Food cue-elicited brain potentials in obese and healthy-weight individuals

Ilse M.T. Nijs*, Ingmar H.A. Franken, Peter Muris

Institute of Psychology, Erasmus University Rotterdam, the Netherlands

A R T I C L E   I N F O

Article history:
Received 3 January 2008
Received in revised form 27 May 2008
Accepted 29 July 2008

Keywords:
Obesity
Cue reactivity
Event-related potentials
P3
Late positive potentials
Food craving

A B S T R A C T

The main objective of this study was to investigate, by means of event-related potentials (ERPs), whether obese individuals process food-related information differently as compared to normal-weight individuals. Because amplitudes of late positive ERP components (P3, LPP) reflect motivational tendencies, obese participants were expected to display enlarged P3 and LPP amplitudes towards food pictures. Obese and normal-weight adults were exposed to pictures of food and control items, while EEG was recorded. Subjective levels of food craving and hunger were also assessed. While there were no differences in ERP amplitudes between obese and normal-weight individuals, significantly larger P3 and LPP amplitudes were elicited by pictures of food items as compared to control pictures. Positive correlations were found between P3 and LPP amplitudes and self-reported increases of hunger. It was concluded that food-related information is processed differently in the brain as compared to non-food-related information, in a manner that reflects the natural motivational value of food. In the present study, there was no indication of an electrophysiological or subjective hyper-reactivity to food cues in obese adults.

© 2008 Elsevier Ltd. All rights reserved.

1. Introduction

In western societies, health organizations raise the alarm because of increasing prevalence rates of overweight (Body Mass Index [BMI] ≥ 25 kg/m²) and obesity (BMI ≥ 30 kg/m²) in the general population. For example, in the Netherlands – where the present study was conducted – an epidemiological study during the period 1998–2001 revealed that 40 to 50% of adults between the ages of 20 and 70 years are overweight, while circa 10% of them are obese (Visscher, Viet, Kroesbergen, & Seidell, 2006). Similar research, conducted between 2002 and 2004, led to the conclusion that about 15% of the Dutch children between 4 and 15 years are overweight, whereas 3% of them can be labelled as obese (van den Hurk et al., 2006). These figures have even doubled since the 1980s, and are expected to double once more in the upcoming two decades if no interventions are undertaken (Bemelmans, Hoogenveen, Visscher, Verschuren, & Schuit, 2004; Schokker, Visscher, Nooyens, van Baak, & Seidell, 2007).

In essence, overweight is the result of a chronic imbalance between energy intake and energy expenditure: more kilocalories are ingested than necessary for the body's metabolism. Although this imbalance is the consequence of a complex interplay between genetic–biological and environmental–behavioral factors, it is the environment, promoting an unhealthy lifestyle and 'obesogenic' behavior, that is held largely responsible for the dramatic worldwide increase in the prevalence of overweight (Hill & Peters, 1998; Hill, Wyatt, Reed, & Peters, 2003). More precisely, the abundant availability of rewarding, thus high-caloric and palatable, food is emphasized to contribute to overeating behavior (Hill & Peters, 1998; Speakman, 2007; Volkow & Wise, 2005). It has been suggested that there are individual differences in the sensitivity and reactivity to the rewarding properties of environmental food cues (Beaver et al., 2006; Franken & Muris, 2005). In sensitive individuals, the mere exposure to palatable food might induce excessive craving and a tendency to indulge in overeating behavior, even in the absence of physiological hunger or nutritional deficits (Berridge, 2007; Jansen, 1998; Wardle, 1990).
Individual differences in food cue responsiveness are assumed to depend considerably on classical conditioning mechanisms (Jansen, 1998; Wardle, 1990). Conditioning models for excessive eating propose that actual food cues and classically conditioned (external as well as internal) eating-related stimuli may become strong predictors for food intake and anticipatorily elicit physiological responses, which are associated with craving. Preliminary evidence suggests that conditioned food cue responsiveness is stronger in obese individuals than in normal-weight persons. For example, Jansen et al. (2003) investigated cue-elicited craving and overeating in obese and normal-weight children. After being exposed to the smell of tasty food or to the taste of an appetizing preload, obese children demonstrated a significantly increased food intake as compared to a control condition without food confrontation, whereas the food intake of normal-weight children generally decreased in the food exposure conditions.

Conditioned cue reactivity models for overeating behaviors have their roots in classical addiction theories, in which conditioned drug cue reactivity and drug craving are believed to contribute considerably to the development and maintenance of addictive disorders and the well-known tendency to relapse when abstinent (Franken, 2003; O’Brien, Childress, Ehrman, & Robbins, 1998; Robinson & Berridge, 1993). Moreover, overeating clearly exhibits other features of addictive behavior: it is characterized by the impulsive seeking and intake of a rewarding substance in spite of the negative health and psychosocial consequences, and attempts to control the behavior frequently result in relapse to initial overeating and intake of high-caloric food (Kramer, Jeffery, Forster, & Snell, 1989; Stalonas, Perri, & Kerzner, 1984; Wadden & Frey, 1997). In addition, similarly to addiction, empirical findings suggest that the overeating behavior of (at least a subgroup of) obese individuals might be the result of a substantially enhanced motivation for food, which may have its origins in the aberrant functioning of reward-related brain processes (Volkow et al., 2002; Wang et al., 2001).

In substance dependent individuals, electrophysiological research, using cue exposure paradigms, has yielded robust findings concerning the processing of drug-related information. When confronted with drug-related pictures, long-latency waves, such as the P3 and Late Positive Potential (LPP), in the event-related potential (ERP) pattern of addicted individuals were found to be significantly increased in centro-parietal regions as compared to non-addicted control subjects, suggesting an enhanced cortical processing of these stimuli (Herrmann et al., 2000; Herrmann, Weijers, Wiesbeck, Bonging, & Fallgatter, 2001; Littel & Franken, 2007; Lubman, Allen, Peters, & Deakin, 2007; Warren & McDonough, 1999). Long-latency ERPs are thought to reflect the allocation of attention and cognitive effort (Kok, 1997). It is assumed that more cognitive resources are allocated to motivationally salient (positive and negative) stimuli. In emotional contexts, there is general agreement that long-latency ERP amplitudes are modulated by the motivational salience of cognitively processed information (Schupp et al., 2000). A sustained selective processing bias, reflecting the activation of the brain’s motivation system, would induce an appropriate behavioral (approach or avoidance) response to motivational salient stimuli (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Franken, Stam, Hendriks, & van den Brink, 2003). Interestingly, in addiction-related ERP-studies the amplitude of LPPs appears to be positively correlated with self-reported drug craving, which supports the idea that LPP amplitude reflects motivational tendencies (Franken, Hulstijn, Stam, Hendriks, & van den Brink, 2004; Franken et al., 2003; Lubman et al., 2007; van de Laar, Licht, Franken, & Hendriks, 2004).

The present study addresses the processing of food cues in normal-weight and obese individuals. The aims of the present study are twofold. The first aim is to investigate whether palatable food-related stimuli result in enhanced processing as compared to non-food stimuli. We expected larger P3 and LPP amplitudes when individuals are exposed to food stimuli as compared to control stimuli (i.e., office items). The second aim was to examine whether obese individuals display enhanced processing of food-related information as compared to normal-weight controls. In other words, this study investigated whether there is a general processing bias for food-related information and whether this bias is enhanced in obese individuals as compared to normal-weight individuals. If obesity indeed is the result of an abnormally enhanced motivation for food, which is characterized by an excessive reactivity towards food cues, larger P3 and LPP amplitudes for food cues would be expected in the obese group. Furthermore, as LPP and P3 amplitudes reflect motivational tendencies, it can be expected that these measures correlate positively with self-report measures of food craving and hunger.

So far, few studies have addressed cortical processing of food information by means of ERPs. These studies were primarily concerned with the influence of hunger and satiety on food-related information processing (e.g., Carretié, Mercado, & Tapia, 2000; Hachl, Hempel, & Pietrowsky, 2003; Plihal, Haenschel, Hachl, Born, & Pietrowsky, 2001). However, for a number of reasons, the results of these studies are rather difficult to interpret when it comes to the mere processing of food stimuli. First of all, actual processing of stimuli was influenced by other cognitive tasks, which the participants had to perform simultaneously, such as stimulus identification or stimulus matching. Second, stimuli were not shown explicitly to participants (as is the case in real world), but presented as words or in a subliminal or deformed way. Third, the focus of these studies was the influence of food deprivation on brain activity in general. With this in mind, the present study adopts a more straightforward approach: participants are passively exposed to pictures of palatable foods as well as neutral control pictures while recording their EEG activity. Further, we not only examine the relation between hunger and ERPs, but are also interested in the influence of food craving on the processing of food-related information, because this process is thought to play a primary role in the origins of overeating behavior. Exploratively, we will also investigate the hemispheric distribution of ERPs: appetitive food cues are expected to predominantly activate left-hemispheric brain areas, since electro-cortical activation in the left hemisphere is believed to be associated with approach behavior towards emotionally pleasant stimuli (Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Sutton & Davidson, 2000).

2. Methods

2.1. Participants

Via advertisements, healthy obese (BMI ≥ 30 kg/m²) and healthy normal-weight (BMI 20–25 kg/m²) men and women between the ages of 18 and 50 years were approached to volunteer in a study concerning brain activity and body weight. Participants were
Twenty photographs of generally palatable and high-caloric food items (e.g., French fries, chocolate) and 20 photographs of office items (e.g., paperclips, stapler) were shown on a computer monitor for a duration of 2000 ms and with a resolution of 1024×768 pixels. All pictures were presented four times with a fixed interstimulus interval of 1500 ms. The pictures were presented to the subjects in a semi-random order, in such way that no more than three pictures of the same category were shown successively.

Visual analogue scales were used to evaluate the valence (0=very unpleasant; 100=very pleasant) and arousability (0=not at all arousing; 100=very arousing) of each food and non-food picture. For this purpose, the participants received a file with printed versions of all pictures. For each picture individually, the participants were asked to place a vertical line on the two VASs, corresponding to their ratings of valence and arousability. The non-food control pictures were expected to be assessed as neutral in valence and low in arousal by all participants. The food pictures, however, were expected to be assessed as significantly more pleasant and arousing than the control pictures.

2.4. Procedure

In order to bring all participants in a comparable hunger state and to exclude direct effects of food intake on ERP responses, participants were requested to eat a light meal 2 h before the start of the experiment, and subsequently to abstain from any food or caloric drinks until the experiment was finished.

On arrival at the university laboratory, the experimental procedure was briefly explained. Participants were given the opportunity to ask remaining questions, and written informed consent was provided. First, all participants completed self-report questionnaires to assess pretest food craving and physiological hunger, as well as the exact time that they had last eaten, their present body weight, and length. Subsequently, participants were seated in a comfortable chair in a dimly-lit, sound-attenuated room and EEG electrodes were attached. Each participant first performed a modified Stroop task including food-related words (data not reported here), followed by the exposure session, during which the pictures of food and non-food items were displayed. The subject was instructed to sit as relaxed and quietly as possible and to look attentively at the pictures. To motivate the participants to remain attentive during the whole task, they were told that questions were going to be asked about the pictures after the experiment. At the end of the experiment, participants filled in the food craving and hunger scales for a second time and were asked to rate the valence and arousability of the pictures. All subjects received a financial remuneration for their participation.

2.5. Electroencephalographic (EEG) recording

EEG signals were recorded, using an Active-Two amplifier system (Biosemi, Amsterdam, the Netherlands), of 64 scalp sites (10–20 system) with active Ag/AgCl electrodes mounted in an elastic cap. Two additional scalp electrodes were used as reference and

---

For replication purposes, a list of the used photographs can be obtained from the first author.
ground electrode, respectively. Furthermore, additional electrodes were attached to the left and right mastoids, and to the supraorbital regions of the left and right eye (VEOG). Online, signals were recorded with a low pass filter of 134 Hz. All signals were digitized with a sample rate of 512 Hz and 24-bit A/D conversion. Off-line, data were re-referenced to a computed linked mastoid. EEG and EOG activity was filtered with a bandpass of 0.10–30 Hz (phase shift-free Butterworth filters; 24 dB/octave slope). After ocular correction (Gratton, Coles, & Donchin, 1983), epochs including an EEG signal exceeding ±100 μV were eliminated. When more than 50% of the epochs contained artifacts, subjects were excluded from further analyses. As a result, two participants had to be excluded (one obese and one control participant). The mean number of included food trials was 67.61 (SE = 1.50), and the mean number of office trials was 67.50 (SE = 1.50). The mean 200 ms prestimulus period served as baseline. EEG was recorded from 200 ms prestimulus to 2000 ms poststimulus. After baseline correction, ERP waves were calculated for each participant, at each scalp site, for the two stimulus conditions. Based on visual inspection of the grand average waveform (Fig. 1) and the existing literature (e.g., Franken et al., 2003) P3 was defined as the average amplitude (μV) within the 300–400 ms time window, while LPP was defined as the average amplitude within the 400–800 ms latency window.

Fig. 1. Grand average food cue- (solid lines) and office cue-elicited (dashed lines) waveforms for left- and right-hemispheric central and posterior electrode clusters in obese (n = 19; black lines) and normal-weight (n = 19; grey lines) subjects.
2.6. Statistical analyses

By means of an independent samples t-test, between-group differences were evaluated with regard to the elapsed time since last eaten (in minutes). To evaluate main and interaction effects for hunger (VAS) and food craving (G-FCQ-S), 2×2 repeated measures analyses of variance (ANOVA) were performed with group (obese/normal-weight) as between-subjects factor and time (pretest/posttest) as within-subjects factor. To compare the valence and arousal ratings of the pictures, 2×2 repeated measures ANOVAs were carried out with group as between-subjects factor and cue category (office/food) as within-subjects factor. In case of significant effects, post-hoc t-tests were conducted.

To analyze P3 and LPP data, repeated measures ANOVAs were performed with group as between-subjects factor, and cue category, hemispheric distribution (left/right) and electrode site as within-subjects factors. Fifty-four non-midline electrode sites were grouped into 6 clusters (e.g., Codispoti, Ferrari, & Bradley, 2007): 2 posterior clusters (left posterior: P1, P3, P5, P7, P9, PO3, PO7, O1; right posterior P2, P4, P6, P8, P10, PO4, PO8, O2); 2 central clusters (left central: FC1, FC3, FC5, FT7, C1, C3, C5, T7, CP1, CP3, CP5, TP7; right central: FC2, FC4, FC6, FT8, C2, C4, C6, T8, CP2, CP4, CP6, TP8) and 2 anterior clusters (left anterior: F1, F3, F5, AF3, AF7, Fp1; right anterior: F2, F4, F6, F8, AF4, AF8, Fp2). For each cluster the ERP amplitudes of individual sites were averaged. A 2 (group)×2 (cue category)×2 (hemisphere)×3 (cluster) repeated measures ANOVA (with Greenhouse–Geisser corrected dfs; uncorrected dfs are reported) was conducted out for each ERP component. In case of significant effects, post-hoc t-tests were conducted with Bonferroni adjustments for multiple comparisons.

To evaluate the relationship between self-reported food craving, hunger, and valence and arousability ratings of pictures on the one hand, and amplitudes of the ERP components on the other hand, Pearson correlations were calculated. For food craving and hunger, G-FCQ-S and VAS difference scores (posttest–pretest) were calculated, because these scores best reflect the responsivity of these variables during the course of the experiment.

3. Results

3.1. Self-report measures

No between-group difference was found with regard to the elapsed time since last eaten (t=1.18, p>.05). Mean hunger and food craving scores for obese and normal-weight participants are displayed in Table 1. Main time effects were found for food craving, F(1,37)=31.66, p<.001, as well as hunger scores, F(1,38)=17.31, p<.001. This result indicates that participants generally reported significantly more food craving and hunger at posttest (after the food picture exposure) as compared to pretest. No significant time×group interaction effects were found (both Fs<1), suggesting that the increase in food craving and hunger was similar in both groups. For hunger, a main group effect was found, F(1,38)=12.66, p<.01. Post-hoc t-tests revealed that group differences were significant at pretest (t=3.29, p<.01) as well as posttest (t=3.29, p<.01): on both occasions, the normal-weight group reported higher levels of hunger than the obese group.

Main effects of cue category were found for the valence, F(1,38)=33.68, p<.001, and arousability, F(1,38)=86.79, p<.001, of the pictures. That is, food pictures were generally evaluated as more pleasant (M=65.58, SD=12.25 vs. M=45.33, SD=15.21) and arousing (M=52.61, SD=18.37 vs. M=20.04, SD=17.69) than office pictures. No main effect of group nor an interaction effect of group and cue category was found.

3.2. Event-related potentials

The analysis of the P3 data yielded significant main effects for cluster, F(2,72)=81.41, p<.001, and cue category, F(1,36)=6.79, p<.05. In addition, a significant interaction effect of cluster and cue category was found, F(2,72)=13.03, p<.01. Post-hoc t-tests revealed that the cue effect was only significant at the central (p<.01) and the posterior (p<.001) clusters. For both clusters, the amplitudes elicited by food cues (M<sub>central</sub>=3.72 µV, SE=.59; M<sub>posterior</sub>=8.61 µV, SE=.70) were significantly larger as compared to the amplitudes elicited by office cues (M<sub>central</sub>=2.92 µV, SE=.57; M<sub>posterior</sub>=6.92 µV, SE=.73). No significant effects were found for group or hemisphere.

A highly similar pattern was observed for the LPP data. That is, significant main effects were found for cluster, F(2,72)=37.84, p<.001, and cue category, F(1,36)=14.17, p<.01, while the cluster×cue interaction effect was also significant, F(2,72)=13.56, p<.001. Post-hoc t-tests demonstrated significant cue effects at the central (p<.001) and the posterior (p<.001) clusters. Again,

Table 1
Mean pretest and posttest food craving (G-FCQ-S) and hunger (VAS) scores in the obese group (N=20) and normal-weight control group (N=20)

<table>
<thead>
<tr>
<th></th>
<th>Obese M</th>
<th>Obese SD</th>
<th>Normal-weight M</th>
<th>Normal-weight SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-FCQ-S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>26.4</td>
<td>11.0</td>
<td>30.3</td>
<td>7.3</td>
</tr>
<tr>
<td>Posttest</td>
<td>33.8</td>
<td>12.8</td>
<td>37.9</td>
<td>9.4</td>
</tr>
<tr>
<td>Hunger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>13.4</td>
<td>16.1</td>
<td>33.3</td>
<td>22.3</td>
</tr>
<tr>
<td>Posttest</td>
<td>22.6</td>
<td>24.5</td>
<td>47.7</td>
<td>23.7</td>
</tr>
</tbody>
</table>

Note. G-FCQ-S = General Food Cravings Questionnaire-State, VAS = Visual Analogue Scale.
amplitudes were significantly larger for food cues ($M_{\text{central}} = 4.47 \mu V, SE = .52$; $M_{\text{posterior}} = 6.00 \mu V, SE = .56$) than for office cues ($M_{\text{central}} = 2.99 \mu V, SE = .48$; $M_{\text{posterior}} = 4.18 \mu V, SE = .59$). No significant effects were found for group or hemisphere.

Fig. 1 presents grand average waveforms for the central and posterior electrode clusters. Fig. 2 displays the scalp distribution of main cue effects (p-values; food>office) for P3 and LPP amplitudes. This figure nicely illustrates that significant cue effects are exclusively observed at central and posterior electrodes.

3.3. Correlational analyses

As can be seen in Table 2, a number of positive correlations were observed between posterior P3 and LPP amplitudes on the one hand, and self-reported increase of hunger (but not food craving) during the experiment (posttest–pretest) on the other hand. No significant correlations were found between ERP amplitudes and self-reported valence and arousability of the food and office pictures.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Pearson correlations between food cue- and office cue-elicited brain potential amplitudes (P3 and LPP, left and right posterior, left and right central) and Increase (posttest–pretest difference scores) of self-reported food craving (G-FCQ-S) and hunger (VAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Food</td>
</tr>
<tr>
<td><strong>P3</strong></td>
<td>G-FCQ-S</td>
</tr>
<tr>
<td></td>
<td>VAS hunger</td>
</tr>
<tr>
<td><strong>LPP</strong></td>
<td>G-FCQ-S</td>
</tr>
<tr>
<td></td>
<td>VAS hunger</td>
</tr>
</tbody>
</table>

Note. N = 38; LPP = Late Positive Potentials, G-FCS-S = General Food Cravings Questionnaire-State, VAS = Visual Analogue Scale.

*p < .05, **p < .01.
4. Discussion

This study investigated brain processing of food-related information in a passive exposure paradigm by means of event-related potentials (ERPs). In line with our expectations, significant larger P3 and LPP amplitudes were found for food stimuli as compared to office stimuli, which were particularly observed at posterior and central electrode clusters. Emotion and addiction researchers agree on the notion that long-latency ERP amplitudes at centro-parietal brain sites are modulated by the emotional and motivational relevance of stimuli. The enlarged ERP waves to food stimuli, which were found in the present study, can be interpreted to reflect the motivational relevance and reinforcing properties of palatable food items to humans. This finding is in accordance with the conclusions of recent neuroimaging studies, in which food-related stimuli were found to markedly increase cortical and limbic brain activity as compared to neutral stimuli in normal-weight individuals, reflecting the natural reinforcing qualities of food (Killgore et al., 2003; Wang et al., 2004).

This is the first study that investigated differences in food-related information processing between obese and normal-weight individuals by means of ERPs. Contrary to our hypothesis, the obese group did not display larger ERP waves, when exposed to food stimuli, as compared to the normal-weight group. This suggests that the obese individuals of our sample did not process food information in a different way and neither attributed greater relevance or salience to food stimuli than the normal-weight participants. A similar pattern was observed in the valence and arousability ratings of the presented pictures: that is, evidence indicated that all participants similarly evaluated food pictures as more pleasant and arousing than control pictures. Further, both the obese and normal-weight group displayed a similar increase of food craving and hunger due to the exposure to food items. Interestingly, differences between obese and normal-weight individuals in the biological responsiveness towards food have been investigated before by means of more direct neuroimaging techniques. For instance, Karhunen et al. (2000) investigated cerebral responses to the exposure to food in obese binge-eating, obese non-bingeing and normal-weight women by means of single photon emission computed tomography (SPECT). Relative to a control stimulus, obese binge-eating women showed a greater increase in cerebral activity (at least in the frontal left hemisphere) when exposed to food than obese non-binge-eating and normal-weight participants. However, and most interesting in light of the present findings, the obese group without self-reported food binges did not differ from the normal-weight group in cortical brain responses to food. These findings suggest that obese individuals without explicit eating disorder symptoms do not respond differently to food cues as compared to normal-weight individuals. In a related study of the same research group, Karhunen, Lappalainen, Vanninen, Kuikka, and Uusitupa (1997) found differences in regional cerebral blood flow between healthy obese and normal-weight participants, when exposed to food. More specifically, increased brain activity as response to food (relative to a control stimulus) was found in the right parietal and right temporal brain regions of obese individuals, which was not the case for normal-weight controls. Importantly, the obese participants in this study had recently finished a weight-loss program and the increased cerebral response to food might have been due to the fact that they were still focused on controlling energy intake. Altogether, the present results seem to be in line with previous research indicating that obese persons do not habitually process food-related information in a different way than normal-weight persons. However, enhanced food information processing might occur in certain situations and states in which food becomes extra relevant to an (obese) individual, for example when dieting or suffering from an (over)eating disorder. Future ERP research should further investigate this issue.

As predicted, significant positive correlations were observed between self-reported increase of hunger during the experiment and P3 and LPP amplitudes, in particular at posterior sites. However, it should be admitted that such correlations not only emerged for EEG activity elicited by food cues, but also for brain activity elicited by office stimuli. Apparently, subjective feelings of hunger not just influenced the processing of food-related information, but seemed to have an effect on general information processing. As mentioned in the introduction of the present article, the effects of the hunger state on information processing has been the topic of a few studies, which generally yielded contradictory results. Perhaps the most relevant study in this perspective is the one by Hachl et al. (2003), who found differences between restrained (i.e., overeating-prone) and unrestrained individuals in the influence of hunger and satiety on information processing. Future research should further elucidate this issue, especially in relation to obesity.

 Investigators, we investigated hemispheric differences in ERP wave patterns to food- and office-related stimuli. We expected effects to be more pronounced in left-hemispheric electrode clusters, since activity in the left hemisphere is assumed to be associated with positive affect and approach tendencies (Davidson et al., 1990). However, in the present study we could not corroborate this hypothesis: no hemispheric differences were found in the ERP amplitudes of our participants. Studies using neuroimaging techniques have reported mixed results concerning hemispheric differences in cerebral activity during food exposure. For instance, the aforementioned study by Karhunen et al. (2000) reported increased blood flow to the exposure to food in the left hemisphere of obese binge-eating women, while in another study (Karhunen et al., 1997) increased frontal responsiveness was situated in the right hemisphere of obese women. Hemispheric differences concerned in brain activity when exposed to food-related cues should be a topic of further studies.

The present investigation has some limitations. Late positive potentials are well-known to be modulated by the relevance of stimuli to the task an individual is subjected to. In the present study, it might have been too obvious that we were interested in EEG responsiveness to food pictures. For this reason, participants might have been more attentive to the food pictures than to the office-related pictures. To exclude task relevance effects, future ERP research should include a third emotionally charged picture category. In this way, it would be possible to determine whether enlarged ERP waves are really reflecting the emotional or motivational relevance of stimuli. Another limitation of this study is that we investigated an imbalanced number of male and female participants. Because men and women might respond differently to food, future studies should investigate sex differences in ERP reactivity to food-related cues. A third limitation concerns the fact that we had no control on participants’ energy intake on the day.
of the experiment. There was an attempt to bring all participants in a similar hunger state by asking them to eat a light meal (like a sandwich) 2 h before the start the experiment, but no recordings were made of what the participants exactly ate before the experiment, nor what they ate during the rest of the day. In addition, because of practical reasons, we also chose to conduct the experiment on different times of day. These might be reasons why both groups differed in initial hunger ratings.

In conclusion, the results of the present study suggest that food-related information is processed differently in the brain than neutral information. Yet, no differences were observed in cognitive and subjective food cue reactivity between obese and normal-weight individuals. This finding is adverse to conditioning models of overeating, which assume that there is an enhanced reactivity to food and food-related stimuli in individuals prone to overeating, such as obese individuals. However, as this is the first study to investigate food cue-elicted brain potentials in obese and normal-weight individuals, conclusions remain preliminary. It remains possible that obese individuals do display enhanced reactivity and motivation to food under certain conditions, such as when stressed, emotional, or food-deprived.

References


