Food Cue Elicited Event-Related Potentials reflect food craving individual differences in adolescents

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This study is designed to investigate the relationship between electrophysiological and behavioral measures in the food research area. In the study, 51 adolescent subjects (age 10-17 yrs) sat through a passive picture viewing task of either food or nonfood pictures wearing an 128 hydrocell EEG net (EGI). The P3 (300-500 ms) and LPP (500-900 ms) event-related potentials (ERPs) were calculated over a head region identified by False Discovery Rate (FDR) to have the largest condition difference (food vs. nonfood). The food condition had a larger P3 and LPP than the nonfood condition over the left-midline parietal. The P3 in both the food and nonfood ERPs was positively correlated to one or more scales of Food Craving Questionnaire-State (FCQ-S) and Food Craving Questionnaire-Trait (FCQ-T). It suggested that the higher P3, the higher tendency of wanting food in different situations. Significant correlation were found in both the food and the nonfood conditions, but not in the difference wave. Our data suggest that in this study, the attentional bias between conditions was not attributed to individual differences in food traits.

Introduction

Extensive research has been conducted in the food related area. However, most studies are from a behavioral perspective and only a few have taken advantage of the electroencephalogram (EEG) technique to study the information processing of food. A few studies found an association between an attentional bias ERP component, the P300 and food related traits (Nijs, et al 2010) and with body fat percentage (Babiloni, et al 2009). Another study (Nijs, 2008) used a passive viewing task found that the P3 and LPP components were correlated with self-reported hunger level, but not correlated with a state sensitive food measurement.

To date most if not all published work have focused on adults. Thus, we explored the association between food-cue elicited ERPs and food trait measures in a healthy adolescent population.

Methods

Participants: 113 10-17 years old (55 males) completed the questionnaires. A random selection of 51 subjects (30 males) participated in the EEG experiment. 41 (23 males) had clean EEG data after preprocessing.

Procedure: After providing informed consent, subjects came for visit 1 and completed questionnaire DEBQ-C and FCQ-T. Visit 2 was scheduled within a month of visit 1. Subject's height and weight was recorded at that time. Subject also completed the picture viewing task with an EEG net on. Stimuli appeared on a 19'' LCD monitor and subjects were 36 inches away from the screen. Right after the EEG task, questionnaire FCQ-S was administrated to the subject.

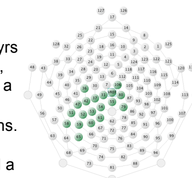
Stimuli: 45 food image and 45 nonfood images were presented on the screen in a pseudo-random order to the subjects. Subjects were asked to image what the food tastes like when they saw a food image. Before each stimulus, a cross sign was presented on the screen for 500 to 800 ms. Then the stimulus picture appeared on the screen and stayed for 1.5 seconds. The inter-trial-interval is 500 to 800 ms.

Questionnaires Measurements:
Dutch Eating Behavioral Questionnaire-Child(DEBQ-C): A 3-point (1-No, 2-Sometimes, 3-Yes) questionnaire consisting of 20 items. It asks questions regarding three aspect of food related behaviors, restrained, emotional and external. A sample question: "Does seeing or smelling food make you feel like eating?".
Food Craving Questionnaire-State: A 5-point questionnaire (1-Strongly disagree to 5-Strongly agree) with 15 items. It first asks what the subject's favorite food is, then provides statements like "I have an intense desire to eat [favorite_food]". It has five scales, desire, positive reinforcement, negative reinforcement, lack of control and hunger.
Food Craving Questionnaire-Trait: A 6-point questionnaire (0-never to 5-always) with 39 items and 9 scales, plan, positive reinforcement, negative reinforcement, lack of control, thought, emotion, environment and guilt. A sample question: "Being with someone who is eating often makes me hungry".

Data Acquisition and Processing: EEG was recorded using DC AMP3.0 (EGI) at 250 Hz sampling rate and Cz reference. In the data preprocessing, EEG was filtered at 0.1 Hz high-pass and 30 Hz low-pass. Then it was segmented at 100 ms before and 900 ms after the picture onset. In the artifact detection, trials with any eye blinks or eye movements or more than 10 bad channels were excluded. Then averaged reference and baseline correction was applied to the data. Subjects with less than 15 trials were excluded. Use False Discovery Rate to determine the region that has the largest condition difference. The calculate the average brainwave during 300-500 ms as P3, and 500-900 ms as LPP.

Results

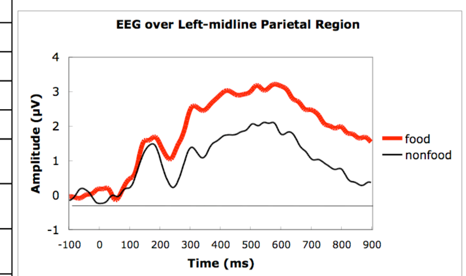
FDR: channels that had significant condition difference over P3 and LPP period: 42, 37, 31, 54, 129, 53, 60, 59, 51, 47, 36, 58, 65, 61, 80, 79, 106, 55, 52. They were in the left-midline parietal region.



Channel Cluster

EEG: Repeated Measures ANOVA Condition(2) x Sex(2) x Age(3: 10-12yrs (n=10), 13-14yrs (n=20), 15-17yrs (n=11)) for P3 and LPP. Condition effect was significant in both components, P3, $F(1, 35) = 39.83$, $p < .001$, partial $\eta^2 = .53$, LPP, $F(2, 28) = 25.24$, $p < .001$, partial $\eta^2 = .42$. It indicated that the food condition generated a larger P3 and LPP than the nonfood condition. There were no significant interactions. Condition x Sex, P3,$F(1, 35) = .16$, ns, LPP, $F(1, 35) < .001$, ns, Condition x Age, P3,$F(2, 35) = .99$, ns, LPP, $F(2, 35) = 1.58$, ns. Condition x Sex x Age, P3,$F(2, 35) = .57$, ns, LPP, $F(2, 35) = .20$, ns.
There was a significant Sex main effect at P3, $F(1,35) = 5.89$, $p < .05$, male (mean = 1.23 μV, SE = .57) had a smaller amplitude than female (mean = 3.26 μV, SE = .61), mean difference = -2.02, SE = .83, but not at LPP, $F(1,35) = 1.55$, ns. No significant Age main effect, P3, $F(2, 35) = .77$, ns, LPP, $F(2, 35) = .85$, ns. No significant Age x Sex interaction, P3, $F(2, 35) = 1.62$, ns, LPP, $F(2,35) = 2.79$, ns.

Measure1	Measure2	Correlation
BMI	Age	r = .45, p < .001, n = 91
BMI	DEBQ-C, restrained	r = .25, p = .02, n = 89,
BMI	DEBQ-C, external	r = -.29, p < .01, n = 89
BMI	FCQ-S, Factor 1	r = -.26, p < .05, n = 87
BMI	FCQ-T, Factor 1	r = -.23, p < .05, n = 90
P3	FCQ-S, Postiive Reinforcement	food, r = .42, p < .01, nonfood, r = .34, p = .04, n = 38
P3	FCQ-S, Lack of Control	food, r = .34, p = .04, nonfood, r = .29, ns , n = 38
P3	FCQ-S, Hunger	food, r = .34, p =.04, nonfood, r = .36, p = .03, n = 38
P3	FCQ-T, Hunger	food, r = .37, p = .02, nonfood, r = .30, p = .06, n = 41



Conclusions

1) The passive picture viewing task generates food, nonfood EEG differences in the left-midline parietal region in adolescents.
2) P3 is positively correlated with hunger in both FCQ-S and FCQT, which replicates Nijs(2008)'s study in adolescents.
3) P3 is also correlated with Positive reinforcement and lack of control in FCQ-S. It indicates that subjects with a higher P3 tend to be more attracted to food in different situations.
4) Neither P3 or LPP is correlated with DEBQ-C. It may suggest that DEBQ-C (3-point) does not have a sufficient range in normal adolescent subjects.
5) More scales in FCQ-S are correlated with the EEG data than in FCQ-T. It may suggest that a state sensitive questionnaire is more likely to be related with the EEG measurement.
6) Questionnaires are correlated with both food and nonfood EEG, but not the difference wave. It suggests that the attentional bias between conditions are not related with food attitudes.
7) LPP is not correlated with any of the measurements. It may indicate that P3 is a better indicator for attentional bias than LPP.

Relevance and future: P3 can be used as a marker for food related traits. Future research needs to be conducted to 1. test whether the marker is reliable at a larger scale. 2. test whether the same marker is able to behave well in populations with eating disorders.

REFERENCES:
Babiloni C, Del Percio C, Valenzano A, Marzano N, De Rosas M, Petito A, Bellomo A, Rossi G, Lecce B, Mundi C, Lizio R, Eusebi F, Cibelli G. (2009) Frontal attentional responses to food size are abnormal in obese subjects: an electroencephalographic study. Clin Neurophysiol. 2009 Aug;120(8):1441-8. Epub 2009 Jul 18.
Nijs IM, Franken IH, Muris P. (2010). Food-related Stroop interference in obese and normal-weight individuals: behavioral and electrophysiological indices. Eat Behav. Dec;11(4):258-65. Epub 2010 Jul 22.
Nijs IM, Muris P, Euser AS, Franken IH. (2010). Differences in attention to food and food intake between overweight/obese and normal-weight females under conditions of hunger and satiety. Appetite. Apr;54(2):243-54. Epub 2009 Nov 14.
Nijs IM, Franken IH, Muris P.(2008) Food cue-elicited brain potentials in obese and healthy-weight individuals. Eat Behav. 2008 Dec;9(4):462-70. Epub 2008 Aug 15.
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