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# Development of A Method for The Musical Expression of Cognitive Food Taste

**So-Eun Kim, Seock-Won Lim and Jae-Kun Chun***

*Department of Food Science and Technology, School of Agricultural Biotechnology, College of Agriculture and Life Sciences, Seoul National University, Seoul, 151-742, Korea*

**Abstract** We developed a musical composition and performing method for the dynamic expression of food taste, to replace the static expression obtained from a numerical sensory score and linguistic method. The musical score was composed using cognitive food sensory data gathered while eating potato chips via a computer equipped with a sound card and a master keyboard, as well as Cakewalk 9.0, Goldwave 5.0, and Windows Media Player. The music score included four lines, one representing sensory data and three reflecting three layers of human consciousness. Different time units were applied by incorporating different repetition cycles for the relevant consciousness layers. The musical scores of individual subjects differed in terms of the score pattern and its sound. The music representing food taste was played by four instruments and showed different sound and acoustic frequency patterns for each individual subject during the consumption of potato chips. The musical expression method was applied to analyze the individual taste characteristics in the cognition of food.

**Keywords:** music, food taste, musical expression, cognitive sensory, consciousness, potato chips

## Introduction

Food taste evaluation is usually conducted with a panel of subjects, and many researchers have studied its methodology, including Thurstone (1), Piggott *et al.* (2), O'Mahony (3), Ennis (4), and Schutz (5). Unfortunately, previous studies have often been complex where the line between objectivity and subjectivity has become blurred. Chun (6, 7) attempted to resolve this inherent problem by developing a new concept for the sensory evaluation of food based on the multi-layered consciousness of humans. This system included three additional consciousness layers (CLs), i.e., the sixth, seventh, and eighth CLs, as proposed by Vasubandhu (8). Chun's concept is that individual sensory properties may be evaluated with subjective and objective factors of food taste. He developed barcode and frequency curve patterns for cognitive sensory evaluation. In particular, the curve patterns could be used to display the cognition state of food (9). In our preliminary study, the cognitive sensory frequency curve was transformed to an audio signal (10).

Similar research approaches have been investigated in music science. DeCasper *et al.* (11) and Kuhl *et al.* (12) studied the effects of musical methods of external stimuli on humans. Szpunar *et al.* (13) experimented with the enjoyment of and memory for musical stimuli as a function of exposure. Their results agreed with the cognitive food sensory approaches of Chun's concept (9).

In his work *Compendium Musicae,* Descartes (1617) affirmed that hearing occurred in a logical manner parallel to the activity of the senses and the memory (14). Buzon (15) indicated that the time courses of present and buried memories are important in cognition. Kant (14) explored the distinctive characteristics and grounds for the judgment of beauty from four perspectives, or moments: their quality, quantity, relation, and modality. Musicians matched these moments to melody, repetition, rhythm, harmony, and tempo and applied them to a musical composition. These ideas suggest that perception and cognition of human consciousness are related to a pattern of cognitive processes as observed in the brain waves, such as an electroencephalogram (EEG) and event-related potentials (ERP). A similarity was also found in the visual sensory system reported by Naatanen (16).

Deliège (17) developed a notion that the categorization processes of listening to music consisted of two distinct steps. The first, cue extraction, was peripheral and perceptual, while the second, access to the evaluation of items during listening, was central. She attempted to relate the music listening process to the module hierarchy of the human mind as proposed in the modularity thesis of Fodor (18). Other researchers have compared the performances of classification, frequency judgment and similarity rated in music field (17, 19). Bregman (20) and Handel (21) also reported on the auditory pattern of perception similar to that of Chun (6).

Hedden (22) used a more elaborate multivariate design in developing his 20-item 'music listening reaction scale' to gather information about how subjects reported reactions to orchestral music. Using factor analysis, Hedden (22) found five different dimensions of response to music: associative, cognitive, physical, involvement, and enjoyment. Yingling (23) hypothesized four reactions in listening to music, associative, emotional, intellectual, and sensory patterns, that were similar to four patterns of multi-consciousness, i.e., fifth, sixth, seventh, and eighth CLs (6). In addition, Lewis and Schmidt (24) clustered listening states into nine categories of mental or consciousness states.

In the musical field, various instruments have been introduced to cover a wide range of acoustic stimuli for the transmission of musical messages, and it has been

*Corresponding author: Tel: 82-2-880-4850; Fax: 82-2-873-5095
E-mail: chunjae@snu.ac.kr
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acknowledged that a typical instrument represents a certain intellectual or emotional state (25).

Likewise, there is potential to express the food stimuli generated during eating as musical sounds composed of various instruments that could be associated with the CL proposed by Chun (6).

In this paper, we sought to develop a method for musical composing and performing based on cognitive sensory patterns obtained from the cognitive sensory evaluation data of eating potato chips.

## Materials and Methods

**Materials** Cognitive sensory evaluation data were obtained from a sensory evaluation test conducted with potato chips. A questionnaire consisting of 158 questions, including 105 subjective and 53 objective parameters, was administered to the 38 study subjects (9).

**Methods** A computerized musical instrument was installed in a desktop computer (Pentium III 750 MHz, 512 RAM, SB Live!! 5.1 audio card) which was attached to a master keyboard with 61 keys, and a patch select function was used. Cakewalk (for composing), Goldwave (for recording), and Windows media player (for playing) were used as software. The musical composing procedure was carried out through several steps as described in Fig 1.

**Coding of cognitive sensory data for the musical composing process** The data from the questionnaires were coded as shown in Table 1. The first column of the table shows the codes of the elements of the questionnaires related to the cognitive sensory test, and the individual respondent data were tabulated under the headings of their individual numbers.

**Conventions applied in the musical composition**
To produce musical elements from the source data, the following six conventions were adopted:
***Convention 1***: The pitch ranges for objective and subjective CLs are defaulted by a rule that the height is inversely proportional to the depth of the consciousness (Fig. 2). The intervals and melody scales are defined by the author's decision (Table 2). For instance, the fifth CL is expressed with the highest tone and the eighth CL with the lowest tone.
The pitch ranges of the CLs on the keyboard were allocated as illustrated in Fig. 2.
***Convention 2***: The rating of the pitch level is defined by a numerical score ranging from 1 to 5; thus, 3 represents a moderate value.
***Convention 3***: The length of a note represents the health of the sensory organs. The healthier the sensory organ is, the shorter the length of the note (Table 3).
***Convention 4***: The instrument performing a note is played within the pitch level. The instruments are chosen to cover the pitch levels (Table 4).
***Convention 5***: Performance of the relevant scores of sixth, seventh, and eighth CLs are played to cover the total

**Table 1. Coding of cognitive sensory data for individual subjects during the musical composing process***

| Code | Individual source data* | | |
|---|---|---|---|
| | Individual 1 | Individual 2 | Individual 3 |
| R8** | 2 | 2 | 5 |
| R9 | 2 | 1 | 5 |
| R10 | 2 | 2 | 4 |
| R11 | 2 | 3 | 2 |
| R12 | 3 | 3 | 3 |
| A1*** | 2 | 3 | 4 |
| A46 | 2 | 3 | 2 |
| B1 | 5 | 4 | 5 |
| B6 | 3 | 2 | 4 |
| C1 | 1 | 2 | 2 |
| C15 | 3 | 2 | 4 |
| D1 | 5 | 2 | 3 |
| D6 | 5 | 3 | 4 |

*The data shown are a part of the source data of 3 individuals among 38 subjects.
**R is the health condition of the sensory organs of a subject.
***A, B, C, and D are codes for the fifth, sixth, seventh, and eighth consciousness layers (CLs), respectively.

**Table 2. Melody scales of source data for four CLs**

| Consciousness layer (CL) | Numerical value of source data | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 5th CL | D5 | G5 | C6 | F6 | A6# |
| 6th CL | G4 | C5 | F5 | A5# | D6# |
| 7th CL | A3 | D4 | G4 | C5 | F5 |
| 8th CL | G3 | A3 | B3 | C4 | D4# |

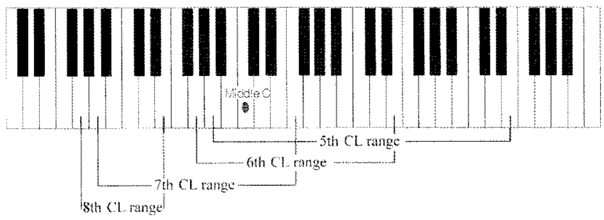


**Fig. 2. Allocation of pitch range of each consciousness layer (CL) on a keyboard.**

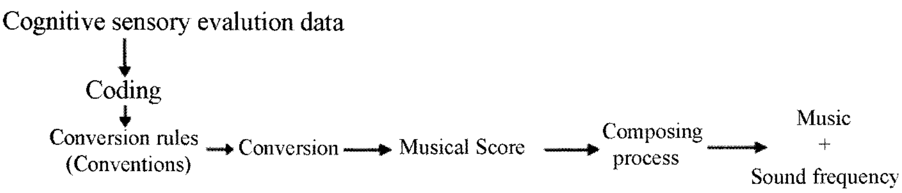


**Fig. 1. Musical composing and performing procedure of the cognitive sensory data of potato chips.**

**Table 3. Expression of the value of sensory sensitivity based on note length**

| | Sensitivity values of sensory organs | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Length of note | Half | Triple Quarter | Quarter | Eighth | Triple Eighth |

**Table 4. Designated musical instruments and repetition cycles in music composition for each consciousness layer**

| Consciousness layers | Musical performance condition | |
|---|---|---|
| | Instruments | Repetition |
| $5^{th}$ CL | Harpsichord | None |
| $6^{th}$ CL | Flute | 5 |
| $7^{th}$ CL | Orchestral Harp | 8 |
| $8^{th}$ CL | Tremolo Strings | 12 |

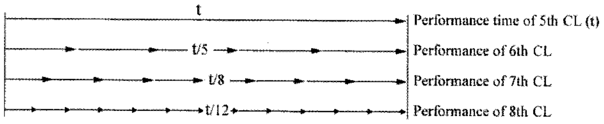


**Fig. 3. Performance duration and repetition times of various consciousness layers (CLs).**

length of the performance by the repetition cycles of the given value defaulted to in Table 4. Since the multi-layered consciousness is considered to operate at different acting rates, the performance scores of each CL are accommodated in the limit of 0.01 - 15 kHz for human audibility (Table 4).

***Convention 6***: Performance duration and repetition times of various CLs are determined on the basis of time period (t) of the fifth CL, as illustrated in Fig. 3.

## Results and Discussion

**Composition of a musical score of cognitive food taste for an individual subject** From the source data of an individual panel, the musical score of cognitive food taste was constructed according to the musical composition procedure established by the given conventions. The resulting musical score of the sensory cognitive response of a subject chosen randomly from the 38 subjects was transformed into an audible sound pattern as shown in Fig 4.

The resulting musical score consisted of four lines, which represented the relevant layers of consciousness as marked on the right side of the score. The first line represented the response of the fifth CL, or the sensorial reactions to 46 questions that became audible with the frequency of 46Hz, supposing that one musical note creates one pulse. When the music was played with a speed of Moderato ( ♪ = 80), the equivalent performance period (t) was 34.5 seconds. The melody of the first line was composed with a five-note scale (Convention 1), and thus occurred mostly in the highest pitch.

The second line, representing the reaction of the sixth CL, consisted of six notes with five repetitions, and the music scale was located at the second-highest pitch after the fifth CL. Lines 3 and 4 covered the notes generated by those of the seventh and eighth CLs under the repetition cycles defined by Conventions 5 and 6, and their notes were distributed in a lower scale than those of the sixth CL.

The presentation of the sense of taste in the form of a musical scale matches Chun's idea that the cognitive processing from food stimuli while eating might take place dynamically with the full participation of the fifth through eighth CLs to reach a final evaluation of taste (6, 26, 27).

To play the musical score, the instruments needed to cover the full range of pitches. The higher values in the data from respondents of the fifth CL, along with the


**Fig. 4. Musical score composed on the basis of cognitive food taste of potato chips for an individual subject.**

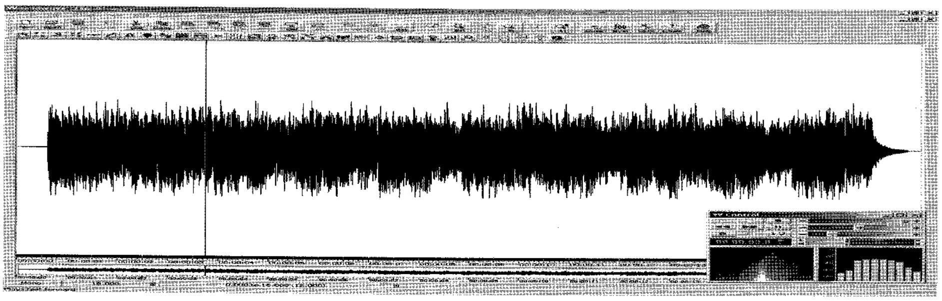

**Fig. 5. Acoustic frequency pattern of cognitive food taste of an individual subject as displayed on the computer screen.**

lower values at the seventh and eighth CLs, resulted in a broader pitch range.

From the audience's point of view, the various pitches can help them mentally experience the versatile feelings of a food. Consequently, a musical score can be used as an alternative expression method for the subjective feelings and conscious backgrounds of a food taster or assessor. In addition, the changes of the notes reflect the dynamic states of taste perception in the listener's mind.

Once the cognitive data were transformed into the musical score, the data could be represented with an acoustic frequency pattern as shown in Fig 5.

The vertical lines indicate the performing spots of the acoustic pattern, and the control box in the bottom right-hand corner of the screen shows the process of sound recording.

**Interpretation of the musical score of potato chip consumption** The taste of potato chips for an individual subject was transformed into a musical format. The length of a note in the first line reflects the state of physical health of the sensorial organs involved in the perception of external stimuli. As shown in Fig 4, the score was composed based on quarter notes, which represent middle values of the source data. Accordingly, the individual subject demonstrated normal health in his/her five sensorial organs.

The scores of lines 2 through 4 were the dynamic displays of the cognition of internal stimuli supplied by the sensorial data. According to the concept of Chun (27), they represent the consciousness undergoing several processes with different time units. The different internal processes were expressed by employing different repetition cycles in the musical score as shown in Fig 4. Therefore, line 2 had five repetitions and 30 notes (6 notes × 5 times) and its performing duration was equivalent to that of line 1. This indicates that line 2 is composed using a triple half note due to the increased note density, and that it represents a normal conscious state in the sixth CL. In the same manner, lines 3 and 4 were composed with triple thirty-second notes (♬) and half notes ( ♪ ) as basic note units, and accordingly they included 120 notes (15 notes × 8 times) and 72 notes (6 notes × 12 times), respectively.

**Comparison of musical scores of individual panels** Scores based on the potato chip consumption by three individual subjects were produced and compared as shown in Fig 6.

As seen in Fig 6, the musical scores showed individual characteristics in two respects. First, line 1 of each of the three individuals differed by note length or by their health condition when they tasted the food. Second, different pitches were observed, which suggests a difference in the response to the food. In line 2, the notes have a similar pattern, but the levels of the notes were remarkably distinctive. Subject 1 was noticeably different from the other two, suggesting that this subject had different conscious states in the sixth CL.

In lines 3 and 4, the note lengths and levels were more varied than in lines 1 and 2. As the number of repetition cycles increased, the increased density of notes in the low range made a low frequency resembling a background humming or a drum. This sound reflected a conscious background governed by the seventh and eighth CLs.


**Fig. 6. Comparison of the musical scores of three individuals eating potato chips.**

**Acoustic frequencies of patterns of food taste in individual subjects** To visualize musical sound, one must monitor the sound frequency or wave. The spectrum of the sound frequency was created through instrumental performance as described in Table 4, and the resulting spectra are shown in Fig 7.

Since the sound frequency pattern was obtained by playing the composed musical score, it could be used as a means of qualitative comparison to differentiate among individuals in terms of food acceptance. The band height represents the pitch height sensed at a given time in the musical score (See Fig 4). The total length of the sound frequency pattern represents the performance time of the relevant musical score. Therefore, the changes in the

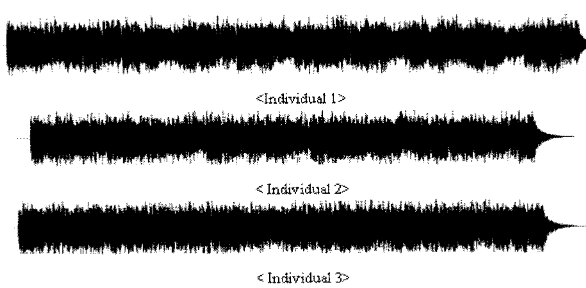


**Fig. 7. Sound frequency patterns of three individual panels.**

frequency height and length reflect how an individual's perception is varied while eating.

Accordingly, the newly developed expression of food taste with musical scores and frequency patterns can be considered another method of expressing the cognitive sensation of eating (9). This method gives new scope to view food taste as a feeling by listening and watching the overall cognitive processes taking place as part of human sensory perception. This musical methodology may be applied to survey and analyze the sensory response to, preferences for, and acceptability of foods.

## Conclusions

The visualization of food taste was reported by Shine and Chun (9) using cognitive sensory data from potato chip consumption based on the multi-layer concept of human consciousness. This study aimed to develop another method that channels data directly from human sensory organs.

Our idea was to include more than one sensory organ in a method of expressing food taste, because the perception of taste involves multiple sensory organs and levels of consciousness that are likely to vary with time.

In this regard, a musical score displaying the intensity and lasting duration of the food taste was developed using data obtained by a cognitive sensory evaluation method that was coded with a five-point scale in the questionnaire (9).

The new method was tested against previously reported source data and proved to be superior to the previous method of expressing the taste sensation. Since this musical method was composed of multiple scores in order to represent sensory and multi-consciousness data, it could be considered to represent the combined results of physical and mental reactions to food. Furthermore, the undisclosed time factor in the conventional methodology could be realized by incorporating different playing cycles for the relevant layers of consciousness. The two most remarkable findings from the musical method presented here were the ability to appeal to human feelings directly by audio signal and the discovery that different musical instruments could express different feelings.

Since the source data for the musical method of cognitive tasting were not prepared exclusively for this method, some outstanding problems in the context of the questionnaire remain to be solved. However, the method may be used to construct cognitive musical notes for individuals and consumer groups.

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