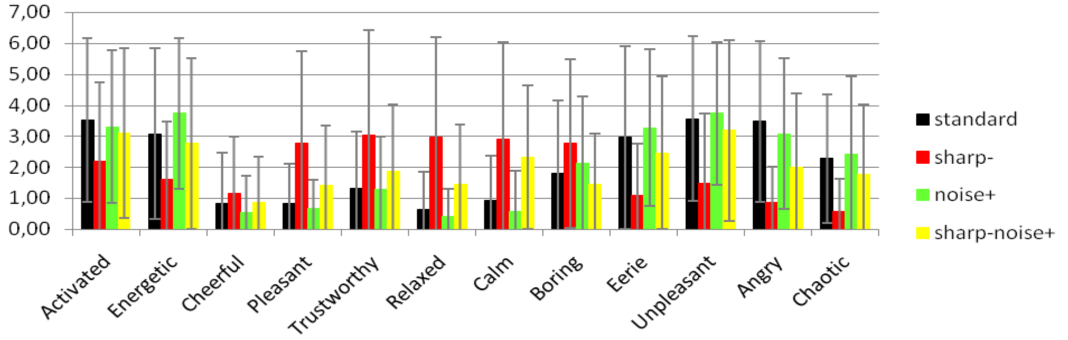


Figure 56: Mean distribution for identified results
of toothbrush sounds Study 4

Mode

Complete results

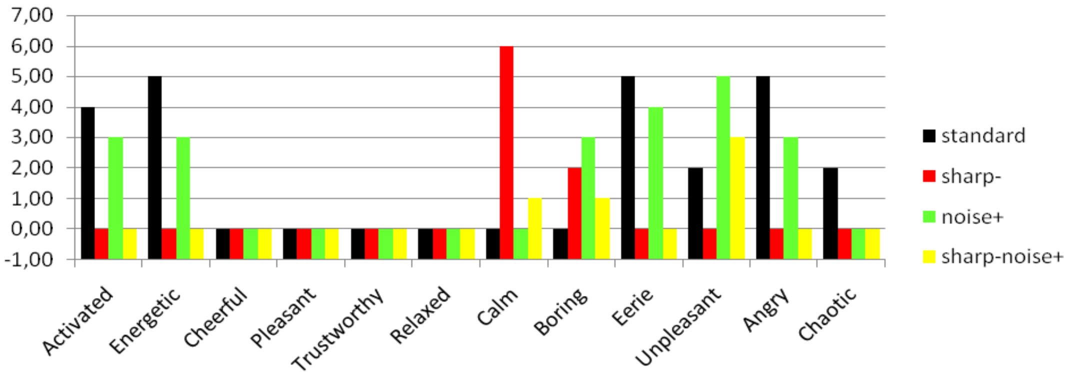


Figure 57: Mode distribution for complete results
of toothbrush sounds Study 4

Results of identified sounds

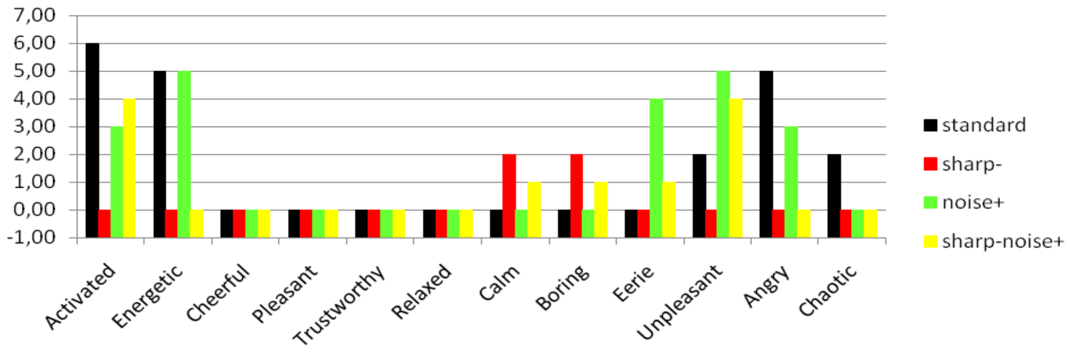


Figure 58: Mode distribution for identified results of toothbrush sounds Study 4

Washing machine

Mean

Complete results

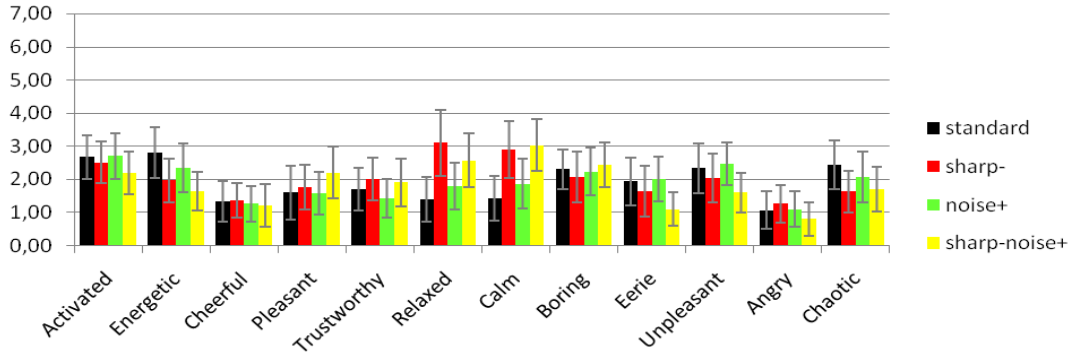


Figure 59: Mean distribution for complete results of washing machine sounds Study 4

Results of identified sounds

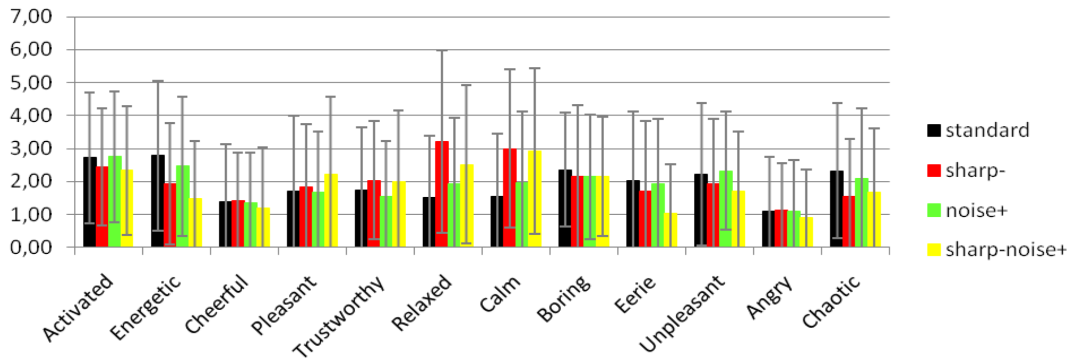


Figure 60: Mean distribution for identified results of washing machine sounds Study 4

Mode

Complete results

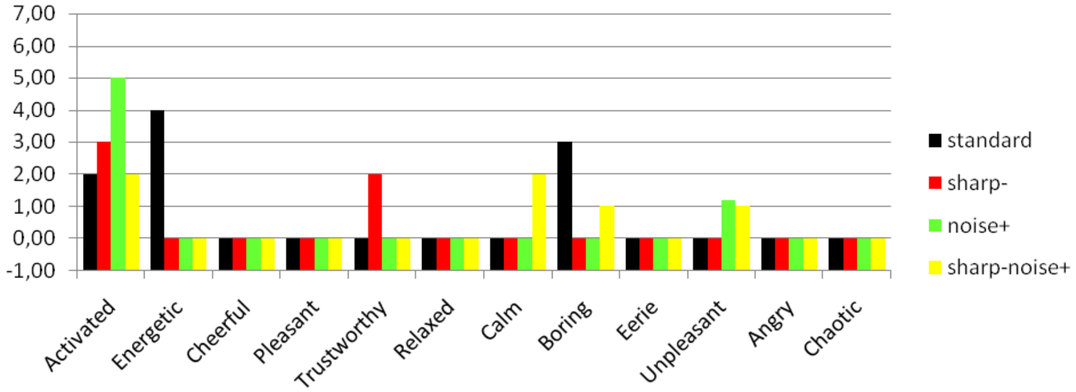


Figure 61: Mode distribution for complete results of washing machine sounds Study 4

Results of identified sounds

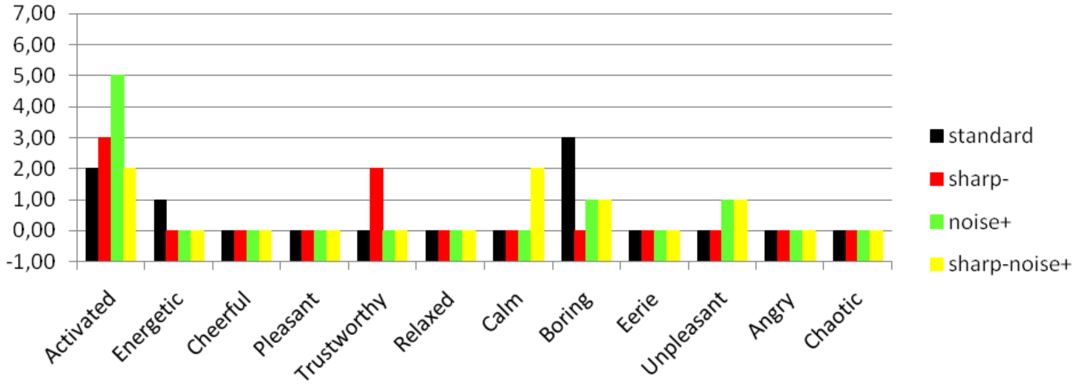


Figure 62: Mode distribution for identified results of washing machine sounds Study 4

APPENDIX L

CD *(PG. 32+33+59+71+80)*

This CD contains:

Thesis report, pdf
Abstract, pdf
Öz, pdf

Thesis	Thesis chapters, doc
Sounds	*Study 2*: Used sounds, wav
	Study 4: Used sounds + alterations, wav
Presentation	Presentation poster A1, jpg
	Presentation pictures, jpg
	Oral presentation, ppt
	Invitation, jpg