Basic Research on the Factors Influencing Perception of Texture from Images

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Abstract. We conduct a subjective evaluation experiment by using the semantic differential method to examine the relation between the shape, color and size of an object in an image and the emergence of texture perception. The experiment consists of an evaluation survey on the perceived texture of a visual stimulus displayed on a monitor. The stimulus is a simple shape (ball, cylinder or box) created using a computer graphics application; ach shape appears in one of three colors (red, blue or green) and at one of two sizes (large or small) for a total of 18 distinct stimuli. The factors were extracted from the data by principal factor analysis, and the factor loadings were calculated by promax rotation. Furthermore, the relations between each factor and texture perception were examined through Hayashi's first quantification method, a kind of regression analysis.

The results indicated relations between each item and the sensations of smoothness, hardness and moistness, which are considered to be representative of texture perception.

Keywords: material perception "Shitsukan", semantic differential method, Hayashi's first quantification method.

1 Introduction

Research on texture perception is currently attracting considerable attention. The study of texture perception in the new academic field of brain information science incorporates the fields of engineering, psychophysics and brain physiology. This study focuses on psychophysics, with expected applications in engineering. Psychophysics explores human senses and aims to clarify the types of information perceived about objects; in texture perception research, the aim is to understand how texture perception arises from that information and to construct a stimulation system that can display simple image data to induce perception of a target texture [1].

Texture perception can be induced through various senses, such as sight (appearance), hearing (the sound produced by an object when touched) and tactile sense (the feel from touching the object). The focus on this study is sight. Taking memory color as a key concept, we focus on color perception in humans and aim to reproduce colors that match the perception characteristics of humans. According to previous research, remembered colors are recalled with increased saturation and brightness compared

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with the original colors [2,3]. Also, it has been suggested that remembered colors tend to remain constant over time, which alters the perception of the original color when it is encountered again. Furthermore, factors other than color, such as size and shape, are also considered to affect texture perception [4]. Although a considerable amount of research has been conducted on the influence of these factors on subjective impression, there is a lack of experimental research on the relation that these factors hold with texture perception.

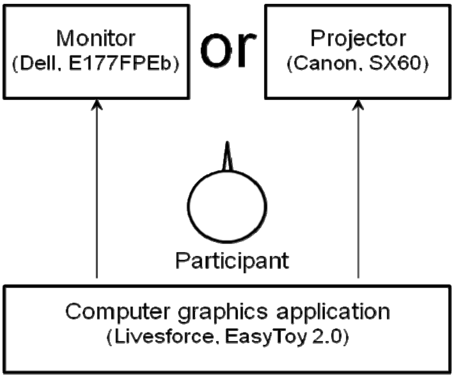
In this context, we conduct a subjective evaluation experiment by using the semantic differential method to examine the relation between the shape, color and size of an object in an image and the emergence of texture perception.

2 Experimental Methods

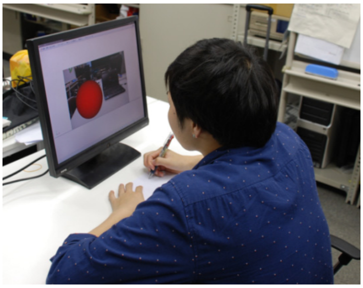
The experimental setup is shown in Fig. 1. Participants completed a texture evaluation questionnaire about a visual stimulus displayed on a monitor or projector set up in front of a participant. The questionnaire consisted of 16 categories deemed valid for evaluating texture on the basis of research into the structure of texture evaluation [4]. Each category was ranked on a 7-point scale. The following word pairs were chosen as response categories:

(1) ugly–beautiful
(2) blunt–sharp
(3) old–new
(4) fine–coarse
(5) dull–glossy
(6) slack–tight
(7) light–heavy
(8) weak–powerful
(9) intricate–plain
(10) wet–dry
(11) moist–powdery
(12) cool–warm
(13) hard–soft
(14) airy–solid
(15) smooth–bumpy
(16) slippery–gritty.

A total of 18 different visual stimuli were prepared using a computer graphics application. The variable items for the stimuli were shape (3 categories: ball, cylinder, box) color (3 categories: red, blue, green) and size (2 categories: large, small). Fig. 2 shows the stimuli and Table 1 lists the items and categories for texture evaluation. Horizontal illuminance in front of the participant was 950 lx throughout the experiment. The 18 different stimuli were displayed in random sequence to avoid the order effect. In regard to the representation of stimulus size, stimuli were presented against a photographic background of a room, to allow for combined analysis of data obtained with different display equipment. The participants were 33 male and female university students. All participants gave consent after they were given a verbal explanation of the objectives of the experiment and the ethical issues related to the handling of data.

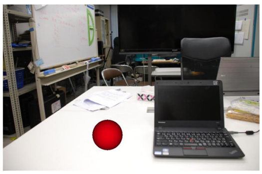


(a) block diagram of experimental devices

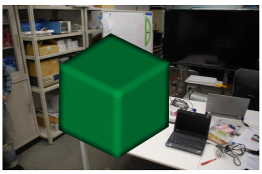


(b) snapshot of experimental condition

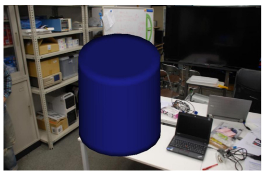
Fig. 1. Experimental setup



(a) ball-red-small



(b) box-green-large



(c) cylinder-blue-large

Fig. 2. Examples of stimuli on display

Table 1. Lists the items and categories for stimulus

stimuli	shape			color			size	
	ball	cylinder	box	red	blue	green	large	small
1	*			*			*	
2	*			*				*
3	*				*		*	
4	*				*			*
5	*					*	*	
6	*					*		*
7		*		*			*	
8		*		*				*
9		*			*		*	
10		*			*			*
11		*				*	*	
12		*				*		*
13			*	*			*	
14			*	*				*
15			*		*		*	
16			*		*			*
17			*			*	*	
18			*			*		*

3 Analysis Methods

The 18 stimulus images were evaluated on an semantic differential scale for the 16 word pairs [5]. Factor extraction by principal component analysis was performed on these evaluation data, and principal component loading was obtained by promax rotation. We used Hayashi's first quantification method [6,7] to investigate the relationship between texture and each item/category for each of the texture-related principal components found to have a high contribution ratio in the principal component loading analysis. A statistical analysis application was used.

4 Results and Discussion

Table 2 shows principal component loading and influential factors based on principal component analysis. Extraction was performed to the 5th principal component because the cumulative contribution ratio was above 60% (62.7%) up to this component. These components were given the following labels based on the characteristics of the response category included in the component:

- 1st principal component, 'light/thin' (3 items),
- 2nd principal component, 'retro' (5 items),
- 3rd principal component, 'smooth' (3 items),

Table 2. Principal component loading and influential factors

word pairs	principal component loading: 1st principal component "light/thin"	2nd principal component "retro"	3rd principal component "smooth"	4th principal component "hard"	5th principal component "moist"
(8) weak–powerful	0.8322	0.1258	0.0917	0.0698	0.0374
(7) light–heavy	0.7977	-0.0752	-0.0291	-0.1611	-0.1021
(9) intricate–plain	-0.6374	-0.0573	-0.0120	0.0286	-0.0382
(2) blunt–sharp	-0.1565	0.5798	0.2046	-0.2423	-0.1030
(1) ugly–beautiful	-0.0207	0.5051	-0.1801	0.0314	0.1184
(6) slack–tight	0.1672	0.4901	-0.1779	0.0583	-0.0342
(5) dull–glossy	0.0469	0.4635	0.0187	0.1260	-0.0351
(3) old–new	0.0943	0.4321	-0.0122	0.2128	0.1392
(16) slippery–gritty	0.0158	-0.0663	0.6669	0.1326	0.0478
(4) fine–coarse	0.0635	-0.1985	0.6617	0.1150	0.0595
(15) smooth–bumpy	0.0254	0.1614	0.5902	-0.1965	-0.0231
(13) hard–soft	-0.0328	0.0678	0.1019	0.7852	-0.0753
(14) airy–solid	-0.0622	0.1341	0.0197	0.6958	-0.0510
(11) moist–powdery	-0.0217	0.0367	-0.0187	-0.0765	0.7120
(10) wet–dry	0.0104	-0.0015	0.1141	-0.0792	0.5544
contribution ratio (%)	19.325	14.728	11.765	9.016	7.841
cumulative contribution ratio (%)	19.325	34.053	45.819	54.835	62.676

- 4th principal component, 'hard' (2 items),
- 5th principal component, 'moist' (2 items).

We focused on the 3rd to 5th principal components, as these have the strongest association with texture.

We performed analysis by Hayashi's first quantification method to discover which items/categories could represent the feelings of smoothness, hardness, and moistness. Quantification method 1 is a method of handling qualitative data as quantitative data by converting to a dummy variable in regression analysis in cases where the independent variable is qualitative data. Tables 3 to 5 show the results of analysis for each feeling.

Table 3. Results of analysis for feeling of smoothness

item	category	quantitative data
shape	ball	**0.320**
	cylinder	**0.043**
	box	-0.362
color	red	-0.165
	blue	0.109
	green	0.057
size	large	0.072
	small	-0.072

Based on the results for 'smooth' in Table 3, the partial correlation coefficient becomes high for shape. This shows that shape makes an important contribution in embodying the feeling of smoothness. In terms of category quantities, the value was positive for ball or cylinder. This shows that balls and cylinders are appropriate for embodying the feeling of smoothness.

Table 4. Results of analysis for feeling hardness

item	category	quantitative data
shape	ball	-0.463
	cylinder	-0.057
	box	**0.520**
color	red	**0.046**
	blue	-0.294
	green	**0.248**
size	large	-9.34E-05
	small	9.34E-05

Based on the results for 'hardness' in Tables 4, the partial correlation coefficient becomes high for shape and color. It was also found that a box and the color red or green are suitable for embodying the feeling of hardness. Based on the results for 'moistness' in Tables 5, the partial correlation coefficient becomes high for color. It was also found that the color green is suitable for embodying the feeling of moistness. Size had little effect on the embodiment of any of these feelings.

Table 5. Results of analysis for feeling of moistness

item	category	quantitative data
shape	ball	-0.078
	cylinder	0.029
	box	0.049
color	red	-0.177
	blue	-0.121
	green	**0.298**
size	large	-0.089
	small	0.089

5 Conclusions

We experimentally investigated the relationship between texture components and imaging information such as color, shape and size of a visual object. The results suggested that the basic elements of image information, namely, a visual object's shape and color can influence texture components. However, this was only a preliminary study. Next we plan to investigate the precise influence of the color and shape of visual objects on the sense of texture in greater detail.

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