EFFECTS OF COLOR ON THE PERCEPTION OF TEXTURE

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ABSTRACT

EFFECTS OF COLOR ON THE PERCEPTION OF TEXTURE

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Texture and color are essential design features which create hedonic and functional product qualities. They should be designed together to achieve the desired effects in product design. The purpose of this study is to investigate the effects of three colors; black, green, and orange, on the perception of three textures; radial, linear, and irregular. The chosen colors and textures are commonly used on the worldwide handheld communication radios. To discover the effects of the colors and the textures in terms of defined statements related with reliability, ruggedness, and ergonomics, an experiment was implemented with thirty-two handheld radio users. The experiment is composed of two stages. In Stage 1, participants rated thirteen statements while experiencing three samples, which have the radial, linear, and irregular textures, only by touching them from inside of a box. In Stage 2, participants rated the same statements with a bonus about aesthetics, while experiencing nine samples, which were created with the combination of the three textures and the three colors by seeing and touching together. The ratings were collected between one and seven. The scores of the samples in Stage 1 and Stage 2 were compared to find out the perception of the textures and the colors individually, and also to reveal the effects of the colors on the perception of texture. The results show that color has an effect on the perception of textures. The thesis presents the findings, and finally discusses their implications.

Keywords: Texture, Color, Perception, Product Attributes, User Experience

ÖZ

RENKLERİN DOKUNUN ALGILANMASI ÜZERİNDEKİ ETKİSİ

Kılıç, Yağmur
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Doku ve renk duygusal ve işlevsel ürün özelliklerinin oluşmasına yardımcı olan önemli tasarım özelliklerindendir. Üründe istenilen etkinin oluşturulabilmesi için iki kavramın beraber tasarlanması gerekir. Çalışmanın amacı üç rengin (siyah, yeşil, turuncu), ve üç dokunun (noktalı, çizgili, düzensiz) insan üzerindeki algısını nasıl değiştirdiğini incelemektir. Çalışmada kullanılmak üzere, dünya genelinde yaygın olan el telsizlerinde kullanılan renkler ve dokular seçilmiştir. Rengin doku üzerindeki etkisini ölçmek üzere güvenilirlik, sağlamlık ve ergonomi çerçevesinde cümleler belirlenmiş ve otuz iki telsiz kullanıcısıyla bir deney yürütülmüştür. Deney iki aşamadan oluşmaktadır. Birinci aşamada katılımcılar üç dokuya sahip üç nesneyi bir kutunun içerisinde görsel temasları olmadan sadece dokunarak deneyimlemişlerdir. Onlara yöneltilen cümleleri, dokunarak deneyimledikleri nesnelerin doğruluğuna göre bir ile yedi arasında puanlandırmışlardır. İkinci aşamada kişiler üç renk ve üç dokunun kombinasyonu ile oluşan dokuz nesneyi hem görerek hem de dokunarak deneyimlemiş ve aynı cümleleri (estetik ile ilgili bir ek cümle ile beraber) yine bir ile yedi arasında puanlandırmışlardır. Nesnelerin birinci ve ikinci aşamada belirlenen konseptler çerçevesinde almış oldukları puanlar karşılaştırılmıştır. Sonuçlar rengin dokunun algısı üzerinde etkisinin olduğunu göstermektedir. Sonuçların sunulmasının ardından çıkarımlar tartışılmıştır.

Anahtar Kelimeler: Doku, Renk, Algı, Ürün Özellikleri, Kullanıcı Deneyimi

To my family…

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CHAPTER 1

INTRODUCTION

1.1 Problem Statement and Motivation for the Study

Texture is an important but underestimated feature in product design. However, in general the tactile sense may play an important role to define products, create emotional connection between products and users, and get usage efficiency. In other words, experiencing objects with the tactile sense could give clues to identify that object. For example, only by touching silicone, metal, or foam, the materials could be recognized, because their softness-hardness or warmth-coldness are learned features throughout many years. Moreover, touching is a way of communication. Basically, hugging someone or shaking one's hand are examples to keep emotions alive, and this relation keeps its importance between an object and a human as well. Handling an object could affect their liking of the feeling about it. Lastly, the tactile sense may inform people about product usage. With conscious application of materials, and texture design, consumers could be directed for the next step of a product usage scenario. Also, this may reduce misuses of a product. Therefore, tactility may have a functional importance as well. Considering this information, a well-designed texture of a product could satisfy consumers hedonically and functionally. Also, a well-designed texture could affect human perception of a product.

Texture should not be considered as the only feature which affects human perception. As is known, features perceived by the visual sense are important as well, and in contrast to the tactile sense, the effects of the visual sense are known by many people. However, color, one of the key elements of the visual sense, is underestimated in a design process, as commonly is texture, and color decision can be left to the end of the process. The uninformed usage of texture and color could create undesired effects

for a product, because these are powerful features, and they should support the functional and hedonic aspects of a product.

In addition, the effects of texture and color should not be considered separately, because product design is a system, and all the elements should be in harmony. Therefore, rather than considering the effects of texture and color individually, they should be designed together. Products may create undesired perceptions on users with the combination of texture and color used together, rather than the usage of only texture or only color. Different colors may change the effects of textures in positive or negative ways. Therefore, the relation of texture and color should be explored, and they should be processed together to achieve the desired effect for a product.

Lastly, brands may not be willing to explore different types of textures and colors, and their implementation on products, because this seems to be a kind of risk in conservative markets. On the other hand, informed usage of textures and colors together may lead to improved design solutions, particularly in areas where customer satisfaction is important. Therefore, reforms about texture and color as parts of product design should take attention as well. The industrial design team of Communication and Information Technologies in Aselsan, a well-established military communication devices manufacturer in Turkey, would like to encourage employees about the exploration of textures and application of different colors, and this thesis would like to support this aim.

1.2 Aim of the Study

The aim of this thesis is to investigate the effects of texture and color individually, and also the effects of color on the perception of texture. In the literature, the importance of the senses, and their effects on each other have been expressed. However, there is a gap about the effects of color on the perception of texture. To discover these effects, this study applies an experiment. The chosen product segment for the experiment is professional communication handheld radios. The reason to

choose this product segment is that the author of the thesis is currently working in the above-mentioned company in the department of communication and information technologies as an industrial designer. Also, this product segment is convenient to experience the tactile and visual senses effectively together. Three types of textures; radial, linear and irregular, and three different colors; black, green, and orange, are chosen to observe their effects on each other. The chosen elements are commonly used features for worldwide communication radio brands.

1.3 Goal of the Study

The results of this study may offer guidance mainly for the design process of professional communication handheld radios. According to the concept of a product, and the desired functional and hedonic features, the most convenient texture and color combinations could be designed. Moreover, texture and color combinations could be designed for specific areas such as push to talk button, battery, or clips of a handheld radio to emphasize their functions and direct users. Also, this study may encourage employees to explore new textures and colors, and apply them for the upcoming products.

1.4 Research Questions

This thesis hopes to achieve its aim by answering the following research questions.

- How do textures affect the perception of products?
- How do colors affect the perception of products?
- What are the effects of color on the user's perception of textures?

1.5 Structure of the Thesis

Chapter 2 contains the literature review. In this chapter, the importance of the senses, their effects on human life, and product life cycle are explored by considering their

functional and hedonic aspects. Following, the terms texture and color are defined in detail, and their hedonic and utilitarian effects on user experience are explored. To sum up, the integration of texture and color is expressed based on the literature.

Chapter 3 is a literature review as well, covering experimental research related with the senses. The effects of individual senses on human perception, or the combination of variable senses, and their effects on each other are investigated. Following, an extensive market research about communication handheld radios is done to decide on the textures and colors to be used in the study. Product spectrums of worldwide handheld radios are analyzed, and the concepts of reliability, ruggedness, ergonomics, and aesthetics are defined in order to apply the experiments.

Chapter 4 is the research methodology chapter. This chapter describes the preparations for the study, and all the processes of the pilot and the main study, including data collection and analysis methods. The results of the experiment are also presented in this chapter.

Chapter 5 is the conclusion chapter. This chapter revisits the research questions and answers them based on the research findings. Limitations of the study are given, and recommendations for further studies are made.

CHAPTER 2

LITERATURE REVIEW

2.1 Hedonic and Utilitarian Qualities of Product Attributes

As defined in the literature consumer preferences are determined by two substantial considerations, which are called hedonic and utilitarian (Dhar and WertenBroch, 2000). The hedonic quality of a product is received from emotions, fantasy and senses, and it is not related with the task orientation of the product in contrast to the utilitarian quality, which is cognitive and non-emotional (Babin et al., 1994, Holbrook and Hirshman, 1982; cited in Jones, Reynolds and Arnold, 2006). Moreover, as Voss, Spangenberg and Grohmann (2003) add, hedonic quality is the result of sensations emerged with experiencing a product, and utilitarian quality is revealed through functions depending on the performance of a product. In other words, hedonic quality is related with pleasure, and hedonic satisfaction is related with the pleasure that people get by experiencing a product, a service or an application. Basically, it depends on how people feel. However, utilitarian means productivity oriented and instrumental; also, the reason of using a utilitarian system is external purposes, not the system itself like in the hedonic systems (Berger and Hess, 2018).

Hedonic quality of a product is evaluated as “wants” and utilitarian quality is evaluated as “should”, so people take the utilitarian side of a product for granted (Bazerman et al., 1998; cited in Kakar, 2017, p. 53). In other words, utilitarian quality of a product is expected unconditionally, however hedonic quality is considered as an unexpected bonus feature (Kakar, 2017). Moreover, hedonic contributions are seen as luxuries in design, but the utilitarian benefits are evaluated as closer to being a necessity more than a luxury (Batra and Ahtola, 1990; Chitturi et al., 2007; Dhar and Wertenbroch, 2000; Strahilevitz and Myers, 1998; all cited in Chitturi, 2009).

Therefore, hedonic quality of a product increases repurchasing and positive word of mouth, however the lack of hedonic quality of a product does not affect the perception negatively (Chitturi et al., 2008; cited in Kakar, 2017). On the contrary, the desired utilitarian quality, which is not surprising for people, does not make contribution to repurchasing and word of mouth, but the lack of utilitarian quality of a product affects them negatively (Chitturi et al., 2008; cited in Kakar, 2017).

Lastly, people generally prefer utilitarian goods rather than hedonic ones (Dhar and Wertenbroch, 2000; Diefenback and Hassenzahl, 2011; cited in Kakar, 2017), because people have the tendency to decide on rational choices (Kakar, 2017). People give high importance to the hedonic dimensions more than the utilitarian ones, only when they are satisfied enough with the functionality of a product (Chitturi et al., 2007; cited in Chitturi, 2009). However, nowadays functionality may not be a distinctive criterion, because many products of different brands perform well, and they may differentiate themselves from their equals with the features that provide hedonic value, in other words, satisfy customers hedonically.

2.1.1 Importance of Sense

Hedonic goods can be shaped by sensorially enriched emotional experiences, because they are "far more subjectively than objectively oriented." (Hirshman and Holbrook, 1982; cited in Gramer and Antonides, 2011, p. 4). This may be true that to satisfy customers hedonically, features that appeal to the senses should be enriched, because the pleasure that a product gives can be defined by the senses. In other words, senses may be the way to interpret pleasure. For example, a product can provide a visual pleasure by its form or color or it may provide tactile pleasure by its material type or the texture it has. Furthermore, the odor of a product may give pleasure, and it could make the product distinct from its competitors with a unique experience. Also, what one hears and tastes may also change the pleasure one gets. Therefore, the features which arouse emotions and create pleasure are felt by senses, and people may desire a product only to have that pleasure it gives and be satisfied

hedonically. As Elokla and Hirai (2013) state, emotions may affect the decision of purchasing a product, the pleasure of ownership and the usage of the product after purchasing it. Therefore, it is important to design a product which could elicit the desired emotions of customers while experiencing it (Elokla and Hirai, 2013), and sensorially enriched experiences may increase the possibility of emerging those emotions.

2.1.2 Effects of Senses on Market Segmentation

Berghman and Hekkert (2017) indicate that products such as cars, phones or clothing could create pleasures by appealing to the senses. For example, one can choose Mini Cooper to seem sporty and cool, however, BMW 7 series can be chosen to seem more classic and elegant. So, what makes a car sporty or elegant? The general characteristic of Mini Cooper's form, especially the headlights, the rim of the steering wheels or car grill, looks agile and energetic (Figure 2.1). Also, with its customizable various color combinations or pattern types for the parts on the shell or the interior parts such as on the front console, seating units, even on the mini carpets, Mini Cooper keeps its dynamism. All these support its sportive side. On the other hand, the characteristics of the lines and the forms of the parts provide aggression and serious impression to BMW 7 executive series (Figure 2.2). In contrast to Mini Cooper, BMW 7 series do not support the crazy color combinations. It has less color choices consisting of less saturated, in short, low in value ones. With their forms, materials, textures, colors or patterns, the interior lining or upholsteries have elegant appearance. These differentiations between Mini Cooper and BMW 7 series show the market segmentation clearly. In other words, it is for appealing to the different user groups' attention like a serious businessman or a cool teen. The purpose is to satisfy the types of pleasure.

Figure 2.1. Mini Cooper JCW 2019 (left: Mini, n.d.; https://www.mini.com.tr/tr_TR/home/range/mini-john-cooper-works.html; right: Carbuzz, n.d.; https://carbuzz.com/cars/mini/john-cooper-works-convertible/photos-interior)

Figure 2.2. BMW 7 Series 2016 (Motortrend, 2015 https://www.motortrend.com/cars/bmw/7-series/2016/2016-bmw-7-series-first-drive-review/)

IPhone users may be strongly dependent on their phones, and changing their iPhone with another smartphone brand may not be an easy option. One of the reasons is that breaking habits is not easy, and the other reason is that with its easy and completely different user interface or its unique round button, the iPhone categorizes its users, and makes them feel special. As Champney and Stanney (2007) state, emotions are part of usability, and also are evaluation criteria for a product. Moreover, Sonderegger and Sauer (2010; cited in Berghman and Hekkert, 2017) contribute that the perceived beauty of a product supports its usability, and its success in the market as well (Landwehr, Wentzel and Hermann, 2013; cited in Berghman and Hekkert, 2017).

Moreover, leather seating unit is a reason of preference especially for businessmen in their offices, because it may give the feeling of quality and symbolize its owner's status as well. The same seating unit, but with a different type of fabric like velvet, may give different pleasure because of the material's effect. Velvet may give a friendly and sincere effect with its fluffy texture, and it can be more convenient for a family's living room. Rather than form, color and pattern combinations, the usage of the different materials on the seating units such as leather or velvet may vary the feelings aroused by its usage.

2.1.3 Integration of Hedonic and Utilitarian Qualities

According to Jones et al. (2006), shopping can evoke emotional responses, and satisfaction is closely related with the emotions elicited during consumption. Therefore, he finds that shopping value has a stronger connection with hedonic value than utilitarian (Jones et al., 2006). Furthermore, Jones et al. prove (2006) that hedonic shopping value has a stronger effect of loyalty and positive word of mouth comparing with utilitarian shopping value. However, when focusing on repatronage intention (continuing being customer of a brand), utilitarian value is more effective than hedonic (Jones et al., 2006). All these affect the success of a product in the market, therefore, it can be stated that both hedonic and utilitarian product attributes are essential. For example, personal computers or internet access do not only contribute to the productivity-oriented aims (Venkatesh, 1996; Venkatesh and Brown, 2001; cited in Berger and Hess, 2018), they also support the pleasure based user experiences (Berger and Hess, 2018). Furthermore, an aesthetically pleasing user interface has hedonic effects on people, but if it reduces effort for the perception, in other words if it provides easy usage and decreases the mental load, the system is utilitarian as well (Venkatesh, 2000; cited in Kakar, 2017). Products, applications or systems may have hedonic or utilitarian effects, also they may have hybrid features, which include both (Kakar, 2017).

The utilitarian side of the product occurs through the technical features that support function, and also it appears thanks to the hedonic features as well. For example, type of engine, fuel consumption, 360 degree video recording, autonomous or semi-autonomous driving type, large animal detection and many more are all related with technical solutions. In addition, operating system, display processor, memory or battery life etc., are technical features of phones independent from hedonic aspects. Also, the structure of a seating unit should be determined by technical analysis to measure its substantiality. However, some utilitarian features of a product could be nested by hedonic features. For example, the buttons on the wheel or the console of an automobile are the reflections of some unseen functional features. The organization, form, color, texture or material choices of these buttons lead to easy usage while driving the car. Buttons which are designed by considering these criteria are helpful for drivers to keep their attention on the road and find the desired button easily at the same time. Moreover, user interface of a smart phone reduces time consumption without complicated usage and makes people feel unstressed and comfortable. Well-designed icons, right color, size and placement for the elements such as fonts on the display, lead to a successful interface design. Furthermore, the right material and texture selections for a seating unit can support the functional effects and lead to comfortable seating for people. Therefore, color, texture, material and form criteria, which directly affect users hedonically, lead to their satisfaction from the usage of a product, and this may be an important factor to support the utilitarian aspects as well.

2.2 Functional Importance of Senses

As Desmet and Schifferstein (2008) state all the five senses may contribute to user experiences related to a product. This contribution can be both functionally and hedonically in the positive or negative way. Functional effects of senses will be discussed in this section.

Desmet and Schifferstein (2008) state that in 1980, there were many accidents caused by the silent Belgium Tourist Tram; because, while crossing the road, pedestrians could not become aware of the oncoming tram and manage their time. After these accidents the alert sound was redesigned effectively (Desmet and Schifferstein, 2008). This is a good example to explain the importance of senses functionally in daily life experiences.

Additionally, to focus on the functional importance of the senses for the small home appliances, kettles could be an effective example. They have small directive lights on them to give feedback to the users about the process. While heating water the light turns red to emphasize "wait" like in traffic lights, and when water boils the light turns green meaning "ready". Additionally, one does not have to follow the light to understand the process all the time. The sound that the button of the kettle creates, informs the user about the finishing process, or the sound of boiling water also gives clues about it. Vavik and Kourennayia (2006) state that senses create an awareness, and inform people about what the product means. According to them, they strengthen the communication between users and products. By doing so, they decrease misuses and accidents. As Elokla and Hirai (2013) state, emotions enroll all our lives because, they direct our choices, help us to protect from a danger or to have a non-verbal communication.

Moreover, it is good to have options to be aware of the process. Together with the functional benefits of senses, sensorially enriched products enable flexible usage for the user, and make them feel well informed, unworried and comfortable. As Sonneveld, Ludden and Schifferstein (2008, p. 2) state "Such a multisensory approach is important, not only to avoid unwanted conflicting messages, but most of all because an integrated and coherent approach of the senses is a powerful approach to enrich the overall experience one is designing for". Nowadays devices like smart watches, phones or tablets are also designed depending on sensorially enriched experiences. For example, when one receives a notification on the smart phone, it can inform the user by vibrating or with the sound that the user chooses or the light with different colors depending on the action type. People do not have to prefer all

these feedback types but more options to be informed make people feel free. For example, in a crowded environment when it is impossible to hear the sound, vibration can lead the user, or when one's phone is in the bag, and it is not possible to see the light and also feel the vibration, sounds can inform them about what is happening. Therefore, it is important to enrich the ways of reliable communication.

2.3 Hedonic Importance of Senses

When we pass from a bakery in the morning the smell of warm bread leads us to close our eyes and take the breath in to smell it deeply (Figure 2.3). The fascinating colors of roses could be another example for that. It is possible to see many tones of red from the tint to the dark on roses, and that gradient scheme influences all of us (Figure 2.4). Also, roses create the desire in many people to touch them, because we all know the effects of velvet leaves and the feelings they give. Furthermore, many people love the soft sound of piano in the background when having a conversation with friends in a café. These are all related with the senses, because as Demirbilek states (2017), senses enable people to experience the events and the environment with which they have an interaction. Therefore, senses are the way of feeling hedonic satisfaction in our lives. The things related with the senses such as color, smell, texture or sound, shape our decisions, because as Curralo (2017) states, emotions hold the power of changing the way people think. In other words, emotions define the way of our looking to the new things, and also, they have an important role on the reactions of humans (Norman, 2004; cited in Curralo, 2017). A café can distinguish itself with its nice music and become a meeting point for many people. Basil can be chosen because of its nice odor even if roses have fabulous color or the exact opposite. People may prefer wearing cotton clothes due to the soft feeling they give. All these preferences can be changed depending on the personal experiences, cultures or the demographic construction of the society (Ritnamkam and Chavalkul, 2016).

Figure 2.3. Left image: freshly baked bread (Needpix.com, n.d.; https://www.needpix.com/photo/1290044/food-loaf-of-bread-wood-bakery-bread)

Figure 2.4. Right image: Sakura-Gasumi Garden, roses in tones of red (Wikimediacommons, 2013; https://commons.wikimedia.org/wiki/File:Rose_Sakura-Gasumi_%E3%83%90%E3%83%A9_%E6%A1%9C%E9%9C%9E_(8026655937).jpg)

As Şener and Kurtgözü (2008, p. 127) state, emotion-driven design is defined as "a tool and an approach to increase the desirability, meaning, affectation, endearment, and other such qualities that people may attach to the presence, ownership and use of products." In addition, it does not only lead to basic feelings such as liking or disliking, it also causes more detailed emotions such as fear, fun, anxiety, anger and more (Şener and Kurtgözü, 2008). Even though the visual features dominate the emotion-driven design, an effective user interaction, material choices, texture of the surfaces, easy usage of a product and more functional and aesthetic features have emotional contributions (Şener and Kurtgözü, 2008).

The degree of satisfaction in product usage is very important for product development and its success on the market, and new ways should be explored to increase the satisfaction rate to gain advantage in the market (Karlsson and Velasco, 2007). As Karlsson and Velasco (2007, p. 124) indicate "Previous values, such as functionality, reliability and cost, have been replaced by other values, such as usability, comfort, and pleasure." According to Desmet and Hekkert (2007, p. 15), aesthetic pleasure is one of the product experiences, and aesthetic level depends on the "product's capacity to delight one or more of our sensory modalities". Therefore, products that lead us to use our senses actively increase our satisfaction, in other

words increase the pleasure that products give with their usage. This is because of a link between a successful design and user's emotion (Saket, Yong, and Behrang, 2013), and senses may elicit emotions in a positive or negative way (Bordegoni, Camere and Schifferstein, 2015). Beautiful appearances, nice smells, the feeling while touching a product or fascinating sounds create emotional responses on the user such as happiness and anxiety (Desmet and Schifferstein, 2008). Therefore, the more positive feelings that a product creates means the more pleasure we get, and it makes the product more successful (Curralo, 2017).

As Desmet and Hekkert indicate (2007), restaurants and such places are often designed to please the senses of people, and this results in some emotional responses, because aesthetic experiences that are enriched with senses include pleasure or displeasure, and these evoke emotions. Therefore, it may be true that sensorially enriched product experiences enhance the satisfaction level of the user. For example, the smell of the deodorant is the main factor affecting purchasing behavior of people. However, the appearance of its bottle with the combination of color and form, and the feeling that the bottle and its material's texture give may increase the pleasure by usage of that deodorant. Also, these features related with visual and tactile senses lead users to select a certain product easily between five or more nice smelling deodorants. Therefore, packaging affects and convinces the customer in the store as well, because the interaction between the consumer and the product occurs by visual and tactile senses firstly during the purchasing (McNeal and Ji, 2003, cited in Ferreira and Capelli, 2012). Hereby, senses may affect decisions of users while purchasing a product.

Furthermore, as Bruens (2007) states, products provide emotional experiences to the user and create a strong relationship between them rather than just function well. For example, the juicer designed by Philippe Starck does not function well but its elegance and romantic appearance is enough to purchase it for some segments (Bruens, 2007).

Peck and Wiggins (2006) question the persuasion levels that people have by touching a product hedonically without any functional reason. They mention that some people use the touch sensation not just for getting information about the product, also about the hedonic pleasure. They are called NFT, meaning need for touch, and not having the opportunity to touch the products while shopping makes them more irritable than the others (Peck and Childers, 2003a; cited in Peck and Wiggins, 2006). Additionally, Peck and Wiggins believe that NFT people could be grouped in two: instrumental and autotelic. People that are instrumental NFT touch to get the clue about the product and create some judgments about the thickness, warmth or the slipperiness. In contrast autotelic people touch only for the desire coming from within, to feel the product more or have fun (Peck and Childers, 2003b; cited in Peck and Wiggins, 2006).

2.4 Color and its Role in User Experience

Color should be explained in order to understand the functional and hedonic effects of it, and to do that firstly, explaining the terms related with color such as hue, value, saturation or chroma will be an effective start (Figure 2.5). The name of the colors in the color spectrum are called *hue* and these are red, orange, yellow, green, blue and violet ranging from the one which has longest wavelength to the one with the shortest (Holtzschue, 2006). Red, yellow and blue are the primary colors and the other three hues in the basic spectrum are called secondary colors. As Holtzschue (2006) states, the order of the six hues is certain, and also they can vary in twelve with six more interval hues such as yellow-green or red-violet, and they are the intermediates (Holtzschue, 2006). Additionally, red, yellow and orange are the warm colors, and the others like blue, green and violet are the cold colors in the spectrum. This diversification is caused by the luminosity which defines the characteristics of hues. Altering the color of a room can affect the perception of humans about the room temperature, even if there is no change (Kopacz, 2003).

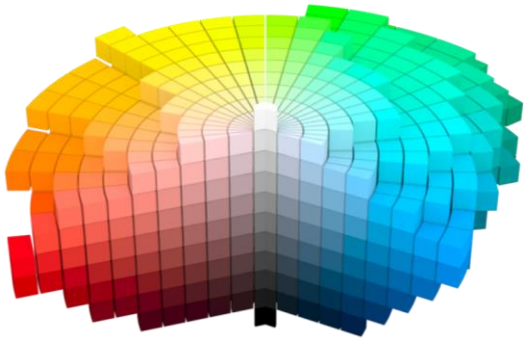

Figure 2.5. Color spectrum (Wikimediacommons, 2009; https://commons.wikimedia.org/wiki/File:Munsell_1943_color_solid_cylindrical_coordinates.png)

Value is a term that depends on the lightness and darkness of the hue with the mixture of black and white (Holtzschue, 2006). In other words it describes how light or how dark a color is (Kopacz, 2003). To perceive an image, it does not have to include hues, the value contrast, in other words the differentiation of the lightness and darkness levels is helpful to distinguish it (Holtzschue, 2006). Also, value is closely related with luminosity (Holtzschue, 2006). As she states, six hues in the color spectrum have different values, because, their luminosities are different. Yellow reflects the light, and it appears in light as well, therefore, it has the highest value in the spectrum. In contrast, violet has the lowest value because it is the darkest hue, due to its absorption of light (Holtzschue, 2006). Additionally, the lighter version of a hue, added white, is called tint, and it reflects the light more. Whereas the darker version of a hue, added black, is named shade, and it absorbs the light more (Holtzschue, 2006). For example, as Kopacz mentions, pink is the tint version of red, in contrary maroon is the shade version of it (2003). Finally, the intensity of a hue or its brilliance, dinginess or aliveness determine the *saturation* of a hue (Holtzschue, 2006). The hue which has the maximum chroma, in other words the purest one could be named as the most saturated one (Holtzschue, 2006).

As Cooperman (2013, p. 12) indicates, “The color of an object is a matter of perception and lighting, not an absolute fact.” According to him, colors of a same view can change depending on the different time of a day such as sunset or night. Weather conditions also affect the light situation (Cooperman, 2013). Moreover as

Holtzschue states (2006, p. 44) "… color has no objective reality. (…) Color is an experience, an insubstantial attribute of other things." For example an apple that has a green and red color combination, gets the grey tones in a dark area, and under the strong incandescent or fluorescent light it seems surprisingly different (Cooperman, 2013).

Moreover, as Cooperman (2013) states, perception of human eye has a very important role, as well as light. Colors of the surroundings, in other words adjacent colors around, directly change the perception of an object's color. According to Chevreul's law of simultaneous contrast, colors used together alter their effects and perception in a human, because they have the tendency to seem different as much as possible, and colors empower the contrast level between them (Cooperman, 2013). Therefore, as he says (2013) designers or painters should be conscious about their color choices, because they can increase the contrast unrestrainedly and decrease the desired effects on their works. For example, an orange necklace could be more convenient for combining with a green dress rather than a red one to stand out from each other, because the usage of green and red empowers their contrast level, and it could make them obstructive for a dress combination. In addition, gray gets a bluish color nearby of orange or it gets reddish by the usage of green together, because gray is very a convenient field to observe simultaneous contrast (Holtzschue, 2006).

Color is an important term that should be considered deeply while organizing a composition to give the right message. In Changewater, triptych paintings by Catherine Kinkade (Figure 2.6), red water takes attention besides trees and the other blue elements on the canvas, even though their hues and values are high as well, because red as a hue has a tendency to advance (Cooperman, 2013). Also, red water destroys the happy feeling in the composition, because it seems like a fire in the background, and it creates a dynamism in the painting (Cooperman, 2013). Therefore, the color choices in a composition, with their hue, value and intensity levels are essential to define the meaning and give the right message (Cooperman, 2013).

Figure 2.6. Changewater, triptych paintings by Catherine Kinkade (Viridian Fine Art, 2019; http://viridianfineart.com/in-the-taoist-tradition/)

2.4.1 Color and Emotion

Colors create an emotional link with people (Bruen, 2007). For example, red could symbolize love inspired by heart and roses as well as its alerting role functionally (Bruen, 2007). Moreover Bruen states (2007, p. 76) “Orange combines the energy of red with the happiness of yellow”, and yellow has the meaning of joy and energy as well, thanks to the metaphor of sun. However, when yellow is darker it gets the meanings of danger, envy and dinginess (Bruen, 2007). Green is the color of nature and it has the fresh and healthy meaning (Figure 2.7), and as a cold color, blue has a restful and reliable effect on people (Bruen, 2007) (Figure 2.8). Colors and their emotional meanings may originate from the elements of nature, which we are used to face with in our daily lives.

Figure 2.7. Left image: Pantone Greenery (Pantone, 2016; https://store.pantone.com/hk/en/articles/news/color-of-the-year-2017.html)

Figure 2.8. Right image: Pantone Classic Blue (Pantone, 2020; https://www.pantone.com/color-intelligence/color-of-the-year/color-of-the-year-2020-tools-for-designers)

According to Cooperman (2013), the first thing that takes human attention is color. However, colors are not enough to keep one's attention on something for long; what would keep one's attention for more than three seconds in a colorful advertisement, among many, would be related with the organization of the color or where and how it is used as well (Cooperman, 2013). As Cooperman (2013) indicates, a successful design of colors in a composition keeps viewers longer on the image, and creates emotional and intellectual feelings. For example, balance is an important term that should be considered, because it changes the effect and the focal point of a composition (Cooperman, 2013). Accordingly, opposite elements increase the strength and intensity of each other. A pattern which is very complex can be identified best on a pure and calm background; for example, in the painting Starry Night by Vincent Van Gogh, the yellow stars in the dark blue sky and the lights on the dark water empower each other by the usage of contrast effectively (Cooperman, 2013). Moreover, while evaluating a color balance, the type of color, its hue, value and intensity, also the location and the size of the color area should be considered (Cooperman, 2013).

Lastly, Cooperman (2013) states that color is a key term which affects the success of the design industry. In other words, it can change the purchasing behavior of customers in a positive or negative way (Cooperman, 2013). Color could be a reason to choose a product between many different brands which have high quality as well, or sometimes it could be a reason to tolerate a product which is of less quality or more expensive than the others just because of the emotion it gives (Cooperman, 2013). Besides personal likings, the culture of a society and lifestyles also affect preferences about the colors, because it is not easy to break habits and ignore social approval (Cooperman, 2013). Colors have very different meanings in societies, so it is usual to find the colors around strange in foreign countries, due to the cultural differences (Cooperman, 2013). For example, United States Conference of Catholic

Bishops states in the 346/e feature that both white and black can be worn at funerals besides purple, because they can all evoke the meaning of death in different cultures (USCCB, 2011). In Asian cultures, white is the color of mourning, so Catholics of Asian-American may prefer white vestment (Kosloski, 2017). However, black is seen as the color of mourning since Ancient Rome, and it is traditionally matched with death as its meaning (Kosloski, 2017).

2.4.2 Color and Function

Generally, color is seen as a cosmetic feature in design (White, 2009). It is used to make the product more appealing for the customers. Color usually has an effect that fascinates people (White, 2009). However, its functional effects should be considered alongside its hedonic effects. Color is an assistant that increases the usability of a product like all the other senses. As White (2009) states, color may be used to guide users about the usage of a product, and explain and emphasize the information that the product is trying to give. According to him, people should firstly decide on the information that they want to emphasize and then use the color conveniently to achieve the goal (White, 2009). Firstly, looking at nature to find evidences about the functional effects of color is important. For example, camouflage patterns with colors are common among animals, because these patterns help them to blend in the surrounding and make them invisible for the possible attacks (Project Learning Tree, 2019). In other words, they are the ways to survive for the species depending on their evolutionary process. Moreover, color is a nonlinguistic communication means between animals to transfer information in the natural life (Neitz and Neitz, 2011; cited in Wu, Tseng and Cheng, 2019), and it is a way for interaction between people in the society as well (Childress, 2008; cited in Wu, Tseng and Cheng, 2019).

As Bruen states (2007, p. 75) “From a purely functional viewpoint, color can play active role in simplifying the perception of complex visual data.” For example, in the calculator designed by Mario Bellini the division and separation of the buttons

are supported by graphics with color differentiation as well as their forms, to prevent mistakes (Bruen, 2007) (Figure 2.9). Furthermore, emergency stop buttons are colored with red, because of its warning effects to take the attention easily and function well. White has a functional duty as well; it radiates less heat, that is why white clothes in summer keep us cooler when compared to black, or the refrigerator which has to keep the nutrition cold is generally designed as white to support its function with less energy (Bruen, 2007).

Figure 2.9. Calculator designed by Mario Bellini, 1974 (Museum of Applied Arts & Sciences, 2012; https://ma.as/442972)

The functional effects of colors are undeniable on the objects that people use in their daily lives. For example, flotation rings are produced with orange to create contrast in the blue seas and to attract one's attention. In addition, first aid packages or ambulance vehicles have white and red color in many countries. White gives hygienic, clean or healthy feelings with its pure effect, and it increases the reliability of the product for people. In contrast, red has an alerting role. It grabs the attention. When red is used on white, it strengthens its powerful effect. Therefore, white and red combination helps to make people aware of the existence of the first aid boxes easily. Also, it is a way to differ ambulances from the other vehicles besides the alert sound.

As Bruen states (2007), green is a functional color for army devices or clothes, and it could be used as a camouflage pattern with the convenient green tones. Additional examples may be given for colors used in the military and defense sectors. Earth toned colors are chosen in the army concept to take advantage of their functional

effects, because the purpose is being camouflaged in nature. For this reason, the geographical location of countries is essential to determine the tones of camouflage patterns, and so camouflage colors of the countries change according to changing natural vegetation. For example, Saudi Arabia has light earth toned color for their devices and clothes because of the arid climate in this region.

As green is used on tactical devices for the army, professional civil devices for polices or security guards have black and dark grey tones. For example, a professional handheld radio is more convenient in black according to the uniform types and working environment of its user groups.

Interestingly, yellow-green, yellow, orange and red could be used as well for the devices in the defense sector. They may be preferred to be used for the specific functions on a device to stand out. To create contrast, in a sea concept, red and orange may be convenient to take the attention, or yellow-green is a better choice for fire safety teams to be flashy and keep the equipment visible in the time of incident.

Colors in tactical and professional handheld radios will be expressed in detail during the market research in Chapter 3.

2.5 Texture and its Role in User Experience

Texture should be defined firstly to express its role in user experience. Cambridge dictionary (2020) describes texture as a quality which can be defined by touching, the degree of smoothness or the roughness of the surface has. Cooperman (2013, p. 289) states “Every object has a tactile quality, even very smooth metallic objects.”, and Bruen (2007) states texture is a quality that can range from smooth to rough. Therefore, this means that texture is not a quality which is only rough, all the surface types have their own texture because all the materials have their own unique texture types (Cooperman, 2013). Also, texture is not a feature perceived by only tactile sense; it could be experienced by visual and auditory senses as well (Klatzky and Lederman, 2010). For example, by seeing the size of grains, their density and

sequencing, texture could be perceived. Also, sound caused by mechanical interaction with objects could be helpful to identify surface properties.

Yanagisawa and Takatsuji (2015, p. 1638) have defined texture as “a design factor” which supports the perceived quality of a product, and it includes physical properties caused by the material itself or the surface finishes. In other words, besides texture being seen with the existence of a material intrinsically, texture can also be created by additional surface finishing techniques such as the engraving of mold-tech patterns (Figure 2.10). Another way of achieving texture is through shaping processes that give a material its final form (Francis, 2016).

According to Standex Engraving Mold-Tech (n.d.), texture is helpful to define a corporate brand identity, and also optimize the surface performance by increasing its ruggedness. This company adds to the quality perception and take one’s attention with sensual movement, by implementing leather textures on surfaces from different materials (Figure 2.11). Also, implementing textures is a way to catch the evolving trends in fashion and interior design (Standex Engraving Mold-Tech, n.d.).

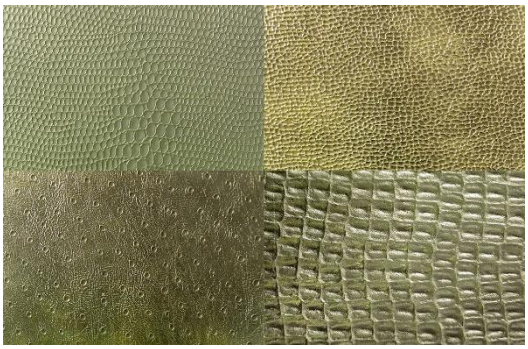

Figure 2.10. Left image: Engraving process (Standex Engraving Mold-Tech, n.d; https://www.mold-tech.com/engraving/)

Figure 2.11. Right image: Leather press (Standex Engraving Mold-Tech, n.d.; https://www.mold-tech.com/soft-trim-tooling/)

Interestingly, Holler et al. (1993; cited in Yanagisawa and Takatsuji, 2015, p. 1638), found in their study that humans have the tendency to describe textures as “smooth-rough”, “hard-soft” and “sticky-slippery” respectively. This means that these three

groups are widely used adjectives while experiencing a texture to describe a surface quality. Moreover, Okamoto, Nagano and Yamada (2013) also state that "roughness", "hardness" and "warmness" are the three substantial dimensions related with tactile perception caused by textures. Roughness is a feature caused by irregular geometries on surfaces (Leach, 2013), and hardness is related with the resistance of a material to the localized deformations under impacts (Faraji, Kashi and Kim, 2018). Moreover, warmness-coldness are features related with the thermal properties of a material, and warmness increases with the ability of heat transfer of a material between textures and human skin (Chen et al., 2009; Shirado and Maeno, 2005; Kawabata and Akagi, 1977; Pac et al., 2001; Yamamoto et al., 2004; Bergman Tiest and Kappers, 2009; cited in Okamoto et al., 2013). Lastly, stickiness-slipperiness are caused by the friction coefficient of surfaces (Chen et al., 2009). Friction coefficient is a value that shows the friction between the mating surfaces, and different materials and surface types caused by different textures could change that value. As the value increases this means that friction between mating surfaces increases as well, and stickiness increases (Chen et al., 2009). Therefore, surface types should be determined by considering the friction coefficient as well, to achieve the desired stickiness-slipperiness level of a surface.

After explanation of essential terms related with texture, the importance of tactile sense for humanity should be explored. People have the tendency to touch products to identify them, because touch is the first sense that is developed for baby embryos, and it allows babies to distinguish the environment (Montagu, 1971; Field, 2014; cited in Demirbilek, 2017). Furthermore, children are very curious about their environment, and they recognize the things around them by touching substantially. Many children burn their hands because of touching the hot glass, cooking pot or heater, but after this experience they learn not to touch them directly. Moreover, people can understand the quality of fabrics by touching, because the feeling of all fabrics like velvet or cotton are different. Thanks to the learned experiences for years, people know the feeling of the texture that those fabrics have, and they can distinguish them easily or decide on the velvet or the cotton with higher quality by

touching. Everybody, ranging from children to adults, identify products by touching besides all the other senses, because the tactile sense is a communication type as well. For example, as Demirbilek indicates (2017) that the feeling that one has when holding something is very significant, because one gets clues about the weight, material type, texture or the temperature of a product. These clues may change the perception of luxury, quality or comfort for people, or these may indicate how to interact with the objects (Demirbilek, 2017).

2.5.1 Texture and Emotion

Due to the importance of the tactile sense, many products lead people to touch, and the feeling that people get by touching directly affects their decision on purchasing a product (Choi and Jun, 2006). Touching a product emerges emotional connections between people and the product. In reference to Mehrabian (1981; cited in Carbon and Jakesh, 2013), Carbon and Jakesch (2013, p. 2125) mention "…active approach behavior can positively influence liking, preference, and attitude toward objects". For example, a client who is torn between two choices because the visuals of them are very similar and pretty as well, can decide on the product depending on the types of textures.

Moreover, to identify a product people have the tendency to touch the product around unconsciously. Therefore as Jansson-Boyd and Marlow mention (2011, p. 257) "Signs such as "Please don't handle the goods!" and "Don't touch the display" should now be considered as blocking an important marketing communications channel", and therefore products that retailers do not allow to be touched seem very unfamiliar to the shoppers (Schifferstien and Desmet, 2007; cited in Jansson-Boyd and Marlow, 2011). The tendency of touching may come from the nature of humanity. Basically, many people prefer greeting each other by handshaking or hugging. These are the ways for people to transfer their emotions by getting in touch, and touching a product also has the same meaning in the background. People can

identify a product and create a connection between them by using their tactile sense effectively (Dahiya, Metta, Valle and Sandini, 2010).

2.5.2 Texture and Function

There are studies carried out on user experience and product development process about choosing the convenient surface roughness. The coarseness level of the surface directly affects the usability of the products. Mizuhara, Hatano and Washio (2013) give the example of touchpads, and explain that they are one of the product segments in which texture plays an important role. If the roughness of a plastic surface is less than it should be, the coefficient of friction is increased with a wider contact area, decreasing the usability of touchpads. On the contrary, if the roughness is more than an optimal level, it could prevent easy sliding, and also harm the fingers. In short, usability of the product is decreased (Mizuhara, Hatano and Washio, 2013). For example, it can be observed with the old touchpads that the sliding is not very easy, because the roughness level is reduced by wear with excessive usage. Due to the increasing contact area of surface with the fingers, the coefficient of friction increases. Therefore, adsoptivity (ability of holding on to a surface) of fingers to the touchpads increases, and sliding becomes hard (Mizuhara, Hatano and Washio, 2013).

In addition, as a functional support, texture can direct people about the usage of a product. For example, rough plastic texture on the holding part of a handheld product, such as a handheld radio from silicone material, prevents the hand from slipping by its surface type, and this directs people about where from and how to hold the product. In addition, 3700, a handheld radio, designed by Aselsan, has the texture differentiation depending on function (Figure 2.10). Knobs to adjust the volume or the channel control have much granulose texture on the surfaces which have contacts with fingers. The aim is to grip the knobs and control them easily, and the surfaces that do not have skin contact are very smooth and glossier to support the meaning differentiation about function and provide easy manufacturing as well.

Figure 2.12. Knob design with texture differentiation on by Aselsan

Moreover, in the study of Karlsson and Velasco (2007, p. 130), participants match *the best fitted tactile requirements* according to the three different product types: chair, steering wheel and pan. As a result of the study, the chair was matched with a texture that is not hard, the steering wheel was matched with a rough surface, and the pan was matched with a smooth and non-slippery surface. The underlying cause of these choices are the desire of experiencing comfort in a chair, having a good grip on a steering wheel, and comfortable gripping with a pan (Karlsson and Velasco, 2007).

Lastly, the functional aspects of texture can be observed in nature also, like the skin of the sharks. Sharks have small structures on their skin like sharp teeth. These particles create very rough skin like sandpaper. The rough skin protects sharks against injury, and when sharks go through the water it reduces the turbulence and water resistance (Meyer, 2013).

To sum up, the haptic sense has two main purposes; one is getting informed about the product attributes such as “texture, hardness, temperature and weight” and the other purpose is leading the hedonic experiences (Lederman and Klatzky, 1987; Klatzky and Lederman, 1993; cited in Klatzky and Peck, 2012, p. 1). In addition, if the material property is related with the utilitarian aspects of a product, consumers are more willing to touch before purchasing (McCabe and Nowlis, 2003; Peck and Childers, 2003; Grohman, Spangenberg and Sprott, 2007; cited in Klatzky and Peck, 2012). Moreover, touching also increases the “ownership”, and so the price that people are willing to pay increases (Peck and Shu, 2009; cited in Klatzky and Peck,

2012, p. 1). The tendencies for unplanned purchases increase as well (Peck and Childers, 2006; cited in Klatzky and Peck, 2012).

Texture is widely used in defense to lead easy handling and manipulating of the devices, and their parts such as knobs, handles and buttons, even while wearing gloves. Ergonomics, also known as human factors, has gained importance during the Second World War due to the inefficient usage of devices and low system performances caused by displays and controls (Henriksen et al., 2008). These led to casualties, and the systems were aimed to be designed suitable for human use. Weak human factors in military results with heavy consequences, and so ergonomics is an important factor in shaping the defense sector. Texture is one of the elements to optimize devices for human use. Therefore, by considering the usage conditions, textures could lead users to handle, grip, and manipulate the related devices as easily as possible in times of emergency.

In Chapter 3, during market research, types of textures and their importance for especially military and professional handheld radios will be expressed.

2.6 Color and Texture Combination

Senses affect their perception, and they may give clues about each other. For example, one can get general information about the haptic features of an object only by looking (Klatzky and Peck, 2012). Moreover, tactile and visual features may affect the taste evaluations of people hedonically, and the perception of sweetness or bitterness levels (Rompay and Groothedde, 2019). For example, a study revealed that sweetness is associated with smooth and organic shapes (Ngo et al., 2011; cited in Rompay and Groothedde, 2019), and also sweetness is linked with circular textures on the surfaces (Rompay, 2017; cited in Rompay and Groothedde, 2019). In another study of Van Rompay et al. (2018; cited in Rompay and Groothedde, 2019), it is proved that a sour ice-cream in a sharp cup rather than a smooth one is perceived as sourer. As a result of these, it may be suggested that the *look and feel properties*

may be manipulated by product packaging, and people may be directed to consume healthy foods (Rompay and Groothedde, 2019, p. 248). Also, tactile quality may have an important role in changing the perception of taste and, it may be used as a tool for overcoming the thought of "healthy is not tasty" (Raghunathan, Naylor, and Hoyer, 2006; cited in Rompay and Groothedde, 2019, p. 248). For example, biscuits which have rough packages are perceived as crispier than the smooth ones even if the biscuits are identical (Piqueras-Fiszman and Spence, 2012; cited in Rompay and Groothedde, 2019, p. 248).

Even though we cannot touch the objects in a photograph, colors, values and lines give clue about the objects' tactile experiences by creating visual illusion (Cooperman, 2013). In the photograph *Hudson River Water Texture*, taken by Marcie Cooperman many highlights with variant values from high to low are important in creating the water texture and helping the viewer to experience it. This means that color combinations are important factors to experience the feeling of texture as a reality or an illusion. Therefore, to give the desired perception for texture, color should be considered.

As Kopacz (2003, p. 161) states, irregular surfaces of textures reflect color through light, and as the texture is increased there will be some surfaces that light will not be able to reach. This will cause shadows on the surfaces, and the original color of the surface will appear darker and less saturated. Also, the same texture with different orientation like horizontal or vertical can change the perception of the colors as well, due to the reflection of the light (Kopacz, 2003). For example, a high glossy metal and a wood with porous surface which both have the same color appear in different visuals, because a glossy surface reflects most of the light uniformly, and it appears lighter in value, more saturated, and with more intensity compared to a wooden surface that may omit the light more (Kopacz, 2003). As seen, material type, pattern or texture also may change the perception of color. Therefore, to achieve the desired effect on the product, the influences of all the parameters on each other should be observed clearly, and the features should be determined and designed together.

Different senses lead the perception of modalities in different ways, and they change the speed of evaluation and creation of responses to the modalities as well (Spence and Driver, 1997; Spence, Pavani, and Driver, 2000; cited in Jansson-Boyd and Marlow, 2007). Therefore, aesthetic evaluations perceived by the visual sense may be changed with the support of additional tactile sense (Jansson-Boyd and Marlow, 2007). Otherwise, color may be a parameter to the perception of texture as well. These will be investigated in the thesis in detail.

CHAPTER 3

RESEARCH METHODOLOGY

In this chapter, research methodologies aim to find out the effects of different senses on the perception of each other are exlored. Later, a methodologhy is planned to observe the effects of textures and colors individually, and the effects of colors on the perception of textures in detail.

3.1 Literature Review for Methodology

The study of Rompay and Groothedde (2019) is a good example to observe a multisensory experience which includes the visual, tactile and taste senses. They want to analyze the effects of haptic and visual senses on the perception of taste, by analyzing the perceived saltiness levels of potato chips depending on the roughness of their packages (2019). To do this, three types of chips: Lays, Pringles and Tyrrells, which have different salt levels are tasted by participants in two cups; one cup is rough, uneven and irregular, and the other one is smooth, even and regular. Participants are allowed to see the texture types of cups, and also feel them by gripping them. Saltiness and intensity of taste levels are rated between 1 and 7 by using the Likert Scale method. Consequently, it is revealed that chips that were consumed in rough cups were perceived as saltier and having more intense taste (Rompay and Groothedde, 2019). This study is one of the ways to see the effects of senses on the perception of each other.

3.1.1 Tactile Sense and Human Perception

In this section, the effects of tactile sense on human perception are expressed in detail. Ferreira and Capelli (2012) have conducted a similar study about the

importance of the haptic sense during purchasing and the consumption process of a product. They want to analyze the effects of texture that is applied on a juice packaging to the taste evaluation. To do that, a first prize tutti-frutti juice was chosen from the market, and poured into two types of bottles; one of them has the texture of a lemon shell, and the other one is a classical bottle without texture (Ferreira and Capelli, 2012). Sixty blindfolded participants evaluated the taste of the juice by drinking from the two types of bottles, without knowing that the juice inside the bottles is the same, and the results were obtained from the questions asked during interviews (Ferreira and Capelli, 2012). The textured package is linked with the skin of orange or lemon, therefore participants think that the juice in the textured bottle has been made from real fruits. In contrast, the juice in the smooth bottle is perceived as cheaper because of the "flexible" and "flimsy" material of the package (Ferreira and Capelli, 2012, p. 9). As a conclusion, packages of the juice change the taste perception of participants, and juice in the lemon textured bottle is defined as higher quality.

Moreover, an experiment is held by Skedung et al. (2011) to observe the perceived finger friction: eight paper samples which are varied on grade, weight and coating, are touched by 25 undergraduates who were blindfolded. Then, perceived coarseness of papers are scaled by the participants freely, depending on their own measuring ratio or natural scale which is called magnitude estimation method (Skedung et al., 2011). Participants experience the eight papers seven times randomly using the same index finger, load and speed to decrease the variances, so 56 estimations are obtained by one participant (Skedung et al., 2011). Later, geometric averages are calculated to find the closest perceived coarseness for a sample (Skedung et al., 2011). After perception experience, the finger friction of participants for all eight samples are measured by a physical device working by force sensors (Skedung et al., 2011). When the results are compared, it is found that there is a negative correlation between the perceived roughness and finger friction, because finger friction increases with the softening surface depending on the large contact areas in contrast to the rough surfaces (Skedung et al., 2011). Therefore, perceived coarseness of many

participants change positively depending on the surface roughness. However, only five participants answer that finger friction increases with the softer surfaces rather than coarser ones. Finally, although it is concluded that perceived coarseness has a direct relation with surface roughness, it has an inverse relation with the finger friction mostly (five opposite views should not be ignored). Therefore, it is not possible to define an absolute outcome, because tactile perception is a subjective term as well (Skedung et al., 2011).

Lastly, Choi and Jun (2007) have a study on the surface roughness of polymer-based plastic products, and the emotion they create on the customer. For the pre-study, 100 adjectives that could be related with the touch sensation on polymer-based products are collected from a group of people, and then they are reduced to 37 adjectives by eliminating the similar ones with the help of linguistic scientists and dictionaries. At the same time, four types of textured plastic samples that have different roughness levels are prepared. Samples are chosen by 94 participants from a box to prevent them from looking at the samples, and they evaluate the samples by means of 37 adjectives between 1 and 7. Choi and Jun (2007) believe that participants express their emotions through textured samples by using adjectives, and the results may be a feedback to control the levels of roughness. For example, to design a product which seems clean, boyish or romantic, the roughness level may be chosen according to the average ratings of the four samples in terms of 37 adjectives (Choi & Jun, 2007).

3.1.2 Interaction of the Visual and Tactile Senses

In this sections, the effects of visual and tactile sense on each other are investigated in detail. For example, Klatzky and Peck (2012) want to measure the tendencies of people about touching a product. Seventy-three students joined their experiment. Twenty-five objects were modelled as 3D mesh. They are the combination of two groups of five objects. Five objects of first group are modelled from rough to smooth by means of texture (micro-structural level), and the other group's five objects are modelled again from rough to smooth by means of shape (macro-structural level).

Twenty-five objects were evaluated only by looking visually, and answering two statements with Likert Scale method. The statements are “This object invites me touch it” and “Touching this object would feel good” (Klatzky and Peck, 2012, p. 3). These questions are referred to as “invite” and “feel” product attributes (Klatzky and Peck, 2012, p. 3). In other words, motivation of participants for touching these abstract objects, and their potential hedonic responses are observed. In addition, twenty-five objects are described to the participants as either made of glass or concrete material, and either in the size of a ping-pong or a tennis ball. These four combinations within twenty-five objects are evaluated by answering the same questions between 1 and 7 as well. Finally, results are obtained in terms of texture, shape, material and size. For example, it is concluded that the effects of texture is more than the effects of overall shape, and the objects which are less complex by means of texture and shape are more worthy to touch them (Klatzky and Peck, 2012). Also, glass is perceived as more touchable than concrete, and objects which have higher measure are more touchable (Klatzky and Peck, 2012).

Following the first experiment, Klatzky and Peck (2012) conduct a second experiment by using real products rather than abstract objects. Glass perfume bottles are chosen as the product category. Firstly, forty-two grayscale bottle images are rated by thirty students from complex to simple in terms of shape, and smooth to bumpy in terms of texture (Klatzky and Peck, 2012). Finally, twenty-five objects are defined to rate them with four statements. The first two of them are the same with the first experiment. The third scale is ugly to beautiful, and the last one is cheap to expensive (Klatzky and Peck, 2012). The results show that the tendency to touch the bottles increases firstly, but then it decreases with the increasing simplicity of shapes and textures (Klatzky and Peck, 2012). This means that when a shape is simpler, participants have less interest in touching them. Similarly, when a shape is too complex, participants also do not have the tendency to touch. On the other hand, attractiveness of the bottles and their perceived price have positive relation with the complexity of shape, but not necessarily with texture (Klatzky and Peck, 2012).

In addition, Jansson-Boyd and Marlow (2007) examine two hypotheses. One of them is that the tactile sense has an effect on the aesthetic evaluation of the product, and the other one is that the visual sense is more effective than the tactile sense on aesthetic evaluation (Jansson-Boyd and Marlow, 2007). For this study, firstly participants rate three visually identical and four visually different DVD containers, by looking without touching them, using the Likert Scale between 1 and 7. Then, participants rate three variable textured swatches (8x15 cm rectangular plates) only by touching, by a "blind haptic evaluation" (Jansson-Boyd and Marlow, 2007, p. 172). Texture A gives a smooth feeling, it is graded finely. Also, it is thin and light. Material of it is a plastic which is used on standard DVD containers. Texture B has a structure like corrugated paper. It has rounded waves in vertical, and the distance of them is 1 mm. Texture C has a matte surface, therefore it does not give smooth feeling as texture A does. Also, bendability of the samples is getting harder from Texture A to Texture C (Jansson-Boyd and Marlow, 2007). In the second part of the methodology, while rating the three textures, participants are allowed to touch the samples whenever they want, and also they can touch the samples at the same time to make an easy comparison. In the third and final step, participants rate a different set of seven DVD containers, three of which are identical visually in the front with three textures attached to them in the back. The other four containers have different covers on the front side, and the different textures are attached at the back sides of them randomly. Participants are not allowed to look at the texture on the back side of the container, but they can touch them freely. Finally, participants evaluate the samples depending on their attractiveness level between 1 and 7. It is concluded from the first step of the methodology that the aesthetic evaluation of people are varied depending on the texture type. This means that haptic evaluation affects hedonic evaluation of the product. For example, in the haptic evaluation of textures, C is the highest rated texture and then B and A follow it. However, when participants rate samples by looking and touching them together, A is rated highest, followed by C and then by B. This is probably because people are used to the feel of DVD containers with texture A (standard smooth plastic). Texture B (corrugated paper)

feels strange to them (Jansson-Boyd and Marlow, 2007). Moreover, it is concluded that DVD containers which have textures A and B at the back are influenced more by the tactile sense rather than the visual sense. However, while evaluating Texture C (matte surface), the visual sense is the only affecting factor. Therefore, it is observed that Hypothesis 2 (visual sense is more effective than tactile sense on aesthetic evaluation) is not true.

Similarly, Marlow and Jansson-Boyd (2011) study the effects of haptic and visual perception on purchasing a product by using biscuit and soup boxes as samples, and they have implemented the same methodology which they applied in 2007. Finally, it is concluded that the visual sense is more influential than the tactile sense for an aesthetical evaluation of these product packages, and this may be the result of the chosen product categories, because fast-moving consumer products are not usually likely to be touched by customers as are DVD containers (Jansson-Boyd and Marlow, 2011). As explored in these two studies, the effects of tactile and visual sense may change depending on the different product categories. In this thesis, the purpose is specifically exploring the effects of colors on the perception of textures. Therefore, an abstract object which is convenient to grip and feel the texture on it may be a good sample to create a successful base for this kind of a study.

Moreover, Ritnamkam and Chavalkul (2016, p. 128) want to find answer the question "What consumers' feeling do textured surfaces in compact cases of cosmetic powder evoke?" Participants evaluate packages that have different tactile qualities without seeing them, in two stages. In the first stage, they express their feelings aroused by touching the packages with their own words. In the second stage, they express their feelings by using the given words which are picked from previous related studies. In the first stage, newer words are explored due to the newer lifestyles, and participants express their basic and complex feelings freely (Ritnamkam and Chavalkul, 2016). However, predefined adjectives may be a guidance for participants, and so the second stage is helpful as well.

Chang and Leu (2003) have a similar study. Nine adjectives are selected for participants to evaluate eighteen samples that are differentiated in terms of three materials (ABS, Rubber and PP) and six etching patterns. Again, the purpose is to measure the effects of the visual and tactile sense separately, and to observe them together with a multisensory experience (Chang and Leu, 2003). As a result, it is shown that the tactile sense is affected from material type mainly, and rubber is in lead between the three of them. However, experiences with visual sense or multisensory experiences are mostly affected by etching patterns. Also, interactions of etching patterns and three materials are not significant. Finally, the results of multisensory experiences are similar to the experiences with the visual sense rather than the tactile sense (Chang and Leu, 2003).

Lastly, Lucassen, Gevers and Gijsenij (2010) have measured the effects of texture on the perception of emotions caused by colors. As a result of the initial trials, and also according to the previous studies, "four emotion scales; warm-cool, masculine-feminine, hard-soft, and heavy-light" are selected (Lucassen, Gevers and Gijsenij, 2010, p. 427). 105 samples are prepared for the participants to evaluate them by ranking with the selected emotion scales. The interesting point of the methodology is that the samples are shown all together, because when it happens in an order, participants may forget their initial rankings. Also, ten participants are chosen from seven diverse nationalities in the average of 31.9 ages, and none of them do not have deficiency in terms of visual sense (Lucassen, Gevers and Gijsenij, 2010). As a conclusion of the study, it is expressed that texture changed the emotion of colors in terms of the mentioned emotion scales. In other words, texture is a powerful criteria that may direct psychological responses.

As a conclusion of the methodology research, it is observed that the senses may affect human perception in a positive or negative way individually. They are subjective, so they can vary between people. Moreover, combinations of senses could change the perception of the reality. There is a gap about the perception of textures when color is involved. In the thesis, the effects of colors on the perception textures are explored.

3.2 Market Research

In this section, professional communication radios for public safety and tactical radios are evaluated in terms of color and texture. At the same time, product attributes of tactical and professional communication radios, and consumers' expectations are evaluated by analyzing the product specifications. Products are chosen from the list of world's 100 leading defense companies which have handheld communication radio designs. These are: General Dynamics, Airbus, Thales, Rolls-Royce, Harris Corporation, Elbit Systems, Rockwell Collins, Aselsan, and Leonardo (DefenseNews, 2019). Then, Harris Corporation, Elbit Systems and Aselsan, which have wide product schemes in terms of concepts and colors are chosen to be analyzed in the thesis. Additionally, Motorola, Hyterai, Icom, Tekk, Kenwood, Luiton, Bittium and Invisio, which are the leading technological brands with their mechanical and ergonomic design solutions in the communication industry are identified; but from among these, finally Motorola, Hytera and Kenwood are chosen to explore in the thesis. Market research on these three brands may create helpful comparisons and discussions for the thesis, based on the usage of the color, texture and material diversely in their products. Therefore, their products are placed on the list of market research as well.

Table 3.1. Company list for market research

Company	**Country**	**World Rank No.***
Harris Corporation	U.S	10
Elbit Systems	Israel	12
Aselsan	Turkey	55
Motorola	U.S	-
Hytera	China	-
Kenwood	Japan	-

* According to DefenseNews 2019

3.2.1 Color Schemes in Military Products

Before exploring the products, common colors of handheld radios, and the reason behind them are mentioned. As indicated in MIL-DTL-53039E, which is a detailed specification document about *Coating, Aliphatic Polyurethane, Single Component, Chemical Agent Resistant*, primary colors of camouflage in the army are "Aircraft Gray, 36300, Aircraft Green, 34031, Black, 37030, Brown 383, 30051, Green 383, 34094, Green 808, 34102, IRR Foliage Green 504, 34160, Tan 686A, 33446 and Woodland Desert Sage, 34201" (MIL-DTL-53039E, p. 2). Combination of these colors can change depending on the geographical features of regions. Moreover, colors of professional radios can change depending on the brands' corporate identity. There is not an obligatory usage of color. However, firms' color choices on professional radios are diverged to serve their purposes effectively. For example, Motorola has a classic traffic yellow color to be flashier and get the attention. Also, colors of radios which are used at sea rather than land or air can vary by aiming to be camouflaged or to get the attention. The purpose of usage is the main factor to decide on the color.

3.2.1.1 Harris Corporation

As a default, Harris chooses yellow to be highly visible or midnight black not to take the attention easily on the handheld professional communication radios (Figure 3.1). Standard grey and military green are also included in the color scheme (Figure 3.2). For example, a policemen or a security guard who works in a mall may prefer black colored radio not to stand out, but a yellow colored one is more convenient for a fireman to be visible in the time of incident. As a default in all the radios, emergency buttons are used as orange-red to be differentiated.

The XL line of radios are willing to meet the expectations of customers in terms of safety, easy usage, ruggedness, reliability, security, compactness and ergonomics (Harris Corporation, 2019a). Moreover, XG-75P two way portable radios are also

claimed to be rugged, durable, and especially dependable (Harris Corporation, 2019b).

Figure 3.1. XL two way radios (Harris Corporation, 2019; https://www.harris.com/product-line/xl-two-way-radios)

Figure 3.2. XG-75P two way portable radios (Harris Corporation, 2019; https://www.harris.com/solution/xg-75p-two-way-portable-radio)

Harris prefers linear lines as texture on the shell for easy gripping (Figures 3.3 and 3.4). Moreover, for the parts which should be pushed to remove, like clip or battery opening, linear lines are used as well to direct the users and ease the process. Push-

to-talk (PTT) or emergency buttons are also designed with textured surface to guide users. Textures are chosen from linear lines again, or regular radial pattern is an option as well.

As mentioned in the data sheet of XG-100P portable radio, it is built to achieve interoperability for public safety professionals (Two Way Radio of Carolina, Inc., 2009). Ruggedness and intrinsically safe are the basic keywords that the radio offers. It has three programmable buttons on the side shell (Figure 3.3). One of them is upper side of the PTT button, and it is yellow ,which differentiates it from the others besides its shape. It may be set as a quick access for an action that is used frequently. The other two user-defined buttons are under the PTT. Both of them are black, and also they have the same shape. Therefore, they differ from each other with the number of dots on them.

Figure 3.3. XG-100P two way portable radio (Harris Corporation, 2019; https://www.harris.com/solution/xg-100p-two-way-portable-radio)

Figure 3.4. Professional radios (Harris Corporation, 2019; from left to right, image 1 https://www.harris.com/solution/xl-200p-two-way-portable-radio, image 2 https://www.harris.com/solution/xg-75p-two-way-portable-radio, image 3 https://www.harris.com/solution/xg-15p-two-way-portable-radio-microphones-and-audio)

3.2.1.2 Elbit Systems

Elbit Systems has a handheld radio which is called SDR-7200, software defined radio (Figure 3.5). It has military green and black versions. Also, it has regular, linear and thick patterns on the two front side edges. The hand does not have a significant interaction with the texture because of the place of the texture. Therefore, the purpose of the texture may not be only functional. It seems that the usage of this pattern on the radio aims to affect human perception mostly, because, SDR-7200 may seem to have a tougher appearance with the usage of this pattern. It makes the product seem secure and reliable as claimed in the product specifications.

Figure 3.5. SDR-7200HH software defined radio by Elbit Systems (Military Technology, 2014; http://www.miltechmag.com/2014/02/defexpo-2014-elbit-systems-presents.html)

3.2.1.3 Aselsan

Aselsan implements three main colors which are mentioned in MIL-DTL-53039E on the tactical communication radios. One of them is military green. It is not exactly the same color as mentioned in the specification. It does not have a certain code in Ral or Federal Standard catalogue, because many years ago, Aselsan produced radios by transferring technology from Philips. Philips prepared a military green for Aselsan. For the continuity of corporate identity of Aselsan, that unique military green has never been changed for years. The other color that is in the scheme of Aselsan is black. The last color is tan, 686A, 33446 which is mentioned in MIL-DTL-53039E. These three color choices of Aselsan can be seen on Ehket-5433 tactical radios (Figure 3.6).

Professional handheld radios of Aselsan mostly have black color. 3700 is the latest example for that (Figure 3.7) and 4900 is the previous one (Figure 3.8). Distinctly, an earlier model, the 4700 has dark blue color because it is the main color of Turkish gendarme. Moreover, red-orange is used on the emergency button as a flashy and

supportive color on 3700. Also, gray metal is used on the main body to get a tougher appearance. It gives users the feeling of safety.

Figure 3.6. 5433-Ehket tactical radio (product rendering from Aselsan HBT offices, 2019; source: author)

Figure 3.7. 3700 professional handheld radio (Aselsan HBT Mechanical Design Department, 2018; photograph by: Fethi Mağara)

Figure 3.8. Atlas professional handheld radio (Aselsan, 2020; https://www.aselsan.com.tr/tr/cozumlerimiz/kamu-guvenligi-haberlesme-sistemleri/telsizler-terminaller/4900-atlas-el-telsizi-ailesi)

Aselsan communication radios mainly have two types of texture. One of them is regular, thick and linear lines like on the shell of the 4900 (Figure 3.8). The purpose of the design is easy handling. The other texture includes regular and spotted pattern like on the PTT buttons of Ehket (Figure 3.6), and 3700 or the clips of 3700 (Figure 3.7). Side plastic shell of Ehket also has the same texture. That part separates the main metal body from hand. By doing so, the felt temperature is decreased, because metal is a good heat conductor. Plastic shell may be more functional than metal for the holding parts of a handheld device. Also, pattern on the plastic shell increases the heat rejection, and it leads hand to grasp the radio easier. At the same time, added plastic parts direct users about how to hold the product.

As a third texture, the negative version of the first two ones may be mentioned. Moreover, thin and frequent lines have also been used as a pattern in earlier models. Finally, rougher textured surfaces that have 42 value in VDI surface finishing scale are very commonly used as well. It can be observed on the black plastic parts of the 3700 shell. Finishing values are varied between 0-45 and the roughness level increases towards the highest value. High values are preferred if a surface has direct

interaction with hand, because it decreases the possibility of the radio sliding from the hand. Additionally, when plastic does not have the same thickness everywhere, undesirable marks (e.g. sink marks) can be observed on the surfaces. Rougher textures may hide mistakes caused by production processes, but the textures with low values show them directly.

3.2.1.4 Motorola

Motorola generally prefers black, public yellow or military yellow as color choices on radios depending on the field of usage (Figure 3.9). PTT buttons of black professional radios may have colored wireframe (Figure 3.10). The aim is to differentiate the PTT button from the others and emphasize it. Emergency buttons have generally red-orange color because of its alerting role.

Figure 3.9. APX Series P25 two way portable radios (Motorola Solutions, 2019; https://www.motorolasolutions.com/en_us/products/p25-products/apx-story.html)

Figure 3.10. ST-7500 Tetra two way portable radio by Motorola (if World Design Guide, 2018; https://ifworlddesignguide.com/entry/254461-st7500-tetra-portable-terminal)

ST-7500 Tetra handheld radio offers compact sizes, and lightweight features for the aim of public safety. The radio has IP67 protection, which defines its ruggedness level (if World Design Guide, 2018). IP67 is waterproofing of a product until one meter for half an hour (Trusted Reviews, 2019).

Motorola radio designs have mainly three types of textures. One of them consists of a regular spotted (radial) pattern. The pattern is used on the surface of PTT button (Figure 3.10 and 3.11) and on the shell of the radio (Figure 3.10). One other type of texture is a linear pattern which is generally used on the clips (Figure 3.11). The last conspicuous texture is the roughness level of the surface texture of some tactical radios (Figure 3.11). It makes the appearance tougher.

With SRX-2200 handheld radio, Motorola aims to satisfy users about ruggedness, and reliability even in the most dangerous environment (Radioparts, n.d.). Moreover, the radio has the T shape, which allows easy handling even if the hand is wet or slippery. Ergonomics is another term that Motorola emphasizes.

Figure 3.11. SRX-2200 P25 two way portable radio by Motorola (Radioparts, n.d.; https://www.radioparts.com/motorola-srx2000-h99ucd9pw5bn)

MTP 8000EX Atex tetra radio has red and black colors on the body (Figure 3.12). By doing so, the radio provides an alerting effect. Also, parts that have different functions are separated from each other clearly. Black PTT button has a regular pattern that includes red dots, and the black knob has red surfaces that create rims as well. All have the same purpose, and they aim to direct users about finger interaction. The radio has T shape, similar to SRX-2200. This allows easy gripping even with gloves.

Figure 3.12. MTP8000EX atex tetra radio by Motorola (Motorola Solutions/EMEA @MotSolsEMEA, 8 February 2017; twitter post, https://twitter.com/MotSolsEMEA/status/829274875776884741)

3.2.1.5 Hytera

Hytera has professional communication radios that are in black generally, but orange, red or green can be used as supportive color choices. In TC-610, the main body has rough textured plastic in black color (Figure 3.13). Orange is used on the side shell to emphasize the function differentiation. They are the holding parts and black PTT buttons are placed on this orange part. Many brands use colored PTT buttons or wireframe to make them visible on the main body, but Motorola chooses another technique with this radio by using color as well to show it.

Figure 3.13. TC-610 analogue two way handheld radio (Left image from https://www.radioparts.com/hyt-tc-610u-2, right image from https://www.hytera-mobilfunk.com/en/product/details/hytera-tc-610/)

VM-780 has orange wireframe on the PTT button to make it stand out (Figure 3.14). Orange emergency button or red on-off button has the same purpose as well. PTT and back shell of the radio have regular spotted (radial) pattern. This gives an understanding of where to contact with hand, because the texture directs users about holding parts of the radio or the buttons that finger can push.

Figure 3.14. VM-780 by Hytera (The Critical Communications Review, 2019; https://www.criticalcommunicationsreview.com/p25/news/99760/hytera-s-latest-bodycam-includes-poc-radio-in-a-single-device)

Hytera PD68X handheld radio has gray metal main body besides black plastic parts (Figure 3.15). The radio seems tough and reliable as does 3700. The pattern on the PTT button emphasizes that it has a function related with hand interaction.

Figure 3.15. PD68X Handheld Radio (Hytera, 2019; http://www.hyteratelsiz.com/wp-download/picture/z1p.png)

Hytera has a handheld radio with blue colored plastic main body (Figure 3.16). The other parts are black and they have patterns which consist of linear, parallel lines. The material it has is more matte than the blue plastic. Therefore, black parts seem more reliable by means of gripping the radio, because blue part seems more slippery. Orange wireframe of the PTT button creates contrast with blue, and it takes the attention mostly.

Figure 3.16. PD715EX digital handheld radio (Hytera, 2019; http://hyteratelsiz.com.tr/urun-detay.php?urun_adi=PD715EX%20ATEX%20DMR%20UHF%20Dijital%20El%20Telsizi&alt_kategori=Dijital%20Telsiz)

3.2.1.6 Kenwood

NX-3220/3320 series have a basic version without screen or key pad (Figure 3.17, left image). This version has a pattern that includes regular spots on the side shell, and PTT has the same pattern as well. Other two programmable buttons are the same in shape, but one of them has a dot to create tactual difference. As mentioned in MIL-STD-1472G (2019), touch sense gains importance when visual identification is limited. Therefore, what people feel while touching a part of an object is important

to differentiate itself from the others. These diversifications may be supported with material and texture.

TK-3230DX has the same pattern type on the shell and buttons (Figure 3.17, right image). Kenwood states that the radio is compact, light and easy to handle, in other words it aims to satisfy users with ergonomics (Kenwood, n.d.).

Figure 3.17. Left: NX-3220/3320 portable radio (Kenwood, n.d., https://www.kenwood.com/usa/com/lmr/nx-3220_3320/); right: TK-3230DX Two Way Portable Radio (Kenwood, n.d., https://www.kenwood.com/usa/com/osbr/tk-3230dx/)

3.2.2 Product Attributes of Handheld Radios

After market research, leading handheld communication radios are explored. They are analyzed depending on color scale and texture types. Their functional effects, and impressions on directing human perception are discussed. Also, product attributes of radios, which they aim to satisfy users about, are found out. The main attributes are safety, ruggedness, ergonomics including comfortable handling, weight, size and temperature, and aesthetics. The effects of color and texture on these product attributes will be explored with the implementation of the methodology in the thesis.

MIL-STD-1472G (2019, p. ii) is a universally valid standard that "establishes general human engineering criteria for design and development of military systems, equipment, and facilities." The purpose of the standard is to get highest performance from all the systems, equipment and manpower as well, by leading designs that convene with human factors. It aims to achieve reliability between user and tool interaction. As many defense companies state in their products' specifications, reliability, ruggedness and ergonomics are the basic product attributes that are aimed for. One of the ways of meeting user expectations, and satisfying them is including these three specifications at an optimum level.

3.2.2.1 Reliability

An important term for handheld communication radios *reliability*. As Motorola states, two types of reliability are observed for wireless technologies (Motorola, 2009). One of them is being ready for communication every time and everywhere for the users, and the other one is about physical reliability. The first term is observed in the topic of reliability, and the other one is expressed in the topic of ruggedness.

If a handheld radio functions well and satisfies users in terms of professional communication, reliable can be used to describe it. Users can trust the handheld radio while communicating with others, because it probably provides fast and confidential communication. As a supportive feature, if a handheld radio gives the professional perception besides its successful performance, users feel free and safe. Handheld communication radios should not create doubt in users' mind about its function, and they should allow a fluent uninterrupted communication. In other words, they should be trustworthy. Reliable communication with handheld radios can be achieved with technical solutions, because it is related with product performance mostly. However, designing the product to change the human perception in accordance with reliability may be possible. The effects of color and texture on the perception of users by means of reliability is observed in this thesis.

3.2.2.2 Ruggedness

Ruggedness is the other term that consumers should be satisfied about, because ruggedness makes users feels comfortable by providing them an ease of mind in terms of product usage and maintenance. The International Electrotechnical Commission (IEC), the European Committee and the United States military set standards for ruggedness that are respected and widely used in the world (Motorola, 2009). Salt, fog, water, humidity or dust resistance, and ability to perform in high and low temperatures provide product ruggedness. Also, vibration, temperature shock testing, drop testing, sun exposure, low pressure, shock and crash testing are the criteria that define the ruggedness level of a product. Handheld radios are generally used in harsh working environments. The possibility of falling down, crashing, getting wet or oscillation of the radios is high. Therefore, radios should be ready for the hard conditions, and also give a rugged impression to the users and make them feel relaxed. Moreover, ruggedness is mentioned in MIL-STD-1472G (4.9, p. 12) as a military standard which should satisfy the user during the product lifecycle such as "operation, maintenance, supply and transport" within the environmental limits. During the usage, users should not have to worry about the maintenance of the radio. In other words, the design of the products should get the user's trust.

3.2.2.3 Ergonomics

Another important term about handheld communication radios is *ergonomics*. Products should be convenient for gripping comfortably for many hours. The form or the tactile quality of a product (the texture caused by the material, painting or pattern) may lead to comfortable handling. For example, as indicated in MIL-STD-1472G (5.1.4.1.2. a Knobs, (4) Rims, p. 51), rotary knobs that are used for adjustments should have rims, and the size of the rims change depending on the size of the knobs. To grasp the small knobs and torque them, knurled rims should be used;

for the usage of larger sized knobs with low torque, serrated rims should be used, but for the usage of them with the high torque, they should have indentation rims.

Moreover, as indicated in the standard, holding surface should create enough friction with appropriate selection of material or texture type (MIL-STD-1472G, 5.1.4.2.2. a Levers, (10) Nonslip Handles, p. 72). The rules in the standard are based on human factors, therefore, easy handling of the radios should not be ignored. Shape and texture may support the ergonomics. In the thesis, the effects of texture on easy handling is investigated. Also, the effects of color on the perception of texture is observed.

Additionally, while designing a handheld radio, the usage with gloves should be considered, because the size parameters may change depending on the ergonomics standards to handle the radio, grip the knobs, and feel the buttons. Therefore as indicated in the standard, "shapes shall be tactually identifiable when gloves must be worn" (MIL-STD-1472G, 5.1.1.4.4.a.3, p. 20). Functionality of texture is effective on the usage of radio with gloves as well, because radio and gloves should hold each other to protect from slipperiness. However, identification of the pattern type clearly is not possible with gloves. In this situation, the effects of textures on human perception may gain more importance. For example, one of the textures may seem more rugged or safe when compared to the others. Besides the end user, customers who decide on the product and purchase it also have a key role in the product lifecycle. Therefore, strengthening the functionality of texture for perception by end users and customers is essential, and the thesis aims to explore the effects of texture and color on human perception.

Compactness is another term that is related with ergonomics. For example, MIL-STD-1472G provides standards about the size of the handles to allow easy handling. Gaps between the handle and the place it is mounted are definite as well. The human hand has a capacity to hold an object comfortably and the mentioned object is a communication device which may be carried on human body or held by human hands for hours. If the size of the radios are convenient to grip them, this means that they

are compact. Radios which cause low physical fatigue thanks to the compact sizes are more successful in terms of human factors.

Moreover, *weight* is another term that causes physical load. Low weight radios are more preferable for easy carriage and usage for hours, just as the feature of compactness. Radios should be under the limit that humans can carry by holding for long periods. Besides the mechanical solutions, I want to observe whether color and texture have any effects on the perception of *size* and weight.

Temperature is an important keyword in communication devices, because they tend to heat a lot. The product specifications that are observed in the thesis mention about the heating levels of their products. Consumers have high expectations about the heating level of the radios, and brands should satisfy users about this point. Temperature is also indicated in MIL-STD-1472G, because it is a human factor that affects the usage negatively or not. Colors and texture may change the human perception about the warmth level of the product. Which texture or color is perceived as warmer is explored in the thesis.

3.2.2.4 Aesthetics

Aesthetics is an essential term that affects the attractiveness of a product. As expressed in the literature review, texture and color are directly related with the hedonic qualities, and they could change the aesthetics assessment of a product for the end user, and customers. Therefore, the leading brands aim to satisfy users in terms of the aesthetics of a product besides its reliability, ruggedness, and ergonomics. In this thesis, the effects of different textures and colors are observed in terms of being aesthetic.

CHAPTER 4

METHODOLOGY

As a conclusion of the market research, four product attributes are determined: reliability, ruggedness, ergonomics (easy handling, weight, size and temperature) and aesthetics. Texture may directly affect easy handling, and also it has a relation with temperature due to its support on heat rejection. An area of inquiry appears as understanding how different texture types affect easy handling or the feeling of temperature. Also, another area of inquiry can be, whether a texture can direct human perception in terms of these attributes even if it does not have a certain relation functionally, like reliability or ruggedness. For example, the possibility of perceiving a product as more rugged or reliable because of the texture usage needs to be explored. Besides, the effect of differing colors on the perception of these textures needs to be investigated in terms of the defined three main product attributes.

Based on these, a study is planned with the aim to find out the effects of three chosen textures commonly used on Aselsan communication devices. The study is planned as an experiment, using three commonly used colors on communication devices in general.

The experiment is composed of two stages. To be sure that texture is the only factor that leads users in their evaluations, the first stage of the experiment takes place by blindfolding the participants. Therefore, the changing factor (variable) is limited to the tactile sense.

In the second stage, color is added as another changing parameter based on the visual sense. The aim is to explore how the texture perceptions change based on color variances in terms of the defined four main product attributes. For example, how color changes the perception of textures about the users' peace of mind in terms of reliability is explored. In addition, people may have different perceptions about

handling a product easily even if their textures are the same because of the color differences. To sum up, the aim of the following experiment is exploring the effects of color on the perception of texture in terms of reliability, ruggedness and ergonomics. The research questions are:

- How do textures change users' perception in terms of reliability, ruggedness and ergonomics?
- How do colors change users' perception in terms of reliability, ruggedness and ergonomics?
- How do colors change the perception of textures in terms of reliability, ruggedness and ergonomics?

4.1 Color choices

For the methodology of the research, three colors are chosen based on the market research. Black is a default color that will be used, because it is a widely preferable color by all of the brands, thanks to its unobtrusive and elegant effect. The other color is military green that is commonly used by most of the brands because of its camouflage effect. Military green and black combinations are common on the products of Aselsan. The third color may be chosen as classic tan. Tan is the third main color that is used on handheld radios and the possibility of combining black and tan is high. However, there is not a possibility of combining military green and tan in the same device, because tan is used by considering the geographical position of countries. For example, it is generally preferred for the southeastern countries. Therefore, orange may be a better choice for the third color, because tones of orange are the most used supportive color for many brands. A generic orange that is currently used by Aselsan is chosen to represent the tones of orange in the market. Black, military green and orange may be used on a device together to differentiate functions or they may generate the color scale of a product line as well. Also, these three colors may be optional for some parts of the radio such as PTT, clips or knobs. Moreover, orange and military green are highly contrast colors. To obtain clear

results, samples should differentiate from each other distinctly in terms of color and texture. Therefore, to explore these three colors with three defined textures and observe their effects on each other may be more helpful.

4.2 Texture Choices

Three textures that are commonly used on the communication radios of Aselsan and also other brands are chosen to be used in the study. One of the textures is formed with regular radial pattern and the other one is formed with linear regular lines. The last one does not have a regular pattern. It is the simulation of ch-45 value that is highly rough. The attributes of these three textures with black, military green and orange in terms of reliability, ruggedness, ergonomics and aesthetics will be explored.

4.3 Procedure of the Study

The study includes two stages. In the first stage, participants explore three textured samples while blindfolded and rate the statements using Likert scale between 1 and 7. A rating between 1 and 7 is preferred to be able to make more precise assessments, and it is also seen that this rating is used in such studies made on senses (Rompay and Groothedde, 2019; Choi and Jun, 2007; Klatzky and Peck, 2012; Jansson-Boyd and Marlow, 2007).

In the second stage participants look at nine samples (in three colors with a combination of three textures) in a pre-defined order. At the same time, they can handle the samples. In other words, participants actively use both touch and visual sense while exploring the samples and rate the statements between 1 and 7.

4.3.1 Statements

Fourteen statements are prepared based on the three defined topics; reliability, ruggedness and ergonomics. Then, a key note is added on the top of the statements: “Please rate the statements between 1 and 7 (from low to high) by imagining that a product has the same features of the samples that you experience”. The researcher phrased the statements as straightforward descriptions of related topics, and then converted them as corresponding scale items (Chang, Lai, and Chang, 2007). To begin with, many statements were written in terms of defined concepts. Then, the statements which have the same meanings were combined, and some of them were eliminated. Also, opinions were taken from four experts who are experienced in the profession. Consistency of the statements with defined concepts were considered, and the number of statements were decreased to thirteen.

The statements are as follows.

Statements Related with Reliability

- The product functions well.
- I can trust the product in cases of emergency.
- I believe that the product is a professional device in terms of functionality.
- I can trust the product in terms of confidentiality (data privacy).

Statements Related with Ruggedness

- The product is rugged and durable.
- The product is durable against impacts and drops.
- The product is enduring for harsh weather conditions.
- Cleaning and maintaining of the product is easy.

Statements Related with Ergonomics

- I can handle the product comfortably.
- I can manipulate the product comfortably.
- The size of the product is convenient to handle it for a long time.

- The weight of the product is convenient to carry it for a long time.
- The product heats easily.
- I like the feeling that the product gives while handling it.

Bonus Statement (for Stage 2)

- The product looks attractive.

Note: The bonus statement is rated only at the second stage with the utilization of visual sense.

4.3.2 Data Collection Charts

Charts were prepared to collect data during the study. For Stage 1, the statements were placed on an A4 size portrait orientation sheet. For Stage 2, the statements were placed on an A4 size landscape orientation sheet. Sheets were prepared in Turkish. Both charts contained all the statements listed in groups. The chart for Stage 2 also included the additional statement on aesthetics.

Additionally, the first sheet has place to write the beginning and ending times of the experiment. Also, I wrote some demographic information about participants like their profession, experience in that profession and their ages. Both sheets include place to write the participant number.

At the beginning of each session, I read the description sentences to the participants and explained the process. While they were experiencing the samples, I read them all the statements and noted their scores.

4.3.3 Pilot Study

The research methodology was tested with a pilot study, to particularly check whether the statements made sense or not for participants, and revise if necessary. Also, if any statement is perceived as a repetition of the others, some of them may

be combined together. The purpose is optimizing statements to get more meaningful results in a shorter time with less mental load for the participants. Also, the size and forms of the samples would be revised with considering the feedbacks.

4.3.3.1 Initial Samples

While developing the methodology nine samples were prototyped with the usage of strawboard. Three layers of a strawboard were stacked on to each other and a prismatic form was created to be practical for the trial. Then, the samples were covered with three types of textured papers with linear, radial and irregular patterns**.** By doing so, three groups including three same samples were created. Then, the samples from all the groups were painted with orange, black and military green respectively with spray painting. Therefore, three textures and three colors were combined with each other. The samples prepared for the pilot study are given in Figure 4.1.

Figure 4.1. Preparation of the samples for the pilot study

4.3.3.2 Participants of Pilot Study

The pilot study was carried out with two participants. One of them is a mechanical designer of communication devices at Aselsan and the other is a systems design engineer who is familiar with the usage of handheld radios. The first experiment took twenty minutes and the other took fifty minutes. The first participant rated statements with his first impressions, without overthinking. The second participant tried to define the samples in detail, and also he was very careful about the consistency of his answers.

4.3.3.3 Feedback about Samples and Revision

The evaluation sheet stated: “Please rate the statements between 1 and 7 (from low to high) by imagining that a product has the same features of the samples that you experience”, with this directive both participants needed to conceptualize the samples as a defined 3D object to imagine the textures and colors on them clearly. However, prismatic samples did not give any clue about the context and sometimes participants had difficulties in imagining a product. Also, one of the participants commented on the size of the sample as “it is not long enough to touch the surfaces easily by thumb while holding it or I cannot feel the texture on the palm of the hand because of its tiny and prismatic form”.

After feedback on the form of the samples, I decided that thin samples would not be convenient for such a study that requires active handing and manipulating. Therefore I prepared mock-ups to design a 3D object which is more oriented and suitable for handling. The revised object has a surface which is convenient for handling, and the other surface is flat, which is not useful for handling. I tried to protect the abstract form of the sample to give chance to participants about imagining a product. People may have the tendency to simulate the sample as a mouse, remote control, phone, battery or another handheld product. The purpose is to help participants about imagining a concept easily, make the process more practical and fluent. Additionally,

the size and the thickness of the sample is more convenient to feel the texture by all parts of the hand easily.

Moreover, because of the lightness of the samples, participants thought that samples did not have enough quality and were ordinary. It may be concluded that perceivable quality is changed depending on the weight. The reason of the light samples is the usage of paper as a material in the mock-ups, but real samples were going to be more perceivable as with weight.

Lastly, according to the feedback of one of the participants, direction of linear texture changed from the vertical lines to the horizontal lines to avoid the slipperiness of the samples.

4.3.3.4 Feedback about Statements and Revision

The fourth statement in the context of reliability about confidentiality (data privacy) was found incomprehensible. Both participants asked "what do you mean?" when they heard the statement and they could not rate it. It did not mean anything for participants, because they did not know the handheld radio context. Also, I realized that, in order to analyze people's perception about an object caused by texture and color, this kind of a detailed statement related with data privacy is not necessary. The thesis is more about the effects of color and texture. Therefore, I decided to eliminate this statement for the final study.

Additionally, the fourth statement in the context of ruggedness is moved to ergonomics context, because it is diverged from the first three statements in terms of meaning. The first three statements can be associated more with a rugged device, but the hygiene and maintenance of a device is more about ergonomics. Also, as observed in the ratings of two participants, the fourth statement is different when compared to the first three ones.

The bonus statement for the second part of the methodology was revised as "this object is aesthetic."

Finally, the directive sentence on top of the evaluation sheet was changed, because it was long. To decrease the mental load of participants, the sentence was edited as shorter and clearer. The revised explanation is:

“You will experience the samples that will be given soon, only by handling them. Please imagine that these samples are a product. Then, rate the statements below for every sample between 1 and 7 (from low to high).”

The final data collection charts can be found in Appendices A, B, C and D, with their translation in Turkish.

4.3.4 Production of the Final Samples

After creating mock-ups from 5 mm white paper by cutting and sanding the final form was determined. It was modelled digitally by using PTC Creo which is a program for solid modelling, and the sample was given its final shape. Then, I tried to model radial, linear and irregular patterns on the sample digitally. It was a hard process because the sample is formed with a curved surface. Therefore, patterns could not be directly projected on the surfaces. The wrap tool was used to roll the patterns on the surface; by doing so, the patterns could be placed on the normal of the surfaces. However, the gaps of the patterns lost their regularity and Creo failed to roll the patterns on some points like rounded edges (Figure 4.2).

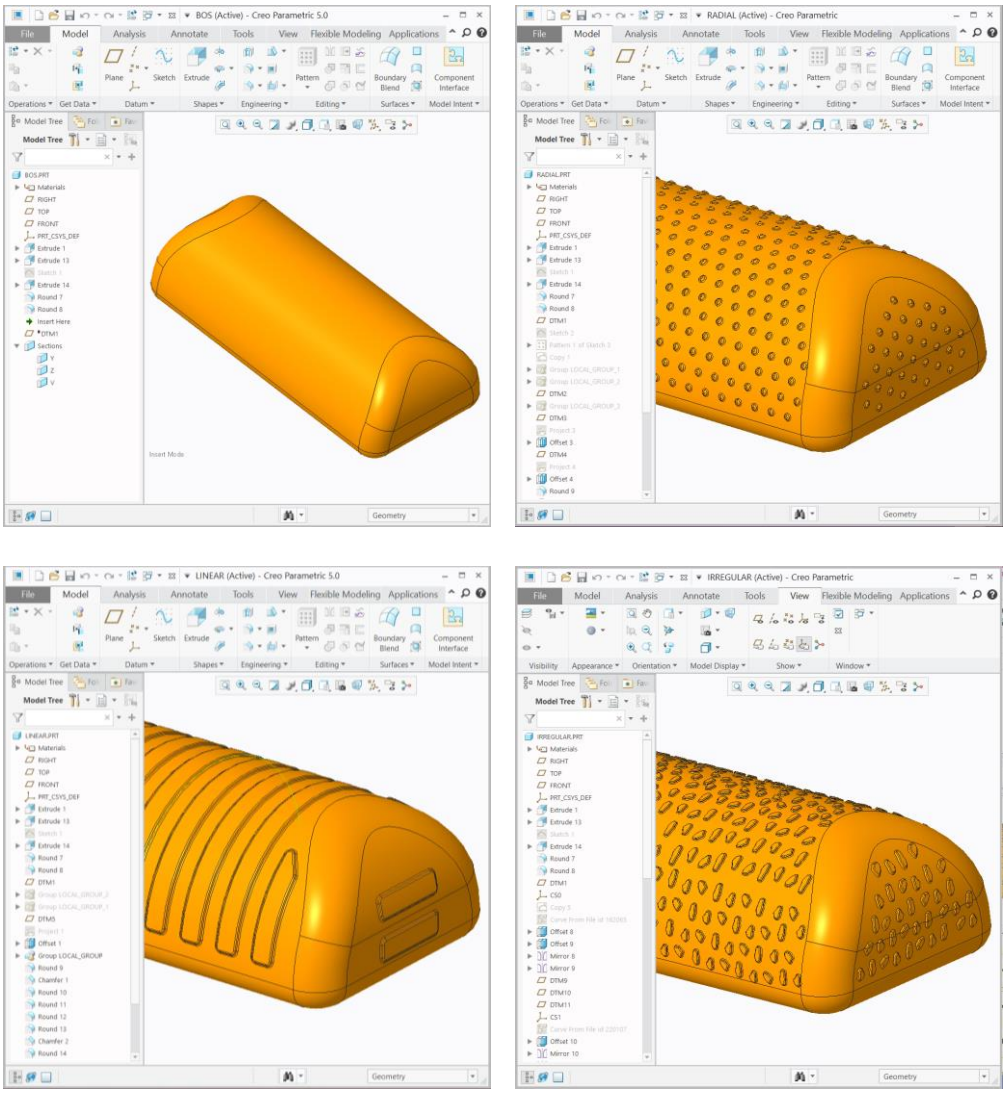

Figure 4.2. From left to right; main body, radial, linear and irregular texture

In the first digital trials, radial patterns were very small; the linear one had thick lines and the irregular one had nonuniform rounded shapes as seen in Figure 4.2. We decided with my supervisor that the irregular pattern was very similar to the radial one, and it may not be distinguished. Therefore, to separate these three types of patterns, the last pattern had to be distinctly irregular.

The wrap tool in Creo did not work successfully to roll an irregular pattern on the surface. Errors in Creo and troubles about modelling began to restrict me about

creating the desired shape and the pattern as well. Therefore, I decided to change my point of view about 3D modelling.

4.3.4.1 Production Method

Aselsan has a 3D printer which is Objet. Objet has two types of materials; one of them is Vero and the other one is Tango. Tango is used to create flexible models and Vero is used for rigid parts. During the discussion with my colleagues, an idea occurred that the main body could be printed with Vero to create the rigid part, and the pattern could be modelled as a sheet by using Tango and then rolled on the surface physically, thanks to its flexibility. Firstly, the idea was tested. One mm offset was given on the surface of the main body and an indentation was created. Patterns were modelled on a sheet by using the project command easily. The purpose was producing the main body and the textured sheet separately and then combining them to each other with bonding. To try the method a solid main body which is full inside with support material was produced with the material Vero by using 3D printer. The other sheet had to be flexible to roll it on the main body after production. Therefore, Tango was used as a 3D printer material. I could not decide on the proper thickness for the sheet at the beginning, so 1 mm and 2 mm thicknesses of textured sheet were printed. The 1 mm sheet had 60 shore and the 2 mm sheet had 50 shore. The shore level defines the flexibility of the material. It should be determined properly in order to bend the plastic sheet easily, but at the same time it should be steady enough to protect its form. After trials, it was seen that the method worked well (Figure 4.3). All the samples could be produced by using the same technique.

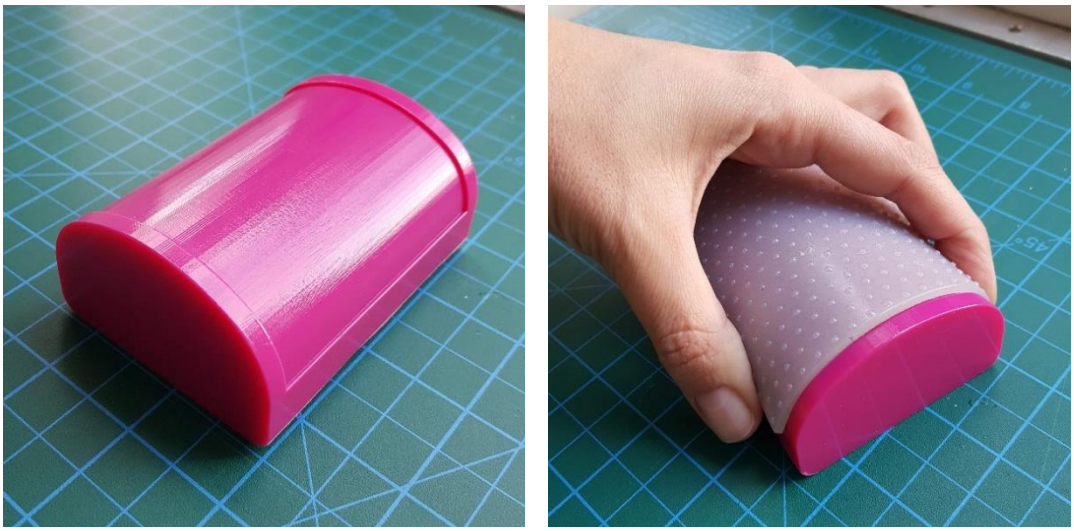

Figure 4.3. The rigid main body and the flexible radial textured sheet

The first prototypes were successful. One mm was enough for the indentation of the surface and the thickness of the sheet as well. The textured sheet was modelled with 0.3 mm offset from the edges of the surfaces to fit well into the indentation. However, it was not enough, because flexible material has tendency to stretch. Therefore for the last samples, 1 mm offset was kept between the edges. Also, 70 shore level was determined to prevent the sheet from uncontrolled stretching. It was seen that 70 shore level was enough to bend the sheet properly.

Next, the rigid samples were modelled with two parts; the body and its cap. The purpose was to empty the inside of the sample to prevent waste of material. By doing so, the samples were produced as two parts (Figure 4.4) and then the parts were assembled together.

Figure 4.4. Second prototypes for the main body

With the second prototypes, the patterns were revised as well. The radial pattern has rounds bigger in diameter, and the gap between the centers of rounds increases as well. The linear pattern has thinner lines and gaps. The reason of changing scales is to organize the radial and the linear textures in the same density, and also to increase their perception when they are experienced only by touching. To perceive the radial texture in smaller sizes and gaps, or the linear texture with bigger lines and gaps could prevent their perception when blindfolded. The irregular pattern was created with unorderly rounds and curved lines (Figure 4.5). The purpose is to differentiate the irregular texture from the radial and linear textures. This pattern was adapted from the illustration titled "Vector Seamless Black And White Organic Jumble Lines Irregular Pattern" obtained from gograph.com/clipart (retrieved on October 2019).

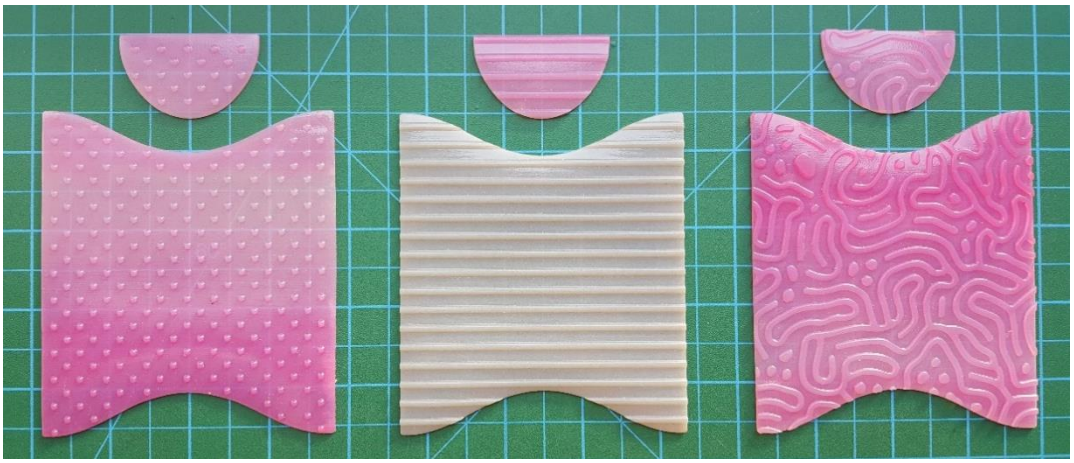

Figure 4.5. Second prototypes for the flexible textured sheets

After the second prototype, a third one was made for the irregular pattern. In this version the scale of the irregular pattern decreased, by doing so the lines got thinner and the number of the spots were increased (Figure 4.6).

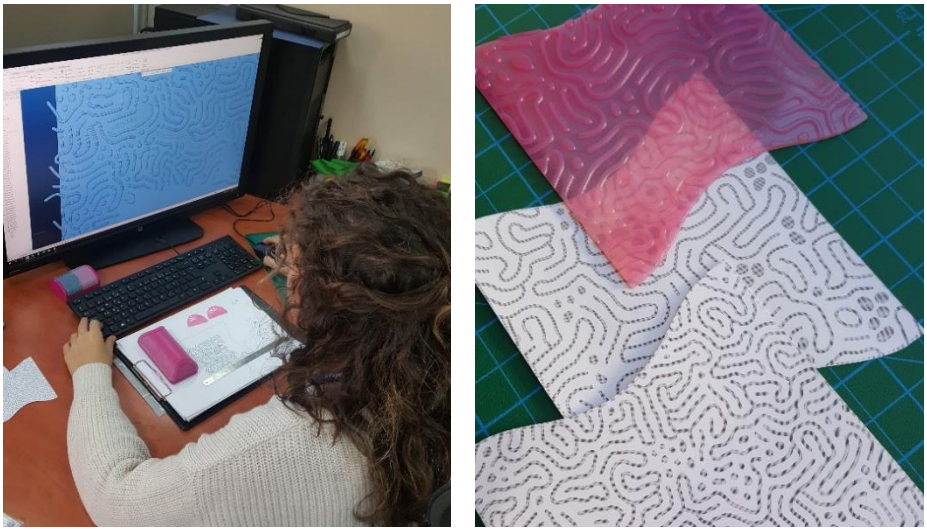

Figure 4.6. Revision of the irregular texture

4.3.4.2 Bonding

Epoxy is convenient to bond the 3D printing materials Vero and Tango. Two types of bonding material were tested with the help of the material engineer at Aselsan. Both of them are epoxy, but the white colored one needs five minutes and the black

colored one needs twelve hours to bond completely. After the bonding process, the sample was covered with paper tape. After twelve hours, epoxies were compared. The white epoxy had some bubbles on the surface, meaning it did not bond entirely. The black one had a more qualified appearance and was better in bonding the materials to each other. Also, the black epoxy begins to hold the surface after half an hour, which means, it allows more time to correct the placement of the sheet on the surface. Therefore, the black epoxy was chosen to bond the final samples (Figure 4.7).

Figure 4.7. Bonding process

4.3.4.3 Painting the Samples

After bonding sheets on the main bodies, samples were ready to be painted green, orange and black. Before giving their final colors, to hide the surface imperfections the samples were painted with filler (Figure 4.8). All the process about painting was done by the support of Aselsan coating unit.

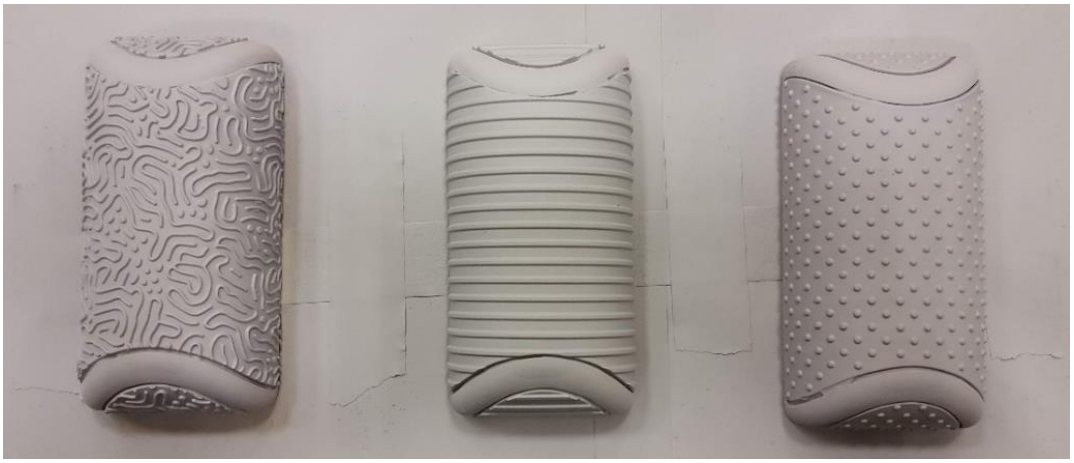

Figure 4.8. Painting the samples with white filler

Twenty four hours were allowed to be sure that the filler was completely dry. The samples were sanded by using sand paper to correct the surfaces. After the sanding process, the samples were ready to be painted in their final color. Then, colors were prepared according to the prescription (Table 4.1), and the samples were painted (Figure 4.9).

Figure 4.9. Coating process; black, green and orange

Table 4.1. Samples

Pattern/Color	**Black**	**Green**	**Orange**
Radial	RB	RG	RO
Linear	LB	LG	LO
Irregular	IB	IG	IO

4.3.4.4 Production of the Visual Shield

In the pilot study, for Stage 1, I wanted from both participants to close their eyes while experiencing the samples. However, for the final experiment I decided to design a semi-closed visual shield (Figure 4.10). In Stage 1, to experience the samples, participants put their hands inside of the box, and I gave the samples orderly from the gaps that was on the behind of the box. They rated the samples without seeing them. The purpose of designing a visual shield was to prevent participants from feeling nervous by closing their eyes.

For Stage 2, the shield was turned upside down, so that the top part became the bottom. By doing so, participants experienced the samples again inside the box, but they could see them. For the second stage, I used the same table lamb which has a daylight bulb to illuminate inside of the box. The reason was to decrease the changing parameters and reaching the same conditions for all the participants in different environments.

4.3.5 Participants

Thirty two participants took part in the experiments. Eighteen of them are professional handheld radio users, fifteen of which are security guards. The rest of fourteen participants are the industrial or mechanical designers of handheld radios or the project managers of them. Thirty-one participants are male, and one participant (Participant 3) is female.

Table 4.2. Participants

Title	Age	Years in Profession	Position in Company
Participant 1	43	22	Industrial Designer
Participant 2	26	3	Systems Design Engineer
Participant 3 (F)	25	1	Mechanical Designer
Participant 4	39	15	Mechanical Designer
Participant 5	33	8	Mechanical Designer
Participant 6	46	30	Security Guard Chief / Retired Sergeant
Participant 7	28	7	Security Guard
Participant 8	38	17	Security Guard / Retired Sergeant
Participant 9	31	7	Security Guard
Participant 10	34	16	Security Guard
Participant 11	27	3	Security Guard
Participant 12	33	15	Security Guard
Participant 13	28	3	Security Guard
Participant 14	35	12	Security Guard
Participant 15	43	21	Security Guard / Retired Sergeant
Participant 16	25	1	Security Guard
Participant 17	29	3,5	Security Guard
Participant 18	27	3,5	Security Guard
Participant 19	40	12	Security Guard
Participant 20	22	7 months	Security Guard
Participant 21	28	4	Materials Engineer
Participant 22	41	19	Mechanical Designer
Participant 23	40	16	Mechanical Designer
Participant 24	40	20	Technician
Participant 25	45	20	Project Manager
Participant 26	40	23	Head Technician
Participant 27	39	16	Project Manager
Participant 28	34	13	Project Manager
Participant 29	29	3	Project Manager
Participant 30	47	12	Project Manager
Participant 31	47	22	Project Manager
Participant 32	42	21	Industrial Designer

4.3.6 Order of the Samples

For the first stage of the experiment, the three black samples, with radial (R), linear (L) and irregular (I) textures each, were tested with the participants without seeing the samples. For this, the participants handled the samples placing their hands through the holes of the visual shield box.

Six combinations of three samples were prepared for this stage: R-L-I, R-I-L, L-R-I, L-I-R, I-R-L, I-L-R. Four of these combinations were repeated five times and the other two combinations were repeated six times, completing all the 32 participants.

The reason for choosing the black samples for this stage of the experiment was the different gloss levels of the colors. The gloss level of orange is highest and green is the lowest. The feeling while touching the different colored samples may change due to the gloss levels besides the different types of textures. Therefore, in Stage 1, I gave the same colored samples even though participants could not see them. The black color which has the middle glossy level was chosen.

For the second stage of the experiment, the nine samples were ordered with different combinations as much as possible (Table 4.3). Therefore, all the participants experienced the samples in different orders. Four samples were experienced first in three times, and the other five samples were tried first in four times. Also, the rest of the order changed all the time. It was aimed to prevent a set of two same samples from following each other as much as possible. Participants could feel tired towards the end of the session, and this could affect the reliability of the results. By shuffling all the samples for every person and changing their order, the final result would be more reliable.

Table 4.3. Order of the samples

Title	1	2	3	4	5	6	7	8	9
Participant 1	RB	IG	LO	LB	LG	RO	IB	RG	IO
Participant 2	LB	RO	IG	LG	RB	IO	LO	IB	RG
Participant 3	RG	IB	LO	RB	IO	LG	RO	IG	LB
Participant 4	RB	LG	IO	RG	LO	IB	RO	LB	IG
Participant 5	LG	LB	IB	RB	RO	RG	IO	IG	LO
Participant 6	IB	RO	LO	LG	IG	RB	RG	LB	IO
Participant 7	RB	IO	LO	IG	LB	RG	LG	RO	IB
Participant 8	IO	RB	LO	LB	IG	IB	RO	LG	RG
Participant 9	RG	IO	LB	IB	LG	RO	LO	RB	IG
Participant 10	LB	RG	IO	IG	LO	RB	RO	IB	LG
Participant 11	RO	LG	IB	RB	IO	LO	RG	IG	LB
Participant 12	LO	LB	IO	RG	IG	LG	IB	RO	RB
Participant 13	IB	LB	RB	LO	RO	IO	RG	IG	LG
Participant 14	RB	RG	RO	LG	LO	LB	IO	IB	IG
Participant 15	LO	LB	IO	RG	IG	LG	IB	RO	RB
Participant 16	RO	IO	LB	RB	LO	IG	RG	IB	LG
Participant 17	IG	LB	IO	LO	LG	IB	RB	RO	RG
Participant 18	IG	RB	LO	RO	IB	IO	LG	RG	LB
Participant 19	LO	RB	IG	RG	IO	LB	IB	LG	RO
Participant 20	LG	RO	LO	IG	RB	IO	RG	LB	IB
Participant 21	LB	IO	LO	LG	RG	IG	RB	IB	RO
Participant 22	IB	RG	LO	IO	RB	LG	IG	RO	LB
Participant 23	RO	RG	RB	LB	LO	LG	IG	IB	IO
Participant 24	IO	RG	LB	RB	LO	IG	LG	IB	RO
Participant 25	RO	IB	LG	IG	LO	RB	IO	RG	LB
Participant 26	IG	LB	RO	LG	IO	RB	LO	RG	IB
Participant 27	RG	IG	LG	LO	LB	IO	IB	RO	RB
Participant 28	LG	RG	RO	IO	LB	IG	RB	IB	LO
Participant 29	IB	LO	IO	RG	LG	RB	IG	LB	RO
Participant 30	IO	RO	RB	IB	LO	RG	IG	LB	LG
Participant 31	IG	LO	RB	LG	RO	IB	LB	RG	IO
Participant 32	LG	RO	IB	IG	RB	IO	RG	LB	LO

4.3.7 Setting of the Experiment

The experiment took place in three different meeting rooms and a rest room for security guards in Aselsan. All the participants were placed in front of a standard table during the experiment. The visual shield was used by all the participants during both stages (Figure 4.10). For Stage 2, the same table lamb was used to illuminate the box and create the same ambiance while experiencing the colors.

Figure 4.10. Experiment

At the beginning of the experiment, I thanked the participants, because of their acceptance about participating in my academic study. Then, I wanted from the participants to read the voluntary participation form and sign it. At the same time, I tried to answers their questions and make their minds clear. After participants felt ready to join the experiment, I explained them Stage 1 by reading the instructions on the A4 sheet, and showed them how to use the visual shield while experiencing the samples without seeing. I simulated the experience as an example by scoring one or two statements to make the process clearer. Then, I gave the first sample to the participant and read the statements. Meanwhile, I noted their scores about the statements. If participants had some trouble about scoring the samples, I directed them to score the samples depending on their first quality impressions. During the all process, I encouraged them to visualize the samples and imagine a product.

The sheet for Stage 1 has 13 statements and the sheet for Stage 2 has 14 statements. For the each stage I was able to collect 32 sheets from 32 participants. The scores were written as a quantitative data between 1 and 7.

The experiments were carried out over 11 days between the dates 15 November and 29 November 2019. The sessions for the experiments took 20.5 minutes in average (Table 4.4).

Table 4.4. Experiment time

Title	Date	Beginning Time	Ending Time	Total Duration of Sessions	Location
P 1	15.11.19	12:40	13:00	20 min	Aselsan-Meeting Room
P 2	16.11.19	18:15	18:51	36 min	Aselsan-Meeting Room
P 3	18.11.19	16:40	17:05	25 min	Aselsan-Meeting Room
P 4	19.11.19	16:35	17:00	25 min	Aselsan-Meeting Room
P 5	19.11.19	17:05	17:30	25 min	Aselsan-Meeting Room
P 6	21.11.19	09:40	10:00	20 min	Aselsan-Security
P 7	21.11.19	10:05	10:20	15 min	Aselsan-Security
P 8	21.11.19	10:25	10:40	15 min	Aselsan-Security
P 9	21.11.19	10:40	11:00	20 min	Aselsan-Security
P 10	21.11.19	11:10	11:30	20 min	Aselsan-Security
P 11	21.11.19	13:40	14:00	20 min	Aselsan-Security
P 12	21.11.19	14:05	14:25	20 min	Aselsan-Security
P 13	21.11.19	14:35	14:45	10 min	Aselsan-Security
P 14	21.11.19	14:55	15:15	20 min	Aselsan-Security
P 15	21.11.19	15:25	15:55	30 min	Aselsan-Security
P 16	22.11.19	09:15	09:30	15 min	Aselsan-Security
P 17	22.11.19	09:00	09:15	15 min	Aselsan-Security
P 18	22.11.19	10:00	10:15	15 min	Aselsan-Security
P 19	22.11.19	09:45	10:00	15 min	Aselsan-Security
P 20	22.11.19	10:30	10:45	15 min	Aselsan-Security
P 21	22.11.19	12:25	12:45	20 min	Aselsan-Meeting Room
P 22	25.11.19	15:30	15:50	20 min	Aselsan-Meeting Room
P 23	25.11.19	16:35	16:55	20 min	Aselsan-Meeting Room
P 24	26.11.19	16:00	16:20	20 min	Aselsan-Meeting Room
P 25	27.11.19	14:45	15:05	20 min	Aselsan-Meeting Room
P 26	27.11.19	15:05	15:25	20 min	Aselsan-Meeting Room
P 27	27.11.19	15:25	15:40	15 min	Aselsan-Meeting Room
P 28	27.11.19	15:45	16:05	20 min	Aselsan-Meeting Room
P 29	27.11.19	16:05	16:25	20 min	Aselsan-Meeting Room
P 30	27.11.19	16:25	16:45	20 min	Aselsan-Meeting Room
P 31	28.11.19	08:20	09:00	40 min	Aselsan-Meeting Room
P 32	29.11.19	12:30	12:55	25 min	Aselsan-Meeting Room
AVE				20.5 min	

4.4 Analysis of the Data

Based on my first impressions, I can say that most of the participants rated the statements carefully, because the experiment seemed interesting and took their attention. However, two participants felt bored and asked the number of remaining samples. Also, two other participants could not differentiate the samples and rated all the statements with same scores. According to my observations, it was in general the security guards of younger age who were bored.

Quantitative data were transferred onto a spreadsheet file, and the mean statement score ($\bar{S}$) was calculated for all the statements. Uncertainty of a score (ε_S) associated with the averaging of the data was calculated for revealing the standard error of the data. Measurement of the standard error is a way to precise the sample mean, in other words find the uncertainty of the mean estimation (Altman and Bland, 2005). Standard error of the mean, which was evaluated based on 95% confidence interval, was calculated using the following formula:

$$S = \bar{S} \mp 1.96 \frac{\sigma}{\sqrt{n}}$$

where σ and n are the standard deviation and the number of participants, respectively. Statements were calculated individually, as well as in groups of reliability, ruggedness, ergonomics and aesthetics. In scientific studies generally 95% confidential interval is chosen. This means that 95% of participants' scores are considered and only the 5% extreme data are ignored. To estimate the means of samples by considering 95% of participants, 1.96 coefficient is used in the formula (McHugh, 2007). The result provides a confidence interval that includes the maximum and minimum mean values. In other words, standard error of mean shows the possibility of range between the samples mean and the population mean (Wassertheil-Smoller, 1995). Moreover, as seen in the formula with the increasing amount of participants, standard error of mean decreases, and this means that the uncertainty about the mean estimation decreases as well.

During the calculation of group scores, uncertainty associated with each statement score was taken into consideration. Accordingly, the uncertainty of a group score (ε_G) was estimated based on the root of the sum of the squares uncertainty approach using the following formula:

$$\varepsilon_G = \frac{1}{n}\sqrt{\sum_{i=1}^{i=k}(\varepsilon_i)^2}$$

where ε_i is the uncertainty of an individual statement score and k is the number of statements used in a group.

The increasing standard error means that the scores of participants are spread more between 1 and 7, and they could not come together. On the contrary, decreasing standard error means that the scores are close to each other. If the scores could change according to the individual tastes, standard errors may be observed higher in value. However, if the concept has common rights independent from the individual choices or if it is dependent to the learned experiences or the years in profession, standard errors could be lower because of the closer scores. For this study, 95% of the different scores should be considered. Therefore, there could not be a certain mean value for the concepts. The means should be evaluated as an interval (add standard errors to the mean and minus standard errors from the mean). By doing so, minorities are considered as well. To observe the changes between the samples, the score intervals are compared. If there is not a possibility of having the same scores, samples would be ranked significantly between each other according to the all thirty two participants. If there is a possibility of having the same scores, the means of samples could be compared, but they could not be ordered certainly according to the all participants.

In order to analyze the scores, a software program which is SPSS was tested. However, due to the less amount of participants and less divergence of the scores between 1 and 7 as dependent values, ANOVA analysis, Analysis of Variances, could not be used. Also, due to the same reasons Regression Analysis could not give

a reliable result, in contrast the results were conflicted. The count of participants should be increased as well to get significant results using SPSS. Otherwise, some contradictions may be observed in the results as experienced in this study. Therefore, the mean and standard deviation of the samples were calculated in Excel file automatically. Then, by coding its formula, standard error of mean was calculated. Depending on the confidence intervals that include maximum and minimum mean values, the samples were compared. If the values do not intersect with each other in the interval, the samples could be ranked significantly between each other. However, if the mean values could intersect between the confidence interval, the samples could not be ranked significantly.

4.4.1 Comparison of Textures in Stage 1

For Stage 1, the mean of the linear textured sample is higher than the radial one, and the mean of the radial textured sample is higher than the irregular one in terms of reliability (Table 4.5). The statements in the reliability concept are “The product functions well”, “I can trust the product in cases of emergency”, and “I believe that the product is a professional device in terms of functionality”. The mean values of these three statements increase from the irregular to the linear textures. However, the textures do not have significant difference between each other.

In terms of ruggedness, the mean of the radial textured sample is higher than the linear one, and the mean of the linear textured sample is higher than the irregular one (Table 4.6). The statements related with reliability are “The product is rugged and durable”, “The product is durable against impacts and drops”, and “The product is enduring for harsh weather conditions”. The mean values for the first and the third statements increase from the irregular to the radial textures, but the linear texture received the lowest score in average about being durable against impacts and drops. There is not a significant difference between the textures.

The first four statements of the ergonomics concepts were analyzed together as a group, because the meanings and purposes of them support each other. Also, depending on my impressions during the experiment, participants could not differentiate these four statements clearly from each other. The mean values of this group for the linear and radial textures come close to each other, and they are higher than the irregular one (Table 4.7). The first two statements are “I can handle the product comfortably”, and “I can manipulate the product comfortably”. The mean values of these statements increase from the irregular textured sample to the linear one. The remaining statements in the group are “The size of the product is convenient to handle it for a long time”, and “The weight of the product is convenient to carry it for a long time”. The mean values decrease from the irregular texture to the radial one in terms of size, and the radial texture has higher scores than the linear one, and the irregular texture has the lowest score in average in terms of weight. The texture do not have significant differences between each other.

The concept of the ergonomics has three remaining statements (Table 4.8). One of them is about ease of cleaning and maintenance. The linear and the radial textures received higher scores than the irregular texture in average.

The other statement is “The product heats easily”. As a positive feature, the radial texture received lower scores than the irregular and the linear one in terms of rapid heating in average.

The final statement is “I like the feeling that the product gives while handling it”. In average, the linear texture received higher score than the radial one, and the irregular texture received the lowest score in terms of liking of the feeling.

The mean values of these three statements do not differentiate from each other significantly.

Table 4.5. Textures and reliability

Reliability	Radial	Linear	Irregular
The product functions well.	5,13 ±0,44	5,22 ±0,43	4,94 ±0,48
I can trust the product in cases of emergency.	4,91 ±0,52	5,03 ±0,51	4,75 ±0,51
I believe that the product is a professional device in terms of functionality.	4,53 ±0,46	4,97 ±0,51	4,50 ±0,51
Mean	**4,85**	**5,07**	**4,73**
Standard Error of Mean	±0,27	±0,28	±0,29
Confidence Interval	4,58-5,12	4,79-5,35	4,44-5,02

Table 4.6. Textures and ruggedness

Ruggedness	Radial	Linear	Irregular
The product is rugged and durable.	5,50 ±0,55	5,47 ±0,53	5,25 ±0,46
The product is durable against impacts and drops.	5,47 ±0,49	5,28 ±0,56	5,41 ±0,43
The product is enduring for harsh weather conditions.	5,59 ±0,43	5,22 ±0,53	5,09 ±0,52
Mean	**5,52**	**5,32**	**5,25**
Standard Error of Mean	±0,28	±0,31	±0,27
Confidence Interval	5,24-5,80	5,01-5,63	4,98-5,52

Table 4.7. Textures and ergonomics-group 1

Ergonomics – 1	**Radial**	**Linear**	**Irregular**
I can handle the product comfortably.	5,63 ±0,39	5,75 ±0,40	5,47 ±0,43
I can manipulate the product comfortably.	5,78 ±0,36	5,88 ±0,35	5,72 ±0,40
The size of the product is convenient to handle it for a long time.	5,63 ±0,39	5,66 ±0,42	5,81 ±0,35
The weight of the product is convenient to carry it for a long time.	6,28 ±0,28	6,13 ±0,33	6,09 ±0,36
Mean	**5,83**	**5,85**	**5,77**
Standard Error of Mean	±0,18	±0,19	±0,19
Confidence Interval	5,65-6,01	5,66-6,04	5,58-5,96

Table 4.8. Textures and ergonomics-group 2

Ergonomics - 2	**Radial**	**Linear**	**Irregular**
Cleaning and maintaining of the product is easy.	**5,03** ±0,52	**5,09** ±0,50	**4,38** ±0,63
Confidence Interval	4,51-5,55	4,59-5,59	3,75-5,01
The product heats easily.	**4,25** ±0,54	**4,47** ±0,51	**4,41** ±0,55
Confidence Interval	3,71-4,79	3,96-4,98	3,86-4,96
I like the feeling that the product gives while handling it.	**5,13** ±0,53	**5,19** ±0,51	**4,44** ±0,62
Confidence Interval	4,60-5,66	4,68-5,70	3,82-5,06

Results

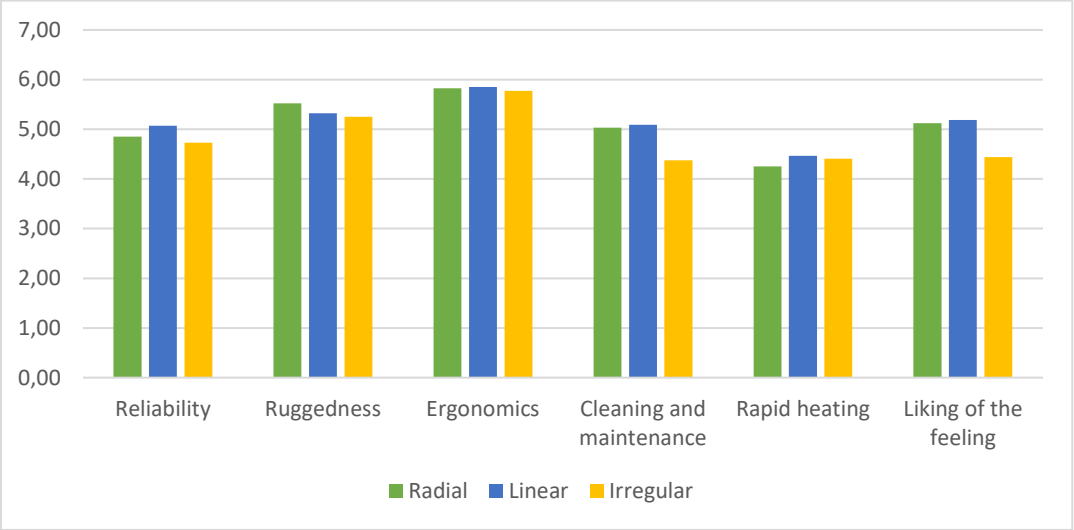

Figure 4.11. Comparisons of textures

To sum up, as seen in Figure 4.11, the linear texture has higher score in average in terms of reliability, cleaning and maintenance, rapid heating, and liking of the feeling. About ruggedness, the mean of the radial texture is higher than the others, and also, it has the lowest score in average in terms of rapid heating. The mean values of the textures in terms of ergonomics are very close to each other. Lastly, except from rapid heating, the irregular texture received lower score than the others for all the concepts in average.

Discussion

Even though the mean values of the textures are different, the textures could not be ranked significantly. According to their confidence intervals, the mean values of three textures could intersect at the same point for all the concepts due to the consideration of standard errors of the means. In other words, the mean values of the samples are varied between plus or minus as standard errors. Therefore, the samples do not have certain mean values that differ them significantly from each other in terms of the six concepts.

The interesting point is that uncertainty values in ergonomics are lower than the other concepts. This means that the scores of thirty two participants are close to each other in terms of ergonomics. The concept of ergonomics is least affected by different textures, compared to the other concepts. The uncertainty level is higher significantly for cleaning and maintenance, rapid heating, and liking of the feeling. This means that the scores of the participants are varied mostly between the 1-7 measurement scales for these concepts.

According to my impressions, participants feel more distant to the irregular texture. The radial and the linear textures are more familiar when experiencing them with tactile sense without seeing them, because people are used to experiencing these textures in their daily lives. However, the irregular texture feels like only a rough surface, the geometry of the pattern could not be identified, and this may have created doubts. In short, the samples with radial and linear texture may have been found to be more familiar than the irregular one. Therefore, participants may have felt more comfortable when touching them. This could be the reason for the lower scores given to the irregular texture in general.

4.4.2 Comparisons of Textures with Colors in Stage 2

The second stage of the study involved textures with the three different colors of black, green and orange. The scores for the statements given in Stage 2 were again calculated for their mean values, as pairs of texture and color. The following sections discuss the results, for each color with different textures.

4.4.2.1 Textures in Black

In terms of reliability, the linear texture in black received the highest score, followed by the radial one, and the irregular texture in black received the lowest score in average (Table 4.9). The linear black is generally voted as more professional than the others.

As for ruggedness, the radial texture in black has the highest score, and the irregular texture in black has the lowest in average (Table 4.10). When observed in detail, the mean of the linear textured black sample is higher than the others about being rugged and durable, and the radial texture in black has higher score in terms of being durable against impacts and drops in average. For the harsh weather conditions, the radial and linear black samples have equal mean values. For all the statements, the irregular textured black sample received the lowest scores in average. The samples do not differ from each other significantly.

The mean values of the statements in the concept of ergonomics increase from the irregular to the linear and then the radial textured black sample (Table 4.11). The samples do not have significant difference between each other.

The standard errors of the means are higher in terms of cleaning and maintenance (Table 4.12). As seen in the table, the linear texture in black has higher score than the others in average, and significantly, the irregular texture in black is found to be the least convenient sample.

The irregular and the radial black samples received lower scores than the linear one in terms of rapid heating in average (Table 4.12). However, the mean values of three black samples are above 4 within the 1-7 evaluation scale. This means that all the samples are found to have the possibility to heat. Also, some of the participants rated the statement as 4 to be neutral, because they could not assess the samples in terms of heat.

Moreover, the mean values of the linear textured black sample is higher than the others in terms of liking of the feeling (Table 4.12). The irregular black sample received the lowest score in average.

Finally, the linear and the irregular black samples have equal mean values about being aesthetic, and they are higher than the radial black sample in average (Table 4.12).

The samples do not differ from each other significantly in terms of rapid heating, liking of the feeling and being aesthetic.

Table 4.9. Textures in black and reliability

Reliability	**Radial Black**	**Linear Black**	**Irregular Black**
The product functions well.	5,47 ±0,43	5,66 ±0,38	5,50 ±0,42
I can trust the product in cases of emergency.	5,53 ±0,36	5,66 ±0,36	5,00 ±0,56
I believe that the product is a professional device in terms of functionality.	5,16 ±0,42	5,59 ±0,44	4,88 ±0,55
Mean	**5,39**	**5,64**	**5,13**
Standard Error of Mean	±0,23	±0,23	±0,30
Confidence Interval	5,16-5,62	5,41-5,87	4,83-5,43

Table 4.10. Textures in black and ruggedness

Ruggedness	**Radial Black**	**Linear Black**	**Irregular Black**
The product is rugged and durable.	5,66 ±0,38	5,75 ±0,37	5,22 ±0,46
The product is durable against impacts and drops.	5,66 ±0,42	5,41 ±0,45	5,09 ±0,44
The product is enduring for harsh weather conditions.	5,66 ±0,44	5,66 ±0,40	5,25 ±0,47
Mean	**5,66**	**5,61**	**5,19**
Standard Error of Mean	±0,24	±0,24	±0,26
Confidence Interval	5,42-5,90	5,37-5,85	4,93-5,45

Table 4.11. Textures in black and ergonomics-group 1

Ergonomics – 1	**Radial Black**	**Linear Black**	**Irregular Black**
I can handle the product comfortably.	5,75 ±0,40	5,72 ±0,39	5,59 ±0,45
I can manipulate the product comfortably.	5,81 ±0,40	5,84 ±0,32	5,66 ±0,45
The size of the product is convenient to handle it for a long time.	5,97 ±0,36	5,88 ±0,30	5,78 ±0,40
The weight of the product is convenient to carry it for a long time.	6,16 ±0,33	6,06 ±0,32	6,00 ±0,38
Mean	**5,92**	**5,88**	**5,76**
Standard Error of Mean	±0,19	±0,17	±0,21
Confidence Interval	5,73-6,11	5,71-6,05	5,55-5,97

Table 4.12. Textures in black and ergonomics-group 2 and aesthetics

	Radial Black	**Linear Black**	**Irregular Black**
Cleaning and maintaining of the product is easy.	**5,09** ±0,48	**5,66** ±0,38	**4,06** ±0,55
Confidence Interval	5,57-4,61	6,04-5,28	4,55-3,55
The product heats easily.	**4,38** ±0,49	**4,47** ±0,50	**4,38** ±0,50
Confidence Interval	4,87-3,89	4,97-3,97	4,88-3,88
I like the feeling that the product gives while handling it.	**5,19** ±0,52	**5,72** ±0,37	**5,00** ±0,53
Confidence Interval	5,71-4,67	6,09-5,35	5,53-4,47
This object is aesthetic.	**5,00** ±0,47	**5,34** ±0,45	**5,34** ±0,61
Confidence Interval	5,47-4,53	5,79-4,89	5,95-4,73

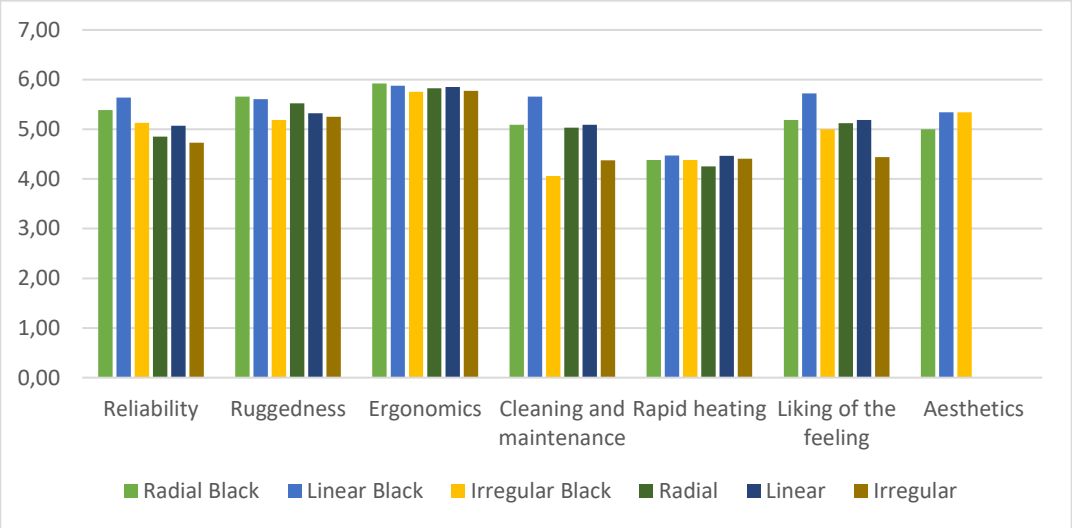

Figure 4.12. Comparisons of textures in black

As a conclusion, in the concept of reliability, cleaning and maintenance, and liking of the feeling, the linear textured black sample received the highest scores in average (Figure 4.12). Also, for the possibility of heating the mean of the linear black is higher than the others as a negative feature, and the radial and the irregular textures have equal mean values. Moreover, the radial texture in black received higher scores in terms of ruggedness and ergonomics in average. About being aesthetic, the linear and the irregular textures in black have equal mean values, and they are higher than the radial one. In terms of reliability, ruggedness, ergonomics, and cleaning and maintenance, the irregular black sample has the lowest mean values.

The mean values of the black samples with three textures and the textures which were experienced in Stage 1 only by touching should be compared. Changing values by seeing the black color help us in explaining the effects of color on the perception of textures. The mean values of the radial, linear and the irregular textures in black are higher than the textures which were experienced in Stage 1 only by touching, in terms of reliability, and the liking of the feeling. Also, the mean values of the radial and the linear textures increase in terms of ruggedness, and cleaning and maintenance. On the other hand, the irregular texture seems to have lower mean

values for both, when the black color is involved. This is the same for ergonomics, only the confidence intervals are very close to each other. As seen in Figure 4.12, the linear texture keeps its scores about rapid heating. However, the mean of the radial texture decreases, and the mean of the irregular texture increases in Stage 2 when experiencing them in black.

Discussion

Even though the mean values of black colored three textures are different for all the concepts, the samples could not be ranked significantly. The reason is the possibility of intersecting mean values in the confidence intervals due to the standard errors of the means. The only significant result is that the cleaning and maintenance of the irregular black sample is found to be the least convenient as seen in Table 4.12.

In terms of ergonomics, the uncertainty levels are lower than the other concepts. This means that the scores of the participants are closer to each other for the ergonomics, especially, for the linear texture in black. The standard error of the mean is the highest for the irregular textured black sample in terms of being aesthetic. People got the chance to observe the geometrical pattern of the irregular texture in Stage 2, and this was a surprising process for many of them. Experiencing the geometry in black may have created both positive and negative impressions on people. This is mostly related with the individual tastes. Therefore, the alteration of scores are more significant between the participants for the irregular black sample. Also, the instability of the irregular texture in black for all the concepts except for rapid heating is higher than the radial and the linear ones.

When comparing Stage 1 and Stage 2, it is significant that the black color affects the radial and the linear textures in a positive way in terms of reliability. Being able to see the color rather than only touching the samples may make people feel more relaxed and comfortable. This could be another reason for the increasing mean values of the radial and linear textures in terms of reliability. For the irregular texture, the effects of black is not significant, because of the uncertainty scores. Even though the mean values for ruggedness change, the effect of black color is not significant for

the all three textures; it is the same for ergonomics, and cleaning and maintenance. Similarly, it seems that black does not affect the perception of textures in terms of rapid heating, and liking of the feeling as well.

4.4.2.2 Textures in Green

In terms of reliability, the linear textured green sample received the highest score, and the irregular textured green sample received the lowest score in average (Table 4.13). In detail, the order is the same for the first two statements. For the third statement about being a professional device, the radial and linear textures have the same mean values, and they are higher than the irregular one. The textures do not have significant differences.

The green sample with linear texture seems to have higher mean about ruggedness, and the irregular one has lower mean (Table 4.14). In detail, the mean of the linear texture in green is higher than the others about being durable against impacts and drops, and enduring against harsh weather conditions, but about being rugged and durable, the radial textured sample in green received the highest score in average.

The green sample with radial texture seems to have higher mean in terms of ergonomics (Table 4.15). The irregular green received the lowest score in average. Differently, the mean of the green sample with linear texture is higher in terms of weight to be carried comfortably, and the irregular one follows it.-The mean values of the three samples are close to each other.

The mean of the linear texture in green is higher than the radial one in terms of cleaning and maintenance (Table 4.16). The irregular green is found to be the least convenient sample significantly, and its mean is below the average.

The mean values about rapid heating increase from the irregular green to linear green.

Moreover, liking of the feeling has the highest score for the radial green in average, and it decreases to the linear and then the irregular one.

Finally, the mean of the irregular green sample is higher than the others, and the linear green received the lowest score about being aesthetic in average.

However, for rapid heating, liking of the feeling and being aesthetic, the textures do not have significant differences from each other.

Table 4.13. Textures in green and reliability

Reliability	**Radial Green**	**Linear Green**	**Irregular Green**
The product functions well.	5,69 ±0,42	5,78 ±0,35	5,47 ±0,48
I can trust the product in cases of emergency.	5,56 ±0,45	5,88 ±0,39	5,34 ±0,55
I believe that the product is a professional device in terms of functionality.	5,72 ±0,44	5,72 ±0,45	5,13 ±0,61
Mean	**5,66**	**5,79**	**5,31**
Standard Error of Mean	±0,25	±0,23	±0,32
Confidence Interval	5,41-5,91	5,56-6,02	4,99-5,63

Table 4.14. Textures in green and ruggedness

Ruggedness	Radial Green	Linear Green	Irregular Green
The product is rugged and durable.	5,75 ±0,39	5,69 ±0,42	5,34 ±0,45
The product is durable against impacts and drops.	5,59 ±0,40	5,69 ±0,38	5,56 ±0,45
The product is enduring for harsh weather conditions.	5,72 ±0,39	5,88 ±0,37	5,50 ±0,48
Mean	**5,69**	**5,75**	**5,47**
Standard Error of Mean	±0,23	±0,22	±0,27
Confidence Interval	5,46-5,92	5,53-5,97	5,20-5,74

Table 4.15. Textures in green and ergonomics-group 1

Ergonomics – 1	Radial Green	Linear Green	Irregular Green
I can handle the product comfortably.	5,97 ±0,40	5,81 ±0,38	5,75 ±0,36
I can manipulate the product comfortably.	5,97 ±0,40	5,91 ±0,34	5,84 ±0,38
The size of the product is convenient to handle it for a long time.	6,03 ±0,35	6,03 ±0,31	5,88 ±0,35
The weight of the product is convenient to carry it for a long time.	6,09 ±0,34	6,16 ±0,33	6,13 ±0,31
Mean	**6,02**	**5,98**	**5,90**
Standard Error of Mean	±0,19	±0,17	±0,18
Confidence Interval	5,83-6,21	5,81-6,15	5,72-6,08

Table 4.16. Textures in green and ergonomics-group 2 and aesthetics

	Radial Green	**Linear Green**	**Irregular Green**
Cleaning and maintaining of the product is easy.	**5,22** ±0,38	**5,31** ±0,45	**3,97** ±0,66
Confidence Interval	4,84-5,60	4,86-5,76	3,31-4,63
The product heats easily.	**4,50** ±0,48	**4,66** ±0,48	**4,34** ±0,51
Confidence Interval	4,02-4,98	4,18-5,14	3,83-4,85
I like the feeling that the product gives while handling it.	**5,56** ±0,51	**5,38** ±0,50	**5,19** ±0,48
Confidence Interval	5,05-6,07	4,88-5,88	4,71-5,67
This object is aesthetic.	**5,25** ±0,47	**5,22** ±0,58	**5,28** ±0,58
Confidence Interval	4,78-5,72	4,64-5,80	4,70-5,86

Results

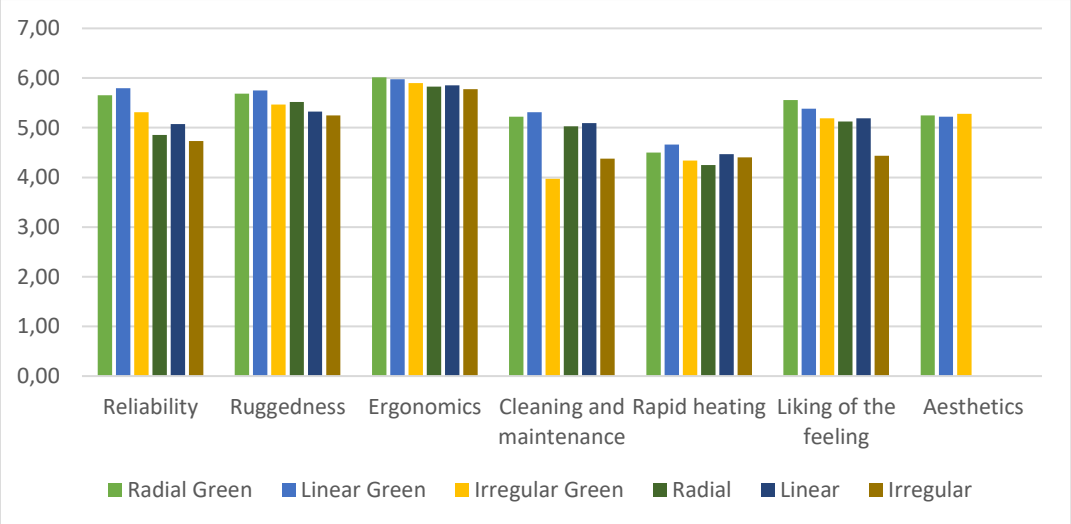

Figure 4.13. Comparisons of textures in green

To sum up, in terms of reliability, ruggedness, and cleaning and maintenance, the green sample with linear texture received the highest scores in average (Figure 4.13).

Also as a negative feature, the mean of the linear green is the highest in terms of rapid heating. Moreover, in terms of ergonomics and liking of the feeling, the radial green received higher scores than the others in average. Except from being aesthetic, the irregular green has lower mean values for all of the concepts, significantly in cleaning and maintenance. Finally, the linear green received the lowest score, and the irregular one received the highest scores about being aesthetic in average. However, the differences between the mean values of the samples are close to each other, so the textures do not have significant differences.

After comparing the different textured samples in green with each other, they should be compared to the samples which were experienced without seeing in Stage 1 (Figure 4.1). When the textures are experienced in green, the mean values of the samples increase in terms of reliability, ruggedness, ergonomics, and the liking of the feeling. Also, in terms of cleaning and maintenance, the linear and radial textures in green have higher mean values than the textures experienced in Stage 1, but the mean of the irregular texture decreases in Stage 2. Finally, the radial and the linear textures received higher scores in average about heating rapidly, when they are experienced in green in contrast to the irregular green sample.

Discussion

The green sample with irregular texture received higher score in average in terms of being aesthetic, even though it has lower mean values in terms of reliability and ruggedness than the others. This means that participants could differentiate and evaluate being aesthetic from the other concepts.

Even though the mean values of textures increase from Stage 1 to Stage 2 in terms of reliability, only the radial and the linear textures in green show significant alteration according to their confidence intervals. It is clear that the green color affects the radial and the linear textures positively, and increases their reliability as the black color does.

The textures in Stage 1 and Stage 2 cannot be ranked significantly for the remaining concepts. The mean values of the textures can show alteration as plus or minus of the uncertainty scores. This means that even though the mean values increase by seeing the green color in Stage 2, it is not accurate for all thirty two participants. To be able to consider the minorities as well, the mean values should be analyzed between the maximum (add uncertainty score to the mean) and the minimum (minus uncertainty score from the mean) scores. The confidence intervals of the textures in Stage 1 and Stage 2 have intersection clusters except from the linear and the radial green in terms of reliability. Therefore, for the remaining concepts, the samples could not be ranked significantly.

Similarly to the previous sections, the textures in green are shown the lowest alteration between the participants in terms of ergonomics, because the standard errors of the textures about ergonomics are lower than the other concepts.

The scores between the participants change the most for the irregular green in terms of cleaning and maintenance.

The interesting point is that the mean of the irregular texture about cleaning and maintenance decreases when the sample is experienced by visual sense as well. When some of the participants see the complexity of the pattern, they may have thought that cleaning and maintenance would be harder than they thought only by touching. Identification of the complex geometry of the pattern in green may be the reason.

4.4.2.3 Textures in Orange

The linear texture in orange received the highest score in average in the concept of reliability (Table 4.17). The orange sample with radial texture follows it. The irregular orange sample received the lowest score in average. The order is the same for all three statements.

The linear texture in orange has higher mean than the other textures in terms of ruggedness (Table 4.18). The mean of the radial sample is lower than the linear one, and the mean of the irregular texture is lower than the radial one with a small margin.

The mean of the linear texture in orange is higher than the others in terms of ergonomics, and the irregular sample has the lowest mean (Table 4.19).

The linear textured orange sample received the highest score in terms of cleaning and maintenance in average (Table 4.20), but the mean of the irregular orange is the lowest one, and it is below the average.

Moreover, the possibility of heating increases from the irregular sample to the linear one according to mean values.

In addition, in terms of liking of the feeling, the mean of the linear orange is the highest, and the mean of the irregular orange is the lowest.

Lastly, the linear orange received the highest score about being aesthetic, and the irregular one received the lowest in average.

Table 4.17. Textures in orange and reliability

Reliability	**Radial Orange**	**Linear Orange**	**Irregular Orange**
The product functions well.	5,09 ±0,59	5,47 ±0,42	5,00 ±0,52
I can trust the product in cases of emergency.	5,13 ±0,53	5,25 ±0,42	4,41 ±0,56
I believe that the product is a professional device in terms of functionality.	4,59 ±0,56	4,75 ±0,48	4,22 ±0,59
Mean	**4,94**	**5,16**	**4,54**
Standard Error of Mean	±0,33	±0,26	±0,32
Confidence Interval	4,61-5,27	4,90-5,42	4,22-4,86

Table 4.18. Textures in orange and ruggedness

Ruggedness	Radial Orange	Linear Orange	Irregular Orange
The product is rugged and durable.	5,03 ±0,49	5,56 ±0,39	5,00 ±0,51
The product is durable against impacts and drops.	5,00 ±0,52	5,25 ±0,47	5,06 ±0,49
The product is enduring for harsh weather conditions.	5,28 ±0,48	5,53 ±0,46	5,16 ±0,54
Mean	**5,10**	**5,45**	**5,07**
Standard Error of Mean	±0,29	±0,26	±0,29
Confidence Interval	4,81-5,39	5,19-5,71	4,78-5,36

Table 4.19. Textures in orange and ergonomics-group 1

Ergonomics – 1	Radial Orange	Linear Orange	Irregular Orange
I can handle the product comfortably.	5,59 ±0,45	5,69 ±0,44	5,41 ±0,41
I can manipulate the product comfortably.	5,63 ±0,46	5,91 ±0,38	5,66 ±0,42
The size of the product is convenient to handle it for a long time.	5,81 ±0,41	5,91 ±0,38	5,78 ±0,39
The weight of the product is convenient to carry it for a long time.	6,03 ±0,39	6,09 ±0,37	5,97 ±0,37
Mean	**5,77**	**5,90**	**5,71**
Standard Error of Mean	±0,21	±0,19	±0,20
Confidence Interval	5,56-5,98	5,71-6,09	5,51-5,91

Table 4.20. Textures in orange and ergonomics-group 2 and aesthetics

	Radial Orange	**Linear Orange**	**Irregular Orange**
Cleaning and maintaining of the product is easy.	**4,84** ±0,54	**5,47** ±0,39	**3,66** ±0,64
Confidence Interval	4,30-5,38	5,08-5,86	3,02-4,30
The product heats easily.	**4,41** ±0,57	**4,63** ±0,48	**4,28** ±0,52
Confidence Interval	3,84-4,98	4,15-5,11	3,76-4,80
I like the feeling that the product gives while handling it.	**5,00** ±0,58	**5,50** ±0,50	**4,75** ±0,63
Confidence Interval	4,42-5,58	5,00-6,00	4,12-5,38
This object is aesthetic.	**4,94** ±0,65	**5,09** ±0,54	**4,66** ±0,67
Confidence Interval	4,29-5,59	4,55-5,63	3,99-5,33

Results

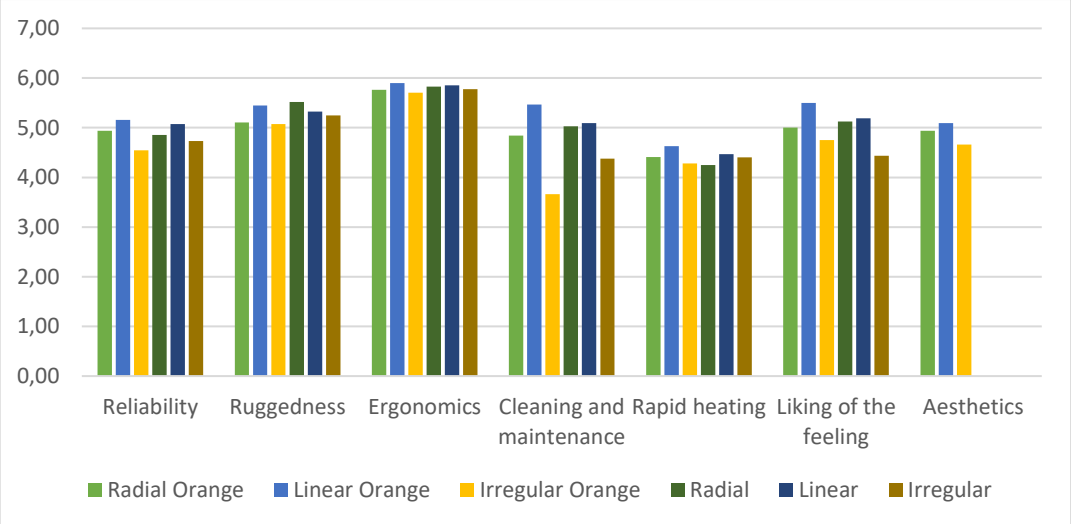

Figure 4.14. Comparisons of textures in orange

For all of the concepts, the linear textured orange sample has higher mean values, even for the rapid heating as a negative feature (Figure 4.14). There is a significant

difference between the linear orange and the irregular orange in terms of reliability, and cleaning and maintenance. The irregular texture in orange has the lowest mean values for all the concepts.

The linear and the radial textures have higher mean values in terms of reliability when they are experienced with orange instead of only by touching, in contrast to the irregular texture. In terms of ruggedness, only the mean values of the linear texture increase in Stage 2. It is the same for ergonomics, and cleaning and maintenance. Liking of the feeling increases in Stage 2 for both the linear and irregular orange samples. This statement is the only one for which the mean of the irregular sample has increased with the introduction of orange color in Stage 2. Finally, the possibility of heating has higher mean values for the linear and the radial textures in orange, in contrast to the irregular orange.

Discussion

Even though the mean values are not equal to each other, the textures in orange could not be ranked significantly for the all concepts. The only significant result is that the linear texture in orange is found to be more convenient in terms of reliability and the cleaning and maintenance than the irregular orange.

Some of the radio users linked the linear texture in orange with professional handheld radios, because the linear texture and the orange color are found familiar. In contrast, some of the participants found the irregular textured orange sample “enjoyable” and “cute”, in their own words, but they could not rate it as professional, or reliable. Moreover, the irregular texture in orange was not found serious enough and was scored as the least aesthetic sample in average.

The mean values change from Stage 1 to Stage 2 in positive and negative ways. However, the textures in orange are not significantly different from the textured experienced in Stage 1. Therefore, it could be said that the orange color does not affect the perception of textures significantly, in contrast to black and green.

Moreover, the uncertainty levels for ergonomics is lower than the other concepts for the textures experienced in orange.

It is surprising that the irregular texture in orange received the lowest score about rapidly heating in average. One of the radio users commented that “The possibility of heating decreases with the lower professional appearance. If I feel that the product cannot work efficiently, it means that the product cannot heat at the same time.” Depending on my impressions during the experiment, it is the same for experienced radio users. Therefore, there may be an inverse proportion between reliability and the possibility of heating.

4.4.3 Comparisons of Colors with Textures in Stage 2

In the session, the perception of the participants of the same texture are analyzed when color is the only changing parameter. The mean values for the statements are discussed for each texture with differing colors.

4.4.3.1 Radial Texture with Three Colors

The mean of the radial texture with green color is higher than the mean values of the radial black and the radial orange in terms of reliability (Table 4.21). The radial orange has the lowest mean, and the order is the same for all three statements.

The mean values of the radial black and the radial green are close to each other in terms of ruggedness, and they are higher than the mean of the radial orange (Table 4.22). The radial green received the highest score in terms of being rugged and durable, and also enduring against harsh weather conditions in average. The radial black has higher mean about being durable against impacts and drops, and the radial orange has the lowest mean values for all the statements.

The radial green has higher mean in terms of ergonomics (Table 4.23). In detail, the order of green, black and orange for the mean values is the same in terms of

comfortable handling and manipulation, and the convenient size to handle the sample for a long time. The radial black sample has higher mean in terms of convenient weight to carry it for a long time. The radial orange has the lowest mean values for all of the statements.

Even though the textures are the same, the mean of the radial green is higher than the radial black and orange in terms of cleaning and maintenance (Table 4.24). The radial orange has the lowest mean.

Moreover, the mean of the radial green is higher than the others about the possibility of heating. The mean values of the radial black and orange are lower than the green one.

The radial green has higher mean in terms of liking of the feeling, and the radial orange has the lowest mean.

Finally, the mean values about being aesthetic increase from the radial orange to the radial green.

Table 4.21. Colors with the radial texture and reliability

Reliability	**Radial Black**	**Radial Green**	**Radial Orange**
The product functions well.	5,47 ±0,43	5,69 ±0,42	5,09 ±0,59
I can trust the product in cases of emergency.	5,53 ±0,36	5,56 ±0,45	5,13 ±0,53
I believe that the product is a professional device in terms of functionality.	5,16 ±0,42	5,72 ±0,44	4,59 ±0,56
Mean	**5,39**	**5,66**	**4,94**
Standard Error of Mean	±0,23	±0,25	±0,33
Confidence Interval	5,16-5,62	5,41-5,91	4,61-5,27

Table 4.22. Colors with the radial texture and ruggedness

Ruggedness	Radial Black	Radial Green	Radial Orange
The product is rugged and durable.	5,66 ±0,38	5,75 ±0,39	5,03 ±0,49
The product is durable against impacts and drops.	5,66 ±0,42	5,59 ±0,40	5,00 ±0,52
The product is enduring for harsh weather conditions.	5,66 ±0,44	5,72 ±0,39	5,28 ±0,48
Mean	**5,66**	**5,69**	**5,10**
Standard Error of Mean	±0,24	±0,23	±0,29
Confidence Interval	5,42-5,90	5,46-5,92	4,81-5,39

Table 4.23. Colors with the radial texture and ergonomics-group 1

Ergonomics – 1	Radial Black	Radial Green	Radial Orange
I can handle the product comfortably.	5,75 ±0,40	5,97 ±0,40	5,59 ±0,45
I can manipulate the product comfortably.	5,81 ±0,40	5,97 ±0,40	5,63 ±0,46
The size of the product is convenient to handle it for a long time.	5,97 ±0,36	6,03 ±0,35	5,81 ±0,41
The weight of the product is convenient to carry it for a long time.	6,16 ±0,33	6,09 ±0,34	6,03 ±0,39
Mean	**5,92**	**6,02**	**5,77**
Standard Error of Mean	±0,19	±0,19	±0,21
Confidence Interval	5,73-6,11	5,83-6,21	5,56-5,98

Table 4.24. Colors with the radial texture and ergonomics-group 2 and aesthetics

	Radial Black	**Radial Green**	**Radial Orange**
Cleaning and maintaining of the product is easy.	**5,09** ±0,48	**5,22** ±0,38	**4,84** ±0,54
Confidence Interval	4,61-5,57	4,84-5,60	4,30-5,38
The product heats easily.	**4,38** ±0,49	**4,50** ±0,48	**4,41** ±0,57
Confidence Interval	3,89-4,87	4,02-4,98	3,84-4,98
I like the feeling that the product gives while handling it.	**5,19** ±0,52	**5,56** ±0,51	**5,00** ±0,58
Confidence Interval	4,67-5,71	5,05-6,07	4,42-5,58
This object is aesthetic.	**5,00** ±0,47	**5,25** ±0,47	**4,94** ±0,65
Confidence Interval	4,53-5,47	4,78-5,72	4,29-5,59

Results

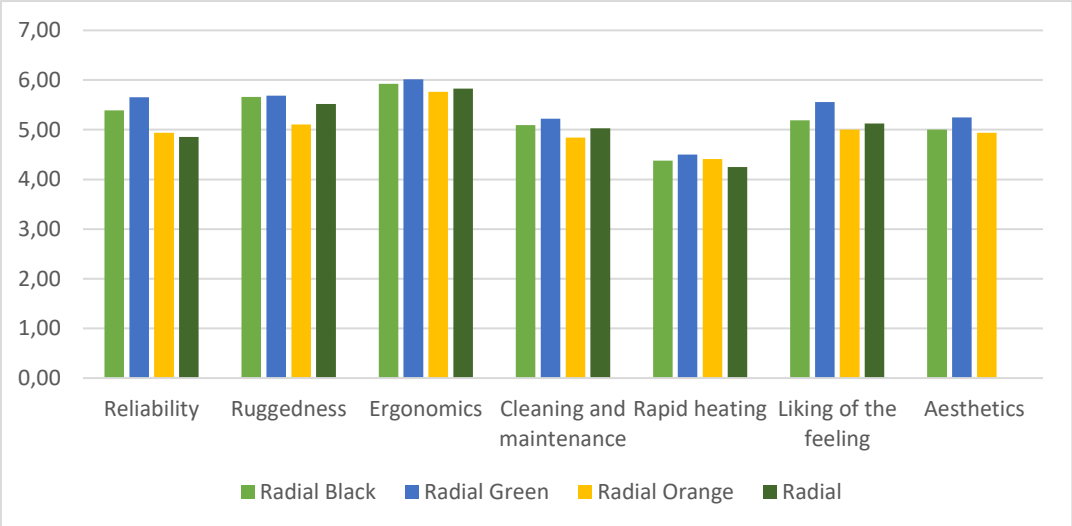

Figure 4.15. Comparisons of colors for the radial pattern

To sum up, even though the textures are the same, the mean values of each sample change depending on the three different colors (Figure 4.15). The green color has

higher mean values with the radial texture in terms of all the concepts. The mean of the radial black is lower than the others in terms of rapid heating as a positive feature. For the remaining statements, radial orange has the lowest mean values.

For all of the concepts, the radial black and radial green have higher mean values than the radial texture which is experienced in Stage 1 only by touching. The mean values of radial orange are higher only for the concepts of reliability and rapid heating than the radial one.

Discussion

Even though the samples have the same textures, the mean values of the concepts are different because of the changing colors. This means that the color changes the perception of participants for the same textures.

In terms of reliability, the radial black and the green could not be ranked significantly even though the mean values of them are different. The reason is the standard errors of the means. However, it is significant that the radial texture in green is found to be more convenient than the radial texture in orange in terms of reliability. Additionally, the radial texture in orange is found to be the least rugged significantly when compared to the radial black and the radial green. For the remaining concepts, the samples could not be ranked significantly, because their mean values intersected according to their confidence intervals.

Finally, when the mean values of the radial textures between Stage 1 and Stage 2 are compared, it is clear that the black and the green color affect the perception of participants positively in terms of reliability. The effects of orange on the radial texture is not significant. Also, for the remaining concepts, the textures with colors do not differ significantly from the ones which were experienced in Stage 1.

Surprisingly, the radial black and the green have similar standard errors of means, but the standard errors of the radial orange are higher than the others. This means that the scores of the participants are varied more when experiencing the radial texture in orange. However, for the black and the green colors, the scores of the

participants are closer to each other. Black and green are more familiar to the handheld radio users, so they may feel more comfortable. However, orange may seem more different and bold. Some of the participants liked it, but it did not appeal to all.

4.4.3.2 Linear Texture with Three Colors

In terms of reliability, the linear texture received the highest score when experienced in green, but the linear orange sample received the lowest score in average (Table 4.25). This order is the same for all three statements.

The linear texture in green has the highest mean in terms of ruggedness, and the linear orange sample has the lowest mean (Table 4.26). Also, the linear orange received the lowest mean for all three statements. The linear green has higher mean values in terms of being durable against impacts and drops, and harsh weather conditions, but for being rugged and durable, the mean of the linear black is higher than the others.

The linear texture in green has higher mean in terms of ergonomics, and the mean values of the linear black and the linear orange are almost the same (4.27). The green sample received the highest scores for all the statements in average, and in terms of manipulating the product easily, the orange sample received the same score with the green one in average. For the comfortable handling, the orange one received the lowest score. For the remaining statements about convenient size and weight, the black sample has the lowest scores.

The linear texture in black has higher mean than the other colored samples in terms of cleaning and maintenance, and the linear texture in green has the lowest mean (Table 4.28).

Moreover, the green and the orange samples have the higher mean values about rapid heating as a negative feature, and they are close to each other.

Also, the mean of the black sample is higher than the others, and the orange sample follows it in terms of liking of the feeling.

Finally, the black sample with linear texture has the highest mean about being aesthetic, and the orange sample has the lowest mean.

Table 4.25. Colors with the linear texture and reliability

Reliability	**Linear Black**	**Linear Green**	**Linear Orange**
The product functions well.	5,66 ±0,38	5,78 ±0,35	5,47 ±0,42
I can trust the product in cases of emergency.	5,66 ±0,46	5,88 ±0,39	5,25 ±0,42
I believe that the product is a professional device in terms of functionality.	5,59 ±0,44	5,72 ±0,45	4,75 ±0,48
Mean	**5,64**	**5,79**	**5,16**
Standard Error of Mean	±0,23	±0,23	±0,26
Confidence Interval	5,41-5,87	5,56-6,02	4,90-5,42

Table 4.26. Colors with the linear texture and ruggedness

Ruggedness	**Linear Black**	**Linear Green**	**Linear Orange**
The product is rugged and durable.	5,75 ±0,37	5,69 ±0,42	5,56 ±0,39
The product is durable against impacts and drops.	5,41 ±0,45	5,69 ±0,38	5,25 ±0,47
The product is enduring for harsh weather conditions.	5,66 ±0,40	5,88 ±0,37	5,53 ±0,46
Mean	**5,61**	**5,75**	**5,45**
Standard Error of Mean	±0,24	±0,22	±0,26
Confidence Interval	5,37-5,85	5,53-5,97	5,19-5,71

Table 4.27. Colors with the linear texture and ergonomics-group 1

Ergonomics - 1	**Linear Black**	**Linear Green**	**Linear Orange**
I can handle the product comfortably.	5,72 ±0,39	5,81 ±0,38	5,69 ±0,44
I can manipulate the product comfortably.	5,84 ±0,32	5,91 ±0,34	5,91 ±0,38
The size of the product is convenient to handle it for a long time.	5,88 ±0,30	6,03 ±0,31	5,91 ±0,38
The weight of the product is convenient to carry it for a long time.	6,06 ±0,32	6,16 ±0,33	6,09 ±0,37
Mean	**5,88**	**5,98**	**5,90**
Standard Error of Mean	±0,17	±0,17	±0,19
Confidence Interval	5,71-6,05	5,81-6,15	5,71-6,09

Table 4.28. Colors with the linear texture and ergonomics-group 2 and aesthetics

	Linear Black	**Linear Green**	**Linear Orange**
Cleaning and maintaining of the product is easy.	**5,66** ±0,38	**5,31** ±0,45	**5,47** ±0,39
Confidence Interval	5,28-6,04	4,86-5,76	5,08-5,86
The product heats easily.	**4,47** ±0,50	**4,66** ±0,48	**4,63** ±0,48
Confidence Interval	3,97-4,97	4,18-5,14	4,15-5,11
I like the feeling that the product gives while handling it.	**5,72** ±0,37	**5,38** ±0,50	**5,50** ±0,50
Confidence Interval	5,35-6,09	4,88-5,88	5,00-6,00
This object is aesthetic.	**5,34** ±0,45	**5,22** ±0,58	**5,09** ±0,54
Confidence Interval	4,89-5,79	4,64-5,80	4,55-5,63

Results

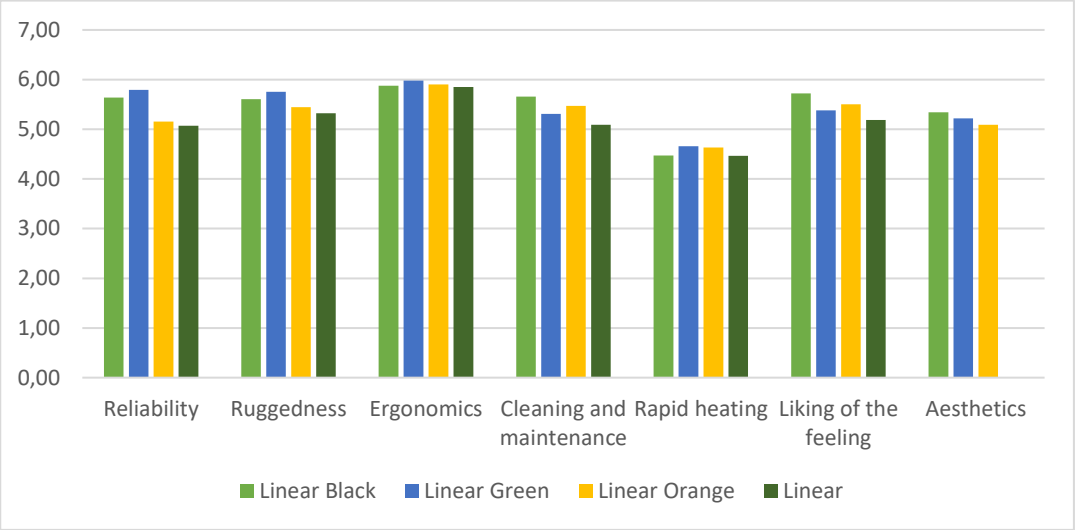

Figure 4.16. Comparisons of colors for the linear texture

To sum up, the mean values change depending on the different colors even though the textures are the same. The linear texture in green has the highest mean values in terms of reliability, ruggedness, and ergonomics. Moreover, the linear black has the highest mean values in terms of cleaning and maintenance, liking of the feeling, and being aesthetic. As a positive feature as well, the mean of the linear black in terms of rapid heating is lower than the others, and the mean of the linear green is the highest.

As seen in Figure 4.16, the mean values increase for all the concepts when the samples were experienced by seeing their colors as well. Differently, the mean values about rapid heating has increased from Stage 1 to Stage 2 as a negative feature.

Discussion

Despite the changing mean values, only the linear texture in orange is found to be the least reliable significantly. The linear texture with three colors could not be ranked significantly for the remaining concepts.

Moreover, it is significant that the black and the green colors affect the perception of participants positively for the linear texture in terms of reliability. By considering

the standard errors and confidence intervals, the mean values of the linear black and green do not have intersection with the mean of the linear texture experienced in Stage 1 only by touching.

Surprisingly, the standard errors of the linear green are higher than the others. This means that the scores of the thirty two participants vary mostly for the linear green. Similar to the findings given in the previous sections, the standard errors in ergonomics are lower than the other concepts.

4.4.3.3 Irregular Textures with Three Colors

Even though the textures are the same, the irregular texture in green has higher mean than the others in terms of reliability (Table 4.29). In detail, the irregular green has higher mean values about being professional and trustworthy in cases of emergency. The irregular orange has the lowest mean values for all the statements.

The irregular texture in green has higher mean in terms of ruggedness, and the irregular orange has the lowest mean (Table 4.30). The order is the same for all three statements.

In terms of ergonomics, the mean of the irregular green sample is the highest (Table 4.31). About comfortable handling and having convenient weight, the orange sample with irregular texture has the lowest mean values. In terms of comfortable manipulating and having convenient size, the black and the orange samples have equal mean values, and they are lower than the green ones.

The irregular black sample received the highest score in terms of cleaning and maintenance in average, and the orange one received the lowest score (Table 4.32).

The mean of the irregular black is higher than the others in terms of rapid heating, and the irregular orange has the lowest mean.

Moreover, the mean of the irregular green is highest, and the orange one has the lowest mean in terms of liking of the feeling.

Finally, the irregular black received the highest score about being aesthetic in average, and the green sample follows it.

Table 4.29. Colors with the irregular texture and reliability

Reliability	**Irregular Black**	**Irregular Green**	**Irregular Orange**
The product functions well.	5,50 ±0,42	5,47 ±0,48	5,00 ±0,52
I can trust the product in cases of emergency.	5,00 ±0,56	5,34 ±0,55	4,41 ±0,56
I believe that the product is a professional device in terms of functionality.	4,88 ±0,55	5,13 ±0,61	4,22 ±0,59
Mean	**5,13**	**5,31**	**4,54**
Standard Error of Mean	±0,30	±0,32	±0,32
Confidence Interval	4,83-5,43	4,99-5,63	4,22-4,86

Table 4.30. Colors with the irregular texture and ruggedness

Ruggedness	**Irregular Black**	**Irregular Green**	**Irregular Orange**
The product is rugged and durable.	5,22 ±0,46	5,34 ±0,45	5,00 ±0,51
The product is durable against impacts and drops.	5,09 ±0,44	5,56 ±0,45	5,06 ±0,49
The product is enduring for harsh weather conditions.	5,25 ±0,47	5,50 ±0,48	5,16 ±0,54
Mean	**5,19**	**5,47**	**5,07**
Standard Error of Mean	±0,26	±0,27	±0,29
Confidence Interval	4,93-5,45	5,20-5,74	4,78-5,36

Table 4.31. Colors with the irregular texture and ergonomics-group 1

Ergonomics - 1	**Irregular Black**	**Irregular Green**	**Irregular Orange**
I can handle the product comfortably.	5,59 ±0,45	5,75 ±0,36	5,41 ±0,41
I can manipulate the product comfortably.	5,66 ±0,45	5,84 ±0,38	5,66 ±0,42
The size of the product is convenient to handle it for a long time.	5,78 ±0,40	5,88 ±0,35	5,78 ±0,39
The weight of the product is convenient to carry it for a long time.	6,00 ±0,38	6,13 ±0,31	5,97 ±0,37
Mean	**5,76**	**5,90**	**5,71**
Standard Error of Mean	±0,21	±0,18	±0,20
Confidence Interval	5,55-5,97	5,72-6,08	5,51-5,91

Table 4.32. Colors with the irregular texture and ergonomics-group 2 and aesthetics

	Irregular Black	**Irregular Green**	**Irregular Orange**
Cleaning and maintaining of the product is easy.	**4,06** ±0,55	**3,97** ±0,66	**3,66** ±0,64
Confidence Interval	3,55-4,55	3,31-4,63	3,02-4,30
The product heats easily.	**4,38** ±0,50	**4,34** ±0,51	**4,28** ±0,52
Confidence Interval	3,88-4,88	3,83-4,85	3,76-4,80
I like the feeling that the product gives while handling it.	**5,00** ±0,53	**5,19** ±0,48	**4,75** ±0,63
Confidence Interval	4,47-5,53	4,71-5,67	4,12-5,38
This object is aesthetic.	**5,34** ±0,61	**5,28** ±0,58	**4,66** ±0,67
Confidence Interval	4,73-5,95	4,70-5,86	3,99-5,33

Results

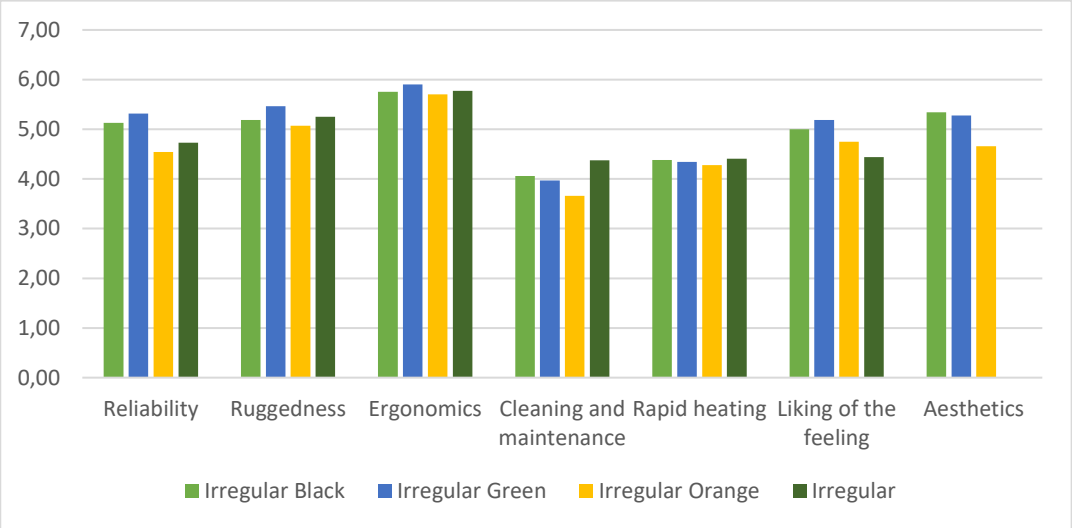

Figure 4.17. Comparisons of colors for the irregular texture

In terms of reliability, ruggedness, ergonomics and liking of the feeling, the irregular green sample received the highest score in average. However, for cleaning and maintenance, and being aesthetic, the mean is the highest for the irregular black. The irregular orange received the lowest scores for all the concepts in average. According to the mean values, the irregular orange sample has less possibility about rapid heating than the others.

Finally, when participants experienced the irregular samples by seeing their colors as well in Stage 2, the mean values of the irregular black and green have increased in terms of reliability, but the mean of the irregular orange has decreased. In terms of ruggedness and ergonomics, only the mean values of the green sample have increased. The mean values of the irregular textured samples in terms of cleaning and maintenance have decreased when seeing them with colors. Moreover, the mean values about rapid heating have decreased in Stage 2. Finally, the mean values about liking of the feeling are higher in Stage 2 when compared to Stage 1.

Discussion

Despite the changing mean values, colors do not affect the perception of the irregular texture significantly. In other words, when the standard errors of the means are considered, the mean values do not change significantly from Stage 1 to Stage 2, the mean values of the irregular texture in Stage 1 and Stage 2 could intersect according to their confidence intervals.

The standard error of the irregular green has the lowest value in terms of ergonomics. This means that the participants come close in their ratings for the irregular green mostly. The standard error of the irregular orange has the highest value in terms of being aesthetic. This means that the scores are varied mostly between the participants.

4.4.4 Data Conclusion

1- As a conclusion, the perception of textures in terms of reliability, ruggedness, and ergonomics do not change significantly only by touching in Stage 1. Even though the mean values of the textures are different in Stage 1, the scores of the thirty two participants spread between 1 and 7 unorderly. For example, even though one of the participants rate the linear texture as the most reliable, another participant could rate it as the least. This means that the scores of the participants do not change with the same order. In other words, the mean of the linear texture is higher than the others, but due to the standard errors, the linear texture could not be ranked as the most reliable sample, because some of the participants have found it to be the least reliable. To sum up, only by touching, three textures could not be differed from each other significantly.

2- Black and green colors affect the perception of the radial and the linear textures positively in terms of reliability. The mean values of the radial black, radial green, linear black and linear green have increased significantly from Stage 1 to Stage 2 by experiencing the colors as well. Significant changes were expected in term of

ruggedness and ergonomics as well from Stage 1 to Stage 2. However, the intervals between the scores of the participants are close to each other in terms of ergonomics. This means that the perception of textures are similar when experiencing them only by touching, or touching and seeing together in terms of ergonomics. Even though, the scores show alteration for ruggedness, they are not in order. Therefore, surprisingly, colors do not affect the perception of textures meaningfully in terms of ruggedness and ergonomics.

3- The linear textures in black, green and orange are found to be more reliable about functionality than the irregular textures in black, green and orange. Also, the interval between the linear and the irregular textures in orange is significantly wide. This means that black and green colors are more convenient in terms of reliability with the radial and the linear texture than the irregular one, and also, this is significant that orange color fits better to the linear texture more than the irregular one.

4- Moreover, the textures in green are found to be more convenient in terms of reliability than the textures in orange. By taking into consideration these results, the irregular orange received the lowest score in average in terms of reliability.

5- Significantly, in terms of ruggedness the black and green colors fit better to the radial texture rather than the orange color. In other words, the orange colored radial texture is found to be the least convenient in terms of ruggedness. This means that the black and green colors emphasize the positive effects of the radial texture in terms of ruggedness more than the orange color.

6- For all three colors; black, green and orange, the irregular texture is found to be the least convenient in terms of cleaning and maintenance. The mean values of the different colored irregular textures are not the same, but they do not have significant difference when considering their confidence intervals. This means that color does not affect the perception of irregular texture in terms of cleaning and maintenance significantly. In addition, surprisingly, the perception of participants do not change from Stage 1 to Stage 2. The reason for this is the high standard errors. They increase the intervals between the maximum and the minimum mean values, and the scores

in Stage 1 and Stage 2 intersect at a point. Also, high standard error means that the thirty two participants rated the statements in a wide range, and their scores could not be gathered at close points.

CHAPTER 5

CONCLUSION

This thesis investigated the effects of textures and colors on the perception of products, and the effects of colors on the perception of textures. At the beginning of the study three research questions were determined. The first question about the effects of textures on the perception of products is answered according to the literature review mostly. The second question about the effects of colors on the perception of products, and the third question about the effects of colors on the perception of textures are expressed according to the results of the study conducted for this thesis. The following sections revisit the research questions.

5.1 How Textures Affect the Perception of Products

According to the study of Ferreira and Capelli (2012), the textures of the juice bottles affect the consumers' taste perception. The bottle which has the texture like orange skin feels like more organic, and healthier. The other bottle which is made by "flexible" and "flimsy" plastic with classic smooth texture feels cheap and unhealthy (Ferreira and Capelli, 2012, p. 9). According to this study, the textures of the bottles change the quality perception of the juice (Ferreira and Capelli, 2012). As Ferreira and Capelli (2012) assumed, consumers use their tactile sense to get clues about the taste of the products. Therefore, texture is an important criterion in the design process to affect the consumer's perception positively.

Moreover, according to the study of Jansson-Boyd and Marlow (2007), it is observed that the three textures affect the perception of DVD containers differently in terms of aesthetics. This means that the hedonic pleasure that a product gives depends on the texture type as well. Also, it is found out that the textures could be more influential than the visual sense in some cases. With another study of Jansson-Boyd

and Marlow (2011), it is observed that the textures affect the perception of soup boxes, and biscuit packages in terms of aesthetics as well. However, visual sense is more influential than the tactile sense for these products, and this is because of the less touch ability of fast-consumer products (Jannson-Boyd and Marlow, 2011). Consequently, the textures affect the perception of products, but the scale of the effects could change depending on the product categories (Jannson-Boyd and Marlow, 2011).

Finally, the mean values of the textures in Stage 1 of the conducted study, and the mean values of the textures when experiencing them in the same colors show alteration in terms of reliability, ruggedness and ergonomics. This proves that the tactile differences caused by textures affect the human perception about the products. In average, the radial, and especially the linear textures received higher scores except from the statement related to rapid heating (Appendix E and F). The irregular texture received lower scores. The reason for this can be explained with the unfamiliarity of the irregular textures for the handheld radio users.

5.2 How Colors Affect the Perception of Products

Color changes the perception of products. To observe this, the mean values of the same textured samples in different colors are compared. The data are collected from the results of Stage 2 of the conducted study. The radial green, linear green and the irregular green are found to be more reliable than the radial orange, linear orange, and the irregular orange respectively. Moreover, the radial black and the radial green are found to be more convenient in terms of ruggedness than the radial orange. When considering the scores of the all participants, these are the significant results related to the effect of colors.

Besides these, all the mean values of the samples for the remaining concepts show alteration according to the different colors. Black and especially green received higher scores in average (Appendix F). Orange color is less likely with the three

textures. However, as a negative feature of the textures in green, they are found to have more possibility about rapid heating than the textures in orange according to the mean values. This is because of the increasing professional appearance with green. As participants indicated, the possibility of heating increases with the reliability, because heat is a feedback as well about whether the products function.

5.3 How Colors Affect the Perception of Textures

Color affects the perception of textures. Some of the participants think that the samples experienced in Stage 2 are different from the samples in Stage 1, even though the textures are the same. For example, the textures in Stage 2 could be perceived as denser and rougher. Besides the physical features, the scores of the textures change in terms of reliability, ruggedness and ergonomics when the colors are involved in Stage 2.

The changes could be in a positive or in a negative way, because the color choices usually depend on the individual taste. However, all the participants have familiarity and experiences with the communication handheld radios. According to them, green and black colors change the perception of the radial and the linear textures significantly in terms of reliability. The reason for this may be related to the learned experiences in profession for years.

The perception of the samples change for the remaining concepts with black, green and orange as well. However, the changes are not in the positive way certainly for all the participants. In other words, the scores do not change from Stage 1 to Stage 2 in a linear line, because individual tastes could play an effective role besides the learned experiences in profession. The scores of ergonomics are very close to each other. This means that the participants are affected less with different colors and textures in terms of ergonomics. The reason for this may be that the ergonomics is an objective concept.

5.4 Insights

Even though the orange color is found to be less reliable than the green color, it is found aesthetically pleasing, especially when used with the radial and linear textures. The reason for this is that the handheld radio users have found the samples in completely orange, unfamiliar, because they are not used to experiencing the radios in orange throughout the years. However, they found it aesthetic as well. In order not to put-off people with the excessive usage of orange, it could be designed for the details to take advantage of its positive effects. An aesthetic appearance could be achieved, the attention is taken for the desired parts, and the products may give the less possibility of rapid heating. Rather than used for the overall product, orange could be used for the details in a design to differentiate the functions. For example, the frame of the PTT and programmable buttons may be designed as an orange line. The frame of the keypads or the prints on the buttons could include orange as well. Knobs could include orange for the surfaces that interact with human hands. Clips of a handheld radio could emphasize their function with an orange detail, or the back shell of the radio could be differentiated from the main body with the help of an orange line.

Moreover, textures should be determined to support the functions. For example, to pull a piece apart (e.g. opening a cap), the linear texture perpendicular to the thumb would be more convenient; or to press the buttons, the radial texture would fit and guide users better. Also, for easy gripping such as knobs, irregular texture would be more helpful. The guidance of the textures to support the parts in order to function better should be considered.

Finally, the appropriate usage of color and texture together can empower their perception. Therefore, for the details in design like battery opening, the effects of color and texture should be considered with their form and function. Including texture and color on the overall product could be unlikeable, like the study has shown for the irregular textured and orange colored sample. However, to diverge the functions and guide the users, color and texture could take an important role as a part

of the design process. In addition, the results are a kind of encouragement for people who are responsible from the design of handheld radios, besides being a guide for the implementation of textures and color. The encouragement may lead to discover and implement different textures and colors to satisfy costumer hedonically and functionally.

5.5 Limitations of the Study and Recommendations for Further Studies

Before the Study

1. 3D modelling of the textures was not easy. Tiny texture particles made the modelling process slower than the usual. Also, PTC Creo, the software used for 3D modelling, gave errors many times because of the high density of the model. In order to model the textures, the particles were created in bigger sizes than the original. This could have reduce the familiarity of the textures for the participants, especially for the irregular one.

For further studies, original textures of the chosen products could be used rather than modelling them.

2. An available orange in the company was used for the samples to represent the tones of orange which were found in market. The applied orange does not have the desired gloss level. It is glossier than the usual oranges that are used in the market.

For further studies, the colors should be prepared to keep their glossiness level as same as possible by considering their receipts. By doing so, gloss level will not be a changing parameter to be considered in the studies.

During the Study

3. Time constraint was one of the important issues during the study. All the security guards had half an hour break to apply the study. This created stress about managing the time.

4. Some of the participants had difficulties about imagining the samples as a defined product. For those, the statements could not be scored easily. I directed them to imagine a technological device which has the same texture and the color with the samples that they experienced during the study. If the difficulties were not overcome, I asked from the participants to imagine a handheld radio directly with the same texture and color.

For the further studies textures and colors could be applied on a defined product. Therefore, participants' skills of imagination would not be that important. They could focus on the main task, and score the statements easier, because they could feel more comfortable.

After the Study

5. The target group includes security guards, industrial, mechanical and systems designers, project managers and technicians who have relation with the handheld radio. This may be among the reasons of the unorderly changing scores. The effects of texture and color are significant, but they could not be evaluated based on a stabile graphic.

Participants from different professions could have evaluated the samples from different points of view. Therefore, for further studies, the target group could be restricted. By doing so, significant insights could be reached.

6. According to the formula, standard error of mean decreases with increasing number of participants. Therefore, further studies may incorporate more participants for more significant results.

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APPENDICES

A. A4 Sheet for Study Stage 1 - Turkish

Katılımcı numarası: **Tarih:**

Görüşme başlama saati:

Görüşme bitiş saati:

Meslek:

Yaş:

Birazdan size verilecek üç objeyi sadece dokunarak deneyimleyiniz. Deneyimlediğiniz objelerin sahip olduğu özellikleri taşıyan bir ürün hayal ediniz. Lütfen hayal ettiğiniz ürünler için aşağıdaki cümleleri 1 ile 7 arasında (düşükten yükseğe) değerlendiriniz.

1	2	3	4	5	6	7
En düşük değer			Ortalama değer			En yüksek değer

GÜVENİLİRLİK	Obj-1	Obj-2	Obj-3
İşlevini yerine getirebilir.			
Acil durumlarda ona güvenebilirim.			
Fonksiyonel açıdan profesyonel bir cihaz olduğunu düşünürüm.			

SAĞLAMLIK	Obj-1	Obj-2	Obj-3
Sağlam ve uzun ömürlüdür.			
Darbelere ve düşmelere karşı dayanıklıdır.			
Zorlu hava koşullarına karşı dayanıklıdır.			

ERGONOMİ	Obj-1	Obj-2	Obj-3
Rahat kavrayabiliyorum.			
Rahat hareket ettirebiliyorum.			
Boyutları onu uzun süre kavrayabilmem için uygun.			
Ağırlığı onu uzun süre taşıyabilmem için uygun.			
Temizliği ve bakımı kolaydır.			
Çabuk ısınır.			
Kavrarken eldeki hissiyatını sevdim.			

B. A4 Sheet for Study Stage 1 – English

Participant number: **Date:**

Start time:

End time:

Job:

Age:

You will experience the samples that will be given soon, only by handling them. Please imagine that these samples are a product. Then, rate the statements below for every sample between 1 and 7 (from low to high).

1	2	3	4	5	6	7
lowest			average			highest

RELIABILITY	S-1	S-2	S-3
The product functions well.			
I can trust the product in cases of emergency.			
I believe that the product is a professional device in terms of functionality.			

RUGGEDNESS	S-1	S-2	S-3
The product is rugged and durable.			
The product is durable against impacts and drops.			
The product is enduring for harsh weather conditions.			

ERGONOMICS	S-1	S-2	S-3
I can handle the product comfortably.			
I can manipulate the product comfortably.			
The size of the product is convenient to handle it for a long time.			
The weight of the product is convenient to carry it for a long time.			
Cleaning and maintaining of the product is easy.			
The product heats easily.			
I like the feeling that the product gives while handling it.			

C. A4 Sheet for Study Stage 2 – Turkish

Katılımcı numarası:

Birazdan size verilecek olan objeleri bakarak ve dokunarak deneyimleyiniz. Deneyimlediğiniz objelerin sahip olduğu özellikleri taşıyan bir ürün hayal ediniz. Lütfen hayal ettiğiniz ürünler için aşağıdaki cümleleri 1 ile 7 arasında (düşükten yükseğe) değerlendiriniz.

1	2	3	4	5	6	7
En düşük değer			Ortalama değer			En yüksek değer

GÜVENİLİRLİK	Obj-1	Obj-2	Obj-3	Obj-4	Obj-5	Obj-6	Obj-7	Obj-8	Obj-9
İşlevini yerine getirebilir.									
Acil durumlarda ona güvenebilirim.									
Fonksiyonel açıdan profesyonel bir cihaz olduğunu düşünürüm.									

SAĞLAMLIK	Obj-1	Obj-2	Obj-3	Obj-4	Obj-5	Obj-6	Obj-7	Obj-8	Obj-9
Sağlam ve uzun ömürlüdür.									
Darbelere ve düşmelere karşı dayanıklıdır.									
Zorlu hava koşullarına karşı dayanıklıdır.									

ERGONOMİ	Obj-1	Obj-2	Obj-3	Obj-4	Obj-5	Obj-6	Obj-7	Obj-8	Obj-9
Rahat kavrayabiliyorum.									
Rahat hareket ettirebiliyorum.									
Boyutları onu uzun süre kavrayabilmem için uygun.									
Ağırlığı onu uzun süre taşıyabilmem için uygun.									
Temizliği ve bakımı kolaydır.									
Çabuk ısınır.									
Kavrarken eldeki hissiyatını sevdim.									

BONUS	Obj-1	Obj-2	Obj-3	Obj-4	Obj-5	Obj-6	Obj-7	Obj-8	Obj-9
Estetiktir.									

D. A4 Sheet for Study Stage 2 - English

Participant number:

You will experience the samples that will be given soon by handling and seeing them. Please imagine that these samples are a product. Then, rate the statements below for every sample between 1 and 7 (from low to high).

1	2	3	4	5	6	7
lowest			average			highest

RELIABILITY	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9
The product functions well.									
I can trust the product in cases of emergency.									
I believe that the product is a professional device in terms of functionality.									

RUGGEDNESS	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9
The product is rugged and durable.									
The product is durable against impacts and drops.									
The product is enduring for harsh weather conditions.									

ERGONOMICS	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9
I can handle the product comfortably.									
I can manipulate the product comfortably.									
The size of the product is convenient to handle it for a long time.									
The weight of the product is convenient to carry it for a long time.									
Cleaning and maintaining of the product is easy.									
The product heats easily.									
I like the feeling that the product gives while handling it.									

BONUS	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9
The product looks attractive.									

E. Order of the samples according to their mean values in Stage 1

Reliability	**1**	**2**	**3**
Mean	Linear 5,07	Radial 4,8	Irregular 4,73
Standard Error of Mean	± 0,28	± 0,27	± 0,29
Confidence Interval	4,79-5,35	4,58-5,12	4,44-5.02

Ruggedness	**1**	**2**	**3**
Mean	Radial 5,52	Linear 5,32	Irregular 5,25
Standard Error of Mean	± 0,28	± 0,31	± 0,27
Confidence Interval	5,24-5,80	5,01-5,63	4,98-5,52

Ergonomics	**1**	**2**	**3**
Mean	Linear 5,85	Radial 5,83	Irregular 5,77
Standard Error of Mean	± 0,19	± 0,18	± 0,19
Confidence Interval	5,66-6,04	5,65-6,01	5.58-5.96

Cleaning and Maintenance	**1**	**2**	**3**
Mean	Linear 5,09	Radial 5,03	Irregular 4,38
Standard Error of Mean	± 0,50	± 0,52	± 0,63
Confidence Interval	4,59-5,59	4,51-5,55	3,75-5.01

Rapid Heating	**1**	**2**	**3**
Mean	Linear 4,47	Irregular 4,41	Radial 4,25
Standard Error of Mean	± 0,51	± 0,55	± 0,54
Confidence Interval	3,96-4,98	3,86-4,96	3,71-4,79

Liking of the Feeling	**1**	**2**	**3**
Mean	Linear 5,19	Radial 5,13	Irregular 4,44
Standard Error of Mean	± 0,51	± 0,53	± 0,62
Confidence Interval	4,68-5,70	4,60-5,66	3,82-5,06

F. Order of the samples according to their mean values in Stage 2

Significantly changed mean values from Stage 1 to Stage 2 with colors

Significantly lower mean values for the same textures in different colors

Significantly lower mean values for the different textures in same colors

Reliability	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Mean	LG 5,79	RG 5,66	LB 5,64	RB 5,39	IG 5,31	LO 5,16	IB 5,13	RO 4,94	IO 4,54
Standard Error of Mean	±0,23	±0,25	±0,23	±0,23	±0,32	±0,26	±0,30	±0,33	±0,32
Confidence Interval	5,56 6,02	5,41 5,91	5,41 5,87	5,16 5,62	4,99 5,63	4,90 5,42	4,83 5,43	4,61 5,27	4,22 4,86

Ruggedness	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Mean	LG 5,75	RG 5,69	RB 5,66	LB 5,61	IG 5,47	LO 5,45	IB 5,19	RO 5,10	IO 5,07
Standard Error of Mean	±0,22	±0,23	±0,24	±0,24	±0,27	±0,26	±0,26	±0,29	±0,29
Confidence Interval	5,53 5,97	5,46 5,92	5,42 5,90	5,37 5,85	5,20 5,74	5,19 5,71	4,93 5,45	4,81 5,39	4,78 5,36

Ergonomics	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Mean	RG 6,02	LG 5,98	RB 5,92	LO 5,90	IG 5,90	LB 5,88	RO 5,77	IB 5,76	IO 5,71
Standard Error of Mean	±0,19	±0,17	±0,19	±0,19	±0,18	±0,17	±0,21	±0,21	±0,20
Confidence Interval	5,83 6,21	5,81 6,15	5,73 6,11	5,71 6,09	5,72 6,08	5,71 6,05	5,56 5,98	5,55 5,97	5,51 5,91

Cleaning and Maintenance	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Mean	LB	LO	LG	RG	RB	RO	IB	IG	IO
	5,66	5,47	5,31	5,22	5,09	4,84	4,06	3,97	3,66
Standard Error of Mean	±0,38	±0,39	±0,45	±0,38	±0,48	±0,54	±0,55	±0,66	±0,64
Confidence Interval	5,28	5,08	4,86	4,84	4,61	4,30	3,55	3,31	3,02
	6,04	5,86	5,76	5,60	5,57	5,38	4,55	4,63	4,30

Rapid Heating	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Mean	LG	LO	RG	LB	RO	RB	IB	IG	IO
	4,66	4,63	4,50	4,47	4,41	4,38	4,38	4,34	4,28
Standard Error of Mean	±0,48	±0,48	±0,48	±0,50	±0,57	±0,49	±0,50	±0,51	±0,52
Confidence Interval	4,18	4,15	4,02	3,97	3,84	3,89	3,88	3,83	3,76
	5,14	5,11	4,98	4,97	4,98	4,87	4,88	4,85	4,80

Liking of the Feeling	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Mean	LB	RG	LO	LG	RB	IG	RO	IB	IO
	5,72	5,56	5,50	5,38	5,19	5,19	5,00	5,00	4,75
Standard Error of Mean	±0,37	±0,51	±0,50	±0,50	±0,52	±0,48	±0,58	±0,53	±0,63
Confidence Interval	5,35	5,05	5,00	4,88	4,67	4,71	4,42	4,47	4,12
	6,09	6,07	6,00	5,88	5,71	5,67	5,58	5,53	5,38

Aesthetic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Mean	LB	IB	IG	RG	LG	LO	RB	RO	IO
	5,34	5,34	5,28	5,25	5,22	5,09	5,00	4,94	4,66
Standard Error of Mean	±0,45	±0,61	±0,58	±0,47	±0,58	±0,54	±0,47	±0,65	±0,67
Confidence Interval	4,89	4,73	4,70	4,78	4,64	4,55	4,53	4,29	3,99
	5,79	5,95	5,86	5,72	5,80	5,63	5,47	5,59	5,33