Timbre Image Scale for Designing Feedback Sound on Button Operation

Shota Imai[1(✉)], Sanae H. Wake[2], Megumi Mitsumoto[1], Mitsuyasu Noguchi[3], Yoshitaka Uchida[3], and Noriko Nagata[1]

[1] Graduate School of Science and Technology, Kwansei Gakuin University, Hyogo, Japan
imachu-shota@kwansei.ac.jp
[2] Information Media, Doshisha Women's College, Kyoto, Japan
[3] Kojima Industries Corporation, Aichi, Japan

Abstract. The purpose of this study is to build an image scale for operation feedback sound. When a sound designer designs the operation feedback sound, the scale could be used as a tool to share the sound image with the product developers. We evaluated the impression of the sound using the semantic differential method. Then, we carried out factor analysis, and obtained four factors: (1) artificiality, (2) liveliness, (3) gorgeousness, and (4) gentleness. From this result, we built two image scales, an artificiality-liveliness scale and a gorgeousness-gentleness scale, and put the 72 feedback sounds on these scales. These could be used to design or choose feed-back sounds that could be adapted to the product design image.

Keywords: Sound · Feedback sound · Touchscreen · User interface · Sound design · Factor analysis

1 Introduction

Operation feedback sounds are used on a lot of electric devices. When you operate a button on a touchscreen, these sounds are heard. Several studies reported these operation feedback sounds can improve the operational feeling and reduce a number of operating errors [1]. We carried out experiment to develop the sound design guideline for improving the feeling of button press [2].

Almost all feedback sounds used on contemporary electronic devices are "beeps." Regarding these sounds, we propose the use of various timbres on feedback sounds. We think they can express product's own unique images and make it easier for users to distinguish between products, allowing users to feel that certain products are better to operate than others.

The purpose of this study is to build a timbre image scale for designing feedback sounds for operation. It can be useful for adapting sound image to product design, which means it can be a tool to share the timbre image between a product designer and a sound designer. We build the image scale based on an impression evaluation experiment.

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2 Impression Evaluation Experiment for Building Image Scale

2.1 What Is an Image Scale?

An image scale [3, 4] is a visual representation of the relationship between stimulus and its impression. The procedure of building an image scale begins with the participants evaluating each of stimulus (e.g., color, sound) image using the semantic differential method. Then, a factor analysis is conducted on the obtained data to extract some factors of the underlying image. And then, rectangular coordinate system could be made using these factors, and the stimulus are plotted on the system.

As an example, Kobayashi et al. built the color image scale [3]. They made connections between colors and adjectives and mapped them on a rectangular coordinate system. The vertical axis of the color image scale is "SOFT-HARD" and the horizontal axis is "WARM-COOL". The scale was built using 180 pairs of adjectives for color. The scale works as a color design support tool for designers who deals with color design.

We think that operation feedback sounds are part of product design, and the timbre image scale could work for the product designers.

2.2 Stimuli

In general, sounds consist of loudness, pitch, and timbre. In this research, we focused on timbre and prepared 72 feedback sounds that were different in timbre.

Sounds Designed by Sound Designers. We asked three sound designers to design operation feedback sounds using various timbres.

We showed the designers the acoustic guideline [2] (see Fig. 1). The guideline indicates the conditions of amplitude envelope: attack time is between 0 ms and 20 ms, decay time is between 50 ms and 100 ms, and total time is between 60 ms and 110 ms. When you hear the operation feedback sound which meets the conditions, you can get the good operation feeling.

Each of the designers had his own plan for designing sounds. One designer designed simple and plain sounds, another designer designed the sounds like sound-effects used in video games, and the third designer designed sounds using recorded material, such as beating or knocking on something. They designed 45 feedback sounds in total.

Sounds Designed by Authors. We designed feedback sounds based on sin wave given the following our rules.

1. Fundamental Frequency: 500 Hz, 1000 Hz, 1500 Hz
2. Harmonics:
   (a) Adding 2nd harmonic tone with 1/2 amplitude to the fundamental frequency
   (b) Adding 3rd harmonic tone with 1/3 amplitude to the fundamental frequency
   (c) Adding 4th harmonic tone with 1/4 amplitude to the fundamental frequency

3. Attack time and decay time of the amplitude envelope:
   (a) Attack time: 20 ms, Decay time: 50 ms
   (b) Attack time: 5 ms, Decay time: 70 ms
   (c) Attack time: 0 ms, Decay time: 90 ms

We designed 27 feedback sounds in total by combining these parameters.

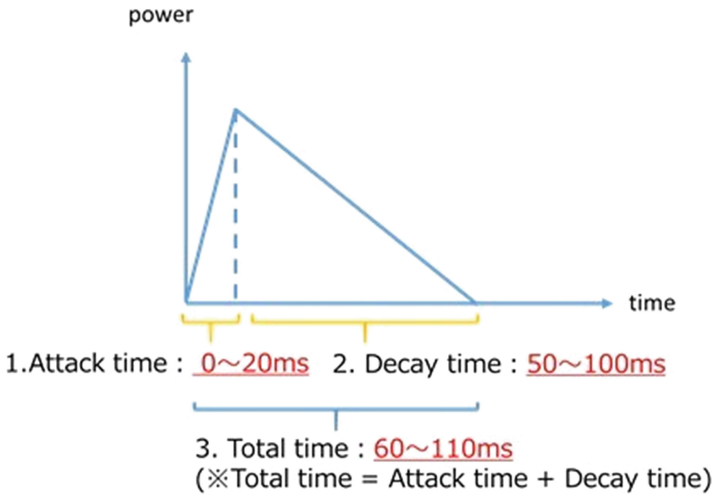

Fig. 1. Guideline for designing feedback sounds

2.3 Bipolar Adjective Pairs for Evaluation

As already mentioned, we think that operation feedback sounds are part of product design. Therefore, we decided to use the adjectives, which are used in design process, for semantic differential method. Saito et al. told that there were 12 clusters of adjectives related to design: "functional beauty," "sense of accuracy," "kindness, cuteness," "sense of quality, soft feeling," "sense of color," "elegance," "strength, familiarity," "traditional beauty," "creation and satisfaction," "modernity, fresh beauty," "luxury," and "noticeability" [5]. We selected 15 adjectives from these 12 clusters, at least one adjective from one cluster, and added another 5 adjectives. Then, we established pairs of adjectives by adding an antonym adjective to each. Table 1 shows the bipolar adjective pairs for evaluation.

2.4 Participants and Procedure

We used semantic differential method for the evaluation. 26 participants (17 men and 9 women) took part in the experiment. Participants evaluated the sound stimuli by just listening to them (they did not operate the button.) 72 stimuli were presented randomly, and the time for evaluation was one minute per stimulus. While a stimulus sound was

Table 1. Selected bipolar adjective pairs

Decorative	Functional	Plain	Gorgeous
Rough	Accurate	Modest	Noticeable
Cold	Mild	Disagreeable	Likable
Bold	Delicate	Not tire of	Tire of
Matte	Glossy	Mature	Childish
Wild	Refined	Calm	Lively
Serious	Airy	Formal	Casual
Classical	Futuristic	Masculine	Feminine
Natural	Artificial	Cheap	Expensive
Complex	Simple	Inappropriate	Appropriate

being replayed 20 times, the participants evaluated it with 20 bipolar adjectives on a 7-point scale using a semantic differential method.

3 Result and Discussion

We conducted a factor analysis to confirm the impression structure. When we conducted the last factor analysis, the items "appropriate-inappropriate," "not tire of-tire of," and "likable-disagreeable," were excluded. Principal factor analysis and varimax rotation were carried out as the method of factor analysis.

Table 2 shows the calculated factor loadings. Specifically, adjectives that had high loadings for factor 1 were "wild-refined," "rough-accurate," "matte-glossy," "masculine-feminine," "classical-futuristic," "modest-noticeable," "cheap-expensive," "natural-artificial," and "decorative-functional." Those with a high loading for factor 2 were "mature-childish," "calm-lively," and "formal-casual." Those with a high loading for factor 3 were "plain-gorgeous," "complex-simple," and "serious-airy," and those for factor 4 were "cold-mild" and "bold-delicate." We named these four factors; artificiality, liveliness, gorgeousness, and gentleness.

4 Building Timbre Image Scales

We built two timbre image scales using the four factors we had gotten from the analysis. The first (and the main) scale is shown in Fig. 2. We used the artificiality factor as a horizontal "NATURL - ARTIFICIAL" axis, and the liveliness factor as a vertical "LIVELY - CALM" axis. We call this scale the "artificiality-liveliness scale" (see Fig. 2). We also made the second scale which is "gorgeousness-gentleness scale" by using the third and fourth factors as the "SIMPLICITY - GORGEOUSNESS" axis and the "MILDNESS - COLDNESS" axis.

We mapped the sounds on the scales using the factor scores as the coordinate values, and also mapped the adjectives using the factor loadings.

Table 2. Factor loadings of each of 17 bipolar adjective pairs in the semantic differential

Bipolar adjective pairs	Factor 1	Factor 2	Factor 3	Factor 4	Communality
Artificiality					
Wild - refined	**0.765**	−0.165	−0.086	0.223	0.333
Rough - accurate	**0.723**	−0.137	−0.004	−0.096	0.551
Matte - glossy	**0.703**	0.044	0.127	-0.01	0.575
Masculine - feminine	**−0.668**	−0.029	0.128	−0.155	0.575
Classical - futuristic	**0.657**	0.155	0.415	−0.096	0.512
Modest - noticeable	**0.609**	0.263	0.181	−0.077	0.669
Cheap - expensive	**0.605**	−0.328	0.2	0.123	0.384
Natural - artificial	**0.552**	0.161	0.459	−0.127	0.637
Decorative - functional	**0.528**	−0.172	−0.09	−0.131	0.558
Liveliness					
Mature - childish	−0.061	**0.732**	−0.095	0.057	0.339
Calm - lively	0.089	**0.686**	0.159	−0.116	0.557
Formal - casual	−0.417	**0.544**	−0.032	-0.021	0.479
Gorgeousness					
Plain - gorgeous	0.397	0.042	**0.621**	0.114	0.551
Complex - simple	0.068	0.005	**−0.573**	−0.077	0.517
Serious - airy	−0.282	−0.307	**0.405**	−0.215	0.472
Gentleness					
Cold - mild	-0.1	−0.046	−0.017	**0.75**	0.487
Bold - delicate	0.084	−0.006	0.091	**0.748**	0.529
Factor contribution ratio	4.244	1.705	1.426	1.352	8.727
Cumulative contribution ratio	24.967	34.997	43.388	51.342	

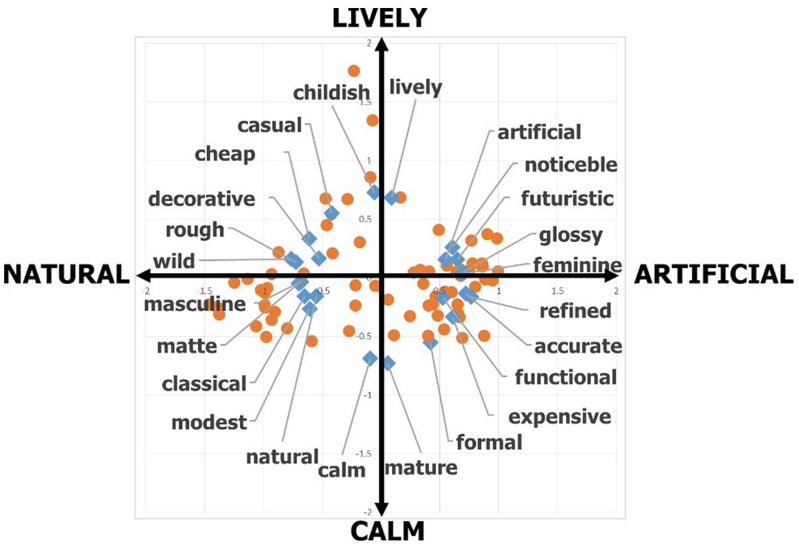

Fig. 2. Artificiality-liveliness scale

5 Conclusion and Future

In conclusion, we built two timbre image scales. These could be useful for selecting or designing operation feedback sounds, the sound images of which are adapted to the product design.

In the future, we will integrate these image scales in the iPad application "Sign Sound Selector (SSS)" [6]. SSS is a tool to share the timbre image between a client (ex. a product developer) and a sound designer. It could be used for designing sound sign and UI sounds.

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