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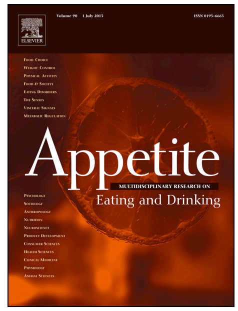

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An event-related potential study of consumers' responses to food bundles

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Abstract

We conducted two event-related potentials (ERP) experiments to investigate consumers' responses to different types of food bundles. In Experiment 1, the participants were instructed to indicate their wanting of a three-yogurt bundle when their neural activity was recorded. The results of self-report wanting scores revealed that the participants wanted bundles consisting of their favorite yogurt products more than those of disliked products. Such a difference in self-report scores was also indexed by the N2 in frontal brain and the P1 in the left hemisphere. By contrast, bundles consisting of three different yogurt products elicited smaller amplitude of the N2 than bundles consisting of two favorite products and one disliked product, but these two types of bundles received comparable wanting scores. Moreover, we asked the participants in Experiment 2 to perform a visual discrimination task on these bundles, and did not found these effects on the N2 or the P1. Collectively, these results revealed neural activities underlying consumers' responses to food rewards, and demonstrated the role of individuals' variety-seeking tendency in wanting process.

Keywords: food wanting; bundles; variety seeking; N2; P1

Bundling is a prevalent promotion strategy, and many factors have been shown to influence consumers' responses to product bundles (Hansen & Martin, 1987; Janiszewski & Cunha, 2004). For example, consumers prefer a bundle more when a separate price is presented for each component than when a single price is presented for the whole bundle (Chakravarti, Krish, Paul, & Srivastava, 2002). Making a selection among different bundles is different from choosing one single product. When choosing one single product, consumers may switch to less-preferred options even when they obtained less pleasure from switching than from repeating more-preferred options (Ratner, Kahn, & Kahneman, 1999), thus demonstrating a variety-seeking tendency (McAlister, 1982; van Trijp, Hoyer, & Inman, 1996). When choosing a product bundle, consumers are less likely to seek variety if they consider these products as a bundle rather than parallel single items (Mittelman, Andrade, Chattopadhyap, & Brendl, 2014). Manufacturers and retailers like to provide food bundles with variety (Howell, 2000), but very few studies have been conducted to systematically examine the component variety of these bundles and consumers' responses to food rewards, such as their wanting for these foods.

Food wanting refers to people's disposition to eat or appetite, and can be triggered by mere exposure to a food or even imagination of this food's taste, smell, and texture (Pelchat, Johnson, Chan, Valdez, & Ragland, 2004). Food wanting has both explicit and implicit forms (Berridge, 2009). The explicit component of food wanting can be directly measured via self-report rating scales, whereas the implicit component of food wanting has been indirectly assessed via participants' performance in a variety of behavioral tasks, including the approach-avoidance task, the implicit association test, and the affective Simon task etc. (for a review, Tibboel, De Houwer, & van Bockstaele, 2015). Kraus and Piqueras-Fiszman (2016) have shown that direct and indirect measures of food wanting can provide consistent findings. However, indirect measures are often assumed to be superior to direct measures, presumably because they can capture unconscious processes and are less susceptible to social desirability concerns (Tibboel et al., 2015; Wiers & Stacy, 2006).

However, it may be difficult to make sure whether the indirect measures are valid. For example, Finlayson and colleagues (2007) used the frequency of a food being chosen in a forced-choice task as an index for food wanting; whereas Finlayson and colleagues (2008) proposed that the frequency of being chosen in a forced-choice task might assess a combination of liking and wanting, and used the participants' reaction times of making a choice to index implicit wanting. Piqueras-Fiszman and colleagues (2014) asked their participants to complete an approach-avoidance task in which they pulled or pushed a joystick upon seeing food images, and used their reaction times to index implicit wanting. They obtained dissociations between the participants' behavioral responses in the approach-avoidance task and self-report ratings, but such indirect measure only appears to be more sensitive than the direct measure in testing participants' disgust and rejection responses.

In contrast, a potentially better way to test consumers' responses to food rewards may be to link them to food-related event-related potentials (ERPs; Carbine et al., 2018; Lin, Cross, Jones, & Childers, 2018). Characterized by a good time resolution, the ERP technology can detect rapid changes that may not be easily captured by behavioral tasks or self-report ratings (Plassmann & Karmarkar, 2015). In recent years, the ERP technique has been increasingly used to study food-related cognitive processes, including attention (Schwab, Giraldo, Spiegl, & Schienle, 2017), inhibitory control (Lapenta, Dierve, de Macedo, Fregni, & Boggio, 2014), and working memory (Rutters, Kumar, Higgs, & Humphreys, 2015).

Notably, Telpaz and colleagues (2015) had their participants view pictures of single products during the electroencephalography (EEG) recording session, and linked the amplitude of the N2 to the binary choices that the participants subsequently made between pairs of these products. Their results revealed that the N2 amplitude was smaller for the products that participants chose more often and liked more, compared to the unselected and disliked products. Considering that the chosen frequency in such a forced-choice task has been linked to wanting (Finlayson et al., 2007, 2008), Telpaz et al.'s (2015) findings suggested that the N2 may be used to index wanting. Moreover, Goto and colleagues (2017) recorded their participants' scalp EEGs while they were rating the pleasantness of and wanting for products in a virtual shopping task. Specifically, their participants were instructed to look at images of products while avoiding eye movements, and then rated their liking for and wanting of these products. Their results also revealed that the N2 amplitude was smaller for the products with high wanting scores than those having low or medium wanting scores.

Therefore, the present study was conducted to assess consumers' responses to food rewards, and we chose the N2 peaking approximately at 160 to 250 ms post-stimulus as an ERP of interests. It should be noted that food wanting and liking are distinctive from each other (Stevenson, Francis, Attuquayefio, & Ockert, 2017), but it is challenging to dissociate them in laboratory-based studies because these two psychological constructs are often intertwined to each other (Havermans, 2011). Moreover, we also chose the P1 peaking approximately at 80 to 140 ms post-stimulus as a second ERP of interest, as previous research has shown that the P1 is sensitive to the influence of motivation (Cunningham, van Bavel, Arbuckle, Packer, & Waggoner, 2012; Hammerschmidt, Sennhenn-Reulen, & Schacht, 2017). Importantly, reward-related stimuli can elicit a larger P1 (Becker, Flaisch, Renner, & Schupp, 2016; Maclean & Giesbrecht, 2015).

In the present study, we presented fruit-flavored yogurt products in the form of three-product bundles as experimental stimuli, and manipulated the level of variety of each bundle. Menon and Kahn (1995) defined a "switch" as occurring when a chosen product was different from any of the previous chosen items in sequential choices. Similarly, we used the total number of switches within each three-yogurt bundle to index the variety of this bundle, and created four different types of bundles with varied levels of variety: (1) 3F bundles consisting of three cups of the same yogurt which was a participant's favorite flavor (number of switch = 0), (2) 3D bundles consisting of three cups of yogurt of the same flavor that the participant disliked (number of switch = 0), (3) 2F1D bundles consisting of two cups of yogurt of the same favorite flavor and one cup of yogurt of the disliked flavor (number of switch =

2), and (4) 3M bundles consisting of three different cups of yogurt in flavors with a medium level of popularity across participants (number of switch = 3).

In Experiment 1, we asked our participants to rate their wanting for these four types of bundles during the EEG recording session. First, we hypothesized that the 3F would receive higher wanting scores than the 3D bundles, so we expected to observe significance differences in the N2 and the P1 elicited by these two types of bundles. Specifically, we hypothesized that the N2 amplitude would be smaller for the 3F bundles than for the 3D bundles, and the P1 amplitude would be larger for the 3F bundles than for the 3D bundles. Second, we hypothesized that the 3M and 2F1D bundles would receive comparable wanting scores, presumably because both of these two types of bundles had pros and cons. That is, the 3M bundles provided the highest level of component variety that a three-product bundle could provide, but they did not contain the participants' favorite product; whereas the 2F1D bundles contained the participants' favorite products, but they also contained a disliked product and only provided a medium level of component variety. Therefore, comparing the N2 and the P1 elicited by the 3M and 2F1D bundles might reveal differences in consumers' responses to these two types of food rewards that might not be easily detected by self-report ratings.

In order to rule out the confounding of visual differences between different types of bundles, we also conducted Experiment 2 as a control experiment in which the participants only performed a discrimination task on the bundles. Collectively, the findings of this study can provide more empirical evidence about the associations between the N2 and food wanting, and extend the scope from wanting for a single product to wanting for a bundle of products. Our findings about the P1 would also provide novel findings to link wanting with an earlier ERP than the N2. Moreover, our findings may demonstrate certain associations and/or dissociations between neural activities underlying the explicit and implicit components of food wanting.

EXPERIMENT 1

Methods

Participants

Twenty-five Chinese participants (21.05 ± 1.57 years, ranging from 19 to 24 years; 11 females) took part in this experiment. We used the G*Power software to estimate the sample size, and the results revealed that a sample of 25 participants can detect the effects with $\eta_p^2 \geq 0.24$ (statistic power = 0.80).

In the present and the following experiments, all participants reported that they were right-handed, had normal or corrected-to-normal vision, and had no history of neurological or psychiatric disorders or head injuries. This study was approved by the ethics committee of the Psychology Department of Tsinghua University, and performed in accordance with the ethical standards laid down in the Declaration of Helsinki. We obtained written informed consent from all of the participants before the experiment started. Each participant received 120 Chinese Yuan (CNY) for their participation.

Pretest on yogurt flavors

In order to determine which fruit-flavored yogurt products should be used in this study, we first ran a pretest to probe the participants' preference on fruit-flavored yogurts. A total of 113 Chinese participants were shown the names of 27 fruit-flavors of yogurt products that are commonly seen in the local market, and indicated their liking of each yogurt flavor on a 7-point scale. Based on these liking ratings, we chose strawberry (5.24 ± 1.43) and yellow peach (5.56 ± 1.71) as two popular flavors. Seaberry (3.05 ± 1.52) and water chestnut (2.92 ± 1.45) were chosen as two unpopular flavors; whereas coconut (4.30 ± 1.80), mulberry (4.66 ± 1.49), and cherry (4.46 ± 1.46) were chosen as flavors with a medium level of popularity.

Manipulation on yogurt bundles

As shown in Figure 1, we created four types of three-yogurt bundles: (1) 3F bundles consisting of three products of the same popular flavor, (2) 3D bundles consisting of three products of the same unpopular flavor, (3) 2F1D bundles consisting of two products of the same popular flavor and one disliked product, and (4) 3M bundles consisting of three different products with a medium level of popularity. These three products were aligned horizontally for each bundle, which allowed us to define a "switch" as occurring when a yogurt product was different from any of the items on its left side. As mentioned in the introduction section, we used Menon and Kahn's (1995) method to calculate the total number of switches for each type of bundles, and the 3F, 3D, 2F1D, and 3M bundles had 0, 0, 2, and 3 switches, respectively.

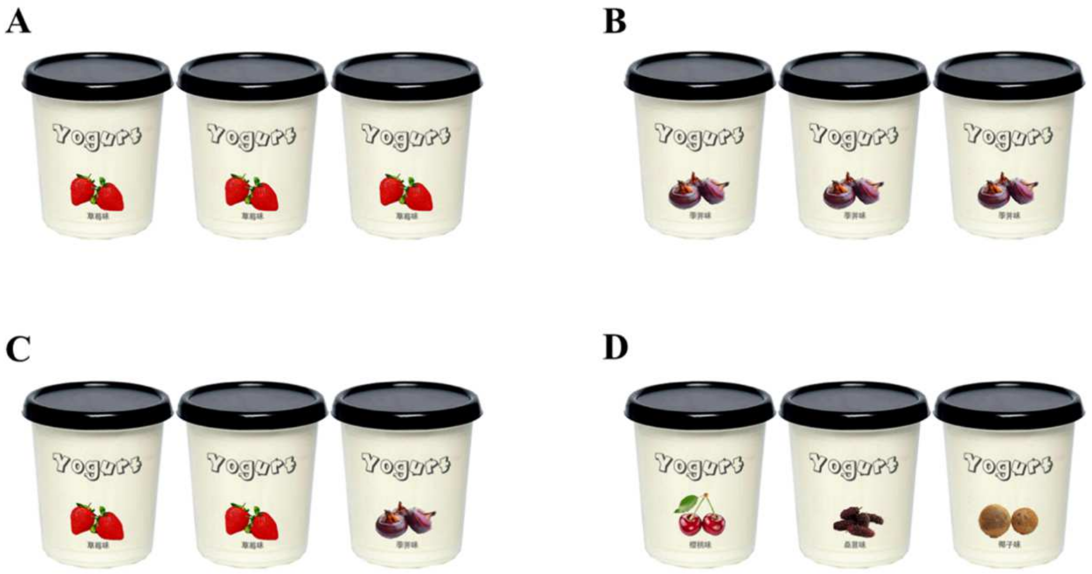

Figure 1. Examples of 3F, 3D, 2F1D, and 3M bundles are shown in panels A, B, C, and D, respectively.

Materials and apparatus

We used Photoshop CS6 software to create individualized images of three-yogurt bundles for each participant. At the beginning of the ERP experiment, we asked each participant to choose a flavor they liked more between the strawberry and yellow peach flavors, and to choose a flavor they disliked more between the seaberry and water chestnut flavors. Specifically, 60% and 40% of the participants chose strawberry and yellow peach as their favorite flavor, respectively; whereas 40% and 60% of them selected seaberry and water chestnut as the disliked flavor, respectively.

During the ERP experiment, the stimuli were presented on a 17-inch monitor with a resolution of 1024 × 768 pixels, at a refresh rate of 100 Hz, and viewed at a distance of approximately 60 cm. As can be seen in Figure 1, the packaging design of each yogurt consisted of a black cover and a white cup body with a fictional brand of "Yogurt." We used Eprime 2.0 software to present the stimuli and to record the behavioral data, and used Inquisit 3.0 software to run the survey on liking ratings.

Design & procedure

Before the ERP experiment started, each participant was asked to indicate to what extent he or she liked each bundle on a 7-point scale, with higher scores indicating higher degree of liking.

During the ERP experiment, the participants were instructed to indicate to what extend they wanted to consume each bundle. Each trial started with a fixation (subtending 0.5° × 0.5° at the center) screen for 800 to 1200 ms. After that, a display of a three-yogurt bundle (each subtending 6° horizontally and 8.5° vertically) was presented against a white background for 2000 ms. The participants were instructed to use a mouse to choose a number from 0 to 100 to indicate their wanting of this bundle, with higher scores indicating higher degree of wanting. Similar to Goto et al.'s (2017) study, we instructed our participants to avoid eye movement during the presentation of stimuli; and we only focused on the ERP data of the first 600 ms in our data analyses. Each participant was asked to complete two blocks of 120 trials each, and equal numbers of different types of bundles were mixed and presented in a random order. When different products were included in a bundle, their locations were counterbalanced across different trials.

Electrophysiological data recording

This ERP experiment was conducted in a dimly lit, sound-attenuated, and electrically shielded chamber at the Psychology Department of Tsinghua University. The EEG signals were recorded by placing passive Ag/AgCl electrodes on 64 scalp sites mounted on an elastic cap (Neuroscan, TX, USA) according to the international 10-20 electrode placement system. An electrode between FPz and Fz served as the ground, with a physical reference electrode located between CPz and Cz. Horizontal electrooculogram (EOG) was recorded from two electrode sites at the outer canthi of each eye, and vertical EOG was recorded from electrodes situated on the infra-orbital and supra-orbital regions of the left eye. The electrode impedances were adjusted to be less than 5 KΩ. Signals were digitized at a 500 Hz sampling rate, amplified by a Neuroscan Synamps2 amplifier with a 0.05-100 Hz band-pass filter, and recorded by Scan 4.3.1 software. All channels were then filtered with a range of 0.1-30 Hz (24 dB/octave roll-off) and re-referenced offline to an average of all scalp electrodes.

Electrophysiological data analysis

We used MATLAB and EEGLAB software to analyze the electrophysiological data. The EEG was segmented into epochs between 200 ms before and 600 ms after the stimulus onset, with 200 ms pre-stimulus EEG serving as a baseline. We used a MATLAB algorithm to detected epochs with potentials exceeding ±75 μV (by comparing the maximum amplitude of sampling points in each epoch and 75 μV) in EOG electrodes and electrodes FP1, FP2, and FPz; and these epochs were then automatically excluded from further analysis. The mean number of rejected epochs was 8.7 ± 8.3, 7.1 ± 6.4, 8.6 ± 8.1, and 10.1 ± 7.6 for the 3F, 3D, 2F1D, and 3M bundles, respectively.

We chose the N2 and the P1 as two ERPs of interest. As for the N2, we focused our analyses on a negative wave peaking approximately at 160 to 250 ms post-stimulus in the electrodes Fz, FCz, Pz and POz (Folstein & van Petten, 2008). As for the P1, we focused our analyses on a positive wave peaking approximately at 80 to 140 ms in electrodes P7, P8, PO7, and PO8 (Caharel, Fiori, Bernard, Lalonde, & Rebaï, 2006). We used a MATLAB algorithm to automatically detect the absolute peaks in the time window of the N2 and the P1 in each channel, and then analyzed the peak values. In the analyses of stimulus-locked ERPs, the p-values of repeated-measure ANOVAs were reported after the Greenhouse-Geisser correction when necessary, and the p-values for multiple comparisons were reported after Bonferroni correction.

Results

Self-report ratings

The mean wanting and liking scores that each type of bundles received are shown in Figure 2. A one-way repeated-measure ANOVA on the wanting scores revealed a significant main effect of Bundle Type, F (3, 72) = 58.65, p < 0.001, η_p^2 = 0.71. Pairwise comparisons revealed that the 3F and 3D bundles received the highest and the lowest wanting scores, respectively, all ts > 5.24, ps < 0.001. By contrast, the 2F1D and 3M bundles received comparable wanting scores, t (24) = 0.95, p = 0.35. A similar ANOVA on the liking scores also revealed a significant main effect of Bundle Type, F (3, 72) = 49.29, p < 0.001, η_p^2 = 0.67. Pairwise comparisons revealed that the

3F and 3D bundles received the highest and the lowest liking scores, respectively, all *ts* > 4.38, *ps* < 0.002. By contrast, the 2F1D and 3M bundles received comparable liking scores, t (24) = 1.02, p = 0.32.

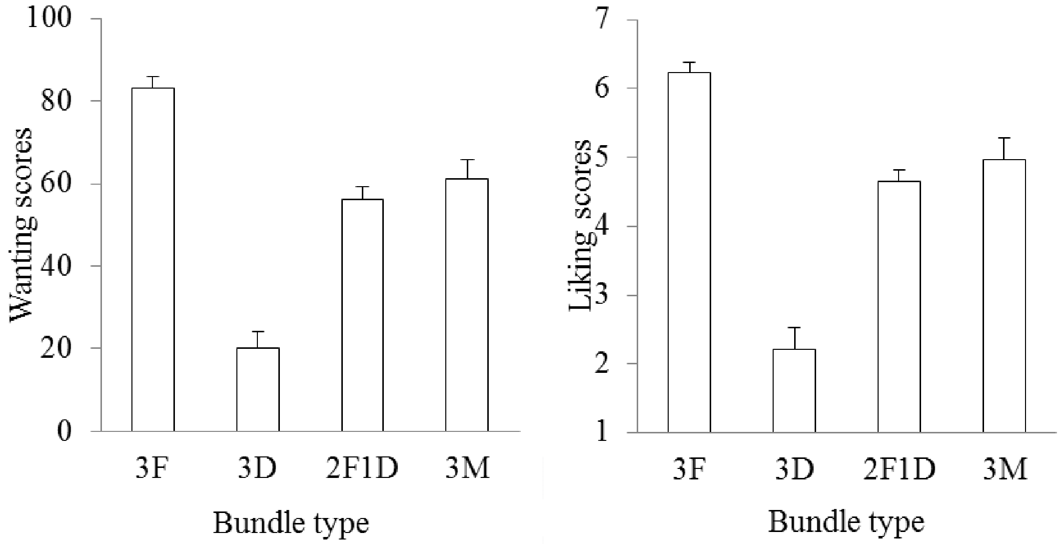

Figure 2. The mean wanting and liking scores for each type of bundles in Experiment 1. Error bars show the standard errors of means.

ERPs elicited by the 3F and 3D bundles

First, a 2 (Bundle Type: 3F or 3D) × 4 (Electrode Site: Fz, FCz, Pz or POz) repeated-measure ANOVA on the N2 amplitude revealed a significant main effect of Bundle Type, F (1, 24) = 5.78, p = 0.024, η_p^2 = 0.19, but it was qualified by a significant interaction term between Bundle Type and Electrode Site, F (3, 72) = 4.92, p = 0.021, η_p^2 = 0.17. The main effect of Electrode Site was not significant, F (3, 72) = 1.10, p = 0.36. In order to interpret the significant Bundle Type × Electrode Site interaction term, we conducted subsequent one-way ANOVAs for each electrode site.

As shown in Figure 3, the results revealed that the N2 amplitude was smaller for the 3F bundles than for the 3D bundles in electrodes Fz, F (1, 24) = 7.05, p = 0.014, η_p^2 = 0.23, and FCz, F (1, 24) = 10.62, p = 0.003, η_p^2 = 0.31; but not in electrodes Pz or POz, both Fs < 3.05, ps > 0.09.

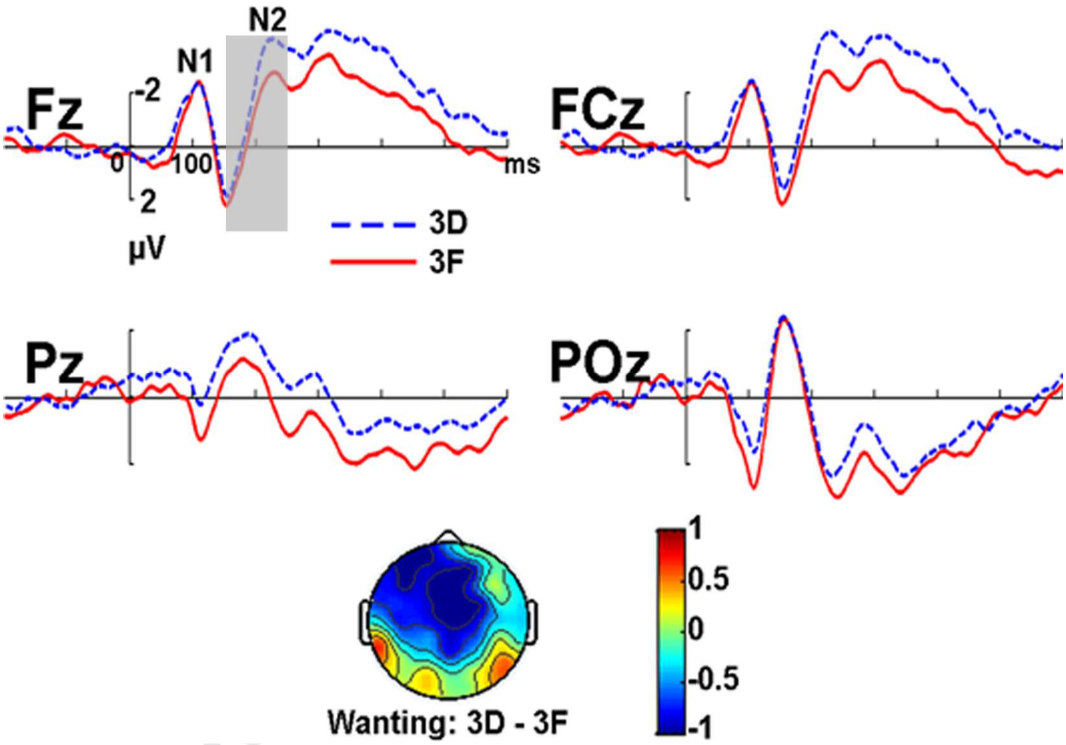

Figure 3. Grand-averaged ERPs elicited by the 3F and 3D bundles in electrodes Fz, FCz, Pz, and POz in Experiment 1. Note that the time window is 160 - 250 ms; and the scalp map shows the distribution of voltage on 205 ms, which is the average latency of the N2 for Experiment 1.

Second, a 2 (Bundle Type: 3F or 3D) × 2 (Electrode Site: P7/P8 or PO7/PO8) × 2 (Hemisphere: left or right) repeated-measure ANOVA on the P1 amplitude revealed a main effect of Bundle Type, F (1, 24) = 4.99, p = 0.035, η_p^2 = 0.17, and a main effect of Electrode Site, F (1, 24) = 76.96, p < 0.001, η_p^2 = 0.76. However, these main effects were qualified by a significant interaction between Bundle Type and Electrode Site, F (1, 24) = 5.96, p = 0.022, η_p^2 = 0.20, a significant interaction between Electrode Site and Hemisphere, F (1, 24) = 4.30, p = 0.049, η_p^2 = 0.15, and a significant three-way interaction, F (1, 24) = 3.74, p = 0.065, η_p^2 = 0.14. Neither of the rest of the main or interaction effects reached the significance level, both Fs < 3.75, ps > 0.06. As shown in Figure 4, subsequent one-way ANOVAs revealed a larger P1 for the 3F bundles than for the 3D in electrode P7, F (1, 24) = 8.87, p = 0.007, η_p^2 = 0.27, and PO7, F (1, 24) = 7.66, p = 0.011, η_p^2 = 0.24. By contrast, such an effect did not reach the significance level in electrode PO8, F (1, 24) = 3.57, p = 0.071, or P8, F (1, 24) = 0.24, p = 0.63.

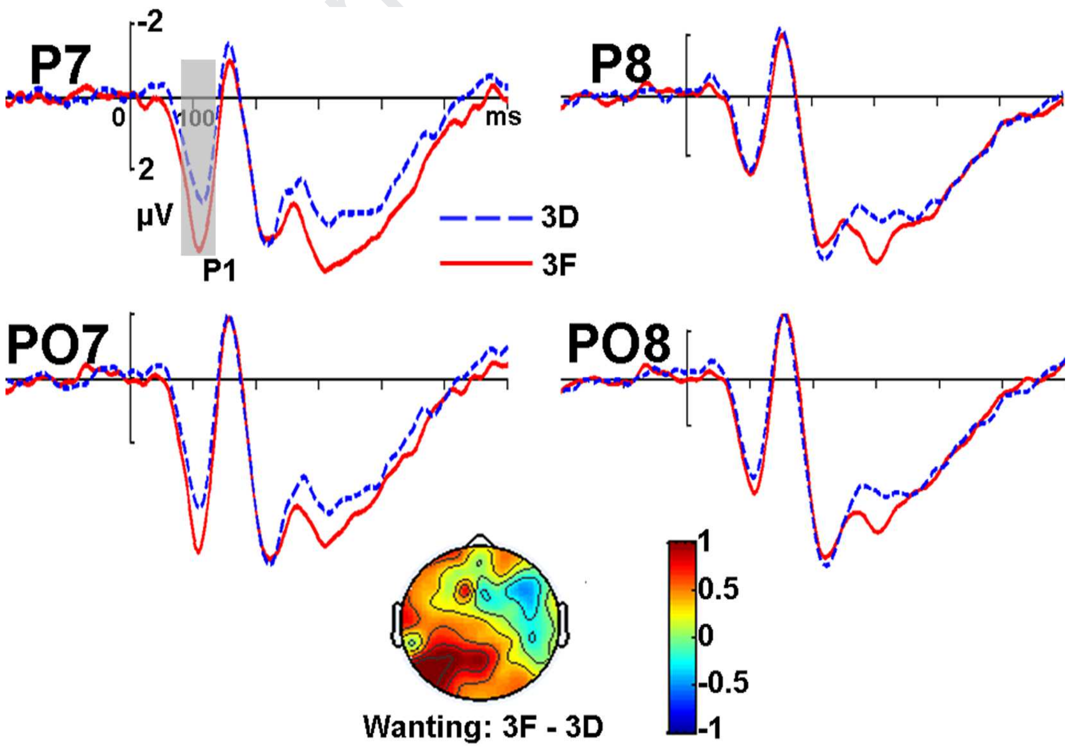

Figure 4. Grand-averaged ERPs elicited by the 3F and 3D bundles in electrodes P7,

P8, PO7 and PO8 in Experiment 1. Note that the time window is 80 - 140 ms; and the scalp map shows the distribution of voltage on 110 ms, which is the average latency of the P1 for Experiment 1.

ERPs elicited by the 2F1D and 3M bundles

A 2 (Bundle Type: 2F1D or 3M) × 4 (Electrode Site: Fz, FCz, Pz or POz) repeated-measure ANOVA on the N2 amplitude revealed a significant main effect of Bundle Type, F (1, 24) = 4.99, p = 0.035, η_p^2 = 0.17. As shown in Figure 5, this result suggested that the N2 amplitude was smaller for the 3M bundles than for the 2F1D bundles in these electrodes. Neither of the other main or interaction effects was significant, both Fs < 2.55, ps > 0.11.

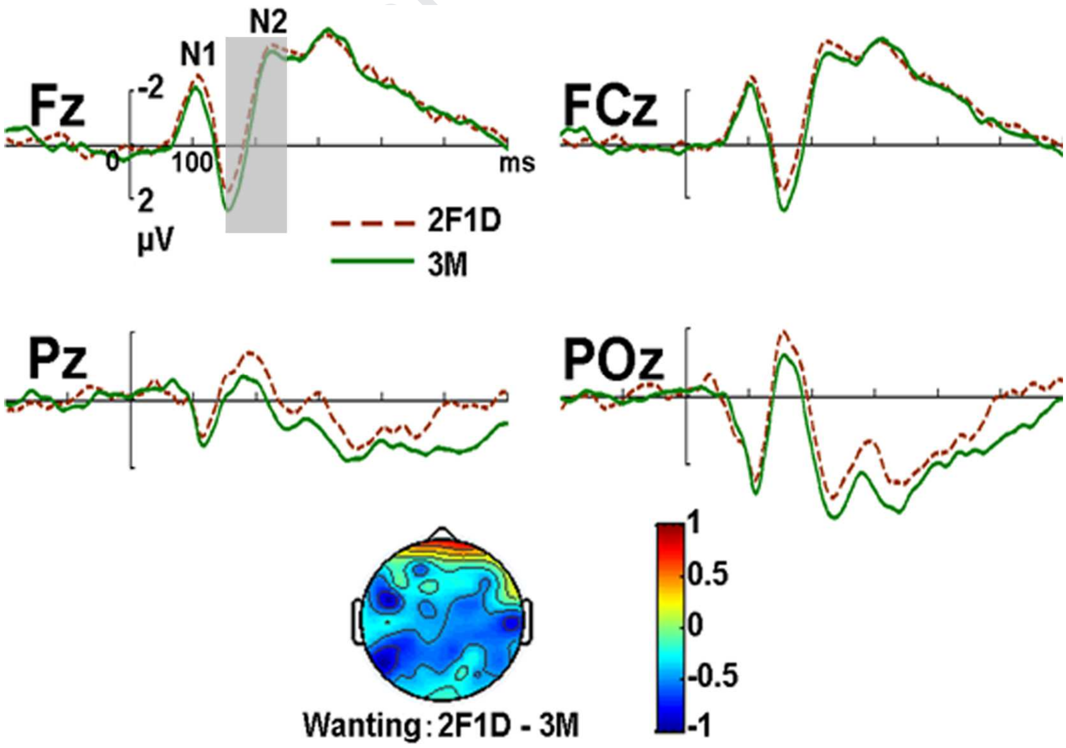

Figure 5. Grand-averaged ERPs elicited by the 2F1D and 3M bundles in electrodes Fz, FCz, Pz, and POz in Experiment 1. Note that the time window is 160 - 250 ms; and

the scalp map shows the distribution of voltage on 205 ms, which is the average latency of the N2 for Experiment 1.

Moreover, we also conducted a 2 (Bundle Type: 2F1D or 3M) × 2 (Electrode Site: P7/P8 or PO7/PO8) × 2 (Hemisphere: left or right) repeated-measure ANOVA on the P1 amplitude. As shown in Figure 6, the results revealed a significant main effect of Electrode Site, F (1, 24) = 96.10, p < 0.001, η_p^2 = 0.80, and a significant interaction term between Electrode Site and Hemisphere, F (1, 24) = 6.18, p = 0.02, η_p^2 = 0.21. None of other effects was significant, all Fs < 1.98, ps > 0.17.

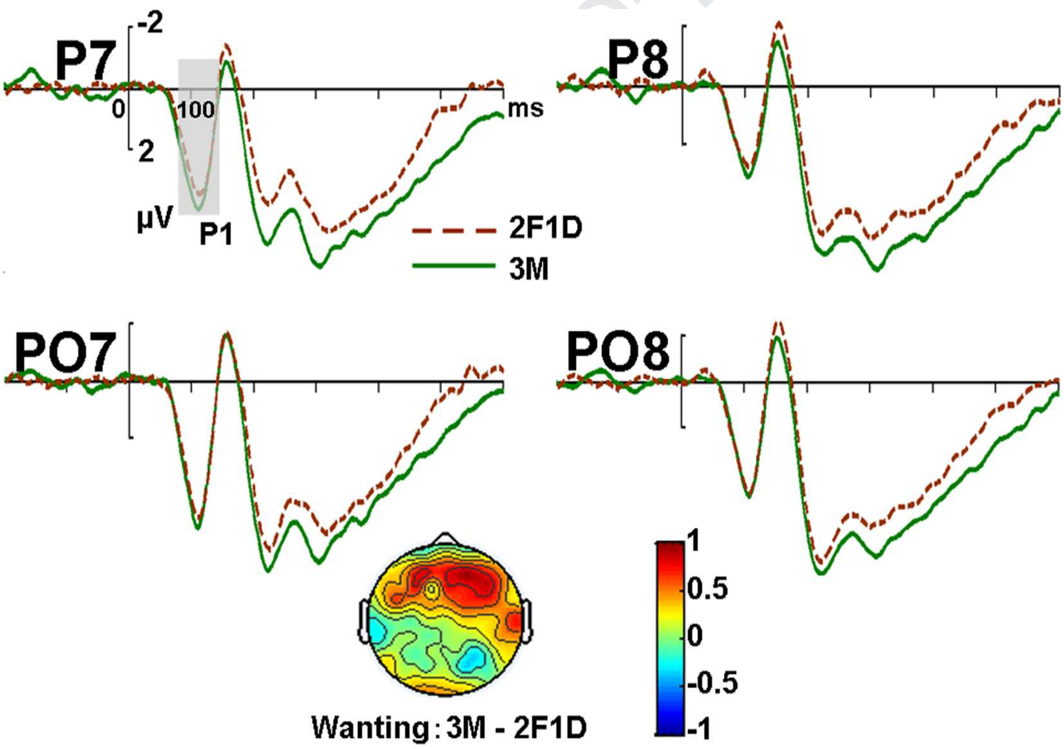

Figure 6. Grand-averaged ERPs elicited by the 2F1D and 3M bundles in electrodes P7, P8, PO7 and PO8 in Experiment 1. Note that the time window is 80 - 140 ms; and the scalp map shows the distribution of voltage on 110 ms, which is the average latency of the P1 for Experiment 1.

Discussion

In the present experiment, the 3F bundles consisting of the participants' favorite yogurt products received higher wanting and liking scores than the 3D bundles consisting of the products they disliked, suggesting that they wanted and liked the 3F bundles more than the 3D bundles. Moreover, the comparisons between these two types of bundles also revealed a significant difference in the N2 in electrodes Fz and FCz, and a significant difference in the P1 in electrodes P7 and PO7. Collectively, these results demonstrate that a smaller amplitude of the frontal N2 can index a higher level of wanting and liking, which is in line with Telpaz et al.'s (2015) and Goto et al.'s (2017) findings. Our results also provide novel findings by associating the P1 in the left hemisphere with the explicit component of wanting and liking.

Moreover, the 2F1D and 3M food bundles received comparable wanting and liking scores, but the ERP results revealed that the amplitude of the N2 was smaller for the 3M bundles than for the 2F1D bundles. Considering the associations between smaller amplitude of the N2 and wanting (Goto et al., 2017, and our own results about the 3F and 3D bundles), this difference in the N2 amplitudes may be attributed to the possibility that our participants might implicitly want and like 3M bundles more than the 2F1D bundles. Alternatively, it should be noted that the EEG signals can also capture the differences in the appearances of these two types of bundles (Luck, 2005). In order to rule out this possibility, we conducted Experiment 2 as a control study, and only asked the participants to visually process the bundles without making any subjective ratings.

EXPERIMENT 2

Methods

Twenty-five new Chinese participants (23.2 ± 2.48 years, ranging from 19 to 27 years; 16 females) took part in this experiment. All aspects of the methods in this experiment were the same as those in Experiment 1 except for the following differences. First, we randomly chose one flavor from the strawberry and yellow peach flavors and one flavor from seaberry and water chestnut flavors to present in the 3F and 3D bundles, respectively. Second, the participants were asked to perform a discrimination task during the EEG session. That is, they were asked to indicate whether two sequentially presented bundles were the same or not within each trial. Each participant completed a total of 288 trials in a random order, and the two sequentially presented bundles were the same in half of these trials but different in the rest of the trials. Each trial started with a fixation screen (800 to 1200 ms), followed by the presentation of one bundle for 1000 ms. After that, a second bundle was presented for 1000 ms or until the participants responded, whichever happened first. Then a blank screen was presented for 500 ms before the next trial started. The participants were instructed to press one of two keys on the keyboards to indicate whether the two bundles were the same or not. When analyzing the ERP data, we only focused on the stimulus-locked ERPs of the first bundle during the first 600 ms. The mean number of rejected epochs was, 13.6 ± 9.1, 15.3 ± 11.2, 13.7 ± 9.4, and 13.0 ±

10.2 for the 3F, 3D, 2F1D, and 3M bundles, respectively.

Results

ERPs elicited by the 3F and 3D bundles

First, we performed a 2 (Bundle Type: 3F or 3D) × 4 (Electrode Site: Fz, FCz, Pz, or POz) repeated-measure ANOVA on the N2 amplitude (see Figure 7). The main effect of Electrode Site was significant, F (3, 72) = 5.05, p = 0.019, η_p^2 = 0.17. However, the main effect of Bundle Type was not significant, F (1, 24) = 0.91, p = 0.35, and the interaction term was not significant either, F (3, 72) = 0.41, p = 0.66.

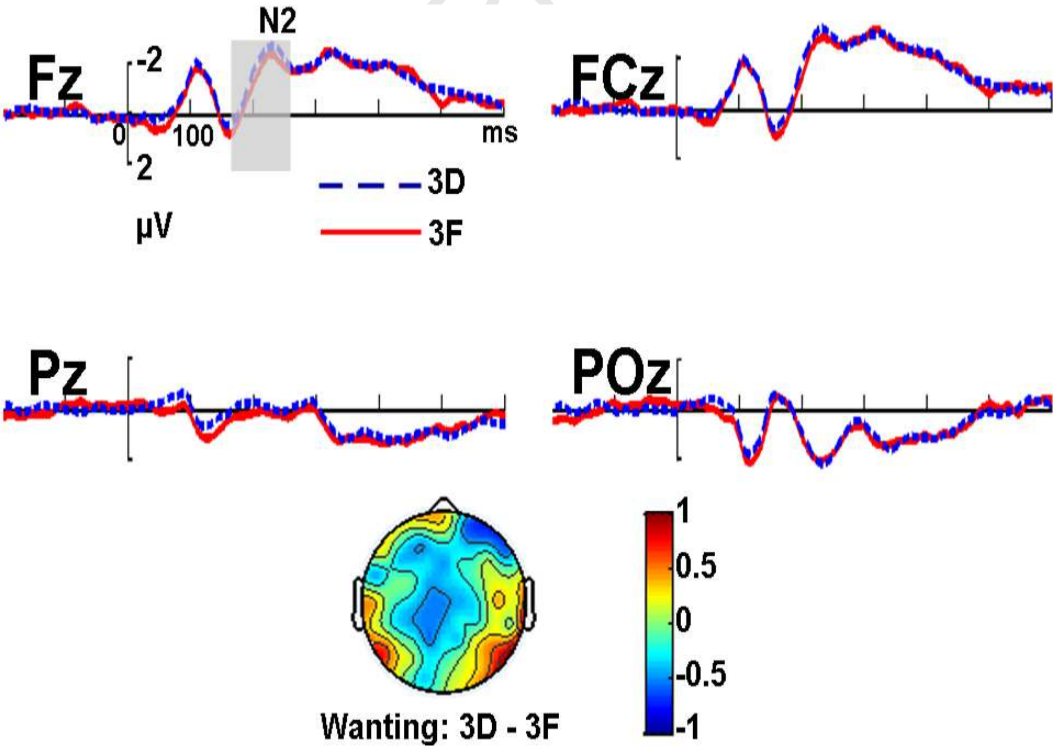

Figure 7. Grand-averaged ERPs elicited by the 3F and 3D bundles in electrodes Fz, FCz, Pz, and POz in Experiment 2. Note that the time window is 160 - 250 ms; and the scalp map shows the distribution of voltage on 210 ms, which is the average

latency of the N2 for Experiment 2.

Second, we conducted a 2 (Bundle Type: 3F or 3D) × 2 (Electrode Site: P7/P8 or PO7/PO8) × 2 (Hemisphere: left or right) repeated-measure ANOVA on the P1 amplitude (see Figure 8). The results revealed a significant main effect of Electrode Site (see Figure 8), F (1, 24) = 10.01, p = 0.004, η_p^2 = 0.29. None of other main or interaction effects was significant, all Fs < 3.28, ps > 0.082.

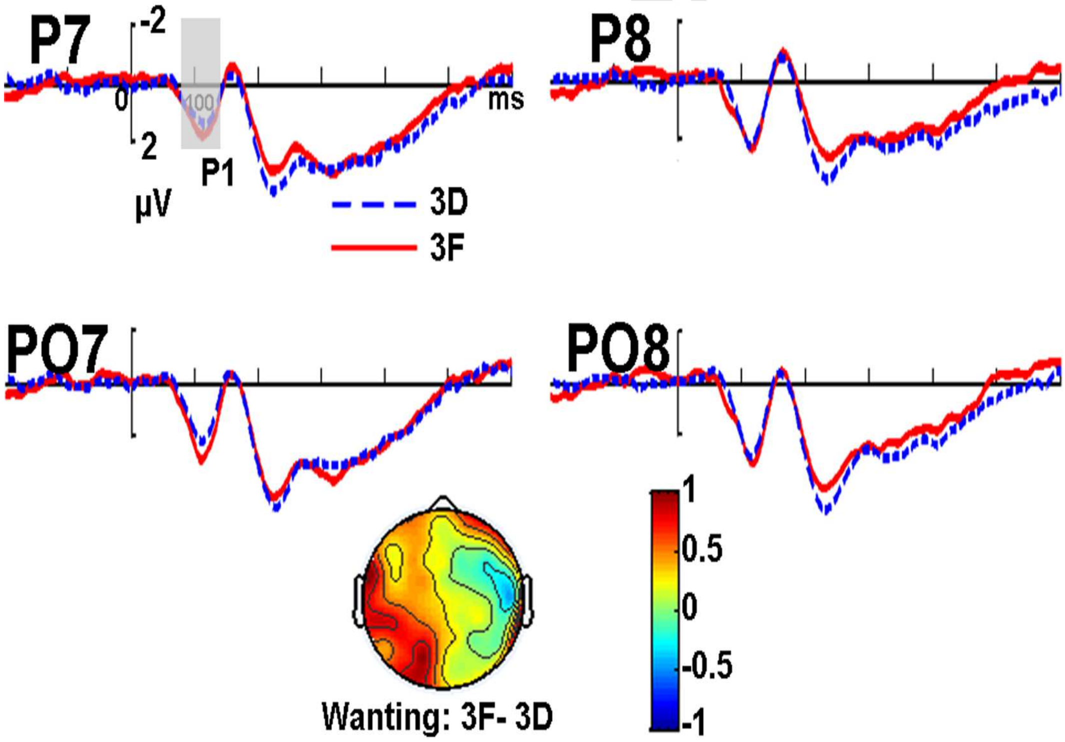

Figure 8. Grand-averaged ERPs elicited by the 3F and 3D bundles in electrodes P7 P8, PO7 and PO8 in Experiment 2. Note that the time window is 80 - 140 ms; and the scalp map shows the distribution of voltage on 110 ms, which is the average latency of the P1 for Experiment 2.

ERPs elicited by the 2F1D and 3M bundles

We also performed a 2 (Bundle Type: 2F1D or 3M) × 4 (Electrode Site: Fz, FCz, Pz, or POz) repeated-measure ANOVA on the N2 amplitude (see Figure 9). The main effect of Electrode Site was significant, F (3, 72) = 4.50, p = 0.03, η_p^2 = 0.16. Neither the main effect of Bundle Type, F (1, 24) = 1.84, p = 0.19, nor the interaction term, F (3, 72) = 0.21, p = 0.84, was significant.

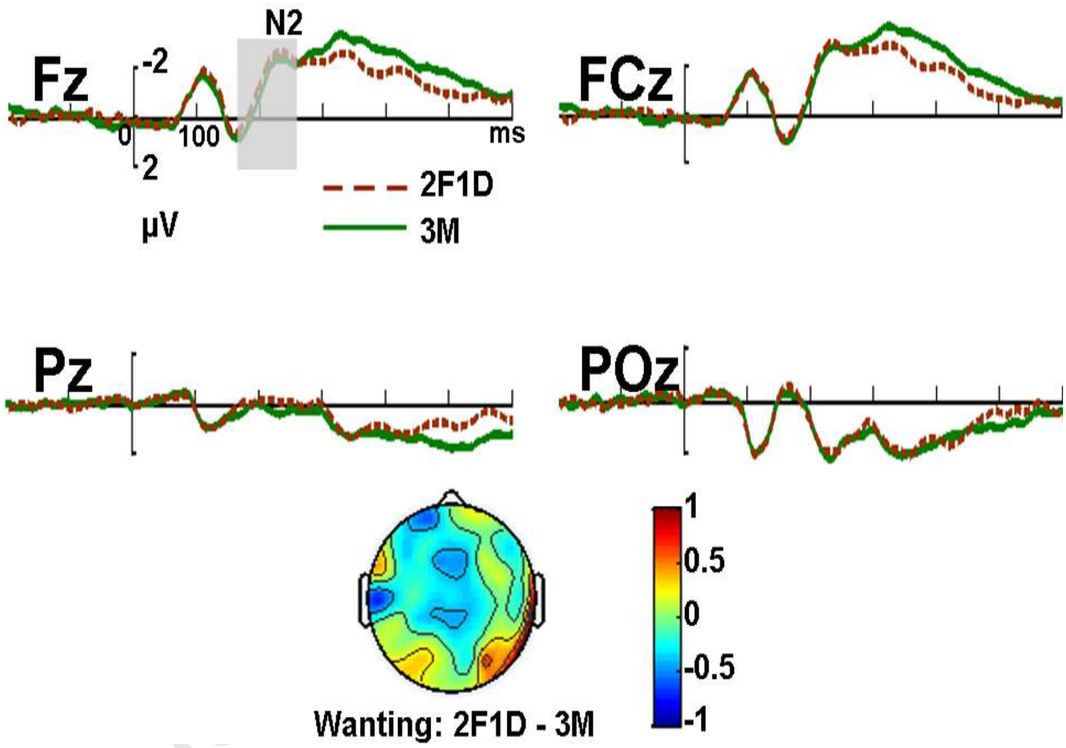

Figure 9. Grand-averaged ERPs elicited by the 2F1D and 3M bundles in electrodes Fz, FCz, Pz, and POz in Experiment 2. Note that the time window is 160 - 250 ms; and the scalp map shows the distribution of voltage on 210 ms, which is the average latency of the N2 for Experiment 2.

Finally, we performed a 2 (Bundle Type: 2F1D or 3M) × 2 (Electrode Site: P7/P8 or PO7/PO8) × 2 (Hemisphere: left or right) ANOVA on the P1 amplitude (see Figure 10). The results revealed a significant main effect of Electrode Site (see Figure 10), F

(1, 24) = 10.09, p = 0.004, η_p^2 = 0.30; whereas none of other effects was significant, all Fs < 2.85, ps > 0.10.

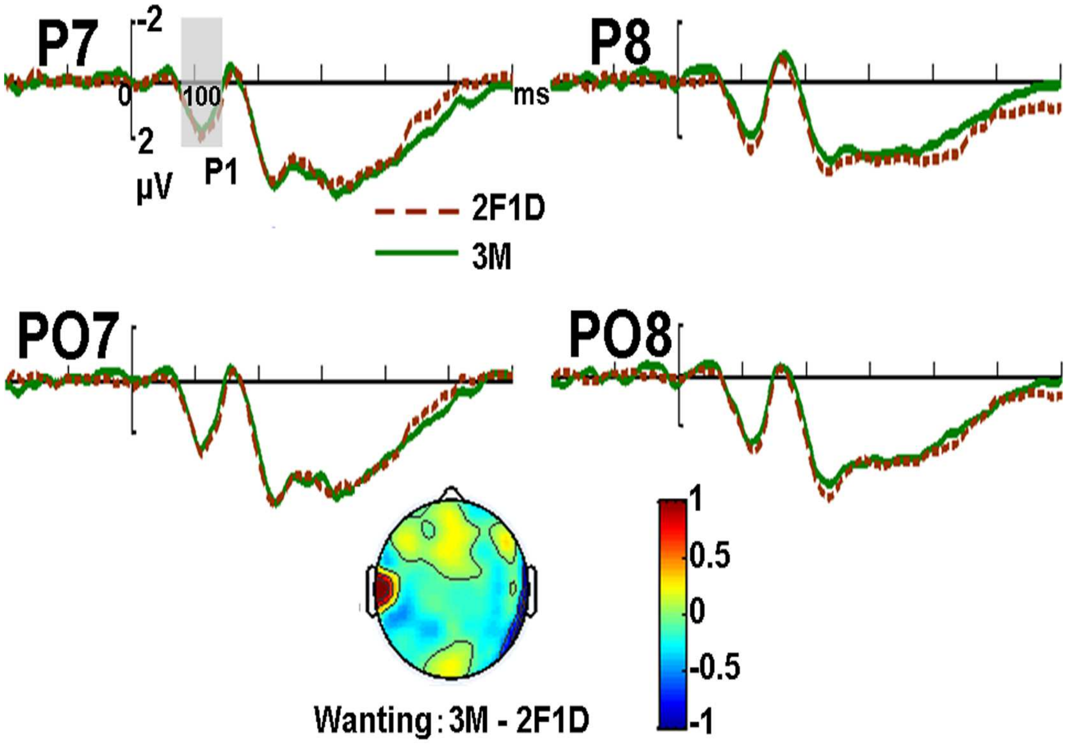

Figure 10. Grand-averaged ERPs elicited by the 2F1D and 3M bundles in electrodes P7, P8, PO7 and PO8 in Experiment 2. Note that the time window is 80 - 140 ms; and the scalp map shows the distribution of voltage on 110 ms, which is the average latency of the P1 for Experiment 2.

Discussion

In this experiment, the participants were only asked to perform a visual discrimination task on the bundles without making any ratings of wanting or liking. The results of this experiment revealed no significant differences in the N2 or the P1 elicited by the 3F and 3D bundles. Similarly, we did not observe any significant differences in the N2 or the P1 elicited by the 2F1D and 3M bundles. Collectively, these results suggest that the significant differences in the N2 or the P1 elicited by different types of bundles we found in Experiment 1 may not be attributed to the differences in the visual appearances of these bundles. That being said, it is possible that the effects of bundle type on the ERPs in Experiment 1 were associated with the context of the wanting task (see Carbin et al. 2018).

GENERAL DISCUSSION

In summary, two major findings emerged from the present study. First, our results associated the N2 with wanting for food bundles, though this wanting effect was intertwined with liking (also see Goto et al., 2017; Telpaz et al., 2015). This result not only extended the scope from wanting for a single product to wanting for a bundle of multiple products, but also specifically linked people’s wanting for food bundles to smaller amplitude of the N2 in frontal region of the brain. Our results also associated wanting for food bundles with the posterior P1. To the best of our knowledge, the present study provides the first empirical evidence to link ERPs earlier than the N2 to wanting. This result associated the P1 to food-related cognitive processes (Becker et al., 2016), and is in line with the literature about that the P1 is sensitive to the influence of motivation (Cunningham et al., 2012; Hammerschmidt et al., 2017).

Second, the results of this study revealed that the N2 may also index the differences in consumers’ responses to food rewards that cannot be easily captured by self-report ratings. That is, our results of self-report ratings did not reveal any significant difference between the 3M and 2F1D bundles, but our ERP results did reveal significant differences in the N2 elicited by these two types of food rewards. The dissociations between self-report ratings and ERPs we observed in this study are in line with the literature that people can generate motivation without conscious awareness (Winkielman, Berridge, & Wilbarger, 2005), and demonstrate that EEG signals are sensitive enough to capture the implicit processes of motivation processes (Jones, Childers, & Jiang, 2012; Pozharliev, Verbeke, van Strien, & Bagozzi, 2015).

It should be noted that the differences in the participants' responses to the 3M and 2F1D bundles (indexed by the N2) may be based on their tendency to seek variety. The 3M bundles did not contain the participants' favorite yogurt products, but it offered the highest level of variety that a three-item bundle could possibly offer. Numerous studies have demonstrated that consumers have the tendency to seek variety (Kahn, 1995; van Trijp et al., 1996), and can make simultaneous choices of multiple products independent of preference for a single product (Read & Loewenstein, 1995; Simonson, 1990). Therefore, it is possible that our participants implicitly wanted (and liked) the 3M bundles more than the 2F1D bundles due to their tendency to seek the higher level of variety provided by the 3M bundles. These results thus demonstrate that the EEG signals can bring more insight about the implicit process that cannot be obtained from purely direct measures (Ayres, Conner, Prestwich, & Smith, 2012).

As with any study, there are some limitations as far as the generalizability of the present study is concerned. First, the experimental design of the present study does not allow for successful dissociation between food wanting and liking (Koranyi, Grigutsch, Algermissen, & Rothermund, 2017). As for future research, it is important to further dissociate wanting and liking by manipulating wanting levels independently from liking levels, such as using hunger or no hunger manipulation (Finlayson et al., 2007, 2008). Second, we only used one type of hedonic foods (yogurt) as experimental stimuli, and it is interesting to extend our findings using more complex food bundles with components of different perceived importance (Yadav, 1994), such as a meal combo. Third, the absence of any significant difference between the liking scores of the 3M and 2F1D bundles in the present study also suggest that preference for single products and variety-seeking tendency may interact to influence consumers' preference for product bundles, which is also interesting to examine in future research.

In conclusion, we used one of the common neuroscience methods, the ERP, to investigate consumers' responses to different types of food rewards in the present study. Our results also demonstrate the important role of bundling in consumer preference, which may help to explain why bundling is such a prevalent and profitable promotion strategy (Hansen & Martin, 1987; Janiszewski & Cunha, 2004). Considering that the ERP data collected with a small group of participants may also be used to predict a large population's behaviors (Knutson & Karmarkar, 2014), our findings also provide rationale to manufacturers and retailers about why they offer product bundles with variety and which type of product bundles they should offer.

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Conflict of Interest Statement

None.

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