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Experimental Verification for Subjective Sense of Object Weight

Proposed User Category based on the individual Kansei by Subjective Weight

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Abstract: Weight is frequently used in product information and the design process. However, the perceived weight is greatly influenced by individual subjectivity. Guessing the exact weight using only numerical information and visual estimation is not easy. Therefore, this study focused on the relationship between the perceived weight and actual weight, and verified the difference between the subjective and physical senses of weight. In other words, we aimed to explore the error range, and to reveal the characteristics of the subjective sense of weight. We performed two experiments. Experiment A is for the 'subjective sense of weight due to the difference in weigh' using models with differing weights but the same size, and Experiment B is for the 'subjective sense of weight by size' using models with differing sizes but the same weight. In the results, the average subjective weight of the 170 g model was 223 g for an error rate of approximately 31%. On the other hand, the average subjective weight of the 100 g model was 103 g. Therefore, the error between the subjective and physical weights was greatest at 100–170 g in Experiment A. In Experiment B, the average subjective weight of the 170 g model with a diameter of 75 mm was 298 g, which is 75% greater than the physical weight. The error for the 170 g model was smallest at -4% when the diameter was 120 mm. In other words, the error decreased with increasing model size in Experiment B.

Keywords: Kansei Evaluation, Subjective Weight, Perceived Weight, Recognition Model, Sensory Measurement.

1. INTRODUCTION

Weight is a property specific to the physical system of an object. It is frequently used in product information and the product design process. In recent years, weight saving of products has become an important issue in manufacturing. Especially in the field of aviation and automotive, they are aiming the weight saving of the machine for energy conservation. And, it is necessary to reduce the weight of the product in order to increase the portability of Electronics.

However, the perceived weight is greatly influenced by individual subjectivity. For example, exactly the same design might be feeling lighter or heavier by a personal impression. Guessing the exact weight using only numerical information and visual estimation is not easy, and individuals can interpret the information differently. Therefore, this study focused on the relationship between the perceived weight (subjective sense of weight) and actual weight (physical weight).

There have been few studies on the perception of weight, and these were limited to particular products. In this study, we therefore limited the shape to a sphere small enough to fit in one hand to serve as basic research that is applicable to various product designs.

In other words, this study verified the difference between the subjective and physical senses of weight. We aimed to explore the error range, and to reveal the characteristics of the subjective sense of weight. It could relate subjective sense of weight to Kansei.

2. OVERVIEW OF RESEARCH

For this study, we performed two experiments. Experiment A is examined for the 'subjective sense of weight due to the difference in weigh' using models with differing weights but the same size. And, Experiment B is examined for the 'subjective sense of weight by size' using models with differing sizes but the same weight.

In Experiment A, the weights of the 100 mm diameter plastic balls were changed. Five different weights of 100–600 g were used to represent electronic products used in daily life. In Experiment B, the plastic balls had diameters of 75, 100, and 120 mm, and two weights of 170 and 460 g were used. Table 1 shows the contents for the experimental models. Figure 1 and figure 2 show the image of the experimental models.

Table 1: Experimental contents

	Shape	Size (Diameter)	Weight
Experiment A	Sphere	Same	Difference
Experiment B	Sphere	Difference	Same

Figure 1: Models for Experiment A

Figure 2: 170 g Models (left) and 460 g models (right) for Experiment B

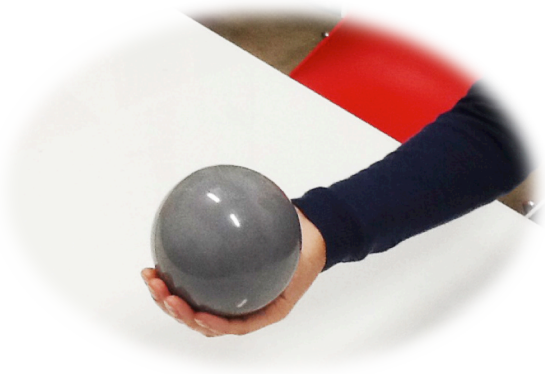

Figure 3: Condition of the experiment

For the experiments, the subjects were asked to weigh a 500 ml PET bottle for 10 s to prepare for this experiment. They were then asked to weigh the nine models of Experiments A and B, which were presented at random. The 50 subjects were all male college students with an average age of 23.5 years; they were all right-handed. Figure 3 shows how to perform the actual experiment.

3. RESULTS AND ANAYSES

3.1. Experiment A

Table 2 shows the overall results of Experiment A. In the table 2, the average subjective weight of the 100 g model (A-1) was 91.2 g for an error rate of -9%. And, 170 g model (A-2) was 222.2 g for an error rate of +31%. Subsequently, 280 g model (A-3) was 326.8 g (+17%), 460 g model (A-4) was 652.6 g (+42%), and 600 g model (A-5) was 761.1 g (+27%). In the results, the average subjective weight of the 170 g model was 222.2 g for an error rate of approximately 31%.

On the other hand, the average subjective weight of the 100 g model was 91.2 g. This produced the smallest error of about -9%. Therefore, the error between the subjective and physical weights was greatest at 100–170 g in Experiment A. In figure 4, we could fine that the subjective weight was judged heavier than the actual weight on below 600 g models. However, individual differences appeared large in all models.

Figure 5 is the graph of user category by error rate. In Experiment A, the group with error rate of less than 20% is 48%. The group with error rate of less than 50% is 36%, and the group with error rate of 50% or more is 16%. According to the personal weight senses, they could be divided into the accurately judging group, judging the objects to be lighter group, and the group that believed the objects to be heavier than the actual weights.

Table 2: Result of Experiment A

Models	A-1	A-2	A-3	A-4	A-5
physical weight (g)	100	170	280	460	600
subjective weight (g)	**91.2**	**222.2**	**326.8**	**652.6**	**761.1**
sd	54.2	111.8	133.0	243.1	224.9
error	-8.8	52.2	46.8	192.6	161.1
error rate (%)	**-9%**	**+31%**	**+17%**	**+42%**	**+27%**

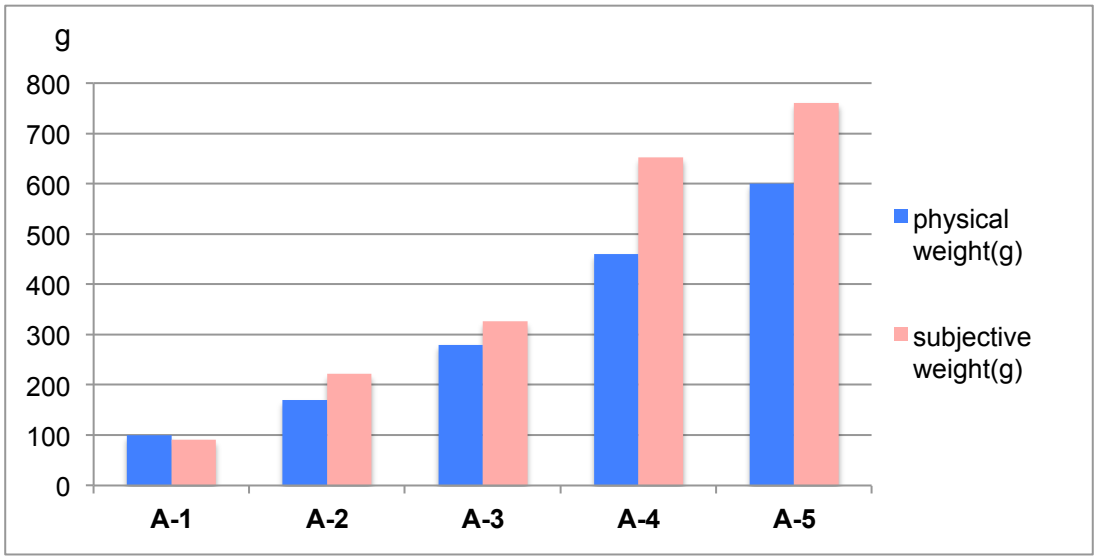

Figure 4: Comparison of subjective weight with physical weight for Experiment A

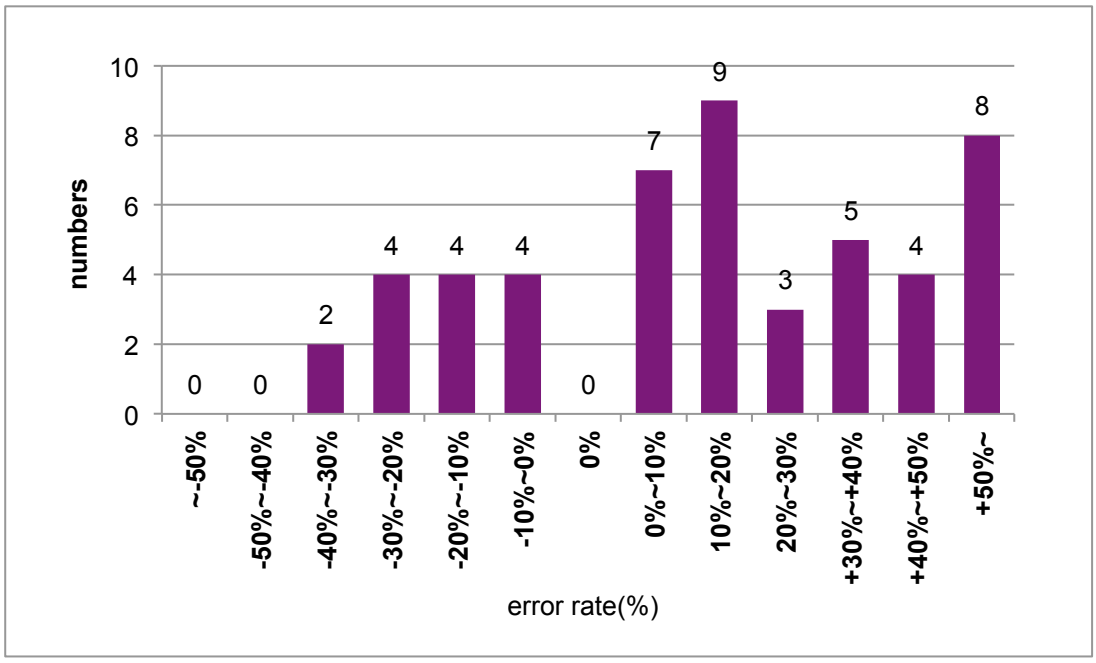

Figure 5: Error rate of Experiment A

3.2. Experiment B

Table 3 shows the overall results of Experiment B. In the table 3, the average subjective weight of the 170 g model with a diameter of 75 mm (B-1) was 305.7 g, which is 80% greater than the physical weight. The 170 g model with a diameter of 100 mm (B-2) was 226.4 g (+33%), and the 170 g model with a diameter of 120 mm (B-3) was 157.8 g (-7%). In this result, the error for the 170 g model was smallest at -7% when the diameter was 120mm.

On the other hand, the average subjective weight of the 460 g model with a diameter of 75 mm was 719.8 g, which is 56% greater than the physical weight. The 460 g model with a diameter of 100 mm was 643 g (+40%), and the 460 g model with a diameter of 120 mm was 539.9 g (+17%). In this result, the error for the 460 g model was smallest at +17% when the diameter was 120mm. Therefore, the error decreased with increasing model size in Experiment B (Figure 6).

Figure 7 and Figure 8 are the graph of user category by error rate for Experiment B. In Figure 7, the group with error rate of less than 20% is 28%. The group with error rate of less than 50% is 32%, and the group with error rate of 50% or more is 40%. In Figure 8, the group with error rate of less than 20% is 32%. The group with error rate of less than 50% is 36%, and the group with error rate of 50% or more is 32%.

Table 3: Result of Experiment B

models	B-1	B-2	B-3	B-4	B-5	B-6
Diameter (mm)	75	100	120	75	100	120
physical weight (g)	170	170	170	460	460	460
subjective weight (g)	**305.7**	**226.4**	**157.8**	**719.8**	**643**	**539.9**
sd	136.2	114.7	93.3	245.2	203.3	221.2
error	135.7	56.4	-12.2	259.8	183	79.9
error rate (%)	**+80%**	**+33%**	**-7%**	**+56%**	**+40%**	**+17%**

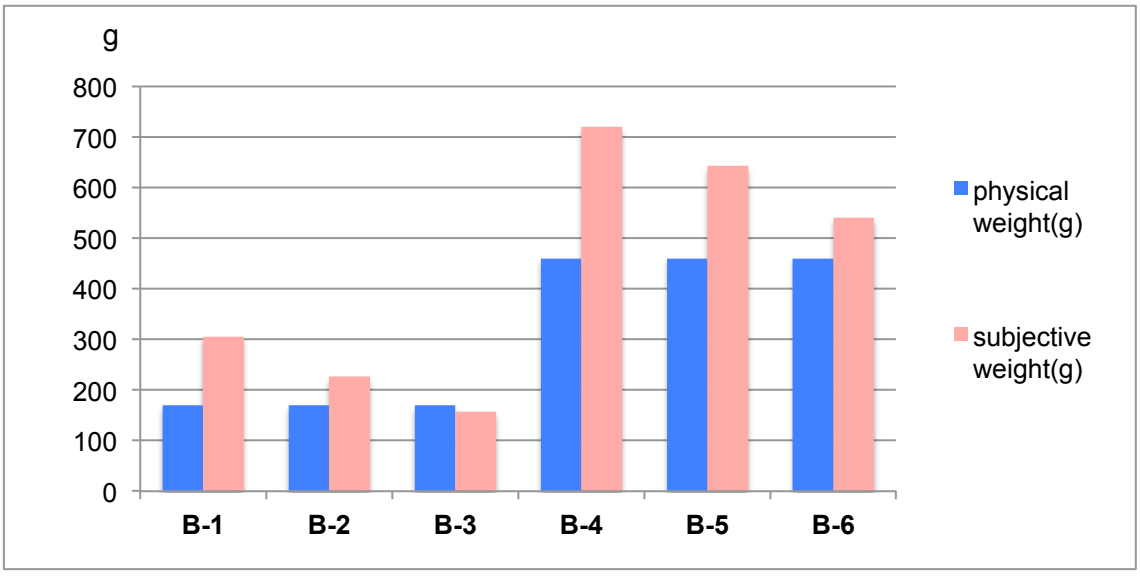

Figure 6: Comparison of subjective weight with physical weight for Experiment B

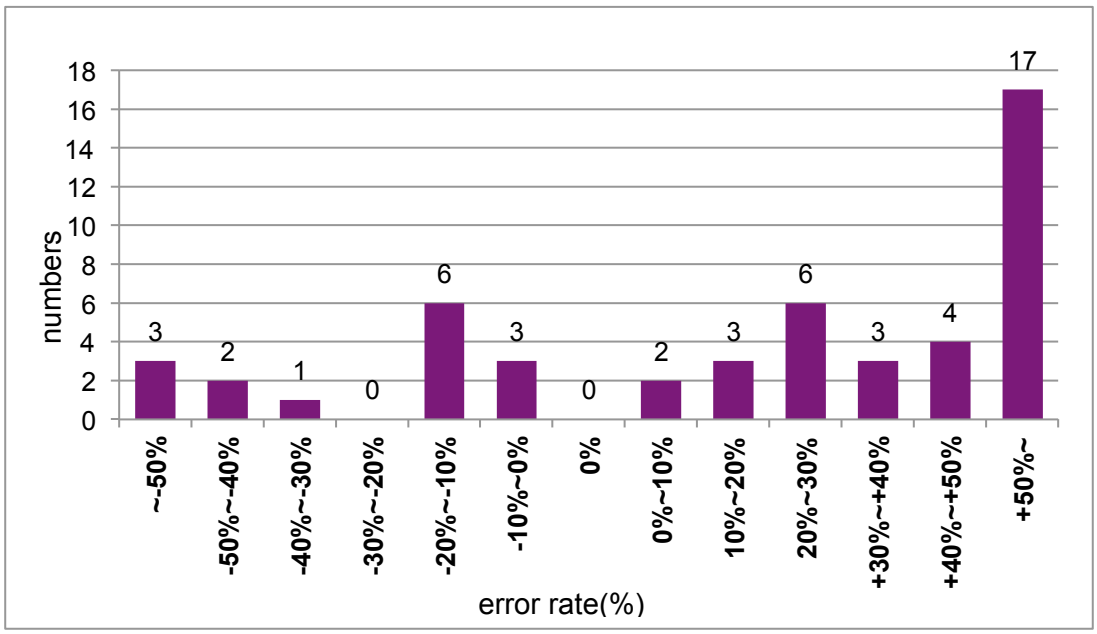

Figure 7: Error rate for 170 g models of Experiment B

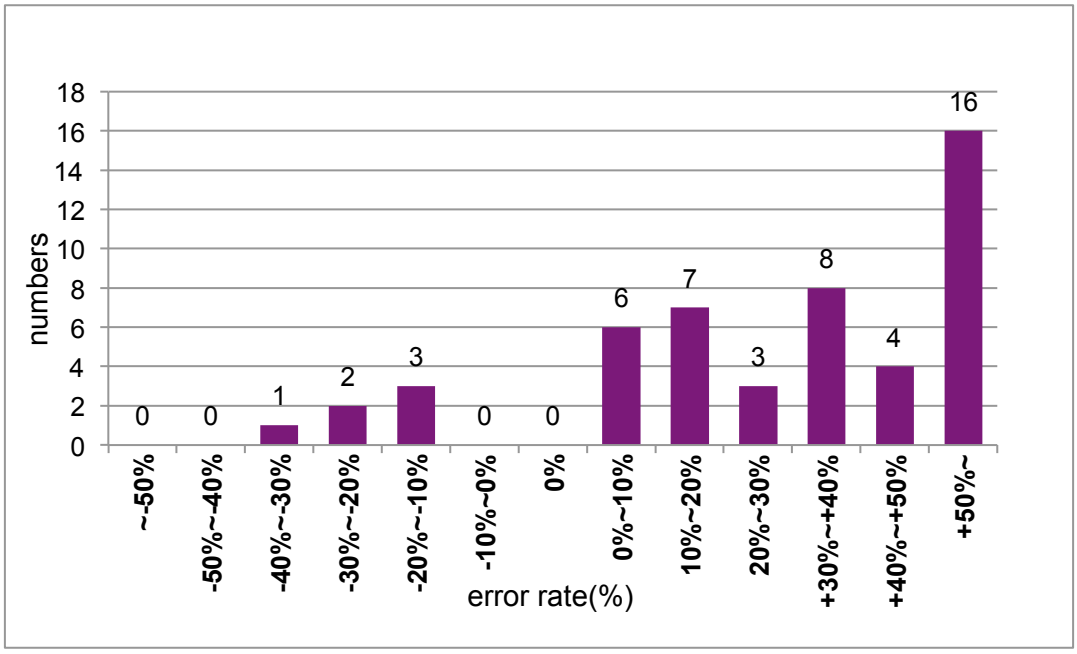

Figure 8: Error rate for 460 g models of Experiment B

4. DISCUSSIONS

This study revealed that there is a large error between the perceived weight (subjective sense of weight) and actual weight (physical weight). Based on these results, we have divided the groups by cluster analysis and subjective weight. Figure 9 is the graph of distribution of user by subjective weigh. The group that feels heavy more than 20% below the actual weight is 50%. The group that feels heavy more than 65% is 26%. The group that feels very heavy more than 120% is 12%. At the end, the group that feels lightly is only 12%.

By figure 9, we found that estimated 90% of people are feeling heavier than the actual weight for the recognition of the object weight. Further, 40% of people feel heavier than 65% than the weight

of the actual weight. This means that it is difficult to accurately recognize the user numerical information is used as the product information.

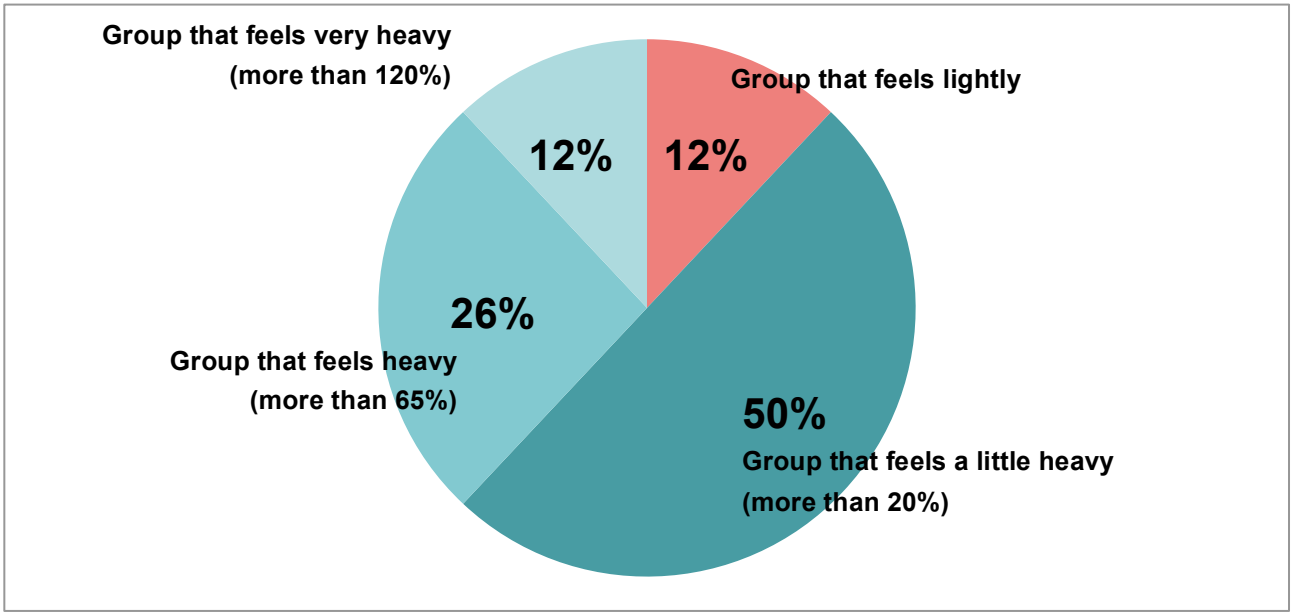

Figure 9: Distribution of user by subjective weight

5. CONCLUSION

From this study, we revealed the following;

- In average, the subjective weight was judged 24% heavier than the actual weight on below 600 g models.

- The greatest difference, between the actual weight and the subjective weight, was on the models that were between 100 and 170 g. When the actual weights were equal but the sizes were different, the bigger objects were considered lighter in their subjective weights.

- In 170 g objects, the size 75 mm model was judged as two times heavier than the 120 mm model. According to the personal weight senses, they could be divided into user groups.

- We think this study could relate subjective sense of weight to individual *Kansei.* Through the analyses of the error range and the characteristics of the subjective sense of weight, we expect the support of design sensibility that made use of the sense of human nature.

In the future, we aim to explore the shape characteristics that affect the perception of weight by creating models of various shapes around the weight range with the greatest error.

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BIOGRAPHY

Short biography of author 1

Miyong Lee received her Ph. D. in Kansei Science of Tsukuba University. Theme of the doctoral thesis is “Recognition Characteristics of Shapes based on Kansei Evaluation: for an Effective Visual Communication in Design” (2009). She is now engaged in Kansei evaluation using a new evaluation method and in the user category based on the recognition of the individual characteristics for various stimuli. She is an assistant professor of research group of micromechanical systems, Division of Human Mechanical Systems and Design, Graduate School of Engineering, Hokkaido University since 2010.

Short biography of author 2

Kazuhiro Nishida was in the master course program of Mechanical Engineering of Graduate School of Engineering, Hokkaido University, when he was engaged in the present research. He was interested in studying “textile feeling” and “sense of weight” for universal design. He completed the master program in 2013, and is now working for aftermarket division in DENSO Corporation.

Short biography of author 3

Yoshihiro Narita is Professor of Mechanical Engineering of Hokkaido University, and he obtained Doctor of Engineering in 1980 from Hokkaido University. His research interests cover Dynamics of machines, System engineering, Composite materials, Optimization, Engineering education and Kansei engineering. He was Executive board director, Division chair and Branch chair of JSME. He is an Executive chairman of the Spring Kansei Conference, March 2014 in Sapporo.