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Cognitive Sensory Evaluation of Potato Chips Using Cognitive Sensory Barcode and Frequency Curve Method

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Abstract

The cognitive sensory evaluation method, which was developed based on the multi-layer consciousness concept, was implemented to obtain a subjective response to a food item. In this method, the cognitive sensory barcode and frequency curve were obtained and analyzed for both an individual and a group. A questionnaire containing 158 questions, including 53 objective and 105 subjective parameters, was designed to evaluate potato chips for 38 subjects. The responses of the subjects were converted into visualized formats using barcodes and frequency curve patterns. The cognitive sensory barcode patterns of individual subjects, which were characterized by the arrays and overlapped height of a bar, showed a unique pattern for each individual. The concept of the individual cognitive barcode and curve patterns was extended to the characterization of the groups of subjects. Clustering analysis was employed to classify the subjects into eight subgroups according to similarities in the bar patterns. The representative cognitive frequency curve of a subgroup was constructed by averaging their patterns for the relevant subgroup. The difference in the cognitive sensory pattern indicated that the consciousness elements of individuals are closely associated with the sensory evaluation of foods.

Key words: cognitive sensory evaluation, barcode, frequency, potato flake, food

Introduction

Despite the unknown human cognitive mechanism in sensory judgment, sensory evaluation methods based on panel tests have been widely used all over the world. Much work on sensory evaluation methodologies has the potential problem of inconsistency due to individual variances among panelists. Chun (2000, 2002) tried to resolve this inherent problem by developing a new concept for the sensory evaluation of food on the basis of a human's multi-layer consciousness. His concept was tested for 12 subjects using cooked-rice, and the experimental result indicated that individual sensory properties could be evaluated with a barcode or frequency curve pattern. He reported the presence of differences in the barcode and curve patterns of the individual participating in the test. He concluded that these differences were caused by the differences in the subjective consciousness parameters of the panelists. Therefore, both the barcode and frequency patterns could be used to display the subjective and objective factors associated with the sensory evaluation process.

This study was aimed to verify the concept of the multi-layer consciousness system by its application to different popular food items with an increased number of subjects.

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Materials and Methods

Materials

Potato chips (200g pack, packaged in laminated aluminum bag, NongShim Co., Korea) were used as the food item. The package was freshly opened prior to the sensory test.

Table 1. Sensory evaluation parameters and contents of the questionnaire for the cognitive sensory evaluation of potato chips

Parameters	Inquiry groups	Contents of questionnaire
Objective parameters	Environment	Brightness, temperature, humidity, audio-factor, visual-factor
	Product property	Taste, flavor, shape, color, chewing sound, texture.
Subjective Parameters	5^{TH} sensory state	Gender, age, weight, height, hunger, health (eye, ear, nose, tongue, mouth, stomach), sensitivity of sense organs, smoking and preference associated with five senses.
	6^{TH} consciousness	Schema, effect of schema, knowledge of product information, family education, education, concentration.
	7^{TH} consciousness	Age of first eat, frequency of eating, cooking experience, ability of association, direction of association, preference of family, hobby, first impression, demand of unconsciousness state, ideology, feeling after eating, faith, rationality, religious teaching, frequency of dreaming, similarity of eating habit.
	8^{TH} consciousness	Eating while pregnant, given digestibility, willingness, awareness of mind, frequency of meditation.

Methods

Panel: Thirty eight subjects (n=38) from the students in majoring food science and technology at Seoul National University were chosen as the panelists.

Questionnaire: The questionnaire developed by Chun (2001) was modified for potato chips and used in this experiment. The questionnaire consisted of 158 questions, and contained 105 subjective and 53 objective parameters (Table 1).

Construction method of cognitive sensory barcode

The data from the questionnaires were stored in a database and used for further analysis. In order to construct the cognitive sensory barcode for an individual subject, three data processing steps were employed. First, the informative sensory register (IS-Register, 5-bit) was prepared and loaded with the digitized value of the answered data from the database for the six inquiry groups (see Table 1). The number of the IS-registers assigned to each subject was 158, which was equivalent to the number of the answered data. Second, the loaded IS-registers for each inquiry group were serialized according to the listed order of the inquiring contents in the questionnaire, and the resultant serialized register for each inquiry group defined as a serialized informative sensory register (SIS-register). Third, the digital bit set “1” in each SIS-register was converted into a bar with a unit width and height, and the thickness of the bar was calibrated by multiplying the relevant weighted value. The lengths of the entire barcode pattern of each inquiry group were identical. Finally, a cognitive sensory barcode was constructed by overlapping the barcode patterns of the six inquiry groups. Computer programs were developed for these procedures through-out this study.

Construction method of cognitive sensory frequency curve

The cognitive sensory frequency curve pattern was constructed using the cognitive sensory barcode described above. By connecting the mid points of the individual bars, the barcode pattern could be transformed to the curve pattern. This process was conducted using a computer program specifically developed during this study.

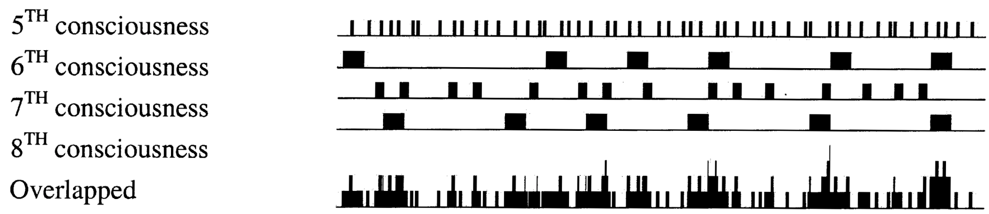

Fig. 1. Cognitive sensory barcode obtained from a panel for potato chips.

Clustering analysis

A SAS clustering analysis was used to classify the panels on the basis of the similarity in the cognitive sensory barcode patterns.

Results and Discussion

Cognitive sensory barcode of potato chips for individual subject

The cognitive sensory response can be considered as a behavior resulting from the full mobilization of the human consciousness process (Chun, 2000). The full mobilization can be expressed as an overlapped form of the participating consciousness layers. This concept provided an idea for this research; the overlapping process of the cognitive barcode-patterns of the relevant inquiry groups to construct an overall cognitive sensory bar-pattern. A typical cognitive sensory barcode obtained from one of the subjects is presented in Fig. 1.

As shown in Fig. 1, the overlapped bars were redrawn on the top part. This prevented the loss of information in the overlapping process due to the previously reported masking phenomenon (Chun, 2000). This highly informative sensory barcode represents the overall sensory responses of an individual, reflecting both the subjective and objective sensory parameters.

Effect of consciousness parameters on the cognitive sensory barcode

The cognitive sensory barcode was designed based on the fact that the sensory response of a subject is closely associated with his or her consciousness state, which indicates that any change in consciousness can result in a different pattern of the cognitive sensory barcode in terms of widths and heights. The width and height of a bar represent the attribute weight and the association intensity of each stimulus, respectively.

Since, the height was determined by the summation of the overlapped array components in the cognitive sensory bar-patterns among the relevant inquiry groups, it indicated the intensity of the stimuli. In Fig. 1, five portions of the cognitive barcode pattern reached the third level, indicating that the stimuli from three layers of consciousness were involved in the sensory cognitive process.

The width was determined by the multiplying attribute weight. Therefore, the more weighted the wider resultant bar. This method was more improved compared the previous method (Chun, 2000) in that it could reflect every sensory stimulus without the loss of any information during the summation process.

The cognitive sensory bar-pattern can be used to identify an individual sensory response and explain the individual variance in the sensory evaluation process. Also, it can be applied to classify panels into several groups according to the pattern similarity within the barcodes.

Development of cognitive sensory frequency curve

Despite the presence of pattern similarity among the barcodes, they are not easy to classify due to the complicated shape of the patterns. An attempt at the better visualization of the sensory pattern was made by converting the barcode pattern into the relevant frequency wave, as reported by Chun (2000). In his first attempt he tried to express all sensory stimuli without any lose due to the overlapping phenomenon. In this study, conversion from the barcode to the frequency curve was accomplished by simply connecting three mid points (left, right and top sides) of each of the rectangular bars. This method was more convenient than the previous transformation process based on the sinusoidal curvature method (Chun, 2000). Fig. 2 shows the cognitive sensory frequency curve converted from the cognitive sensory barcode pattern for potato chips.

As mentioned above, with the cognitive sensory frequency curve it was much easier to figure out both the difference and similarity than with the barcode pattern. The height of the wave represented the degree of association of consciousness, which came from the occurrence of overlapping among the consciousness layers. Several waves were able to be observed in the cognitive sensory frequency curve of an individual (Fig. 2 b).

Cognitive sensory frequency curves of a subject group

The cognitive sensory frequency curves obtained from

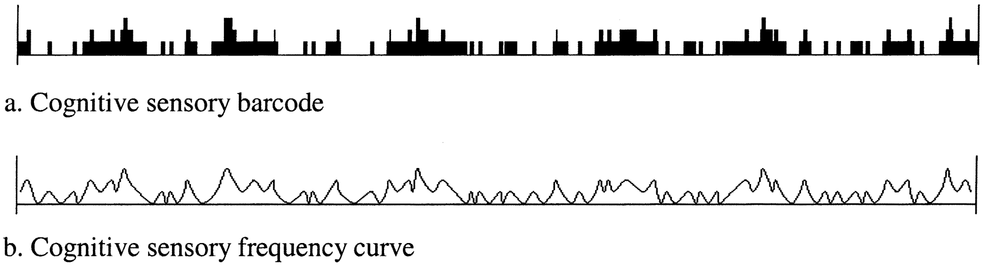

Fig. 2. A cognitive sensory frequency curve converted from a cognitive sensory barcode for potato chips

for the selected subjects potato chips are shown in Fig. 3. From the curves, two facts were found; 1) none of the individual curves were identical, and 2) there were common parts among the curves. These findings provided the possibilities for its application; the former can be used to identify individual sensory characteristics, and the latter to make clusters according to pattern similarities.

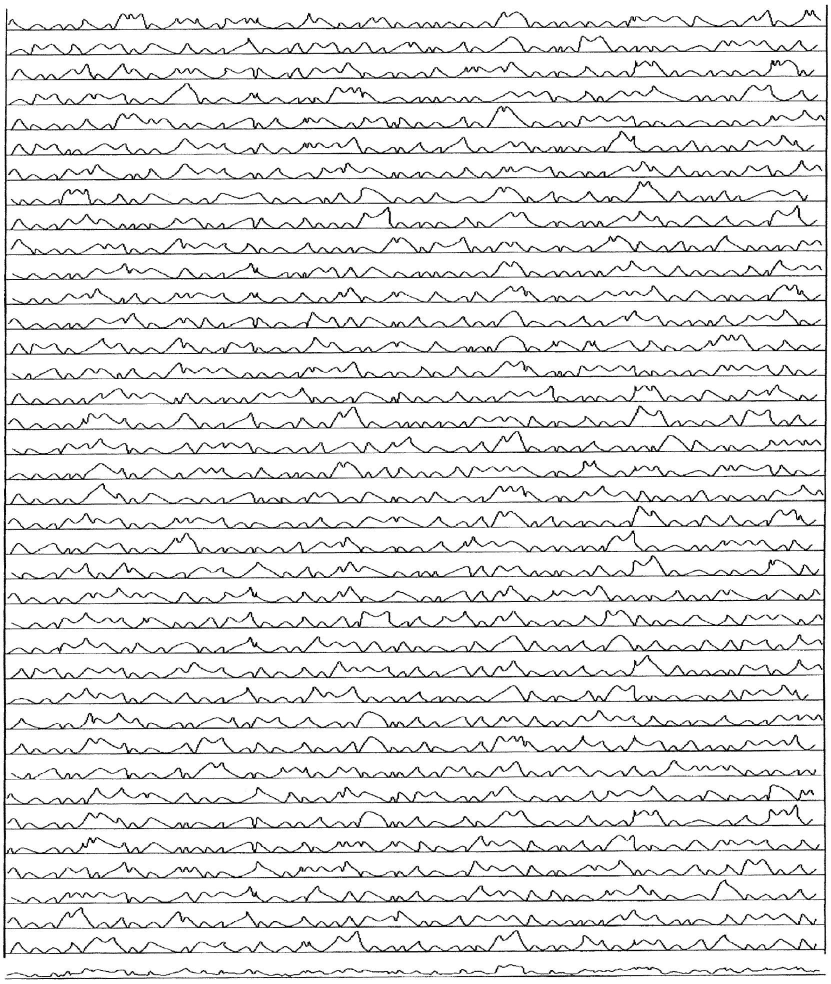

Fig. 3. Cognitive sensory frequency curves of 38 subjects of the student group.

Clusters of subjects based on cognitive sensory similarity

From the cognitive sensory frequency curve of a group (Fig. 3), it was possible to qualitatively classify the group by simple observation. The quantitative clustering could also be achieved by applying relevant statistical clustering.

Fig. 4 shows the eight clusters obtained using the SAS clustering method for the group of 38 individuals. Different subgroups are marked with different brightness for the convenience of the readers.

In Fig. 4, groups 2 and 3 had similar patterns because they belonged to the same branch. Likewise, groups 1, 2 and 3 were also similar for the same reason. According to this logic, it could be stated that the shorter distance between groups the greater the similarity.

In the clustering analysis, the 5^TH consciousness was excluded for two reasons. Firstly, the responses of the 5^TH layer (except of some physical contents in the questionnaire) were considered as a result of the human consciousness obtained through the consciousness reactions of the 6^TH, 7^TH and 8^TH layers. Secondly, physical factors in the 5^th layer, such as gender, age, body weight and height, were irrelevant to the aim of this study, which focused on the human consciousness aspect.

Cognitive sensory frequency curve of a subgroup

From the patterns similarity in the sensory frequency curves, an attempt was made to obtain representative curve patterns by averaging the curve patterns within a subgroup. Fig. 5 illustrates how the representative sensory curve was constructed from the individual curve patterns.

Characterization of subject groups based on their representative sensory curve.

In the previous report of Chun (2002), sub-grouping

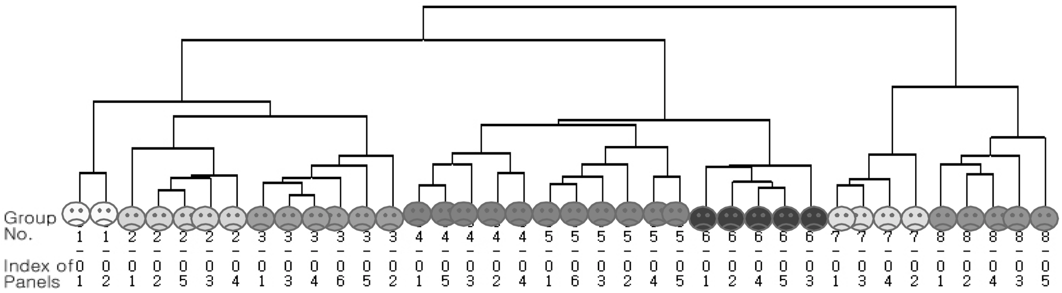

Fig. 4. Clusters of 38 individuals of SNU according to pattern similarity of cognitive bar code.
Index of panels refers to the ID code of panels in each subgroup.

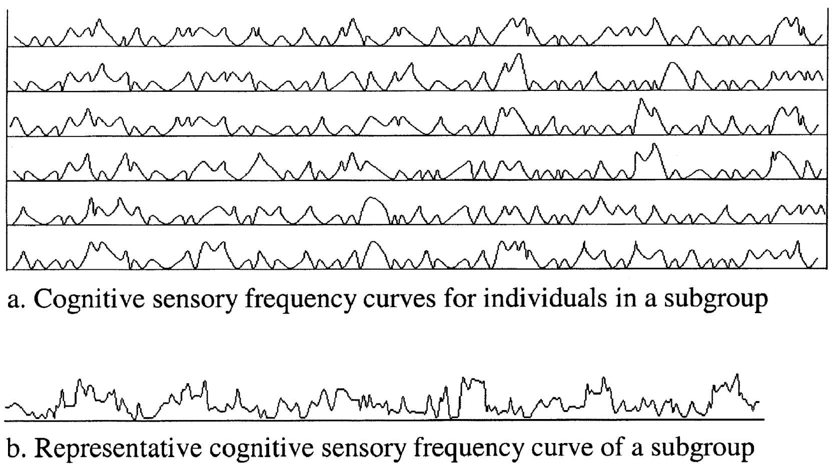

Fig. 5. Individual curves and the representative curve of a subgroup.

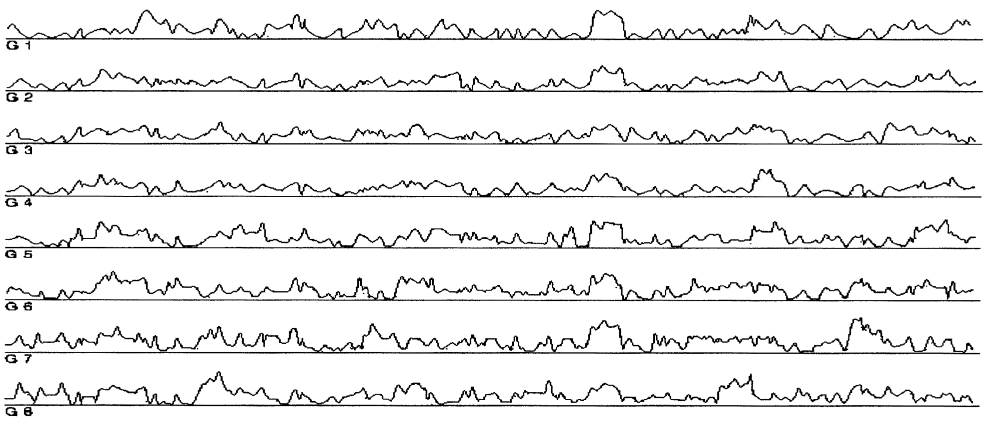

Fig. 6. Representative frequency curves of each subgroup.
G n: group number

was qualitatively made by observation with the naked eye. In this experiment, subgroups were made in a more quantitative way. This result opened the way to make subgroups by a statistical method using the consciousness parameters, which had previously been neglected.

In Fig. 6, each subgroup explicitly shows its own characteristics, with a distinguishable shape of curve. This explained that the differences in the subgroup were caused by the characteristic consciousness of the subgroup. In addition, all the representative frequency curves had common shape parts. This finding strongly suggested the presence of common consciousness factors among individuals in a subgroup. The common part of each subgroup was the result of either the identical response to the questionnaire or common factors in the consciousness background among individuals within the subgroup. The similarity in the middle of the curve patterns in Fig. 6 was due to the same education level of the subjects, as they were in the same university class.

Conclusion

The multi-layer consciousness concept was been introduced by Chun (2000) through an experimental approach using cooked-rice. Scientific evidence of the concept, with a more generalized food item, was required. To obtain a generalized result, Potato chips, a globally known snack food, was chosen as a specimen and the number of panelists was increased to 38. Herein, the improvement of the methodology and the data processing methods, such as the contents of the questionnaire, the construction of database for the answered data and the computer programs to construct barcode and frequency patterns, have been elaborated. Conversion from the barcode to the frequency curve was simplified by eliminating the complicated transformation process, which might cause artifact waves due to the nature of a sinusoidal curve. Since the cognitive patterns were constructed on the basis of the arrays of the contents in the questionnaire, the criteria for the array order would be an important factor. The importance of the cognitive sensory barcode and frequency curve lie in their usage for the characterization of individual sensory properties and the classification of the subjects into several groups according to the similarities in their patterns. The grouping of the subjects, performed on the basis of the visualized patterns, was in good agreement with that obtained using the statistical clustering method.

Acknowledgements

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