Finding Favorable Textures for Haptic Display

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Abstract. Haptic display is a powerful sensory medium to transfer information that gives a sense of haptic. We argue that giving haptic information positively affects only when the haptic makes a good impression. We examine the best materials that people feel pleasant to touch. Consequently, people prefer textures with uniform grain of brush, cotton clothes and silk. Throughout this paper, we propose a new approach to design of haptic display using tactile preference.

Keywords: Haptic display · Textures · Design for all methods · Emotional and affective interaction for universal access · User experience

1 Introduction

Recently, haptic technology is regarded as a strong medium that delivers the sense of emotion effectively to the users [1]. The existing research focus on the materialization of realistic haptic interaction. For example, TeslaTouch reproduces different textures using electro-vibration [2]. However, haptic technology is not advanced enough to represent every single texture.

This paper contains hypothesis, experiments, and conclusion of three-step research. The first introduces 'visual tactility' and shows the importance of the correspondence between two different sensory feedbacks. The next explores the conditions that make people dislike haptic display in depth. The last suggests some guidelines on prioritization of haptic display development. In conclusion, we suggest a new approach about haptic display based on these findings.

2 Correspondence Between Haptic and Visual Information

Since haptic display enables multimodal communication, some researchers have interest in the integrated sensory experiences. Looking at the surface, people can imagine the texture of the surface without touching it actually; this virtual texture is called 'Visual tactility' [3]. Previous works show that the visual tactility significantly affects the perceived tactility [4]. We hypothesize that user's satisfaction is related to the correspondence of visual and haptic information. Thus, we design a sequence of experiments to verify this.

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Table 1. Four type of the experimental conditions. (A and B be any source)

Condition	Haptic info.	Visual info.	Agreement
H	A		–
V		B	–
H + V	A	A	Agree
H-V	A	B	Disagree

Fig. 1. Sample materials for Exp.1 (from the left, Grass mat, E.V.A., Cork, Acryl, Rubber, Cotton, and Air cap).

2.1 Experiment

Feigyn et al. were interested in a training method using haptic and visual stimulus [8]. Therefore, they experimented to compare the performance of participants with either existent or nonexistent haptic and visual sources. Similarly, we measured the sensory and emotional responses of the participants so that we could verify how each conditions effect on user experience. There are four types of experimental conditions (Table 1). H and V are abbreviations of 'Haptic Source' and 'Visual Source'. We vary the existence of each sensory information. The 18 sample boxes contain haptic sources and visual sources of seven materials (Fig. 1). Although reconstructed texture might be slightly different from the original texture as Lee told [9], here we are assuming that reconstructed texture would be as precise as the original texture. We have 18 participants (twelve males and six females) whose ages range from 17 to 43 (average: 23.3) (Tables 2, 3).

Sensory Evaluation: Choe suggested these adjectives [5] to measure haptic senses. Sensory response is measured using Korean adjective pair evaluation (1-10 scale) using six aspects of haptic sense - roughness, hardness, dryness, coldness, stickiness, and thickness.

Emotional Evaluation: For emotion evaluation, the participants selected associated adjectives for the given experiences in the sensory evaluation. After, the adjectives were classified into positive, negative, and neutral groups. For example, 'pleasure', 'intimacy' and 'cozy' were classified in the positive group, while 'uncomfortable', 'dizzy', and 'nervous' were in the negative group. Some adjectives such as 'artificial' and 'slippery' were classed in the neutral group, because they do not give neither positive nor negative feelings. We compare the frequencies of the positive and the negative adjectives in order to objectify the emotional responses for the given condition.

Table 2. Result of emotional responses, the number of each adjective

Condition	Positive adj.	Neutral adj.	Negative adj.
H	25	9	12
V	28	9	14
H + V	38	12	14
H-V	14	13	14

Table 3. Result of emotional responses, the percentage of adjectives by the conditions

Condition		Positive adj. (%)	Negative adj. (%)
Haptic source	Exist	51.0	26.5
	Not Exist	54.9	27.5
Visual source	Exist	51.3	26.9
	Not Exist	54.3	26.1
Correspondence	Agree	59.3	21.9
	Disagree	48.6	29.0

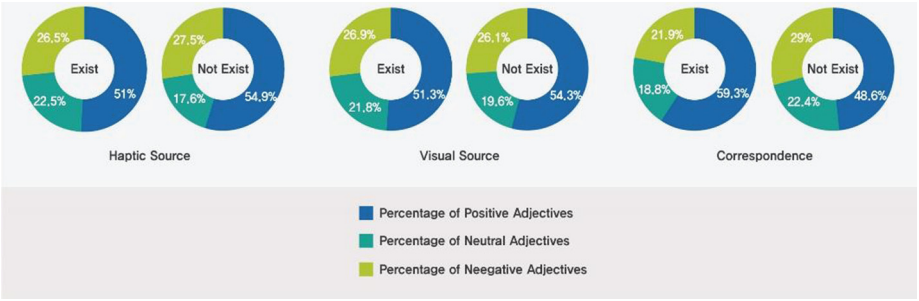

Fig. 2. The effect of existence and correspondence of haptic and visual information to the emotional response.

2.2 Results

The correlation between H and V is 0.06, between H and H + V is 0.63, and between V and H + V is 0.25. If two stimuli are given simultaneously, they both effect on the integrated tactile. When we compare H + V and H-V, H-V gives median of H and V scores. Although the haptic gives the larger effect, the visual information can easily mutate the integrated tactile. The mere existence of visual and haptic information have no positive effect on the emotional response. Resultantly, their correspondence is the unique factor to increase positive emotion (See Fig. 2).

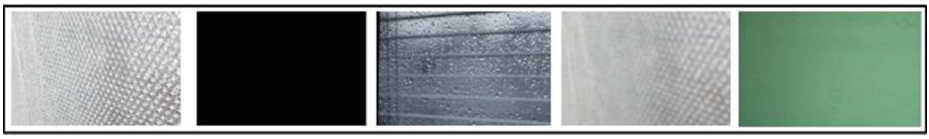

Fig. 3. Image sources for Exp.2 (from the left, Air cap, blank, window, blurred air cap, and E.V.A.).

3 When Do People Dislike Haptic Display?

The first experiment shows that people sometimes dislike haptic display. Subsequently, we design following research that includes an experiment and discussion to figure out when people dislike haptic display.

3.1 Experiment

We examine whether the positive emotion is directly related to the user's satisfaction. Six participants (3 male and 3 females with average age 22 years) evaluated their emotional responses by marking points in the quadrant of two axes (likeness and naturalness) on -3-3 scales. We choose haptic sources as Air cap and E.V.A, which brought the most distinct and the haziest results in the first experiment. Glass, a general surface of devices is another haptic source. The visual sources are given as Fig. 3.

Afterwards, the participants answer to question about haptic display and the human factors based on their experiences.

3.2 Results

The emotional responses are categorized as 'agreement', 'neutral', and 'disagreement' groups. There are eight agreements, seven neutrals, and 15 disagreements. The naturalness condition is clearly distinct depend on the experimental conditions. The likeness condition has less distinction.

3.3 Interview

What they expect before manipulating haptic display? Imaging the Air cap, users expected round face (Visual), soft surface (Haptic), crisp sound (Auditory), tension and enjoyable feeling (Emotional), some changes after the burst (Interaction) in common. This implies the needs for multi-sensory communication.

What is that they feel about the discord between haptic and visual information? Among six participants, all of them agreed that the discord decreases the naturalness. Three participants mentioned that the discordance can disturb the understanding of the visual information. Three of them agreed that the disagreement brings unpleasant feelings. Two of them regarded that the texture is most important while the other participant regarded as expectation to be the most important.

When do people dislike haptic display? People expect to haptic display in visual, auditory, haptic, and interactive ways. Users' satisfaction decreases with their unfulfilled expectation. Users expect that visual and real tactility be well matched. Until and unless haptic and visual information correspond well, haptic device is better off without the haptic information. According to the first experiment, haptic information with discordance is disturbing rather than helping users to communicate. Even if visual and haptic information is well matched, users would hate the experience if the given texture is uncomfortable or unwanted.

4 Finding Favorable Textures

From the previous experiments with 32-participants, we observe that people do not satisfy with haptic display when expectation failed visually, auditory, haptic, and interactively (especially when there is discordance between haptic and visual feedback, and when the given texture is unwanted).

According to a clinical psychologist Anzieu, D. [6], touch is a basic primal sense and he defines the concept of the 'skin ego', which means that the skin is the psychological border that distinguishes oneself from others. Based on this theory, we can understand the phenomenon that people usually touch with their intimate people with affection. Unlike the other sensory communication, the users must directly contact their skin with the haptic display to feel the tactile sensation, thereby the preference for the texture is reflected with satisfaction for the haptic display. Accordingly, we explore which texture gives a positive feedback on users to make haptic display more attractive.

On-line Survey. Jani Heikkinen, T.O. et al. found that people expect familiar textures that we can easily find in the daily life in haptic communication [10]. Therefore, we conducted an on-line survey about the daily materials. Total 406 participants (210 males, 196 females, age: 41.7 years on average) answered to the question, "Please select from the list of all materials that provide positive feelings to you". This survey had been conducted for 15 days, while the nationalities of the participants are Korea, China, U.S.A., and Europe (Germany and France). They answered through the Internet, and we gave every participant the same choices. We referenced this survey result to choose the experimental materials, because the most likable materials globally supposed to be chosen.

Pre-experiment. We had to do pre-experiment to choose the representative texture and to examine the questionnaires. We asked ten people to rank the preference for twenty materials.

4.1 Experiment

We assert that asking the preference of individuals is valuable in the HCI field, because haptic experience is essential and subjective. Besides, we use AHP (Analytic Hierarchy Process), a tool that determines the importance of several factors using a matrix to order the materials used in this experiment [7], to objectify people's preferences. We selected

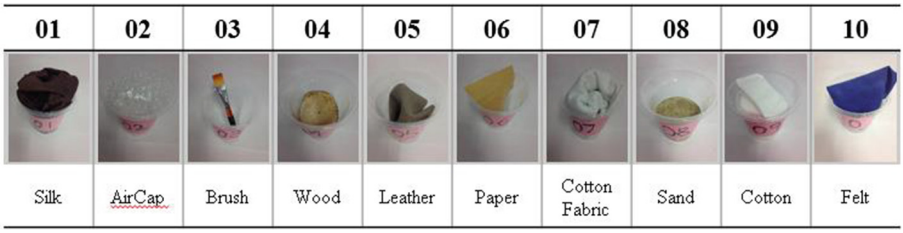

Fig. 4. Experimented materials selected by the survey and the pre-experiment

Fig. 5. Experiment 3 Environment

10-materials which are likely to be preferred from the result of the survey and the pre-experiment (See Fig. 4). These materials are Silk, Air cap, Brush, Wood, Leather, paper, Cotton Fabric, Sand, Cotton, and Felt which we can easily use in daily life. Twenty-five participants (age range of 19 to 40, 11 females and 14 males) responded after touching the 10-materials arranged in transparent vessels. They were asked to compare all pairs among the ten in 5-scale based on their personal preferences (Fig. 5).

4.2 Results

As a result, we obtain weights for the materials. (See Fig. 6) Because the consistency index is 0.0035 (acceptable level is < 0.100), this result is acceptable. Subsequently, brush, cotton fabric, and silk are most highly weighted. Indeed, these highly-ranked materials provide emotional satisfaction to individuals. Since we have chosen 10-materials to be likely to represent favorable feeling based on multiple experiment, we also infer that these materials would be highly ranked in the other experiments.

5 Discussion

This research is different with the presented studies which based on the technology, focusing on the human senses and investigating what users would feel when they experience through haptic devices.

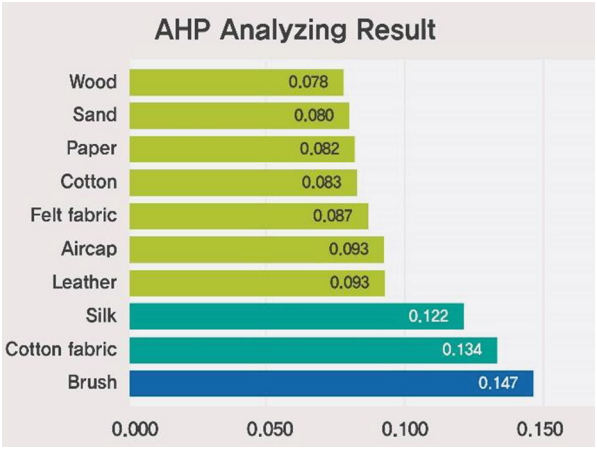

Fig. 6. AHP analyzing results

5.1 Correspondence

If we only take technical issue into the consideration, technology by itself may be developed. However, this research considers that consumers do not ensure that they would use the technology. According to the result, users are more cautious about haptic display. First, they are unpleasant when the visual and haptic stimulus discord. Also, they take an umbrage at the display that present a bad tactile. It is an important fact that people do not feel better even if the present display adds haptic technology. Agreement between haptic and visual sources is required condition for positive haptic display. Previously, it was found that two senses interfere each other when they are concurrently provided [4]. Nevertheless, our finding stands alone with the point of emotional differentiation.

5.2 Textures

In order to develop a positive haptic display, we argue that technology should allow user to feel transmitted texture with pleasure. Also, the textures of 'silk' and 'brush' are the most significant textures. The high ranked textures have some features of softness, fine-grained and familiarity in common. Despite of individual differences, there clearly exists some textures that please most people. Developing haptic display, such an overwhelming texture has a priority to be implemented. To sum up, we need to reproduce likable textures more delicately than unlikable textures in order to attract people to feel friendly about haptic display.

5.3 Future Haptic Display

Engineers work out various methods of actuators in haptic display such as electrotactile and vibrotactile. Even though present technology is rapidly growing, it requires more time to reproduce an exact texture in haptic display. In particular, 'sand' and 'soft

cotton fabric' are too detailed to be implemented, although people prefer such textures. However, favorable texture should accompany delicate technology that represents temperature, z-force, and the softness. Conversely, the mere rough haptic display would not give users any reason to purchase.

Eventually, ideal display will be affective and has emotional relations with us, not just a rigid plastic and metal. As mentioned above, expansions of haptic will equal to expansions of oneself. To overcome the boundary between 'myself' and 'other', true ubiquitous beginning would come from haptic technology. Therefore, it is ponderable that haptic display, which is representing ourselves, has to give us 'good feeling'.

6 Conclusion

High-technology does not always give pleasure to people. Indeed, there was an important observation by experiments that users are not always favorable to haptic technology although it is an advanced technology. We argue that developed haptic display must be loved by people. To do so, we should aim to reproduce the likable texture first on haptic display. Considering that haptic display is one of the fundamental technology that will be applied in the future, we investigate haptic display that provides pleasant and familiar feeling to human individuals. Herein, this paper finds what kinds of materials gives positive feedback to the users.

Attractive haptic also gives several ways to think. For example, the preference would depend on the mode of haptic experience. Currently, we investigated only one form of haptic experience using fingertips. However, each of the body parts including facial skin, palm, lips, and foot would give totally different preference. The mechanism of human haptic is too complex to be defined in a simple manner. For that reason, the possibilities of the further research are unlimited in this area. Of course, there are also still a few loose ends to reproduce texture technology. However, we want to emphasize that studies on the human preference are essential as well as the technologies themselves in order to construct a technology system related to human-computer interaction.

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