Studies on Method for Measuring Human Feelings

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Abstract. In this paper it is studied how to measure human feelings. Since human feelings are not simple and very complicated and it is not easy to evaluate them. Generally human feelings are considered nonlinear and methods for paired comparison are useful to deal with nonlinear problems. For the reason it is studied how to use paired comparison for measuring human feelings. Among many methods for paired comparison Case V of Thurston's method is perceived. For the measurement obtained by Case V of Thurston's method for paired comparison is useful because the units of the measurement are the standard deviations of the standard normal distributions Here it is discussed to measure human feelings using paired comparison.

1 Introduction

Methods of paired comparisons are useful for measuring human sensations or feelings. Measuring human sensations is a main concern of the study of Psychophysics created by Fechner in 1860. Thurstone's method of paired comparisons, which is a typical method of paired comparisons, was proposed as a method of psychophysical analysis and developed by Mosteller. Thurstone's method is a series of methods from questionnaire survey to statistical analysis for the analysis of human sensations and has been developed mainly for sensory tests as are Scheffe's method and Bradley's method. Besides these methods for paired comparisons, there are methods using paired comparisons to measure human subjective evaluation, which start with paired comparisons and end up solving eigenvalue problems. One is Guttman's method and another is AHP (Analytic Hierarchy Process), proposed by Saaty. Guttman's method was developed with the aim of determining the order of priority to demobilize American soldiers after the Second World War. AHP was studied as a method to properly combine subjective judgment with a systematic approach and is now widely adopted in Europe, U.S.A. and other areas in various fields, such as economic problems, management problems, energy problems, policy decision, and city planning. Among the above mentioned methods for paired comparisons, Thurstone's method has a long history and is a typical method in Psychometrics, useful for measuring not only sensations, but also feelings. Taking the feelings about food, for example, it is possible to measure our feelings about food or to classify menus on home dining tables according to human feelings using the method and related techniques.

2   Difference of Sensations and Feelings

Human sensations and perceptions are considered separately in psychology, and human sensations and feelings should also be considered separately. We feel something about objects in the manner shown in Figure 1: first, we are conscious of the existence of objects through sensory organs, perceive them based on our knowledge, recognize them through our experience or learning, and feel something about them variously mixing our preference, emotion, or sentiment. Methods for paired comparisons have been used for measuring human sensations and when sensations are measured by using paired comparisons, pairs of objects are compared. On the other hand, for measuring human feelings, words are useful to make comparisons. In order to measure our feelings for food, the framework of human meal behavior should be defined.
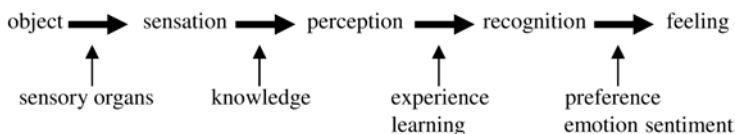
object ⟶ sensation ⟶ perception ⟶ recognition ⟶ feeling

sensory organs   knowledge   experience   preference
                                learning   emotion sentiment

Fig. 1. Process of having feelings toward objects

3   Framework of Human Meal Behavior

We must take meals to be alive and active. Regardless of our situation or interest in taking meals we cannot survive without eating. This is the reason for behavior relating to eating conveniently at meals. e also eat not only for the need to be alive but for enjoyment. Enjoying meals means to search for good taste or to put much importance on the culture of taking meals. This is the reason for the earnestness of meals and meal behavior. Moreover food has the health-related function such that eating certain foods is good for our health and eating others is bad for our health. In this manner, we are concerned about our bodies when eating. This is the reason for behavior relating to eating healthily at meals. In the towns in Japan, for example, many fast food shops or convenience stores can be found and it follows that there are quite a few people who want to finish their meals conveniently. On the other hand, when fast food shops first appeared in Italy in the 1980s, people felt that these shops would ruin Italian food culture and in 1986 at a village BRA in Italy, the slow food movement arose against fast food. In 1989, the slow food convivium (President: Carlo Petrini) was established with the aim of preserving Italian food culture and now has more than seven hundred thousand members from all over the world. Slow food convivium is now established at several places in Japan (Tokyo. Miyagi, Yamagata etc.), too. It can naturally be said that there are many people who consider meals important and serious in terms of their attitude to life, that is, they take meals earnestly. In addition to human "convenience-oriented meal behavior" and "earnestness-oriented meal behavior", human "health-oriented behavior" is also obvious because we have been seeing various foods known as "health food" or "natural food" sold and now many kinds of functional food can be found. For the above reasons the framework of human meal behavior is defined as "convenience", "health", "earnestness".

4   Thurstone's Method of Paired Comparisons

In Thurstone's method of paired comparisons there are 5 ways - case I, case II, case III, case IV and case V depending on assumptions about the distribution of human sensations. Since case V gives us scales, the units of which are the standard deviations of the standard normal distribution, the scales are very helpful for us to compare human sensations or feelings among many objects. In case V of Thurstone's method, however, it is assumed that human sensations are normally distributed and the standard deviations of each distribution are equal. It is therefore necessary to find out whether scales obtained by paired comparisons fit the assumption of case V of Thurstone's method.

5   Experiment by Paired Comparisons

The results are shown an experiment on human feelings about food by paired comparisons conducted with the stimuli being the words "convenience", "health" and "earnestness". In the experiment, the subjects, 135 University students, were equally divided into 3 groups, that is, each group consisted of 45 subjects and were asked three different questions, depending on group, with respect to 200 menus on home dining tables. Specifically, one group was asked whether each menu was convenience oriented or health oriented, another group was asked whether each menu was health oriented or earnestness oriented, and the third group was asked whether each menu was earnestness oriented or convenience oriented.

6   Test of Goodness of Fit

As for the results obtained, we need to test the goodness of fit to the model assumed in Case V of Thurstone's method of paired comparisons. To do this we obtain the estimated proportions EP_{ch}, EP_{he} and EP_{ec} corresponding to the differences of the convenience-oriented and health-oriented average values, the health-oriented and earnestness-oriented average values, and the earnestness-oriented and convenience-oriented average values respectively. We also obtain the true proportions TP_{ch}, TP_{he} and TP_{ec} for EP_{ch}, EP_{he} and EP_{ec} respectively. Now for each proportion an arcsine transformation is made as follows:

$$
\begin{aligned}
E\theta_{ch} &= \arcsin \sqrt{EP_{ch}} \\
E\theta_{he} &= \arcsin \sqrt{EP_{he}} \\
E\theta_{ec} &= \arcsin \sqrt{EP_{ec}} \\
T\theta_{ch} &= \arcsin \sqrt{TP_{ch}} \\
T\theta_{he} &= \arcsin \sqrt{TP_{he}} \\
T\theta_{ec} &= \arcsin \sqrt{TP_{ec}}
\end{aligned}
\tag{1}
$$

We calculate the test statistic

$$
\chi_0^2 = \frac{n[(E\theta_{ch}-T\theta_{ch})^2+(E\theta_{he}-T\theta_{he})^2+(E\theta_{ec}-T\theta_{ec})^2]}{821}
\tag{2}
$$

and obtain the critical value $\chi^2(df_1,\alpha)$ at the significance level α for degrees of freedom

$$df_1 = \frac{1}{2}(n-1)(n-2) \tag{3}$$

where n is the number of stimuli. If $\chi_0^2 < \chi^2(df_1, \alpha)$ is satisfied, it is determined that feelings fit the assumption of Thurstone's method .

The fitness of feelings to Thurstone's assumption has been tested for 200 menus on home dining tables including fried fish dressed with liquid starch and seafood and vegetables dressed with liquid starch. In this case stimuli are menus with convenience-oriented feelings, health-oriented feelings and earnestness-oriented feelings. Hence there are three stimuli, $n=3$. Substituting this in (3) we obtain $df_1 = 1$. Thus the critical value at 5% level of significance comes out

$$\chi^2(1, 0.05) = 3.84 . \tag{4}$$

The test statistic χ_0^2 was obtained from (2) to be 1.93, which is less than the critical value 3.84 for fried fish dressed with liquid starch and 4.84, which is not less than the critical value 3.84 for seafood and vegetables dressed with liquid starch. It is therefore statistically determined that the observed feelings fit the assumption of Case V of Thurstone's method for fried fish dressed with liquid starch but the observed feelings do not fit the assumption for seafood and vegetables dressed with liquid starch. The results were obtained for 200 menus on home dining tables as follows: the observed feelings fit the assumption for 51 menus and do not fit the assumption for 149 menus. These results show that it is considered impossible for evaluation of feelings to use the values obtained from the experiment. It is therefore necessary to consider another method to analyze human meal feelings. Thus a method is considered to classify menus on home dining tables according to human feelings using the method of paired comparisons.

7   Agreement of Feelings

In order to classify menus on home dining tables using the data obtained from the experiment on human feelings, it is necessary to confirm the agreement of the observed feelings among many subjects. To do this, coefficient of agreement is used.

Let k be the number of subjects, n be the number of stimuli and x_{ij} be the number of subjects who choose stimulus i in the comparison of stimuli i and j. Coefficient of agreement is given by

$$u = \frac{2[\,_k C_2 \times\,_n C_2 - \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} x_{ij}(k - x_{ij})]}{\,_k C_2 \times\,_n C_2} - 1 \tag{5}$$

where $-1 \le u \le 1$. The values obtained by (5) show how the observed feelings agree among subjects. To test the significance of agreement on feelings, the chi-square test is conducted. To do this, first, we calculate the test statistic

$$\chi_0^2 = \frac{4}{k-2}[\,_k C_2 \times\,_n C_2 - \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} x_{ij}(k - x_{ij}) - \frac{kn(k-1)(k-3)(n-1)}{8(k-2)}] \tag{6}$$

and next we obtain the degrees of freedom. The value of the degrees of freedom is given by

$$df_2 = \frac{kn(k-1)(n-1)}{2(k-2)^2} . \tag{7}$$

If $\chi_0^2 \geq \chi^2(df_2, \alpha)$ is satisfied, it is determined that feelings agree at the significance level α. Here $k = 45$, $n = 3$ hence we have $df_2 = 3.21$. The critical value $\chi^2(df_2, 0.05)$ at 5% level of significance comes out as

$$7.81 = \chi^2(3, 0.05) < \chi^2(df_2, 0.05) < \chi^2(4, 0.05) = 9.50$$
$$\therefore 7.81 < \chi^2(df_2, 0.05) < 9.50 . \tag{8}$$

The test statistic χ_0^2 is calculated by (6). It is 4.98 for fried fish dressed with liquid starch and 5.91 for seafood and vegetables dressed with liquid starch. Both values of χ_0^2 for fried fish dressed with liquid starch and seafood and vegetables dressed with liquid starch are less than 7.81 hence they are less than the critical value $\chi^2(df_2, 0.05)$. It is therefore determined that the observed feelings for fried fish dressed with liquid starch and seafood and vegetables dressed with liquid starch do not agree among subjects. The agreement of feelings was tested with respect to 200 menus on home dining tables and it has been concluded that the observed feelings for 35 menus (17.5%) agree and those for 165 menus (82.5%) do not agree among subjects. Tables 5 and 6 show 15 menus in which feelings do not agree (Table 1) and feelings agree (Table 2) as examples. In these tables, the values of the agreement of coefficient u and test statistic χ_0^2 for each menu are also shown.

Table 1. The menus in which feelings do not agree

Menus	u	χ_0^2
Slices of seafood	-0.02	0.33
Pasta salad · Salad noodles ·Chinese noodles salad	-0.01	2.00
Eggs fried in a pan	0.01	4.05
Cooked rice and red beans	0.01	4.79
Cheese	0.01	4.98
Tea	0.01	5.17
Broiled vegetables	0.02	5.54
Chinese soap	0.02	6.10
Bread	0.03	6.84
Broiled shellfish	0.03	7.03
Pickled ume	0.03	7.03
Vegetables boiled down in soy	0.03	7.40
Boiled fish paste	0.03	7.40
Minced fish	0.03	7.77
Boiled plain ·chowder	0.03	7.77

Table 2. The menus in which feelings agree

Menus	u	χ_0^2
Toast	0.04	9.70
Stick salad	0.07	12.61
Meuniere of fish	0.09	15.96
Rice ball	0.12	19.49
Mixed rice	0.13	20.79
Rice fried in a hot pan	0.14	22.10
Fish teriyaki	0.18	27.49
Kinds of bean curd	0.20	31.03
Mixed salad	0.24	35.86
Steak	0.27	40.51
Green fruit	0.27	40.51
Gratin	0.29	43.86
Bacon	0.30	44.42
Laver	0.30	44.79
Dried vegetables and seafood	0.38	56.33

8 Classification of Menus

Menus on home dining tables are classified into four groups: a group of convenience-oriented menus, a group of health-oriented menus, a group of earnestness-oriented menus, and a group of non-oriented menus. The menus for which it is statistically determined that the observed feelings do not agree among subjects are put into a group of non-oriented menus. Therefore fried fish dressed with liquid starch and seafood and vegetables dressed with liquid starch, taken as examples of menus on home dining tables from 200 menus, belong to a group of non-oriented menus. There are 35 menus among 200 menus in which feelings do not agree and those menus belong to a group of non-oriented menus. The menus listed in Table 1 therefore are examples of non-oriented menus. As for the menus in which feelings agree, if the scale of the convenience-oriented feeling is the largest compared with those of two other feelings, the menu is put into the group of convenience-oriented menus, if the scale of the health-oriented feeling is the largest, the menu is put into the group of health-oriented menus, and if the scale of the earnestness-oriented feeling is the largest, the menu is put into the group of earnestness-oriented menus. Table 3 shows examples of the menus in which it is statistically determined that feelings agree and their scales for convenience-oriented feeling, health-oriented feeling and earnestness-oriented feeling. In terms of Table 3, this means that corned beef turns out to be a convenience-oriented menu because the scale for the convenience-oriented feeling is the largest, yogurt turns out to be a health-oriented menu because the scale for the health-oriented feeling is the largest, and spagetti turns out to be an earnestness-oriented menu because the scale for the earnestness-oriented feeling is the largest.

Table 3. Scales of menus

Menu	Convenience	Health	Earnestness
Corned beef	1.499	-1.442	-0.057
Yogurt	-0.615	1.923	-1.308
Spagetti	0.304	-1.513	1.209

9 Final Remarks

The measurement of human sensations or feelings is helpful in various fields and methods of paired comparisons are useful to do this. Studies on methods of paired comparisons have a long history and many methods have been proposed. In order to use methods of paired comparisons effectively, it is important to determine what to measure, sensations or feelings etc., choose appropriate methods from the many methods of paired comparisons, and consider how to use them according to the problems at hand.

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