Attentional biases among body-dissatisfied young women: An ERP study with rapid serial visual presentation

Xiao Gao, Xiao Deng, Nanjin Chen, Wenbo Luo, Li Hu, Todd Jackson, Hong Chen

Key Laboratory of Cognition and Personality of Ministry of Education, Southwest University, Chongqing, China
School of Psychology, Southwest University, Chongqing, China
Department of Orthodontics, The Affiliated Hospital of Stomatology, Chongqing Medical University, Chongqing, China
Laboratory of Cognition and Mental Health, Chongqing University of Arts and Sciences, Chongqing, China
The Cairns Institute, James Cook University, Cairns, Queensland, Australia

1. Introduction

Cognitive-behavioral models have implicated biases in the processing of information related to body size, shape, and food to explain the development and maintenance of eating disorders (ED) and body image disturbances (e.g., Vitousek and Hollon, 1990; Williamson et al., 1999). In general, previous studies suggest that individuals who are overly concerned with their body weight show biased attention toward body shape and weight (Ferrato et al., 2003; Jansen et al., 2005; Lee and Shafran, 2004; Smith et al., 2006). While attentional biases have a critical role in cognitive-behavioral accounts, their nature and course is not well understood owing to ambiguities in the results of cognitive–experimental studies on body dissatisfaction and ED.

The majority of studies have used a modified Stroop task and found increased emotional Stroop interference for words and pictures related to eating and shape (for a review, see Lee and Shafran, 2004). Given the significant limitations of the modified Stroop task as a measure of selective attention, which were well documented in former literatures (Dobson and Dozois, 2004; Lee and Shafran, 2004), no firm conclusions can be drawn about the existence of an attentional bias in ED patients on the basis of results in the emotional Stroop paradigm.

Other strategies have been employed in attempts to clarify the nature of attentional biases in these groups. Using the dot-probe paradigm, Rieger et al. (1998) reported that ED patients were faster responding to probes in the location of previously presented words denoting a large physique, and slower responding to probes in the location of previously presented words denoting thinness. Shafran et al. (2007) found that an ED sample was faster responding to probes in the same location as over-weight or neutral body shape pictures—a bias that was not observed for thin shape pictures. Glautier et al. (2010) reported that undergraduate women were faster to discriminate the direction of a cue that appeared in the location previously occupied by thin rather than fat body figures. This bias was found using both 150 ms and 500 ms presentation times but was weakest for women who had a higher body mass index (BMI) and elevated body dissatisfaction. These findings suggest that ED and body dissatisfied samples display different attentional bias patterns.
toward negative fatness-related information and positive thinness-related information, with preferentially processing negative body information and/or resisting or avoiding thin body information (Vitousek and Hollon, 1990; Williamson et al., 1999).

However, dot-probe paradigms with reaction time (RT) measures provide only a discrete snapshot of responses after the onset of stimuli and fail to elucidate how attention is deployed prior to behavioral responses (Hermans et al., 1999). Recently, using the dot-probe paradigm and eye movements (EM) tracking, Gao et al. (2011) assessed biases in specific component processes of visual attention in relation to body-related stimuli among weight-dissatisfied (WD) young women. Results indicated that WD women showed initial orienting, speeded detection, and initial maintenance biases toward fat body words in addition to a speeded detection–avoidance pattern of biases in relation to thin body words.

Recently, brain imaging techniques such as functional magnetic resonance imaging (fMRI) could help us to pry into the underlying mechanism of attentional biases observed in behavioral and EM experiments. It was reported that the right amygdala and left medial prefrontal cortex (mPFC) was significantly more activated in ED patients than health controls during the presentation of negative body image words (Miyake et al., 2010) but not positive body words (Redgrave et al., 2008), which suggested that these brain activations may be associated with abnormalities of body image perception. Amygdala activation may be involved in fearful emotional processing of negative words concerning body image and strong fears of gaining weight. One possible interpretation of the finding of mPFC activation is that it may reflect an attempt to regulate the emotion invoked by the stimuli.

Again, the preceding review gave support to the hypothesis that negative body image words connoting fatness and positive ones connoting thinness are processed differently not only in ED patients but also in non-clinical sample of weight dissatisfied individuals. During the early stages of cognitive processing, women with extreme weight dissatisfaction may have an attentional vigilance that they were more easily captured by fat body words, which might have been a function of amygdala activation in the emotional processing of comparatively threatening stimuli that reflected personal concerns with overweight and fatness (Gao et al., 2011; Miyake et al., 2010).

However, during the late stages of processing, women with weight concerns have different attentional bias patterns toward different body-related words with a maintenance bias toward fat body words and an avoidance bias toward thin body words, which might involve the mPFC activation (Gao et al., 2011; Miyake et al., 2010; Rieger et al., 1998).

It should be noted that findings in this literature have predominantly concentrated on the spatial domain of attention, while little research was conducted to explore the attentional bias in dimension of time. In our real life, the large amount of visual information is like a river, and our visual attention is like a door by the river. We could only see a very small part of the river through this door at a certain time as we could only pay attention to a certain limited amount of visual information at a time. Visual information flows in and out from our visual working memory sequential and continuously in time. When processing the information flow, is fat-related information more easily captured than thinness ones among WD women? There is no clear answer to this question at present. Another limitation in the previous literature has been the failure to assess the brain dynamics of attentional biases because fMRI only provides a map of brain activity. Event-related potentials (ERPs) provide more real-time and direct measures of attention-related cerebral processing and therefore are especially useful in examining the temporal character of attentional biases patterns. Another limitation has been the failure to adequately test the hypothesis that cognitive biases are a function of disordered body schemata, rather than disordered eating (Williamson et al., 1999). It has been hypothesized that attentional biases arise as a result of underlying negative body image schemata and highly efficient knowledge structures about body size and shape that act as a filter and amplifier during information processing (Chen and Jackson, 2006; Jansen et al., 2005; Vitousek and Hollon, 1990). To do so requires evaluations of non-clinical samples.

To address these shortcomings, the present study investigated the attentional bias of processing body words among body-dissatisfied females by means of ERPs, which offer the opportunity to assess facets of brain functioning during information processing. Abundant ERP studies have been done on emotion, anxiety, and depression. Previous studies have demonstrated that N100 and N170 are significantly affected by the early phase of perception and attention processing (Bar-Haim et al., 2005; Carretié et al., 2001, 2004; Huang and Luo, 2006; Montalan et al., 2008), P2 is one of the sensory ERP components, suggested to be sensitive to emotional or motivational stimulus content (Bernat et al., 2001; Li et al., 2008; Yuan et al., 2007). N300 has been demonstrated to be an emotion-sensitive potential, and it largely reflects the dimensionality of affective valence (Carretié et al., 1997). P3 reflects later and higher levels of information processing during cognitive stages. Past studies indicated that P3 amplitudes are sensitive to emotional stimuli as indexed by larger amplitudes in response to them (Ito et al., 1998; Schupp et al., 2004a; Schutter et al., 2004). However, to the best of our knowledge, no ERP study has been conducted on body-related information processing in ED samples or non-clinical vulnerable individuals. Moreover, since little is known about the temporal consequences of identifying body-related information in an ongoing task, a rapid serial visual presentation (RSVP) task was used to explore the character of the time-based attentional bias (Luo et al., 2010). In the dual-task mode of this paradigm, when the stimulus onset asynchrony (SOA) between the first target (T1) and the second target (T2) is approximately 200–500 ms, the correct detection of T1 impaired T2 detection; this effect is called attentional blink (AB). When the SOA between T1 and T2 is more than about 600 ms, the AB effect would disappear because long time duration could allow recovery of attentional resources from AB effect. The most typical emotional adaptation of this task is to look at the effect of neutral targets identified at T1 on emotional versus neutral targets identified at T2. When T2 is a negative (Anderson & Phelps, 2001; Ogawa and Suzuki, 2004) or emotionally arousing stimulus (Anderson, 2005; Keil and Ihssen, 2004; Reinecke et al., 2008), the AB is markedly attenuated, which means that attention was easily captured by negative or emotional arousing information. Most researches focused mainly on AB effect in RSVP, few have explored the processing mechanism after AB recovery. The main purpose of the current study was to assess time course of brain mechanism of processing body image schemata related information when the attentional resource are adequate. Therefore, all T2 were presented about 600 ms after T1 presentation. Data from the dot-probe and eye movements studies showed that spatial visual attention was either drawn to or captured by fatness-related information among extremely weight-concerned women (Gao et al., 2011), which would indicate that this facilitating effect of negative body image schemata would enable WD women response more accurate to fatness-related T2 in the current RSVP paradigm.

Thus, on the basis of previous findings (Gao, 2010; Gao et al., 2011; Miyake et al., 2010; Redgrave et al., 2008; Shafarian et al., 2007) that WD women show vigilance toward fat related information in early processing stage and they process fat and thin related information differently in late processing stage, we hypothesized that (1) WD women would have an early negative bias as reflected by larger N100, N170 and P2 amplitudes elicited by fat body words; (2) late ERP components such as N300 and P3 would be sensitive to different body-related words only among WD women; (3) compared with the controls, WD women would have a higher correct rate in responding to fat body words T2, following correct T1 identification in the RSVP task.
2. Method

2.1. Participants

The final sample included 17 body-image-dissatisfied women and 15 control group women drawn from undergraduate classes at Southwest University (SWU) in Chongqing, China. All were right-handed non-smokers, with no history of current or past neurological or psychiatric illness as well as normal or corrected-to-normal vision, and normal color vision as assessed by several basic color tests. Demographic information of participants is presented in Table 1.

2.2. Body image screening measure

The assignment of a subject to the weight dissatisfaction group (WD group) vs. control group was based on a body image screening measure: Negative Physical Self-Fatness Scale (NPS-F; Chen et al., 2006). The 11-item NPS-F assesses thoughts, feelings, and behaviors related to fatness and overweight concerns. Items were rated on a five-point scale, ranging from 0 = not at all like me to 4 = very much like me. Sample items include “I am very distressed when I think about my weight”, “I am fat in others’ eyes”, and “I have tried many ways to lose weight.” Scores were obtained by summing the scores of all items and dividing this total by 11 to yield an average score ranging from 0 to 4—higher scores reflected a higher level of dissatisfaction. The NPS-F is reliable, α = .88; stable over three weeks, r = .89, and nine months, r = .70 (Chen, 2007; Chen and Jackson, 2007); it has satisfactory convergent and discriminant validity (Chen et al., 2006; Jackson and Chen, 2008a,b). Its alpha coefficient was α = .88 in the current study.

2.3. Stimulus material and RVSP

Sixty-three upright words (20 fat-related words, 20 thin-related words, 20 neutral household words, and 3 instrument-related words) printed in red as targets and 96 inverted neutral household words printed in white as distracting stimuli were used. The 40 weight-related words were adapted from recent work (Chen, 2007; Chen and Jackson, 2005, 2006; Gao, 2010). They are listed in Appendix A with corresponding English translations. The screen resolution was 72 pixels per inch.

The RVSP procedure was programmed with E-Prime 1.2 (Psychology Software Tools, Inc., Pittsburgh, PA). At the beginning of the formal experiment, a white fixation point and a blue fixation point appeared successively in the middle of the screen and lasted for 500 ms and 300 ms, respectively. Shortly thereafter, 14 words of distracting and target stimuli were displayed, with each being visible for 119 ms. The distracting stimuli consisted of 12 inverted neutral household words; the T1 stimulus was one of three upright words of instrument, with the probability of the occurrence of each being the same; the T2 stimulus was one of the four conditions: (1) T2 absence, (2) one of 20 fat-related words, (3) one of 20 thin-related words, and (4) one of 20 neutral household words, with the probability of the occurrence of each being the same. All stimuli were displayed in the center of the screen. T1 appeared randomly and equiprobably in the third, fourth, or fifth position in the word series, while T2 appeared in the positions of the sixth (lag 6) word after the T1 stimulus (see Fig. 1 for examples). After presentation of T2 stimuli, the screen remained black and blank for 600 ms.

This task was done in dual task mode. Participants were presented with a question about T1 (“Please identify the first upright word, 1 = Piano, 2 = Flute, and 3 = Erhu”) and a question about T2 (“Please identify the second upright word, 1 = fat body words, 2 = thin body words, 3 = household words, and 0 = blank screen”). They were asked to make as accurate a judgment as possible. The question appeared until a response was made or for 5000 ms maximum. The subject would be led into the next word series after a 500 ms period during which the screen remained black and blank.

In the formal experiment, the task was divided into four blocks. The subject was allowed rest between consecutive blocks. In order to get rid of the superposition of front and rear electroencephalograms and to obtain ERP components elicited purely by T2, corresponding baseline tasks were designed on the basis of the methods of previous studies (Luo et al., 2010; Sergent et al., 2003; Vogel et al., 1998). In baseline tasks, words at T2 were absent and replaced with a black and blank screen for 119 ms, with other conditions remaining unchanged. Each subject completed a total of 256 trials. The study includes 8 conditions (three categories of words and “T2 absent” × two groups) and 64 trials were presented for the conditions of three categories of words and “T2 absent”.

2.4. Procedures

Following ethics approval from SWU, participants were recruited via on-campus advertisements. Subsequently, 300 undergraduate women engaged in the initial phase of the study. After reading a general overview of the research and signing an informed consent, participants completed individually administered self-report measures of age, weight, height, handedness, and history of neurological or psychiatric illness as well as the NPS-F (Chen et al., 2006). Basic and color vision tests were also completed. After a three-week delay to introduce a lag before the experiment, appointments were made with women randomly selected from subgroups who scored higher than 2.5 (n = 17) or lower than 1.5 (n = 17) on the NPS-F. Data from two female students in the control group were excluded owing to their reaction time (RT) data being over three standard deviations above the mean RT, which resulted in 15 participants in the control group involved in the final analysis.

Participants were asked to consume their regular meals but to refrain from drinking caffeinated beverages for 12 h before the experiment. They were told the task focused on determining reaction speed of stimuli and would last for about 30 min. Individual testing sessions were scheduled between 8:30–11:30 am and 2:00–5:30 pm in a quiet and soundproof room. Following their session, the women were debriefed about the research purposes and paid 20 Yuan as compensation for their time.

2.5. Electrophysiological recording

Brain electrical activity was recorded from 64 scalp sites using tin electrodes mounted in an elastic cap (Brain Product, Germany), with the left and right mastoid references. The 64 channels were placed according to the 10–20 international system location (Jasper, 1958). The vertical electrooculogram (EOG) was recorded from two electrodes placed 1 cm above and below the left eye, and electrodes placed beyond the outer canthus of each eye recorded the horizontal EOG. Interelectrode impedance was maintained below 5 kΩ. The EEG and EOG were amplified using a 0.01–100 Hz bandpass and continuously sampled at 500 Hz/channel for off-line analysis. Eye movement artifacts (blinks and eye movements) were rejected offline. Trials with EOG artifacts (mean EOG voltage exceeding ±80 μV) and those contaminated with artifacts due to amplifier clipping, bursts of electromyographic (EMG) activity, or peak-to-peak deflection exceeding 80 μV were excluded from averaging.

### Table 1
Demographic information of participants: mean (standard deviation).

<table>
<thead>
<tr>
<th></th>
<th>WD group</th>
<th>Control group</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>17</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>20.71 (1.45)</td>
<td>21.00 (1.37)</td>
<td>.36</td>
<td>.553</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.08 (3.22)</td>
<td>19.90 (1.28)</td>
<td>13.57</td>
<td>.001</td>
</tr>
<tr>
<td>NPS-F</td>
<td>2.73 (38)</td>
<td>1.03 (55)</td>
<td>106.81</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Note: WD-Group = Weight dissatisfied group; NPS-F = Negative Physical Self-Fatness Scale.
2.6. Data analysis

To make sure that two groups show no cognitive ability difference during the RSVP task, a one-way ANOVA on T1 response accuracy rate was carried out with group type as the between-participants variable. Then a two-way repeated ANOVA on T2 response accuracy was conducted to determine group and stimuli type differences with the between-participants factors of group and within-participants factor of stimuli type. Participants with missing data or false judgments for T1 on any trial were excluded from the analyses of T2 judgments. We analyzed the ERPs elicited by fat-related, thin-related, and neutral words. Individual-subject averages were derived for correct trials and at least 40 trials were available for each subject and word type differences using the between-participants factor of group and word type. Eight three-way repeated ANOVAs were utilized to determine group and word type differences using the within-participants factor of stimuli type. Participants with missing data or false judgments for T2 on any trial were excluded from the analyses of T2 judgments.

3. Results

3.1. Behavioral performance

A one-way ANOVA revealed no significant group difference of response accuracy for T1, F (1, 30) = .17, p = .89. A 2 (group) × 3 (stimuli type) repeated ANOVA on T2 response accuracy revealed neither significant main effects for group, F (1, 30) = .01, p = .99, or stimuli type, F (2, 60) = .49, p = .609, nor significant interaction for group × stimuli type, F (2, 60) = .07, p = .925 (Table 2).

Table 2

<table>
<thead>
<tr>
<th></th>
<th>WD group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>T1</td>
<td>.96 (2.99)</td>
<td>.96 (2.81)</td>
</tr>
<tr>
<td>T2</td>
<td>.96 (2.97)</td>
<td>.96 (3.09)</td>
</tr>
<tr>
<td>Fat words</td>
<td>.96 (2.79)</td>
<td>.96 (3.08)</td>
</tr>
<tr>
<td>Thin words</td>
<td>.96 (2.86)</td>
<td>.96 (2.89)</td>
</tr>
<tr>
<td>Neutral words</td>
<td>.96 (3.83)</td>
<td>.96 (3.77)</td>
</tr>
</tbody>
</table>

Note. WD-Group = Weight dissatisfied group.
3.88 \mu V, p = .001) than to thin-related words (P7: \(-3.07 \pm 3.81 \mu V; \ PO7: \ -4.76 \pm 2.81 \mu V\)) at P7 and PO7, whereas they showed significantly larger N170 amplitudes in response to fat words (P8: \(-6.57 \pm 5.39 \mu V; \ PO8: \ -7.85 \pm 4.80 \mu V; \ O2: \ -6.61 \pm 4.68 \mu V\)) than to thin body words (P8: \(-4.54 \pm 3.89 \mu V, \ p = .001; \ PO8: \ -6.29 \pm 5.27 \mu V, \ p = .001; \ O2: \ -4.68 \pm 3.86 \mu V, \ p = .001\)) and neutral words (P8: \(-4.72 \pm 3.47 \mu V, \ p = .008; \ PO8: \ -6.30 \pm 5.02 \mu V, \ p = .006; \ O2: \ -4.60 \pm 3.86 \mu V, \ p = .001\)) at P8, PO8 and O2 sites. Thin body words elicited smaller N170 amplitudes among WD group (P7: \(-3.07 \pm 3.81 \mu V, \ p = .041; \ PO7: \ -4.76 \pm 2.81 \mu V, \ p = .008\)) than among control group (P7: \(-5.95 \pm 3.81 \mu V; \ PO7: \ -7.96 \pm 3.53 \mu V\)) at P7 and PO7 sites. Moreover, in control group all stimuli elicited larger amplitudes at PO7 than at P7, O1, P8, and O2 (all \(p < .047\)). However, in WD group different pattern emerged with regard to fat- and thin-related words. Fat body words elicited larger amplitudes at PO7, P8, PO8 and O2 than at P7 (all \(p < .045\)). Thin-related words elicited larger amplitudes at PO7, O1 and PO8 than at P7 (all \(p < .013\)). Neutral words elicited larger amplitudes at PO7 than at P8 and O2 (all \(p < .041\)). Other main effects and interactions were not significant.

Main effects of electrode in N170 latency were marginally significant, \(F(5, 150) = 2.90, p = .052\). No other significant main effect or interaction was obtained.

3.2.3. P2

A 2 (group) \times 3 (stimuli type) \times 9 (electrode) ANOVA for P2 amplitudes revealed a significant main effect for stimuli type (Figs. 2 and 3c), \(F(2, 60) = 33.03, p < .001\). Fat words (10.73 \mu V, \(p < .001\)) and thin body words (10.69 \mu V, \(p < .001\)) elicited larger P2 amplitudes than neutral words (8.01 \mu V). Also, a significant main effect at electrode was obtained, \(F(8, 240) = 2.88, p = .035\) affected P2 latency. The post hoc LSD-t tests showed that fat words (252.47 ms, \(p = .039\)) and thin body words (255.05 ms, \(p = .011\)) elicited longer P2 latencies than neutral words (247.96 ms). Meanwhile, shorter P2 latency was found at Fz (249.14 ms, all \(p < .016\)).

<table>
<thead>
<tr>
<th>Neutral words</th>
<th>Fatness-related words</th>
<th>Thinness-related words</th>
</tr>
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<tbody>
<tr>
<td><strong>F3</strong></td>
<td><strong>Fz</strong></td>
<td><strong>F4</strong></td>
</tr>
<tr>
<td>C3</td>
<td>Cz</td>
<td>C4</td>
</tr>
<tr>
<td>P3</td>
<td>Pz</td>
<td>P4</td>
</tr>
<tr>
<td>-200</td>
<td>0</td>
<td>1000</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>1200</td>
<td>400</td>
<td>800</td>
</tr>
<tr>
<td>-4</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

Fig. 2. Grand average ERPs elicited by fatness-, thinness- and neutral words recorded at the indicated electrode sites among two groups (WD group: \(n = 17\), Control group: \(n = 15\)).
and F3 (249.55 ms, all ps < .016) than AF4 (254.87 ms), F4 (254.43 ms) and FC4 (253.91 ms). Other main effects and interactions were not significant.

3.2.4. N300

2 (group) × 3 (stimuli type) × 15 (electrode) ANOVA results for N300 310–390 ms mean amplitudes revealed a significant main effect for stimuli type, \( F(2, 60) = 27.91, p < .001 \). Neutral words (−0.83 \( \mu \)V) elicited larger N300 mean amplitudes than fat words (1.02 \( \mu \)V, \( p < .001 \)) and thin body words (1.67 \( \mu \)V, \( p < .001 \)). Also, a significant main effect of electrode was obtained, \( F(14, 420) = 9.88, p < .001 \) (Figs. 2 and 3c). The post hoc LSD-t test showed that larger N300 amplitudes were elicited at Fz (−0.83 \( \mu \)V, all ps < .019) and F3 (−0.88 \( \mu \)V, all ps < .014), and smaller N300 amplitudes were elicited at P4 (2.22 \( \mu \)V, all ps < .043). Other main effects and interactions were not significant.

3.2.5. P3

2 (group) × 3 (stimuli type) × 15 (electrode) ANOVA results for P3 410–480 ms mean amplitudes revealed a main effect for stimuli type

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**Fig. 3.** Scalp topography of ERPs generated by fatness-, thinness-related and neutral words (WD group: n = 17, Control group: n = 15). (a: N100 components at 100 ms among each group; b: N170 components at 235 ms among each group; c: P2 at 250 ms, N300 at 345 ms among two groups; d: P3 components at 470 ms among each group.)

**Fig. 4.** Grand average ERPs elicited by fatness-, thinness- and neutral words recorded at the indicated electrode sites among two groups (WD group: n = 17, Control group: n = 15).
of a top-down alerting mechanism that aims to generate rapid responses to potentially threatening stimuli (Santos et al., 2008).

At approximately 220 ms after stimulus onset, obvious bi-lateral occipito-temporal N170 activity was elicited in all conditions. The presently observed N170 latencies (~220 ms) were about 50 ms later than those typically reported (~170 ms). However, we believe they were not atypical for several reasons. Firstly, the N170 component was a typical ERP component in visual words recognition (Johannes et al., 1995; Kutatı et al., 2006; Swick and Knight, 1996). Secondly, the amplitude recorded at the lateral occipito-temporal site (PO7, PO8) was larger than those elicited at other electrode sites, which was in the expected pattern that it is maximal at occipito-temporal sites. Thirdly, in visual perception, the N170 component reflects the dissociation of stimuli into categories (Caldara et al., 2003; Montalan et al., 2008; Rossion et al., 2003).

Most studies found that N170 does not discriminate emotional valences (Eimer et al., 2003; Herrmann et al., 2002; Münte et al. 1998) or found that N170 distinguishes only fearful expressions from the other expressions (Batty and Taylor, 2003; Stekelenburg and de Gelder, 2004; Pourtois et al., 2004; Leppanen et al., 2007). Montalan et al. (2008) also found that the N170 component was modulated by the valence of emotional words, with negative adjectives eliciting larger N170 amplitudes than positive adjectives. In Luo et al. (2010), N170 amplitude was enhanced during the processing of only fearful face stimuli in the lag 2 condition, but enhanced during the processing of happy face stimuli in the lag 6 condition. The authors suggested that it would be advantageous to process threat stimuli free from hindrance during times of strained attentional resources. In the present study, N170 amplitudes were affected by stimulus type among WD women with larger N170 amplitudes being elicited by fat body words at occipito-temporal electrodes, while no such N170 amplitude effect was found within the control group. These findings might indicate that about 230 ms after T2 presentation, the processing of fat-related words occupied more visual attentional resources than thin-related and neutral words even beyond the attentional blink (at lag 6). Unlike facial expressions, body-related words are not that evolutionarily salient. Therefore, the vigilance for detecting body-esteem threats may be more attentional consuming than processing fearful faces. The current findings are also consistent with Vitousek and Hollon’s (1990) proposal that people with elevations in weight or body dissatisfaction are more prone to show hypervigilance upon exposure to body or weight information. The larger N170 amplitudes elicited by fatness-related words may suggest that fatness-related words were preferentially processed during early stages presumably for their ego-threat properties to WD women.

Moreover, interesting findings were observed when compared N170 amplitudes among different electrodes. All stimuli elicited larger amplitudes at PO7 than at P7, O1, P8, and O2 in control group. Also, neutral words elicited larger amplitudes at PO7 than at P8 and O2. These findings were consistent with left-lateralized word N170 found in previous researches (Mercure et al., 2008; Rossion et al., 2003). However, different pattern emerged with regard to fat- and thin-related words in WD group. Fat body words elicited larger amplitudes at P07, P8, P08 and O2 than at P7. Thin-related words elicited larger amplitudes at PO7, O1 and P08 than at P7, which indicated stronger activation at electrodes on right hemisphere elicited by fat body words. Fat body words may serve as ego threats to women who feel extreme dissatisfaction with their body weight and shape, and they may feel high emotional arousal when they were exposed to fat body words. Heller’s integrative hypothesis proposed to explain the mechanisms of brain asymmetry in emotion (Heller, 1993) indicated that the right parieto-temporal regions played a crucial role in experiencing arousal of emotions. Moreover, a larger amount of studies have reported right hemisphere dominance in processing high arousing stimuli, especially negatively valenced emotion (Keil et al., 2002; Rozenkrants and Polich, 2008; Zhang et al., 2011). Also, using low resolution brain electromagnetic tomography, Esslen et al. (2004) found that a small area in the right temporal lobe was significantly activated in fear compared to the neutral condition. In the
current study, the different pattern elicited by three categories of stimuli between both sides of electrodes among WD group may result from the combination effects of left-lateralized word N170 and right brain hemisphere dominance of processing negative emotion aroused by fat body words. It should be noted that future researches are needed to investigate basic mechanism of this issue.

4.2. Classifying of body words and neutral words

At approximately 250 ms after stimulus onset, obvious frontal P2 activity was elicited in all conditions, and larger P2 amplitudes and longer P2 latency was detected for body words than for neutral words among two groups. Frontal P2 is considered as indexes of the attention-related process, with larger P2 amplitudes indicating attentional enhancement or more attentional resources involving (Carretié et al., 2001, 2004). Also, frontal P2 is indicative of rapid detection of typical stimulus features (Thorpe et al., 1996). The current findings may indicate that compared with processing neutral words, more attentional resources were needed when processing both negative and positive body-weight-related words, irrespective of whether women were satisfied with their bodyweight. Longer P2 latency may reflect that it was more difficult to process body-related words than neutral words. One possible interpretation of the findings was that when participants identified body words, they not only needed to identify whether it was a body word but they also needed to distinguish fat body words from thin body words, whereas they only needed to identify whether the stimuli was neutral, which may result from task difficulty difference between identifying body words and neutral words.

At approximately 350 ms after stimulus onset, obvious frontal, central, and parietal N300 activity was elicited in all conditions. Neutral words elicited larger N300 mean amplitudes than fat body words and thin body words, irrespective of body satisfaction. Combined with enhanced P2 amplitudes following the presentation of body-weight-related words, reduced N300 amplitudes elicited by body-weight-related words may indicate that after detecting body-weight-related words, initial evaluation of body-weight-related words was inhibited. These findings may indicate that after rapid detection of typical stimuli features, the available energetic resources must immediately be re-allocated for further evaluation of the relevant stimuli.

With regard to P2 and N300 amplitudes, no difference was observed between two groups or between two categories of body-weight-related words. These findings were inconsistent with previous researches. Posner and Raichle (1997) argued that the P2 and N300 might be involved in the detection and evaluation of angry facial expressions. Carretié et al. (1997) also argued that the N300 might reflect an arousal dimension of affective characteristics of visual stimuli. Moreover, the N300 in the anterior brain region has been positively associated with arousing negatively valenced stimuli, whereas a more posterior N300 distribution was related to arousing positively valenced stimuli. One possible explanation for the current findings might be that during this stage of processing, attentional resources were allocated to task-related stimuli classification but not to the valence of stimuli among both groups. This inference could be supported by longer P2 amplitudes elicited by body-weight-related words than by neutral words, irrespective of valence of body-weight related words. If the attention was automatically captured by stimuli valance, shorter P2 latency in response to negative versus positive arousing stimuli would be observed (Carretié et al., 2001). Therefore, in the current study the processing of valance of body-weight-related words among WD group was suppressed during this processing stage.

4.3. Differentiate fat words and thin body words during late processing stage among the WD group

In the present study, the control group showed significantly different amplitudes in response to three categories of stimuli with fat body words and thin body words eliciting larger P3 amplitudes than neutral words. Findings with regard to the control group were consistent with previous findings that emotionally valenced stimuli elicited larger centro-parietal P3/LPC amplitude than neutral ones, while no difference was found between positive and negative stimuli (Schupp et al., 2004b).

However, WD group participants showed significantly different amplitudes in response to three categories of stimuli with thin body words eliciting the largest P3, followed by fat body words and the least neutral words. P3 signals the cognitive evaluation of the stimuli’s meaning (Yuan et al., 2007: Ito et al., 1998), during which a deliberative and controlled process is involved. In this stage, information is represented and analyzed more fully, with more factors considered and more experiences referenced, such as the individual’s experiences, expectations, and inner/outter environment (Huang and Luo, 2006; Ito et al., 1998). In this stage, positive thin body words and negative fat body words can be discriminated clearly within WD women, and thin body words recruits more physiological and psychological resources, presumably because of its importance for their weight esteem.

These findings were inconsistent with previous findings that negative information triggered larger P3/LPC amplitudes than positive and neutral ones (Huang and Luo, 2006; Ito et al., 1998; Luo et al., 2010). Meanwhile, some studies (Schupp et al., 2004b) also reported that emotional information elicited larger amplitudes than neutral ones irrespective of the valence when enough attentional resources were available. Several reasons could account for these findings and the discrepancy found between the current study and previous studies. Firstly, P3 was found to relate to working memory refreshment (Delplanque et al., 2004). Under the guidance of body schemata, more experiences were retrieved from long-term memory into working memory during processing thin body words within WD women. These experiences may refer to self-evaluation on their own body shape, other’s evaluation on their bodyweight, and the negative affect aroused by discrepancy between one’s own weight and the popular thin ideal. Secondly, according to the semantic network theory of emotion (Bower, 1981), emotions are represented as nodes in a memory network, which are all linked together. Although thin body words are “objectively” rated as comparatively positive, among WD women, these words may have been processed as ego threats or aroused negative emotion because they highlighted a gap between perceptions of self and thin ideals (Heinberg and Thompson, 1995; Posavac et al., 1998). Consequently, more nodes in memory network, including positive and negative emotion-related ones, were activated during processing thin body words, while only negative emotion-related ones were activated during processing fat body words. Therefore, more cognitive resources were mobilized in processing thin body words as reflected by the larger P3 amplitudes. Finally, late positive potentials are modulated by emotional arousal level (Schupp et al., 2000). The larger P3 amplitudes elicited by thinness-related words in the present study might be due to the arousal values of positive thinness-related words, which may not be the same to each group and which might be more emotionally arousing than negative fatness-related words to WD women.

4.4. Limitations and future research

Although the assessment of attentional bias via ERPs was the key strength of this research, its main limitations also provide important foundations for future work. In the current study, since we did not consider the attentional resources modulation of body-related information processing, all T2s were presented at lag 6 in the dual task mode of RSVP. However, the expected influence of extreme weight concerns on body-related AB effect reflected by behavioral performance was limited by this manipulation, because the SOA between T1 and T2 in the current study was out of the range in which typical AB happens. More positions of T2 (e.g., from lag 1 to lag 6)
should be considered in future researches. Furthermore, valence ratings of “positive” (i.e., thin) and “negative” (i.e., fat) body words were from people who did not experience extreme concerns with fatness or overweight. However, there is a possibility that thinness-related words are associated with more negative affect (e.g., anxiety) among people with extreme weight concerns or eating disturbances (e.g., Shafran et al., 2007). Therefore, in future researches, valence and arousal ratings of stimuli might be made by participants themselves to ensure a match with “objectively rated” valences.

5. Conclusion

To the best of our knowledge, the current study may be the first ERP study to investigate the temporal character of attentional biases for body-related words in a non-clinical sample of body-weight-dissatisfied women. Consistent with the hypotheses, the amplitudes of N100, N170, and P3 are sensitive to different body-related words in the RSVP paradigm only among body-dissatisfied women. Attention biases toward body-weight-related words were evident during both sensory and cognitive stages of information processing. Findings are also consistent with hypotheses of cognitive-behavioral accounts of body image disturbance, which propose, in part, that individual differences on cognitive tasks reveal underlying psychopathology; attentional biases reflect disordered body schemata, not disordered eating, and can therefore be seen in non-clinical samples (Williamson et al., 1999).

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Appendix A. Stimulus words

<table>
<thead>
<tr>
<th>Fatness related words</th>
<th>Thinness related words</th>
</tr>
</thead>
<tbody>
<tr>
<td>肥胖 [Big and corpulent]</td>
<td>瘦弱 [Lean]</td>
</tr>
<tr>
<td>肥胖 [Elephant’s legs]</td>
<td>瘦小 [Petite and slim]</td>
</tr>
<tr>
<td>肥胖 [Fat (adj.)]</td>
<td>瘦小 [Petite and slim]</td>
</tr>
<tr>
<td>脂肪 [Fat (n.)]</td>
<td>瘦弱 [Thin]</td>
</tr>
<tr>
<td>肥胖 [Obese]</td>
<td>瘦小 [Petite and slim]</td>
</tr>
<tr>
<td>围腰 [Waist]</td>
<td>瘦小 [Petite and slim]</td>
</tr>
<tr>
<td>围嘴 [Jowls]</td>
<td>瘦小 [Petite and slim]</td>
</tr>
<tr>
<td>围裙 [Waistcoat]</td>
<td>瘦小 [Petite and slim]</td>
</tr>
</tbody>
</table>

References


