DETECTION OF SUBCONSCIOUS TASTES FOR FOOD USING EVENT-RELATED POTENTIAL AND FMRI

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ABSTRACT

In recent years, consumer interest in food safety has increased after occurrences of several food-related events. Therefore, we believe that there will be an increasing demand for development of food products that appeal to consumers' subconscious tastes. For this purpose, a technology that objectively investigates consumers' subconscious tastes for food is indispensable. Therefore, we initiated the development of a method for investigating subconscious tastes for food on the basis of event-related potentials. This report presents the findings of the first stages of our studies aimed at developing a method for investigating tastes for food on the basis of event-related potentials (ERP) as responses to visual stimuli.

Keywords: *subconscious taste, food, event related potential, visual stimulus*

1. INTRODUCTION

Several studies have been conducted in Japan and across the world to investigate human tastes in food. A majority of such studies are based on an organoleptic evaluation method (generally called "panel test"), which is a method for investigating senses that are consciously perceived by human beings. Although many studies using biological signals have also been carried out, most of subjects of the researches are tastes that are consciously perceived.[1]-[6] However, research on tastes in food and food sensitivity within the investigable range by use of conventional panel tests is inadequate to develop high-value-added food products and menus to keep abreast of needs of consumers in food-manufacturing and food-service industries. Therefore, we aim to develop a method to investigate subconscious tastes in food

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and food sensitivity that are difficult to investigate using conventional panel tests. This study reports on the development of a technique for investigating subconscious tastes in food on the basis of event-related potential (ERP) responses. ERP is a kind of cerebral evoked potentials.[7] In addition, to investigate the association between subconscious tastes in food and realizable tastes and to obtain reference data, we conducted our research on the basis of electroencephalographic (EEG) activity in our subjects using functional magnetic resonance imaging (fMRI) when subject's preference was indicated only as "like" or "dislike".

2. METHOD FOR DETERMINING TASTES IN FOOD USING ERP.

2.1. Measurement of ERP in response to visual stimuli

An event-related potential (ERP) comprises of a brain wave; it is a brain-surface potential stemming from cerebral activity that occurs in synchronization with a certain event. ERP is attracting attention as a tool for understanding the brain mechanisms related to human cognitive and psychological activities. P300, a component of ERP, is induced in a human being when nontarget images are repeatedly shown along with target images shown at a low frequency.

We propose a method for investigating tastes in food using brain-computer interface (BCI) or brain-machine interface (BMI) technology [8]-[13]. We hypothesize that showing pictures of a subject's favorite foods as low-frequency stimuli in popular oddball experiments can become target stimuli which evoke P300.

For the purpose of the study, we prepared 100 colored images of various kinds of food ingredient and food items using a computer. The ingredients and food items were carefully selected so as to mainly include those food items that the Japanese people consumed daily, including liquids and solids that were liked by most people and those that were either liked or disliked. We randomly arranged these 100 images, inserted a black image between every 2 images, and placed a black image at the beginning and at the end, thereby creating a set of 201 images. The image set contains photographs of single item of food, ones of beverage, and ones of setout.

We used 1 person per experiment. The subject was asked to sit in an office chair in a silent room with a monitor placed at a distance of 50 cm in front of the subject (Figure 1). Then the subject was not hungry. We used a portable electroencephalograph (Polymate AP1000, TEAC Co. Ltd., Japan) to record ERP using unipolar lead electrodes connected to both ear lobes as reference electrodes and another 16 electrodes according to the International 10-20 System (channels Fp1, Fp2, F3, F4, C3, C4, P3, P4, O1, O2, F7, F8, T3, T4, T5, and T6). The sampling frequency was 1000 Hz.

The following instructions were given to the subject:

a) "you are going to see 100 images of food items in a series. Check if these include your favorite food items."

b) "The image will change every 1.5 s. There are black images among these images. Blink your eyes when a black image is displayed." (Figure 2)

To display the food images, we synchronized them and sent pulse signals from the computer, these pulse signals were simultaneously recorded along with the ERP during EEG.

The measurement of ERP was completed after all images were displayed. Subsequently, the subject was shown a list of all food items that were displayed and asked to select his/her favorite food items.

Five healthy adults with ages ranging from 20-23 years (average age, 22 years) participated in this experiment.

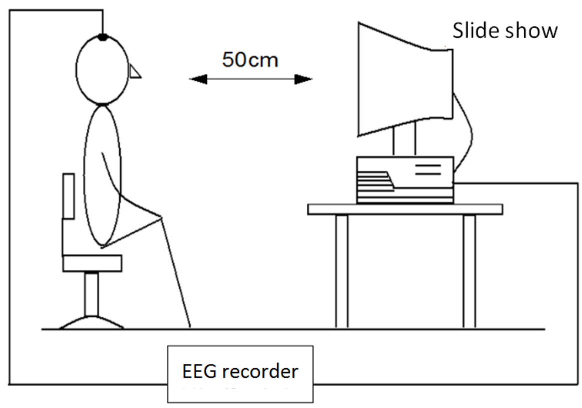

Figure 1: ERP recording.

Figure 2: Visual stimuli for ERP recording.

2.2. Analysis of ERP in response to visual stimiuli

We deducted 1.5 s from the time for which the stimulus was shown before and after each stimulus. The subjects' responses were evaluated on the tastes of the following conditions: (a) stimulus with a target image; (b) stimulus with a nontarget image; and (c) data recorded when P300 was assumed to occur from visual stimulation regardless of whether a target image or a nontarget image was displayed. We deciphered the wave profiles for (a), (b), and (c) to count occurrence rate of P300.

3. FMRI-MEASUREMENT EXPERIMENT

In addition to the experiment conducted to measure the ERP, we conducted an fMRI-measurement experiment to identify the existence of the cerebral region that reflects intuitive tastes in foods that are not influenced by intake of various kinds of food items and are not altered arbitrarily. The subjects for this experiment were 5 healthy male adults of ages 21-23 years (average age 22). They were not hungry then. In this experiment, each subject was asked to select 3 most favorite and 3 least favorite food items or seasonings from among 50 kinds of food items and seasonings. The food items and seasonings chosen by each subject were respectively used as stimuli for fMRI measurement. The measurements were performed using position to prevent head movements as much as possible. The subjects were presented with small amounts of food items or seasonings an indicated times. The subjects were asked to swallow the food or seasoning within few seconds and to be ready for the next stimulus. Five stimuli of each kind, food item or seasoning, were presented successively. The fMRI measurements were performed with a 15-s stimulus presentation time and 45-s interval between 2 successive stimuli. Similarly, fMRI measurements were performed using 3 kinds of food items and seasonings that the subjects liked and disliked.

The different preferences of the subjects were well-suited for the purpose of this study because food preferences were the focus of the study. This was a preliminary experiment for investigating the possibility of localization of cerebral activation caused by intuitive tastes of food that we believe to be closely related to subconscious tastes of food, which we attempted to investigate using the ERP analysis described in the previous section. Figure 3 and 4 show the regions of the brain activated by the presentation of the "like" and "dislike" stimuli.

4. RESULTS OF THE EXPERIMENT AND DISCUSSION

On the basis of the wave forms obtained from the ERP-measurement experiment, we inferred that P300, apparently, is not generated in all instances of stimulation by target images. Table 1 shows visually confirmed P300 generation. On the basis of data reported in Table 1, we inferred that there is a certain difference between the subjects' conscious tastes and subconscious tastes. Although we selected easily recognizable images of food items for the ERP-measurement experiment, the subjects were unable to recognize a few images. The unrecognized food images were not common for all subjects, but recognition changed depending on the combination of images and subjects.

Table 1: Occurrence rate of P300

Subject	Number of target stimuli	Occurrence rate of P300 on target stimuli	Occurrence rate of P300 on nontarget stimuli
Male, 22y	26	5 / 26	6 / 74
Female, 21y	9	1 / 9	6 / 91
Male, 23y	10	1 / 10	3 / 90
Male, 23y	25	2 / 25	7 / 75
Male, 22y	10	3 / 10	1 / 90

As shown in Figure 3 and 4, from the fMRI experiment, we were unable to identify the region of the brain activated by "like" or "dislike" stimuli that was not affected by the kind of food and physical and chemical characteristics of the of the food. The major problems with the experiment were as follows: (1) the subjects experiment extreme distress while swallowing the food in the supine position with the head firmly fixed, and (2) the number of subjects was inadequate for the wide diversity of taste and texture stimulation.

The results of our study revealed that individuals may have subconscious tastes in food that are different from the tastes that are recognized or perceived by the individual at a conscious level. Some factors such as noise elimination and extraction of certain components during the electroencephalographic data-processing process were not considered in this study; therefore, we believe there is scope for improvement in the accuracy of P300 detection. It is necessary to perform more detailed analyses of the original electroencephalographic data of our study and reinvestigate cognition of target stimuli and response to nontarget stimuli.

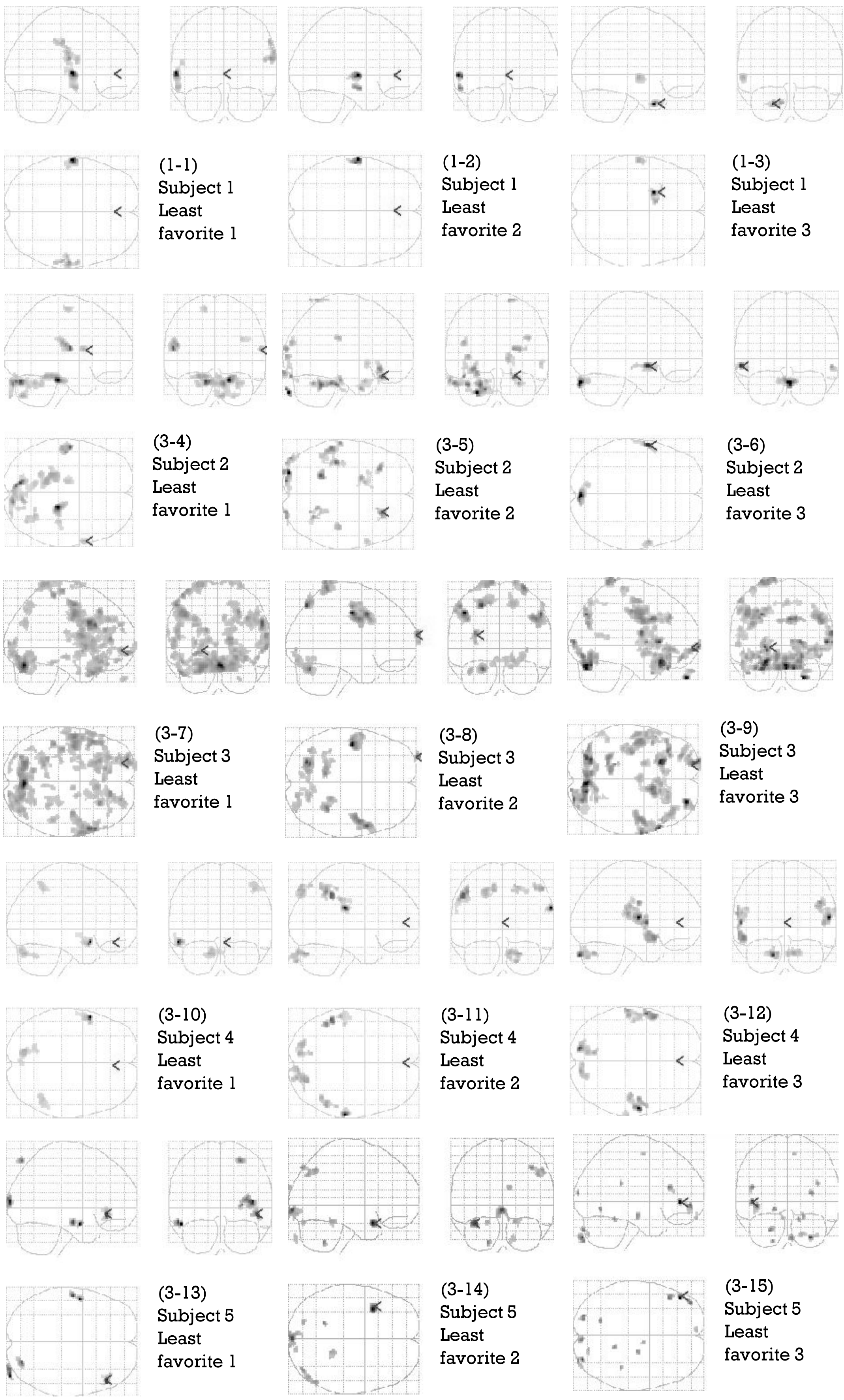

Figure 3: fMRI by the stimuli of least favorite food items.

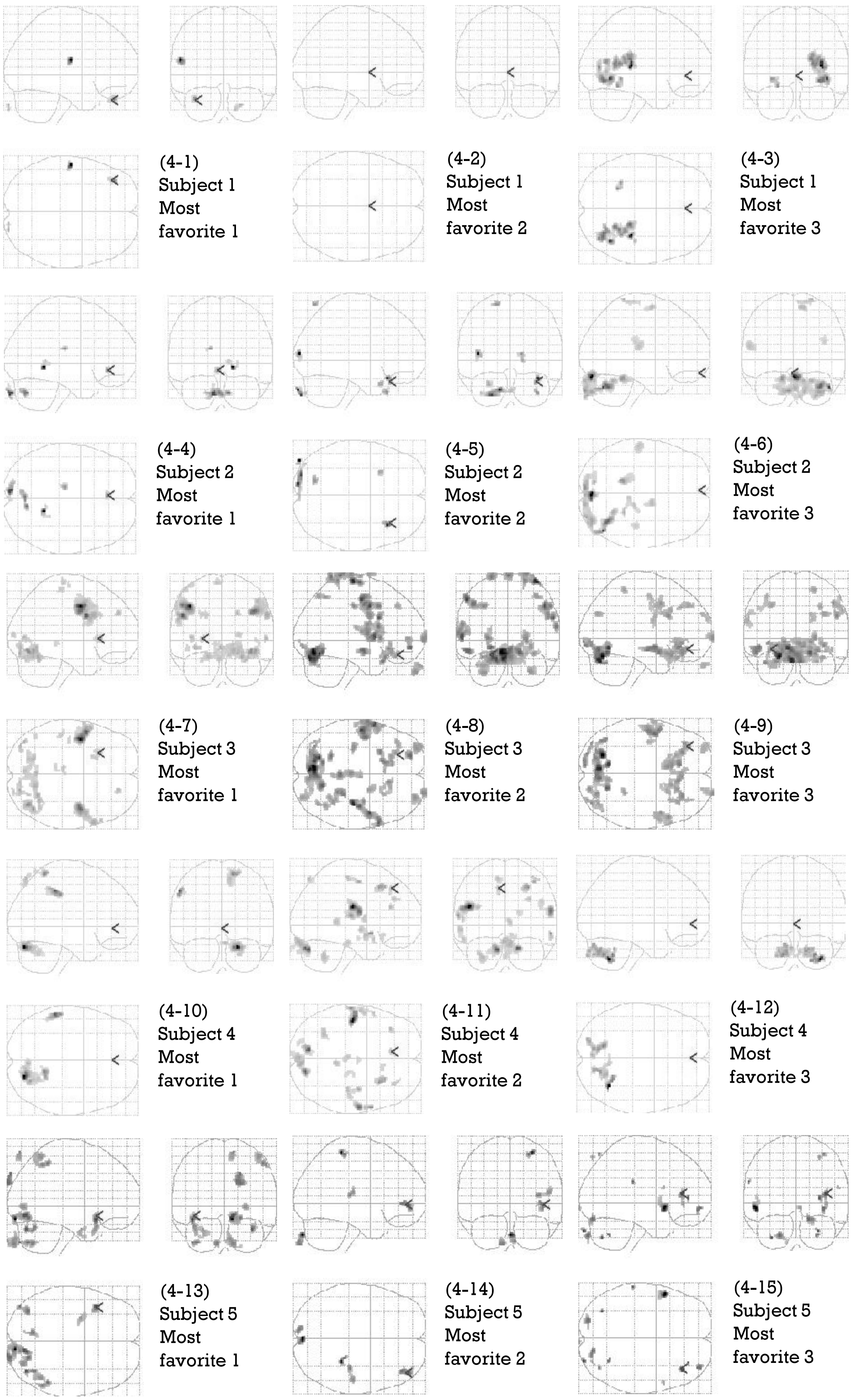

Figure 4: fMRI by the stimuli of most favorite food items.

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