Hierarchical Structuring of the Impressions of 3D Shapes Targeting for Art and Non-art University Students

Saki Miyai[1(✉)], Kenji Katahira[1], Masashi Sugimoto[1], Noriko Nagata[1], Kunio Nikata[1,2], and Keigo Kawasaki[2]

[1] Kwansei Gakuin University, 2-1, Gakuen, Sanda, Hyogo, Japan
saki-M@kwansei.ac.jp

[2] Kanazawa College of Art, 5-11-1, Kodatsuno, Kanazawa, Ishikawa, Japan

Abstract. The spread of digital fabrication technologies such as 3D printers has increased opportunities to utilize 3D data. A support system for users without specialized knowledge must model the relationships between impressions received from shapes and the shapes' physical elements. Regarding the structure of impressions, previous works have hypothesized that a hierarchical structure with a lower layer closely related to physical parameters and an upper layer representing more abstract impressions. To extract the hierarchical structure of impressions for 3D shapes in this work, we conducted the Evaluation Grid Method to visualize an impression's hierarchical structure. Ten art university students and 10 non-art university students participated in the experiment and provided impressions they had formed from the 3D shapes presented as photographs. We extracted the hierarchical structure, including the impressions used in previous works in the upper side. The impressions representing the state and the features of shapes were extracted in the lower side. By classifying the language expressions representing the state and features from aspects of the shape's local features, the language expressions were classified into some similar viewpoints between participants' groups. While the language expressions representing abstract impressions varied between groups, and the language expressions related to "activity" were extracted only from art students. These findings revealed that there is not only a generality in the viewpoint strongly related to physical quantity but also differences based on knowledge and experience among individuals with regard to the more abstract impression.

Keywords: Kansei · Hierarchical structure · Evaluation grid method

1 Introduction

In recent years, the spread of digital fabrication technologies representing 3D printers has increased opportunities for personal fabrication. In addition, the development of information and communication technology (ICT) has made it possible to freely share the 3D data and knowledge required to create 3D models. Thus, the opportunities to utilize 3D data are increasing even for general users. However, utilizing 3D data requires specialized knowledge and skills, so it may be difficult for general users to

C. Stephanidis (Ed.): HCII 2019, CCIS 1032, pp. 385–393, 2019.
https://doi.org/10.1007/978-3-030-23522-2_50

create 3D models. On the other hand, even such general users express their feelings (Kansei) such as ‘pretty’ or ‘soft’ when they look at objects. Therefore, support for creating based on Kansei is considered effective. One example of support for creating based on Kansei is a proposal system for shapes that is close to the user’s desired impression. Thanks to this system, general users can utilize 3D data more intuitively. This support system necessitates structuring the impressions (Kansei) that people receive from the shapes and grasping the relationships between Kansei and the physical elements of 3D shapes.

Regarding the structuring of Kansei, various previous works have hypothesized a hierarchical structure that shows the relationship between a person’s psychological quantity and the physical elements of objects [1–4]. Although the hierarchical structure of Kansei hypothesized in these research has various names, a common point is that impressions and images are caused by physical elements and attitude, behavior and emotions that include such as ‘favorite’ are evoked. In this research, we define the hierarchical structure of Kansei consisting of three layers based on this common point: physical element, impression, and emotion as shown in Fig. 1. This hierarchical structure assumes a causal relationship between factors and results. The lower side shows the factor, and the upper side shows results evoked by the factor. We show the definition of each layer in order from the lower side. The physical element shows the physical parameter of stimuli. The impression layer shows the evaluation of the stimuli based on knowledge and experience. The emotion layer shows comprehensive evaluations of the stimuli, emotions, and attitudes based on comprehensive evaluations.

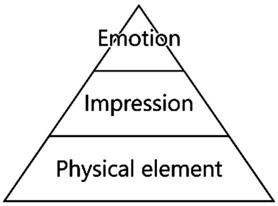

Fig. 1. The hierarchical structure of Kansei

2 Previous Work

Regarding evaluations based on Kansei, many works [3, 6–9] target various objects using Osgood’s SD (Semantic Differential) method [5]. The SD method determines an impression of objects by evaluating the objects with adjectives (pairs of adjectives).

In the work considering the hierarchical structure of Kansei, Katahira et al. [3] conducted a experiment using the SD method for 3D shapes. As a result, the “Uniformity (Evaluation) Factor”, the “Potency Factor” and the “Activity Factor” were derived as the main factors that related to the impression layer as shown in Table 3. They also extracted the main factor related to the attitude of preference in our emotion layer, and they modeled the relationship between the impression layer and the emotion layer.

The previous work revealed the relationship between the impression layer and the emotion layer but not the relationship between the impression layer and the physical element. It is difficult to expose the relationship between the impression layer and the physical element because the impression layer mixes concrete impressions strongly associated with physical element and abstract impressions strongly associated with the emotion layer. Understanding the relationship between the concrete impression and the abstract impression could reveal more details about the correspondence between the impression layer and the physical element.

3 Purpose

This work aims to clarify the impression's hierarchical structure. To extract the impression's hierarchical structure, we conduct an experiment with the evaluation grid method [10], which is a semi-structured interview. The evaluation grid method approach extracts the causal relationship between evaluations of what people perceive from object and what they evaluate from the percept. First, we focus on the participant's evaluation (language expression) of the object. By performing ladder-up to get an impression evoked from the language expression, we extract a comprehensive and abstract language expression. Alternatively, by performing ladder-down to get the factor of the language expression, we extracted an objective and concrete language expression. By performing ladder-up and ladder-down, we collect the causal relationship data between evaluations of objects. From the obtained data, we clarify the impression's hierarchical structure. We also investigate whether there is a difference in the impression layer's hierarchical structure depending on the presence or absence of production knowledge, for university students who have knowledge of art and university students who do not have knowledge of art.

4 Evaluation Grid Method Experiment for Extracting Causal Relationship of Language Expressions

4.1 Stimuli

The stimuli are 90 screenshots from 3D shapes' animations used in the previous work [3]. The screenshots were located where the shapes' features were considered most representative. We show the stimuli in Fig. 2. We presented 18 pictures per participant. In selecting 18 stimuli, to avoid variability in the similarity of stimulus set, we conducted a cluster analysis using the score for each stimulus obtained in previous work [3]. We selected almost the same number of picture at random from three obtained clusters and produced five sets with 18 pictures each.

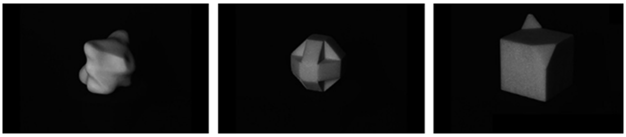

Fig. 2. Example of screenshot

4.2 Participant

The participants are 10 university students majoring in art (art students) and 10 university students majoring in other (non-art students). Two participants from each student group evaluated for one stimulus set.

4.3 Procedure

Participants classified the stimuli into 3 to 7 groups in terms of “similar impressions”. Next, they mentioned the “different impressions” between and within stimuli groups as far as they could think. By conducting ladder-up and ladder-down on the obtained language expressions, we extracted the causal relationships of the impressions of 3D shapes.

5 Extracting the Hierarchical Structure of Impression Layer

5.1 Analysis

Using E-Grid (a visual analytics system for evaluation grid method) [11], we conducted an analysis to categorize language expressions with the same meaning among the language expressions obtained from the participant groups. E-Grid can extract an evaluation structure diagram that is easy to interpret by setting a threshold to exclude language expressions whose contribution to the evaluation structure is small due to few

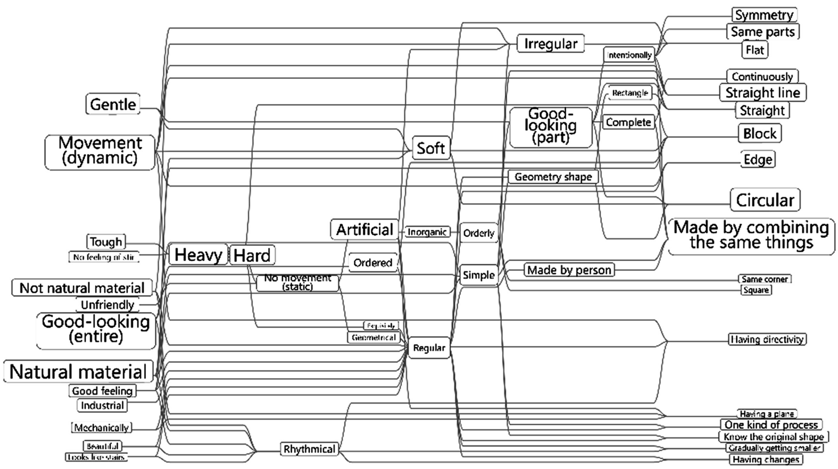

Fig. 3. Relationship diagram of impressions for non-art students

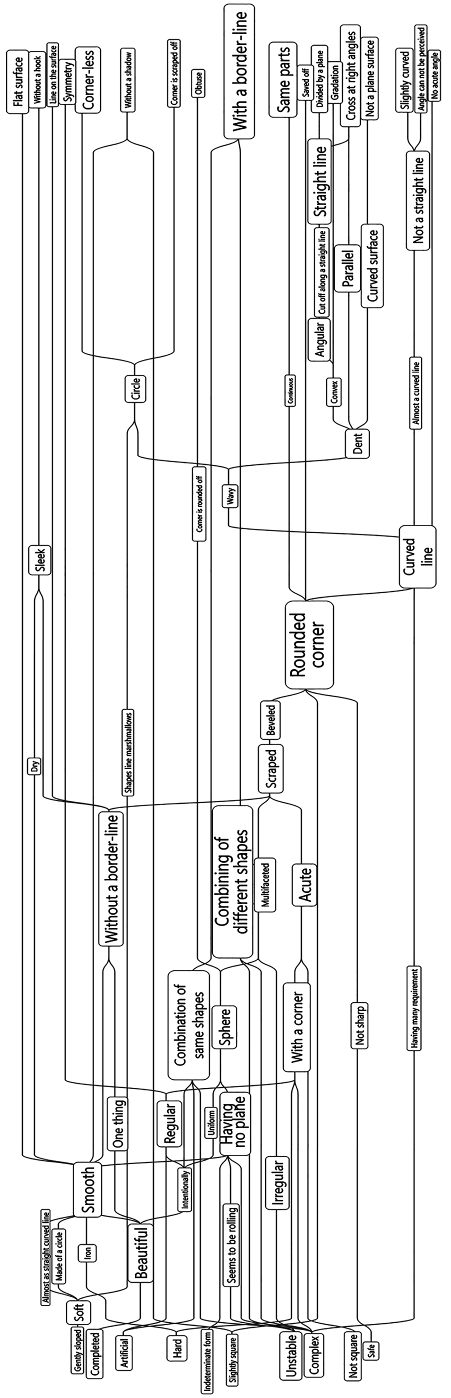

Fig. 4. Relationship diagram of impressions for non-art students

appearances and little connection with other language expressions. In this work, we set the threshold to 0.06, which includes less language expressions mentioned by only one person and more occurrences of categorized language expressions.

5.2 Result

We show the hierarchical structure of impressions for 3D shapes obtained by analyzing each participant group (Figs. 3 and 4). The left side of each figure shows the more abstract upper concept. The right side of each figure shows the more concrete lower concept. An item's size increases as its language expression is used more often. In the non-art university students' result, language expressions like 'symmetry', 'same parts' and 'squared' are obtained in the lower concept. Language expressions like 'unstable', 'soft' and 'hard' are obtained in the upper concept. In the art university students' result, language expressions like 'straight', 'square' and 'symmetry' are obtained in the lower concept. Language expressions like 'beautiful', 'heavy' and 'active' are obtained in the upper concept. These results showed that many impressions used in the previous SD method experiments [3, 6–9] appear as abstract impressions in the upper concept and that the states and features of shapes appear as concrete impressions in the lower concept.

6 Comparison of Language Expressions of Non-art University Students and Art University Students

6.1 Analysis

From the results of the hierarchical structure of impression layer for each participant group, we extracted the concrete impression that represented the state and feature of shapes and the abstract impressions such as adjectives used in the previous SD method experiment. To investigate which part of the 3D shapes participants viewed and evaluated, we classified the concrete impressions into 3D shape viewpoints.

6.2 Result

Table 1 shows the results of classifying the concrete impressions into the 3D shapes' viewpoints. The concrete impressions extracted from the non-art students' result were classified into eight viewpoints: Feature of shapes, Processing of corner, Outline of shape, Split into elements, Feature of element, Arrangement, Plane and Surface. The concrete impressions extracted from the art students' result were classified into six viewpoints: Feature of shapes, Processing of corner, Outline of shape, Feature of element, Arrangement and Plane. Because concrete impressions were classified into almost the same viewpoints among the participant groups, it is clear that there is no difference in the viewpoints when a person evaluates 3D shapes, regardless of their knowledge about creating.

The results of extracting the abstract impressions are shown in Table 2. The results show that the language expressions of competence used in the previous work [3], such

Table 1. The concrete impression and its viewpoint for each participants' group.

Art university students		
View point	**Impression representing state & features**	
Feature of shapes	Rectangle	Square
	Circular	Block
	Geometry shape	
Processing of corner	Edge	
Outline of shape	Straight	Straight line
Feature of element	Same parts	Same corner
	Made by combining	One kind of processing
	Same things	
Arrangement	Symmetry	
Plane	Flat	Having plane

Non-art university students			
View point	**Impression representing state & features**		
Feature of shapes	Sphere	Circle	Triangle
	Circle base	Similar to sphere	Not rectangle
	Rectangle	Cube	Not sphere
Processing of corner	Angular	Acute	Rounded corner
	Meet and form right angle	With corner	Scraped
	Acute angle	Corner less	Beveled
Outline of shape	Single line	Curved line	Not straight line
	Arc of circle	Billowing	
Split into elements	Single thing	Not single line	Without border line
	With border line		
Feature of element	Combination of different things	Combination of same things	Different shaped (parts)
	Same size	Same parts	
Arrangement	Symmetry	Overlapped	
Plane	Flat surface	Having plane	Multifaceted
	Divided by plane	Curved surface	Having no plane
Surface	Sleek	Thorny	Not dented
	Harsh	Gradation	Dented

Table 2. The abstract impressions of each participants' group.

Art university students			
Abstract impression			
Gentle	No movement (static)	Having changes	Soft
Unfriendly	Movement (Dynamic)	Intentionally	Inorganic
Tough	Not feeling of stir	Mot natural material	Orderly
Good feeling	Heavy	Natural material	Simple
Good-looking (whole)	Rhythmical	Hard	Having directivity
Beautiful	Irregular	Industrial	Know original shape
Ordered	Good-looking (part)	Mechanically	Geometrical
Regular	Made by person	Artificial	Exquisitely

Non-art university students			
Abstract impression			
Soft	Iron	Regular	Intentionally
Completed	Beautiful	Uniform	Irregular
Hard	Seems to be rolling	Unstable	Not sharp
Complex	Smooth	Safe	Artificial

as 'hard' and 'soft,' and the language expressions of evaluation, such as 'unstable' and 'irregular' are obtained from non-art and art university students. On the other hand, the art student results show language expressions of activities, such as 'with movement' and 'heavy' and language expressions of impressions they had of people, such as 'friendly' and 'cold'. Because the language expressions representing the abstract impressions differed depending on the participant groups, it turned out that there is a difference based on knowledge and experience regarding more abstract impressions.

7 Conclusion

The purpose of this work is to clarify the hierarchical structure of the impression layer and investigate the difference of impression depending on the presence or absence of knowledge and experience with creating. For these purposes, we employed the evaluation grid method to extract the detailed hierarchical structure of impressions for 3D shapes. Moreover, we compared the results between two participants' groups varied in that levels of knowledge and experience for creating, that is, non-art university students and art university students. As a result of analyzing the causal relationship of evaluation using E-Grid, the impressions used in previous SD method works were extracted as abstract impression in the upper side. The impressions represent the state and features of shapes were extracted as concrete impressions in the lower side.

While there was no difference between participants' groups in the concrete impressions, some differences between participants' groups were found for the abstract impressions. These results suggest the generality in the concrete impressions that are considered to be strongly related to the physical quantity, and the differences based on the knowledge and experiences in the abstract impressions. This work aid the development of a support system for users with less specialized knowledge and experience.

Appendix

See Table 3.

Table 3. The main factor of 3D shapes & adjective pairs in each factor in previous work [5].

Factor name	Adjective pairs			
Potency	soft – hard	weak – strong	smooth – rough	intense – mild
	relaxed – tense	distinct – vague	blunt – sharp	
Activity	active – passive	gay – sober	excitable – calm	delicate – rugged
	cheerful – cheerless	dynamic – static	heavy – light	
Evaluation	healthy – unhealthy	ordered – unordered	stable – unstable	connected – disconnected

References

1. Okamoto, S., Nagano, H., Kidoma, K., Yamada, Y.: Specification of individuality in causal relationships among texture-related attributes, emotions, and preferences. Int. J. Affect. Eng. **15**(1), 11–19 (2015). https://doi.org/10.5057/ijae.ijae-d-15-00018
2. Chen, X., Barnes, C.J., Childs, T.H.C., Henson, B., Shao, F.: Materials' tactile testing and characterisation for consumer products' affective packaging design. Mater. Des. **30**(10), 4299–4310 (2009)
3. Katahira, K., Muto, K., Hashimoto, S., Tobitani, K., Nangata, N.: The hierarchical approach to the semantic differential method. Trans. Jpn. Soc. Kansei Eng. **17**(4), 453–463 (2018). https://doi.org/10.5057/jjske.tjske-d-17-00075
4. Yamada, A., Hashimoto, S., Nagata, N.: Automatic Impression Indexing based on Evaluative Expression Dictionary from Review Data. Trans. Jpn. Soc. Kansei Eng. **17**(5), 567–576 (2018). https://doi.org/10.5057/jjske.tjske-d-18-00065
5. Osgood, C.E., Suci, G.J., Tanenbaum, P.H.: The nature and measurement of meaning. Psychol. Bull. **49**(3), 197–237 (1952)
6. Takahashi, S.: Aesthetic properties of pictorial perception. Psychol. Rev. **102**(4), 671–683 (1995)
7. Inaba, Y., Ishi, H., Kochi, J., Gyoba, J., Akamatsu, S.: Manipulating higher-order impressions of a class of 3D objects using the morphable 3D model: measurement of impressions by the SD method and psychological evaluation of the transformation. Inst. Electron. Inf. Commun. Eng. **109**(28), 13–18 (2009)

8. Tanaka, Y., Oyama, T., Osgood, C.E.: A cross-culture and cross-concept study of the generality of semantic spaces. J. Verbal Learn. Verbal Behav. **2**(5–6), 392–405 (1963)
9. Kawachi, Y., Kawabata, H., Kitamura, M.S., Shibata, M., Imaizumi, O., Gyoba, J.: Topographic distribution of brain activities corresponding to psychological structures underlying affective meanings. Jpn. Psychol. Res. **53**(4), 361–371 (2011)
10. Sanui, J.: Visualization of users' requirements: Introduction of the Evaluation Grid Method. In: Proceedings of the 3rd Design and Decision Support Systems in Architecture and Urban Planning Conference, Japan, vol. 1, pp. 365–374 (1996)
11. Onoue, Y., Kukimoto, N., Sakamoto, N., Koyamada, K.: E-Grid: a visual analytics system for evaluation structures. J. Vis. **19**(4), 753–768 (2016). https://doi.org/10.1007/s12650-015-0342-6