A Framework for Affective Quality of Ear-related Product Design

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Abstract

Since wearable devices are attached to the body, the sense of fitness can be an important element. In this study, therefore, the affective quality of ear-related product was examined to quantify the structure of the process of affective quality. First, vocabularies related to the sense of fitness (the sensation when a person wears ear-related products) were collected and selected for the evaluation of affective quality of ear-related products. Second, factor analysis was conducted for these vocabularies. As a result, the hook part has four major affective vocabularies and the earplug part has three major affective vocabularies. Third, a causal relationship between the sense of fitness and affective quality variables was identified using structural equation modeling. The result showed that the design element that has the greatest impact on the fitness of the ear-related product is the earplug. Above all, a sense of comfort showed a significant impact on overall satisfaction. Through this study, we identify not only the main factors that affect the satisfaction from the sense of fitness but also product design elements that affect the sense of fitness were also identified.

Keywords: Affective Quality, Ear-related Product, Structural Equation Modeling

Introduction

With the development of smart phones and hardware technology, the interest on wearable devices is increasing. Among them, smart watches and wireless headsets are most commonly used [1]. Wireless headsets not only effectively provide auditory information while the user is moving, but are also widely used for their various interactions. Aside from the interaction between the device and the user, another important issue of wearable devices is the sense of fitness the user feels.

The sense of fitness is one of the five senses, and is categorized as somatosensory. Somatosensory refers to the sensation of the entire body that is caused by the posterior root of the spinal nerve. Somatosensory reacts to various stimuli through different receptors, and also receives different stimuli depending on the body part [2].

When describing a sensation that is caused by physical stimulation like the sense of fitness, people feel differently from a single stimulation, causing the description to be unclear and abstract. However, past studies on the sense of fitness of ear related products were conducted with only one indicator which is simple satisfaction, without considering the complex and implicit feelings of human nature [3]. Also, studies only analyzed the sense of fitness on the earplugs, eliminating analysis on the sense of fitness for the remaining part of the headset [4].

Therefore, this study specifies the affective quality of wearing ear-related products, and quantifies the reaction structure of affection through structural equation, by categorizing the factors that influence the satisfaction of fitness into the earplug and the hook. First, we collected and selected vocabularies associated with the sense of fitness of ear-related products to assess affective vocabularies. Next, we conducted factor analysis on the result of affective evaluation related to sense of fitness.

Method

Selection of key affective vocabularies

In this study we selected some key affective vocabularies for the affection analysis of ear-related products’ sense of fitness. From the affective vocabulary used in previous studies [5, 6], 172 words related to the sense of fitness were extracted, and 20 major affective vocabularies shown in Table 1 were selected after conducting a survey.

Table 1. 20 affective vocabularies associated with the sense of fitness

| Soft, Big, Comfortable, Heavy, Hard, |
| Pliable, Round, Luxurious, Thick, Neat, |
| Solid, Elastic, Deep, Natural, Curved, |
| Smooth, Snug, Refined, Simple, Tight |

After selecting affective vocabularies related to the sense of fitness, for the affective factor selection related to wireless headsets, 20 people wore various types of wireless headsets and evaluated them with the affective vocabularies through a 7-point Likert scale.

An exploratory factor analysis (utilizing the SPSS 23.0) on evaluation results on the 20 affective vocabularies was carried out. Among the 20 affective vocabularies, 13 and 9 adjectives for the hook and the earplug respectively, turned out meaningful. Its components are categorized in Table 2, 3.
Table 2. Rotated factor matrix of the hook

| Component          | Hook | 1     | 2     | 3     | 4     |
|--------------------|------|-------|-------|-------|-------|
| Natural            | .816 | -.007 | .243  | .051  |       |
| Snug               | .802 | .070  | .090  | .237  |       |
| Neat               | .782 | -.148 | .011  | .032  |       |
| Tight              | .625 | -.032 | .191  | -.292 |       |
| Soft               | .558 | .286  | .236  | .296  |       |
| Big                | -.023| .807  | -.012 | .155  |       |
| Thick              | -.024| .783  | .174  | -.182 |       |
| Heavy              | .018 | .684  | .101  | -.033 |       |
| Pliable            | .222 | .078  | .774  | .260  |       |
| Curved             | .056 | .178  | .707  | -.246 |       |
| Elastic            | .316 | .044  | .682  | .350  |       |
| Solid              | .132 | .358  | -.247 | -.792 |       |
| Smooth             | .334 | -.200 | -.019 | .545  |       |
| Explanatory power (%) | 22.358 | 15.768 | 14.044 | 11.268 |  

Table 3. Rotated factor matrix of the earplug

| Component | Earplug | 1     | 2     | 3     |
|-----------|---------|-------|-------|-------|
| Hard      | .841    | .258  | .073  |       |
| Solid     | .786    | .277  | .157  |       |
| Pliable   | -.777   | .070  | .273  |       |
| Elastic   | -.712   | .197  | .355  |       |
| Big       | -.004   | .838  | .019  |       |
| Heavy     | -.029   | .793  | -.057 |       |
| Thick     | .342    | .736  | .101  |       |
| Neat      | .085    | .031  | .910  |       |
| Natural   | .268    | -.029 | .857  |       |
| Explanatory power (%) | 29.252 | 22.898 | 20.073 |

Table 4. Major affective vocabularies of hook associated with the sense of fitness

| Major affection of hook | Measured affective vocabularies |
|--------------------------|---------------------------------|
| Sense of comfort         | Natural, Snug, Neat, Tight, Soft|
| Sense of volume          | Big, Thick, Heavy               |
| Sense of pliability      | Pliable, Curved, Elastic        |
| Sense of material        | Solid, Smooth                   |

Table 5. Major affective vocabularies of earplug associated with the sense of fitness

| Major affection of earplug | Measured affective vocabularies |
|----------------------------|---------------------------------|
| Sense of comfort           | Natural, Neat                   |
| Sense of volume            | Big, Thick, Heavy               |
| Sense of material          | Hard, Solid, Pliable, Elastic   |

Theoretical model

As mentioned earlier, somatosensory is dispersed throughout the entire human body, and the affection and sensitivity for each body part is different. Therefore, in this study, we primarily divided the wireless headset into the hook and the earplug and developed a theoretical model (Shown in Figure 1) that shows the impact each affective factor can have on the satisfaction of fitness, to create an evaluation model on the sense of fitness on ear-related products.

Figure 1. Causal relationship model of the sense of fitness

Participants and Products sample

The participants in the evaluation of the sense of fitness were 20 in total, 12 men and 8 women. The average age was 26.8(±2.4) years old. There were no problems with participants experiencing the affection of the headsets.

This study evaluated five ear-related products, the Samsung Pleomax Das-H9012K, Plantronics Voyager 855, Beats by Dr.Dre Powerbeats 2 Wireless, Jabra Sport+, and Plantronics BackBeat Fit. To minimize visual contamination, brand logo and brand name of the products were covered with tape.
Research procedure
This affection evaluation was in three conducted stages. During the preparation stage, the study’s objective and procedure were explained to the participant. During the practice stage, the participant was allowed to freely put on any of the five types of headsets before the main evaluation. During the main evaluation stage, the five headsets were distributed randomly to control exogenous variables, and participants evaluated the 20 affective vocabularies, as well as the still task and the movement task both considering various usage environments through the 7-point Likert scale. Finally, evaluation on the subjective preference of the earplug part and the hook part of the headsets was carried out.

Results
To verify the statistical significance of the cause-and-effect relationship model displayed in Figure 1, the SmartPLS 3.0 for Bootstrapping analysis was used. Bootstrapping sampling was carried out 1,000 times and the significance of the latent variable at significance level 0.05 and the path coefficient between latent variables were verified. The results of the Bootstrapping evaluation showed that the cause-and-effect relationship of every independent variable and subordination variable except the hook’s satisfaction and fabric sensation had an influence which had statistical significance. Among the standardized path coefficients on each channel, overall satisfaction of wireless headsets and satisfaction of earplug were 0.752, being the most influential. The overall satisfaction level and hook satisfaction level was 0.257, earplug satisfaction level and sense of volume was -0.222, earplug satisfaction level and sense of material was 0.167, earplug satisfaction level and sense of comfort was 0.526 in Table 6.

Also the explanation power (R-Square) on the major affection of each group had shown that the earplug satisfaction level was 0.627, hook satisfaction level was 0.694, and the overall satisfaction level was 0.674. In other words, the earplug’s sense of volume, sense of material, sense of comfort showed 62.7% of the earplug satisfaction level, while the hook’s sense of volume, sense of pliability, sense of material, and sense of comfort was accountable for 69.4% of the hook’s satisfaction level, and the satisfaction level of the earplug and hook accountable for 67.4% of the overall satisfaction level. The final overview of the study model on the sense of fitness of wireless headsets is as shown in Figure 3.

![Figure 3. Causal relationship model of satisfaction of the sense of fitness](image)

Table 6. The results of bootstrapping

| Type   | Independent Variable     | Dependent Variable   | Sample Mean | Standard Error | T Statistics | p-value |
|--------|--------------------------|----------------------|-------------|----------------|--------------|---------|
| Earplug| Earplug satisfaction     | Overall satisfaction | 0.752       | 0.054          | 13.864       | 0.000** |
|        | Sense of volume          | Earplug satisfaction | -0.222      | 0.091          | 2.410        | 0.016*  |
|        | Sense of material        |                      | 0.167       | 0.080          | 2.102        | 0.036*  |
|        | Sense of comfort         |                      | 0.676       | 0.063          | 10.903       | 0.000** |
| Hook   | Hook satisfaction        | Overall satisfaction | 0.257       | 0.053          | 4.793        | 0.000** |
|        | Sense of volume          | Hook satisfaction    | -0.367      | 0.070          | 5.083        | 0.000** |
|        | Sense of pliability      |                      | 0.159       | 0.078          | 1.986        | 0.047*  |
|        | Sense of material        |                      | -0.030      | 0.070          | 0.794        | 0.427   |
|        | Sense of comfort         |                      | 0.526       | 0.088          | 6.081        | 0.000** |

*: significant at $\alpha=0.05$, **: significant at $\alpha=0.01$
Discussion and Conclusion

With the continuous development of smart device technology, the interest and sales of wearable devices increase correspondingly. Thus, the sense of fitness is a critical matter, to further understand this, we identified various types of affection when people wear ear-related products, and modeled the impact each affection factor has on the satisfaction of fitness using structural equation. The structural equation modeling showed that the most influential factor of ear-related products is the earplug rather than the hook, and the earplug’s sense of comfort especially has the biggest influence. In other words, a natural and neat feeling of ear-related products is the most important to its satisfaction level. As for the hook, results showed that people did not feel a significant difference regarding the sense of material, and this can be because most of the hooks of wireless headsets have an active touch that has on effect only when the headset is worn, so the sensitivity towards different fabrics of the various headset hooks seems to be low. This indicates that when it comes to the satisfaction of the hook, sense of comfort, volume, and pliability were more relevant than the sense of material. Moreover, sense of volume showed a negative relationship with the satisfaction of fitness, in both the hook and the earplug.

The limit of this study is that we only covered the sense of fitness of ear-related products with simple affective vocabularies, without considering design variables such as material and size. Thus, a future study considering other design variables seems necessary. However, the sense of fitness of ear-related products and preferred affective factors derived from this study are expected to play a crucial role in customer-based product development.

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