Cognitive and emotional conflicts of counter-conformity choice in purchasing books online: An event-related potentials study

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**A B S T R A C T**

Using event-related potentials (ERPs), this study investigated the neural substrates of the conflicts in counter-conformity choices in purchasing books online. For each trial, a participant decided whether to buy a book according to the title keyword, as well as the numbers of positive and negative reviews on the book. A participant’s choice was termed conformity if she/he decided to buy the book under the condition of consistently positive reviews, or not to buy the book under the condition of consistently negative reviews, whereas the case was counter-conformity if a participant did the opposite. In the time window 300–600 ms after the stimulus onset, a strong negative deflection of ERP (N500) was recorded when participants made counter-conformity choices. The topographic distribution of the N500 (N400-like) is not typical of the semantic N400. The N500 might be evoked by the cognitive and emotional conflicts faced by participants in counter-conformity choices. The present findings provide evidence that the N400 can be elicited by non-semantic conflicts.

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1. Introduction

People tend to believe what most others believe, even though these beliefs may not be true (Deutsch and Gerard, 1955). Conformity behavior describes various social and economic situations in which individuals are strongly influenced by the decisions of others (Asch, 1956), such as in financial investment, technology adoption, firms’ strategic decisions, political voting, and dining and fashion trends. Conformity behavior is particularly prominent in consumer decision-making (Venkatesan, 1966; Lascu et al., 1995), especially in online shopping (Chen, 2008). In online environments, consumers can conveniently access word-of-mouth information, such as product reviews. Online word-of-mouth has a powerful influence on consumer decisions. For example, the results from behavior research (Chen, 2008) showed that a consumer often considered the product reviews of others when choosing a product. The more positive reviews a product has received, the more possibly a consumer purchase the product. In this situation, the consumer infers product quality from other consumers’ reviews and conformity behaviors occur (Chen, 2008).

There are also quite a few counter-conformity behaviors. Counter-conformity behavior describes various social and economic situations in which individuals excessively contradict public information, such as the recommendations or opinions of the majority, and do the opposite (Levy, 2004). Eznger and Polborn (2001) put forward a counter-conformity model in the context of labor market. They found that if the value of the counter-conformity strategy is sufficiently large, one always opposes his/her predecessor’s report. Levy (2004) found that decision makers, motivated by reputation concerns, tend to choose a counter-conformity strategy. Hornsey et al. (2003) experimentally examined the influence of group norms on social issues with a moral component, and found that participants who had a strong moral basis for their attitude showed counter-conformity on public behaviors. In order to satisfy the need for uniqueness, consumers tend to engage in counter-conformity behaviors (Tian and McKenzie, 2001).

Both the conformity and counter-conformity behaviors have long been investigated in behavioral and modeling studies (Chen, 2008; Hornsey et al., 2003; Tian and McKenzie, 2001; Eznger and Polborn, 2001; Levy, 2004). Their neural bases remain unknown. Brain imaging techniques, such as functional magnetic resonance imaging (fMRI) and event related potentials (ERPs), have made it possible to precisely record the brain activity associated with high-level cognitive processes. Berns et al. (2005) used fMRI to investigate the neurobiological correlates of social conformity and independence during mental rotation task. Their study showed that conformity was associated with functional changes in an...
occipital-parietal network, and independence was associated with increased activity in the amygdala and caudate (Berns et al., 2005). Amygdala activation has been associated frequently with negative emotional states (LeDoux, 2000). The amygdala activation in Berns et al.’s experiment was perhaps the clearest marker of the emotional load associated with standing up for one’s belief when it was inconsistent with that of the majority (Berns et al., 2005). When an individual persists in independence, the emotional load might result from the cognitive conflict between one’s belief and the majority belief.

However, studies concerning the neural basis of conformity are few in number, and none appear to exist concerning the basis of counter-conformity. In short, little is known about the neural mechanisms of conformity and counter-conformity. We therefore designed an ERP experiment involving the purchasing of books online to investigate the neural basis of conformity and counter-conformity. The specific purpose of this study was to investigate the brain activity underlying the process of conflict in counter-conformity choices. We wanted to know what ERP components counter-conformity choices evoke and whether their amplitudes are modulated by the level of conflict.

Previous studies have found several conflict-related ERP components, such as N2, Ne/ERN and N400. The N2 was considered to reflect conflict detection (van Veen and Carter, 2002; Yeung et al., 2004). The Ne (error negativity) or ERN (error-related negativity) was elicited after onset of the erroneous response and might reflect a special response conflict related to error (Falkenstein et al., 2000). The N400 has often been considered to reflect the conflicts related to semantic meaning (Gunter et al., 1994; McPherson and Holcomb, 1999). However, recent studies have demonstrated that the N400 or N400-like might also reflect some other (non-semantic) conflicts (Olivares et al., 2003; Steffensen et al., 2008), such as cognitive conflict (Liotti et al., 2000; Mai et al., 2004; Qiu et al., 2007) and emotional conflict (Taatke et al., 2009).

2. Materials and methods

2.1. General approach

In the present experiment, the participants were asked to decide whether they bought a book according to the title keyword, the numbers of positive and negative reviews of the book. The three items of information were showed simultaneously in the center of a computer monitor. This simulation environment for purchasing books online was similar to amazon.com. As some participants may have read some of the chosen books, only the title keyword rather than the full title was presented in stimulus to prevent recognition of the books. Furthermore, the given title keywords across the trials were very similar to each other, minimizing participants’ preference for a particular book. Under this situation, the numbers of positive and negative reviews acted as the crucial deciding factor in determining a participant’s book purchase. There are two types of choices: conformity and counter-conformity. A participant’s choice was termed conformity if she/he decided to buy or not to buy a book following the opinion of majority reviews of the book, whereas the choice was termed counter-conformity if a participant’s choice was opposite to the majority opinion.

Counter-conformity, in a broad sense, is a special conformity. Previous studies have demonstrated that conformity could result from normative and informational influences (Deutsch and Gerard, 1955). Normative influence leads individuals to conform to the expectations of others, while informational influence leads to the acceptance of information received from others as an indicator of reality. The reason why participants adopt conformity strategies in the present experimental context is the lack of complete information to make decisions independently, instead of normative pressure to conform to the expectations of others.

Clearly, participants did not have actual, material consequences that followed from real-world book purchase decisions, such as one’s personal budget. However, self-esteem as decision makers, a concern in the in real-world, may extend to labora-
yory decision situations (Tetlock, 1991), and encourage the participants to make their best choices. Whether making conformity (narrow sense) or counter-conformity choices, participants show self-esteem. Making conformity choices indicates that the participants try to make equally good choices as most of the others made. Making counter-conformity choices indicates that the participants are trying to make unique choices, different from most of the choices made by others.

2.2. Participants

Thirty-one university students (15 females) were recruited from Zhejiang University in China. Their mean age was 22.7 years (range 21–27). They gave written informed consent and participated in the experiment as paid volunteers. All participants were right handed, had normal or corrected-to-normal vision and had no history of neurological or mental diseases. In addition, all of them were taking a customer relationship management (CRM) course and needed to buy reference books.

Nine participants were excluded because the numbers of their counter-conformity choices were less than 12, which was a critical value determined based on the minimum number of trials present in previous ERP studies (Boksem and De Cremer, 2010). In order to investigate the neural mechanism of counter-conformity choices, it is imperative that participants have a personality trait of moderate counter-conformity. If a participant seldom makes counter-conformity choices, then he/she should be excluded from this experiment. The final sample consisted of 22 participants (10 females). The numbers of counter-conformity choices for all participants were more than 12, ranging from 15 to 48. Their mean age was 22.6 years and ranged from 21 to 25 years.

2.3. Materials

A stimulus (called a picture) was composed of three items (see Fig. 1): a book title keyword (for example; “customer loyalty”); the number of positive reviews (for example; 300) and the number of negative reviews (for example; 100). In a stimulus, the title keyword was in a line, and the numbers of positive and negative reviews were in another line, all in Chinese. Forty-five books were chosen from the field of CRM; which should have attracted the attention of the participants; who were majoring in the CRM course. The title keyword of each book was limited to four Chinese characters. In each trial, the total number of reviews, which was equal to the sum of the numbers of positive and negative reviews presented in each stimulus, was randomly generated from the range of 400–500 or 5–50. The two ranges were given for two reasons. First, there was a need to reflect the real-world situation. The range of 400–500 was determined based on the mean and distribution of the total numbers of reviews for books in the best seller lists on the websites of Amazon and Dangdang (the largest e-bookstore in China); whereas the range of 5–50 was determined based on the mean and distribution of the total numbers of reviews for books out the best seller lists. Second, there was a need to increase the number of counter-conformity choices per participant. In general, in most participants, the tendency of counter-conformity is much less strong than that of conformity. If the number of trials is not high enough, it is likely that the mean number of counter-conformity choices per participant will not ensure an adequate sample size for statistical analysis.

The rate of positive reviews (the proportion of positive reviews to total reviews) was fixed at 60, 75, 75 and 100 percent, corresponding to four categories of review, i.e., absolutely negative review, relatively negative review, relatively positive review, and absolutely positive review. The rate of 50 percent was not included in the present experiment because, in this situation, participants’ choices are neither conformity nor counter-conformity, no matter whether they decide to buy or not to buy the books. The stimulus consisted of 360 pictures: 45 books × 4 categories of review × 2 ranges of total number of reviews.

2.4. Procedure

Participants sat in a comfortable sofa located in a shielded room and were instructed to avoid blinking or moving their eyes. The stimulus (white on a black background) were presented continuously and randomly in sequence in the center of a computer screen, with a visual angle of 2.38°×2.4°.

The experimental paradigm is illustrated in Fig. 1. Each trial began with a fixation point (‘+’) appearing for 500 ms. Then a stimulus was presented for 1400 ms. Participants were asked to decide, as quickly as possible, to buy or not to buy a book based on the book’s title keyword, and the number of positive and negative reviews in the stimulus. In addition, participants were told that: (1) the books presented in the stimuli were the important reference books needed for their CRM course (the

Fig. 1. Sequence of stimuli on an individual trial. Note: PR, positive review and NR, negative review.
The mean number of valid trials for buying and non-buying in four categories of review.

Table 1

<table>
<thead>
<tr>
<th>Condition</th>
<th>Number for buying</th>
<th>Choice type</th>
<th>Number for non-buying</th>
<th>Choice type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolutely negative review</td>
<td>3.86</td>
<td>Counter-conformity</td>
<td>85.01</td>
<td>Conformity</td>
</tr>
<tr>
<td>Relatively negative review</td>
<td>8.53</td>
<td>Counter-conformity</td>
<td>80.49</td>
<td>Conformity</td>
</tr>
<tr>
<td>Relatively positive review</td>
<td>70.43</td>
<td>Conformity</td>
<td>18.52</td>
<td>Counter-conformity</td>
</tr>
<tr>
<td>Absolutely positive review</td>
<td>79.21</td>
<td>Conformity</td>
<td>9.75</td>
<td>Counter-conformity</td>
</tr>
</tbody>
</table>

Note: Number for buying denotes the mean number of valid trials in which the participants decided to buy the books. Number for non-buying denotes the mean number of valid trials in which the participants decided not to buy the books.

instructor of the experiment was the module convenor of the CRM course and the stated need for CRM reference books was realistic for our student participants; (2) the price of every book was assumed to be the same, for example, 30 Yuan (Chinese unit of currency); and (3) the purchasing decision for each book was independent. Participants were instructed to press the left key if they decided to buy or to press the right key if they decided not to buy. The next trial started after the participant responded or after 1400 ms from the onset of the stimulus if the participant did not press any key. The 360 trials were divided into four blocks, and there was an interval between the two blocks for the participants to rest. The trials in which participants pressed neither the left key nor the right key were considered invalid.

2.5. Electroencephalogram recording and analysis

The electroencephalogram (EEG) was continuously recorded (band pass 0.05–100Hz, sampling rate 500Hz) with Neuroscan Synamp2 Amplifier (Scan 4.3.1, Neurosoft Labs, Inc., Sterling, USA), using an electrode cap with 64 Ag/AgCl electrodes mounted according to the extended international 10–20 system and referenced to linked mastoids. Vertical and horizontal electrooculograms were recorded with two pairs of electrodes, one placed above and below the left eye, and the other 10 mm from the lateral canthi. Electrode impedance was maintained below 10kΩ throughout the experiment.

EEG recordings were segmented in epochs of 1500 ms (−100 to 1400 ms), with a 100 ms pre-stimulus baseline. Electrooculogram artifacts were corrected. Trails contaminated by amplifier clipping, bursts of electromyographic activity, or peak-to-peak deflection exceeding ±80 μV were excluded from averaging. The mean number of eliminated trials was 3.61 per participant. The rejection rate was 1.01 percent. The remaining trials were baseline corrected. The EEG epochs were averaged separately for conformity and counter-conformity choices, and the averaged ERPs were digitally filtered with a low pass filter at 12Hz (24 dB/Octave). The mean number of trials (epochs) introduced in the analysis was 312.07 ± 7.25 (mean ± SE) for conformity choice, and 40.12 ± 2.68 (mean ± SE) for counter-conformity choice. As expected, more trials entered into the ERP averages of conformity choice than that of counter-conformity choice, but the numbers of trials were sufficient for each condition.

Two types of time-locked ERP were analyzed. Stimulus-locked ERP waveforms were averaged from 100 ms before and 800 ms after the onset of stimulus, and as mentioned above the first 100 ms pre-stimulus was used as a baseline. Response-locked ERP waveforms were averaged from 300 ms before and 500 ms after the recorded response, with a baseline from −300 to −200 ms. The amplitudes of different ERPs were compared by using within-subjects repeated measure ANOVAs. The ANOVA factors include choice type (conformity and counter-conformity), electrode site (e.g., 31 electrodes covering over the whole surface of the head), review-consistency (absolutely consistent review and relatively consistent review) and review-valuation (consistently positive review and consistently negative review).

3. Results

Statistical analysis showed that the range of total number of reviews (5–50 or 400–500) did not have an effect on behavioral and ERP results. The mean number of trials per participant for conformity and counter-conformity were not significantly different for the ranges of 5–50 and 400–500, \( F(1, 21) = 2.811, p = 0.128 \), \( F(1, 21) = 2.844, p = 0.126 \), respectively. Also, the mean reaction times (RTs) to conformity and counter-conformity were not significantly different for the ranges of 5–50 and 400–500, \( F(1, 21) = 2.950, p = 0.120 \), \( F(1, 21) = 2.643, p = 0.138 \), respectively; and the stimulus-locked ERP amplitudes of conformity and counter-conformity between 300 and 600 were not significantly different for the ranges of 5–50 and 400–500, \( F(1, 21) = 0.042, p = 0.842 \), \( F(1, 21) = 0.753, p = 0.408 \), respectively. As mentioned before, the reason we designed two ranges of total number of reviews was to obtain a sufficient mean number of counter-conformity responses per participant. It is a foregone conclusion that the experimental results for the two ranges do not show a significant difference. The present results are consistent with the conclusions of previous research on conformity.\(^1\) We will report and discuss the integrated results of experiment for two ranges in the following section.

3.1. Behavioral results

Among 360 trials, the mean numbers of valid and invalid trials per participant were 355.8 and 4.2, respectively. In invalid trials, participants pressed neither the left key nor the right key. Among the valid trials, the mean number of trials for conformity was 315.14 ± 7.37 (mean ± SE), for counter-conformity, 40.66 ± 2.71 (mean ± SE). The mean numbers of valid trials for buying and non-buying in four conditions are shown in Table 1.

The results (Table 1) show that most of participants’ choices were conformity and the conformity rate was near 90 percent (mean ± SE, 88.57 ± 2.40%), but still some of their choices were counter-conformity and the counter-conformity rate was more than 10 percent (mean ± SE, 12.90 ± 0.86%). These results support our speculation that when deciding whether to buy a book with consistent reviews, although participants have significant preference to conformity, they still have a small tendency of counter-conformity, especially those with a personality trait of moderate counter-conformity. The overwhelming majority of conformity choices do not obscure the reality of counter-conformity choices. Furthermore, participants had a significant negativity bias of book reviews. For example, there were few numbers of choices of buying the books with negative reviews (i.e., 3.86 + 8.53) compared with the numbers of choices of not buying the books with positive reviews (i.e., 9.75 + 18.52). This result is consistent with research on “word-of-mouth” effects, that people are more sensitive to negative word-of-mouth than to positive word-of-mouth (Allsop et al., 2007). In addition, as we expected, the number of counter-conformity choices for absolutely consistent reviews (i.e., 3.86 + 9.75) is less than that for relatively consistent reviews (i.e., 8.53 + 18.52).

Mean reaction times (RTs) were 653 ms for conformity (SE = 20) and 731 ms for counter-conformity (SE = 29). RTs

\(^1\) Previous studies (e.g., Turner, 1991; Lascu et al., 1995) have shown that the size of reference group is much less important than unanimity of the group members in the conformity resulted from informational influence. In informational conformity behavior, “consensus mattered more than numbers” (Turner, 1991) and a unanimous majority of three was far more influential than a majority of eight in which the participant was accompanied by one dissenter (Asch, 1951; Rook, 2006). In this experiment, the numbers of positive reviews and the numbers of negative reviews in stimuli for two ranges were designed based on the same rule, and the structures of the consensus levels of reviews for two ranges were same. For either the range of 5–50 or 400–500, in each stimulus, the rate of positive review was always one of 0.25, 75, and 100 percent, and the number of trials was same (45) for all four rates. As discussed above, the participants made conformity/counter-conformity choices primarily due to the lack of available information. The consensus level of reviews, instead of the range, exerted a more important effect on conformity/counter-conformity choices. Therefore, it is not surprising that the range of total number of reviews did not have effects on experimental results.
to counter-conformity were longer than RTs to conformity, $F(1, 21) = 12.92$, $p < 0.001$.

### 3.2. Stimulus-locked ERPs

#### 3.2.1. Event-related potentials for counter-conformity and conformity

**Fig. 2** shows the grand-averaged ERP waveforms for conformity and counter-conformity choices at 31 electrode sites in nine regions of interest (ROIs): left frontal (FP1, F3, F7, FC3, FT7), midline frontal (FPZ, FZ, FCZ), right frontal (FP2, F4, F8, FC4, FT8), left central (C3, T7), midline central (CZ), right central (C4, T8), left posterior (CP3, TP7, P3, P7, O1), midline posterior (CPZ, PZ, OZ) and right posterior (CP4, TP8, P4, P8, O2). Counter-conformity choices elicited a strong negative ERP deflection between 300 and 600 ms at almost all electrode sites. We performed a 2 (choice type: conformity vs. counter-conformity) \( \times 31 \) (electrode site: 31 electrodes, see above) within-subjects repeated measure ANOVA on ERP amplitudes between 300 and 600 ms. The main effect of choice type was significant, $F(1, 21) = 20.23$, $p < 0.001$. The mean ERP amplitude across the 31 electrodes in that time window for counter-conformity was significantly different from that for conformity. In addition, the interaction between choice type and electrode site was significant, $F(30, 630) = 4.01$, $p = 0.012$. The simple effect analysis showed that the differences between the mean ERP amplitude for counter-conformity and that for conformity were non-significant only at TP8 [$F(1, 21) = 0.21$, $p = 0.649$], TP7 [$F(1, 21) = 0.01$, $p = 0.979$], P4 [$F(1, 21) = 0.90$, $p = 0.353$], O2 [$F(1, 21) = 1.56$, $p = 0.251$] and OZ [$F(1, 21) = 0.75$, $p = 0.395$], and significant at the other 26 electrodes (with maximum $p$ value of 0.036 at O1 and minimum $p$ value of $<0.001$).

#### 3.2.2. Difference waves for counter-conformity minus conformity

The grand average difference potentials (counter-conformity minus conformity) were calculated in the time window 300–600 ms at every electrode, showing that one of the largest peak amplitudes (negative-polarity) was at FCZ (mean ± SE, $-4.57 ± 0.35 \mu V$), and the latency was about 500 ms (N500). The N500 difference waves reflect the N400-like effect. The difference waveform at representative electrode FCZ is shown in the left of Fig. 3. The scalp distributions of grand average difference potentials between 475 and 525 ms are shown in the right of Fig. 3.

From 300 to 600 ms, ERP differences between counter-conformity and conformity were compared for each ROI separately, left frontal [$F(1, 21) = 15.92$, $p = 0.001$], midline frontal [$F(1, 21) = 22.98$, $p < 0.001$], right frontal [$F(1, 21) = 16.06$, $p = 0.001$], left central [$F(1, 21) = 19.13$, $p < 0.001$], midline central [$F(1, 21) = 20.25$, $p < 0.001$], right central [$F(1, 21) = 16.94$, $p < 0.001$], left posterior [$F(1, 21) = 11.72$, $p = 0.003$], midline posterior [$F(1, 21) = 10.55$, $p = 0.004$] and right posterior [$F(1, 21) = 1.40$, $p = 0.250$]. The $p$ values were less than 0.01 for eight of nine ROIs. The highest $F$ value was indicated for the midline frontal ROI, whereas no significant difference was indicated for the right posterior ROI. At the same time windows, ERP differences were compared also for left hemisphere (FP1, F3, F7, FC3, FT7, C3, T7, CP3, TP7, P3, P7, O1) and right hemisphere (FP2, F4, F8, FC4, FT8, C4, T8, CP4, TP8, P4, O2), $F(1, 21) = 5.01$, $p = 0.046$. Left hemisphere elicited a larger N500 than right hemisphere.

In sum, counter-conformity elicited an N400-like effect that was distributed broadly over the whole surface of the head and maximal over midline frontal electrodes, and that had slightly larger over left than over right hemisphere electrode sites.

#### 3.2.3. Event-related potentials for counter-conformity under different conditions

This study focused on the conflict-related N400-like evoked by counter-conformity choices. Therefore, the N500 elicited by counter-conformity choices under four different conditions (i.e., absolutely consistent reviews vs. relatively consistent reviews, consistently positive reviews vs. consistently negative reviews) were analyzed.

As analyzed above, the counter-conformity choices elicited maximal N400-like effect over midline frontal electrodes. Nine representative electrodes surrounding midline frontal, i.e., FP1, FPZ,
Fig. 3. Left: Grand average ERP difference waveforms at FCZ for counter-conformity minus conformity choice. Right: The scalp distributions of grand average difference potentials between 475 and 525 ms.

FP2, F3, FZ, F4, FC3, FCZ, FC4 were selected. For ease of presentation, here we report only analyses on data from the nine electrodes. Fig. 4 shows grand-averaged ERP waveforms at the nine representative electrodes for counter-conformity choices under four different conditions. A 2 (review-consistency: absolutely consistent review vs. relatively consistent review) × 2 (review-valence: consistently positive review vs. consistently negative review) within-subjects repeated measure ANOVA was conducted on the N500 amplitudes

Fig. 4. Top: Grand-averaged ERP waveforms at the nine representative electrodes for counter-conformity choices under absolutely and relatively consistent reviews. Bottom: Grand averaged ERP waveforms at the nine representative electrodes for counter-conformity choices under consistently positive and negative reviews.
between 300 and 600 ms. The main effect of review-consistency was obtained, $F(1, 21) = 9.427, p = 0.011$. The N500 amplitude to the counter-conformity choices under absolutely consistent reviews (mean $\pm$ SE, $-3.07 \pm 0.39 \mu V$) was larger than that under relatively consistent reviews (mean $\pm$ SE, $-0.37 \pm 0.11 \mu V$). However, the main effects of review-valence were not significant, $F(1, 21) = 2.06, p = 0.166$. The N500 amplitude for the counter-conformity choices under consistently negative reviews (mean $\pm$ SE, $2.10 \pm 0.32 \mu V$) was not different from that under consistently positive reviews (mean $\pm$ SE, $1.69 \pm 0.26 \mu V$).

### 3.3. Response-locked ERPs

Counter-conformity choices elicited a more negative deflections peaked at approximately 30–70 ms after the response (called response-related negativity (RRN)) than conformity choices did. Response-locked grand-averaged ERPs for conformity and counter-conformity choices at representative electrodes FZ, FCZ and CZ are depicted in Fig. 5. The mean amplitude across the three electrodes between 0 and 110 ms for counter-conformity was significantly larger than for conformity, $F(1, 21) = 5.26, p = 0.032$. No significant interaction for this negative component was found between choice type and electrode site, $F(2, 42) = 1.79, p = 0.194$. As seen in Fig. 5, both counter-conformity and conformity choices elicited a positive deflection (called response-related positivity (RRP)) after RRN. The RRNs for counter-conformity and conformity peaked at about 200 ms and 140 ms, respectively. Counter-conformity and conformity amplitudes for the RRP were extracted as the average of 20 ms pre-peak to 20 ms post-peak positive amplitude and averaged across three electrodes (FZ, FCZ and CZ). The RRP was significantly larger in amplitude for counter-conformity than for conformity, $F(1, 21) = 5.91, p = 0.024$. No significant interaction for RRP was found between choice type and electrode site, $F(2, 42) = 0.31, p = 0.607$.

### 4. Discussion

The purpose of the current study was to investigate the processing course of conflicts evoked by counter-conformity. According to cognitive dissonance theory (Festinger, 1957; Kassarjian and Cohen, 1965), consumers will face intense cognitive and emotional conflicts when making counter-conformity decisions. We speculate that the two types of conflicts induced by counter-conformity choices might evoke N400 or N400-like. The experimental results support our speculation.

Behaviorally, we found that the mean RT for counter-conformity choices (731 ms) was much longer than that for conformity choices (653 ms). This indicates that the participants might confront conflicts and needed time to process these conflicts when making counter-conformity decisions.

In the stimulus-locked ERP waveforms, we found that counter-conformity choices elicited a strong negative deflection between 300 and 600 ms after stimulus onset, and showed an evident negative component with a peak latency of 500 ms in the difference waves of counter-conformity minus conformity in that time window (N500). The N500 observed in this study is the same as the N400 or N400-like observed in previous studies, which is a conflict-related ERP component. We speculate that the N500 might reflect cognitive and emotional conflicts faced by participants when they make counter-conformity choices. We attempt to explain the speculation from the following four perspectives.

Firstly, the topographic distribution of the N400-like (N500) effect evoked by counter-conformity choices is not typical of the semantic N400 effect, and the N500 likely reflects non-semantic conflicts. Previous research has shown that the semantic N400 effect was distributed over centro-parietal (Kutas and Federmeier, 2000) or centro-posterior sites (Hagoort et al., 2004) and was slightly larger over the right than the left hemisphere (Kutas and Hillyard, 1982; Kutas and Federmeier, 2000; Kiehl et al., 2006). Inconsistent with the topography of classical semantic N400 effects, the present counter-conformity related N400-like (N500) effect was distributed broadly over the whole surface of the head and maximal over midline frontal electrodes. Furthermore, it was slightly larger over the left than the right hemisphere. These differences may indicate that the present N500 does not share the same neural generators of semantic N400 and likely reflect cognitive processes of non-semantic conflict.

Secondly, previous studies have demonstrated that N400 (including N400-like) can be evoked by non-semantic conflicts including cognitive and emotional ones. The N400 has been thought to reflect the conflict between semantic information and semantic context or expectancy (Kutas and Hillyard, 1980; Gunter et al., 1994; McPherson and Holcomb, 1999). However, some studies found an analogous N400 elicited in non-linguistic paradigms (Olivares et al., 2003; Steffensen et al., 2008). In a Stroop color-word interference task, the incongruent color word elicited a more negative wave (peak at 410 ms) than the congruent color word (Liotti et al., 2000). Liotti et al. suggested that the N410 might reflect the cognitive conflict between the meaning and the color of the word. In a riddle-guessing task, Mai et al. (2004) found that Aha answers (answers leading to participant’s sudden insight) elicited a more negative ERP deflection (N380) than did No-Aha answers 250–500 ms after onset of the answer. They suggested that the N380 probably related to the cognitive conflict between old and new cognitive modes at the moment of insight. In a Chinese character-generation task, Qiu et al. (2007) found that unexpected and incorrect answers elicited a more negative ERP deflection (N320) than did consistent answers between 300 and 400 ms after the answer was delivered. They speculated that the N320 likely reflects the cognitive conflict between old and new ways of thinking while identifying and judging characters. In a modified emotional Stroop task, Taake et al. (2009) found that a significant emotional RT (response time) slowing was modulated by a fronto-central negativity (N380) in the high anxiety sensitivity group. They proposed that the N380 might reflect emotional conflict. In general, not only semantic conflicts, but also non-semantic conflicts, such as cognitive and emotional conflicts, can elicit N400.
Thirdly, according to cognitive dissonance theory, it is inevitable for participants to face strong cognitive and emotional conflicts when or after making counter-conformity choices. It is therefore a natural speculation that the N500 might reflect these cognitive and emotional conflicts. Cognitive dissonance theory is considered to be one of the most influential theories in psychology (van Veen et al., 2009). This theory states that post-decision dissonance is an inevitable consequence of decision making (Oshikawa, 1969). Consumers’ cognitive dissonance is a psychologically conflictive state experienced by consumers after they make purchase decisions (Elliot and Devine, 1994; Sweeney et al., 2000). It includes both cognitive and emotional conflicts (Sweeney et al., 2000). Cognitive conflict refers to one’s awareness that an experience or idea is not consistent with one’s existing concepts (Watson and Moritz, 2001). Emotional conflict refers to the psychological discomfort experienced by an individual (Sweeney et al., 2000), such as tension, worry, anxiety and depression. Emotional conflict is closely related to the individual’s cognitive conflict and the two types of conflict are not independent. In the present study, counter-conformity choice implied that a participant decided to buy a book with consistently negative reviews, or not to buy a book with consistently positive reviews. When making a counter-conformity choice, a participant will experience significant dissonance and face strong cognitive and emotional conflicts simultaneously. First, the participant knows that his/her decision criterion was opposite to that of the majority, so he/she might be involved in the cognitive conflict between his/her own criterion and that of the majority. In addition, the participant is aware of the risk of counter-conformity choice. In general, a book with consistently positive reviews may really be good, while one with consistently negative reviews may really be bad. In this sense, a counter-conformity choice means that the participant bought a bad book or did not buy a good book. Thus, a participant might doubt the correctness of his/her decision and this would inevitably lead to emotional conflict. We speculate that the N500 elicited by counter-conformity choices might reflect the cognitive conflict and/or emotional conflict, although it is impossible to separate one conflict from the other with the current experiment paradigm.

Fourthly, several further analyses support our speculation that the N500 might be evoked by the conflict(s) (cognitive conflict or/and emotional conflict) faced by participants when making counter-conformity choices.

1. The comparison of ERP components elicited by conformity and counter-conformity choices supports our speculation. As showed in Fig. 2, counter-conformity choices elicited remarkable N500 (N400-like) in the time window of 300–600 ms over most electrodes. However, conformity choices did not evoke the N500 or any other conflict-related negativity. Why did conformity and counter–conformity choices elicit different components? A conformity choice means that the participant’s decision is consistent with the opinion of most or even all consumers. People tend to believe that the opinion of the majority is right even though this belief may not be often true (Deutsch and Gerard, 1953). When a participant makes a conformity choice, he/she knows that his/her decision is consistent with the opinion of the majority, and therefore the decision risk is not high. He/she faces little or no conflict. In contrast, as discussed above, a participant will face intense conflict when making a counter-conformity choice. In brief, counter-conformity choices, due to high conflict, elicited the N500, and conformity choices, due to little or no conflict, did not elicit similar component. It is likely that the lack of N400-like in the condition of conformity choices might stem from the lack or insufficiency of conflict. This reveals, from the opposite perspective, that the N500 might be evoked by the conflict.

2. The comparison of ERP components elicited by counter-conformity choices under absolutely and relatively consistent reviews supports our speculation. A counter-conformity choice under absolutely or relatively consistent reviews means that the participant’s decision is opposite to the opinion of all or most reviewers. Obviously, a participant will face more intense conflict when making a counter-conformity choice under absolutely consistent reviews than under relatively consistent reviews. As analyzed before, counter-conformity choices elicited larger N500 under absolutely consistent reviews than under relatively consistent reviews (see the top of Fig. 4). This result indicates that the N500 amplitude is a function of conflict level. The higher the level of conflict is, the larger the N500 amplitude. If the N500 is not elicited by conflict, it is impossible that the N500 amplitude is modulated by the level of conflict.

3. The comparison of ERP components elicited by counter-conformity choices under consistently positive and negative reviews supports our speculation. ERP data showed that the amplitude of N500 elicited by counter-conformity choices under consistently negative reviews was not significantly different from that under consistently positive reviews (see the bottom of Fig. 4). This result indicates that participants do not have a bias, from the perspective of neural activity, towards the number of negative or positive reviews. When making decisions or evaluations, people generally place greater emphasis on negative information than on positive information (Fiske, 1980; James and Hensel, 1991). The overwhelming preponderance of research findings confirms that consumers tend to assign disproportionate value to negative word-of-mouth in the decision-making process (e.g., Richins, 1983; Weinberger, 1986). It is plausible that the ERP data of the present experiment do not support the finding of previous studies that consumers have a negativity bias towards word-of-mouth. In contrast, the negativity bias is supported by the behavioral data, which showed the mean number of counter-conformity choices per participant under consistently negative reviews was significantly less than that under consistently positive reviews (see Table 1). One possible explanation for the contradictory results is that the number of negative reviews cannot evoke a strong stimulus to the neural system of participants as can the contents themselves of negative reviews. In our experiment, a participant only knew how many consumers gave negative reviews to a book, and he/she did not read those reviews. The participant did not know the described details in negative reviews, such as the “bad” extent and “bad” attributions of the book. The negativity bias in counter-conformity behaviors indicated that participants gave greater attention to the number of negative reviews than to the number of positive reviews. The selective attention to negative information is an inertial behavior in human. Because inertia was at work, the participants’ negativity bias in counter-conformity choices was unconscious. Unconscious negativity bias may have led to the seemingly paradoxical results. On one hand, participants were more sensitive to the number of negative reviews than to the number of positive reviews due to subconscious inertia, and thus showed a negativity bias in the behavior of counter-conformity choices. On the other hand, the negativity bias did not reflect correspondingly in psychological and neural layers just because of its unconsciousness. The counter–conformity choices under consistently negative reviews might evoke slightly larger conflicts than ones under consistently positive reviews. However, the difference of conflict level between two conditions was not large enough to lead to obvious differences in neural activities. So the amplitudes of the N500 elicited by counter-conformity choices under two conditions were not significantly different. In fact,
this ERP results also implicitly indicate that the N500 amplitude is a function of conflict level, and therefore supports our speculation.

In the response-locked ERP waveforms, we found that counter-conformity choices elicited a larger negative component peaked at approximately 30–70 ms after the response than conformity choices (see Fig. 5). Obviously, this component is a response-related negativity (RRN) (Mathalon et al., 2002), which typically peaks within 100 ms following a response and is most strongly pronounced at frontocentral midline scalp sites (Amadio et al., 2004, 2008; Hirsh and Inzllicht, 2010). The RRN often occurs shortly after an erroneous responses (Falkenstein et al., 1991; Gehring et al., 1993), known as the error-related negativity (ERN) or error negativity (Ne). However, recent studies have demonstrated that the RRN can also be evoked by correct responses on tasks involving high response conflict (Bartholow et al., 2005), known as the correct response negativity (CRN), or ERN-like. The finding of CRN shows that the RRN reflects response conflict, regardless of whether there is an erroneous response or correct response. Errors are simply an extreme form of response conflict, but are not unique (Bartholow et al., 2005). In our study, regardless of whether participants made conformity or counter-conformity key-presses, their responses were consciously intended and were correct. Therefore, the RRN was clearly present following correct responses. Why did counter-conformity responses elicit larger RRN than conformity responses? A likely explanation, we argue, is that participants faced more conflict between consciously intended responses and prepotent response tendencies (MacDonald et al., 2000) when making counter-conformity responses than when making conformity responses. Conformity behaviors are often spontaneous and unconscious, because people tend to believe what most others believe (Deutsch and Gerard, 1955). In contrast, counter-conformity behaviors are generally cognitive and intuitive. It is not surprising that consumers have automatic or prepotent tendencies to conformity when they make purchase decisions. In our experiment, when making counter-conformity key-presses, participants inevitably confronted high response conflict between intended counter-conformity responses and automatic conformity response tendencies. However, participants faced low or no response conflict when making conformity key-presses because consciously intended responses were consistent with prepotent response tendencies. These results show that the level of response conflict modulates the amplitude of RRN. In fact, the conflicts occurring both before the response (cognitive and emotional conflicts reflected in the stimulus-locked N500) and after it (response conflict reflected in the response-locked RRN) stem from the same source: inconsistency between participants’ choices and part or all of reviews. The high conflict of counter-conformity stems from the inconsistency between participants’ choices and most or all of the reviews, and the low conflicts of conformity (only in the situation of relatively consistent reviews) stems from the inconsistency between participants’ choices and a small part of the reviews. The conflicts reflected in two negativities are the same in nature. Two negativity components can be used to reflect the conflicts faced by participants when making counter-conformity choices.

Consistent with our prediction, the RRN was followed by a positive ERP deflection peaked at about 140–200 ms after the response, the response-related positivity (RRP) (Mathalon et al., 2002), and counter-conformity choices elicited a larger RRP than conformity choices. The RRN includes post-error positivity (Pe) and correct response positivity (Pc) (Mathalon et al., 2002). The Pe is a positive deflection often observed in combination with ERN and it occurs between 100 and 400 ms after the ERN (Overbeek et al., 2005; Larson et al., 2010). Previous studies (e.g., Falkenstein et al., 2005; Wiersema et al., 2007) have shown that the Pe seems at least to reflect the conscious recognition of an error and may be related to further cognitive or affective-motivational processing after recognition of an error. The Pc is a positive deflection often observed after CRN (e.g., Mathalon et al., 2002; Bates et al., 2004; Easdon et al., 2005). However, the Pc has generally been used as a comparison baseline for the Pe (e.g., Mathalon et al., 2002) and little has been discussed about it (Bates et al., 2004). In our experiment, a counter-conformity choice is a decision opposite to the opinion of majority. After making a counter-conformity response, a participant may fear that he/she have made an unwise decision because majority opinion is often right. This situation is as if the participant commits an error, although his/her counter-conformity response is consciously intended and correct. The participant’s doubt about the correctness of his/her counter-conformity choice and its induced psychological discomfort might lead to the result that counter-conformity elicits larger RRP than conformity.

5. Summary and future researches

In the stimulus-locked ERP waveforms, counter-conformity choices elicited a strong negative deflection of ERP, which peaks at about 500 ms (N500). Dozens of previous studies have revealed that the N400 was elicited by semantic conflicts. Recent studies reported that N400 (including N400-like) can also be evoked by non-semantic conflicts, including cognitive and emotional conflicts. In our study, the analysis of the difference waves (counter-conformity minus conformity) showed that the topographic distribution of the N500 (N400-like) effect evoked by counter-conformity choices is not typical of the semantic N400 effect. The N500 likely reflects non-semantic conflicts. According to cognitive dissonance theory, it is inevitable that a consumer will confront strong cognitive and emotional conflicts when or after making counter-conformity choices. We speculate that the N500 might be evoked by the cognitive and emotional conflicts faced by participants when making counter-conformity choices. Our speculation is supported by several further analyses.

It is a very important deduction that the N400 (including N400-like) might reflect cognitive and emotional conflicts. If this deduction is true, it will provide further evidence for the conclusion of recent studies related to non-semantic N400: cognitive conflict (Liotti et al., 2000; Mai et al., 2004; Qiu et al., 2007; Yin et al., 2008) and emotional conflict (Taake et al., 2009) can evoke N400. However, the evidence supporting the deduction in the present experiment is indirect. Furthermore, the current experiment paradigm does not allow us to dissociate the contributions of cognitive and emotional conflicts to the N500. In order to test the reliability of the deduction, we need to utilize other brain imaging techniques such as fMRI to conduct further experiments. Previous fMRI studies have shown that cognitive conflict will trigger a response in the anterior cingulate cortex (ACC) in the Stroop and other tasks (Botvinick et al., 2001), and emotional conflict will trigger a response in the amygdala and dorsomedial prefrontal cortex (DMPFC) (Etkin et al., 2006). We can conduct fMRI experiments under the same tasks and context as the present ERP experiment, and scan the participants when they make purchase decisions. If more significant neural activities in the amygdala and (or) DMPFC are elicited by counter-conformity choices than by conformity choices, this will show that participants face more remarkable emotional conflict when or after making counter-conformity choices. If more significant neural activities in the ACC are elicited by counter-conformity choices than by conformity choices, this will show that participants face more remarkable cognitive conflict when or after making counter-conformity choices.
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References


