Event-Related Potential Correlates of the Occupational Gender Stereotype-Activated Effect

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【Abstract】 Objective: To explore the occupational gender stereotype-activated effect by using ERPs. Methods: The experiment adopted the semantic/associative priming paradigm. Specially, we took masculinize and feminine words as priming stimuli and the male and female stereotyped occupational words as target words. We used the explicit matching task to examine the occupational gender stereotype-activated effect. Results: Compared with the congruent condition, responses were slower and less accurate in incongruent condition. N400 amplitudes were larger in incongruent condition than in congruent condition. In "woman" priming condition, female subjects showed faster responses and better accuracy than "man" priming condition. The averaged P600 amplitudes were larger In "woman" priming condition than "man" priming condition. Conclusion: Our findings on behavioral data and N400 amplitudes identify the occupational gender stereotype. The production mechanism of N400 effect that belongs to occupational gender stereotype-activated effect might be semantic matching rather than spreading activation. Finally, females show in-group bias effect in behavioral results and P600 amplitudes, which may start at the post-perceptual stage.

【Key words】 Occupational gender stereotype-activated effect; In-group bias effect; N400 effect; ERPs

中图分类号：R395.1 DOI: 10.16128/j.cnki.1005-3611.2016.03.001

职业性别刻板印象激活效应:一项ERP研究

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【摘要】 **目的:**采用事件相关电位技术考察职业性别刻板印象激活效应。**方法:**使用语义联想启动范式,以代表"男性"或"女性"的单词为启动刺激,以职业性别刻板印象词为目标刺激,让被试判断启动词和目标词是否一致。**结果:**行为结果发现对比一致条件,不一致条件下被试的反应时更慢,正确率更低;对比男性启动条件,女性被试在女性启动条件下反应时更快,正确率更高。ERP结果发现,对比一致条件,不一致条件诱发了更大的N400波幅;对比男性启动条件,女性被试在女性启动条件下诱发了更大的P600波幅。**结论:**这些研究结果可能表明职业性别刻板激活效应是存在的,且支持语义匹配模型,而不是扩散激活模型;女性被试具有内群体偏见效应;职业性别刻板印象激活效应和内群体偏见效应都发生在知觉加工的晚期阶段。

【关键词】 职业性别刻板印象激活效应; 内群体偏见效应; N400效应; ERPs

1 Introduction

Stereotype was a cognitive phenomenon that commonly existed in human's social interaction activities. It had attracted so many researchers' attention as soon as it was proposed, especially gender stereotypes and occupational gender stereotypes. Many studies showed stereotype's contents and valence could affect follow-up information processing after stereotype information was activated. Namely, there was the stereotype-activated effect[1-3]. However, the cognitive mechanism of stereotype-activated effect were rarely explored, for the reason that many previous studies always used behavioral method.This method had drawbacks that could never be overcome, for example, subjects couldn't be

【基金项目】 国家自然科学基金青年项目(31500883),中国博士后科学基金面上项目(2014M561086),湖南省社会科学基金青年项目(15YBA264),湖南省教育科学"十二五"规划课题(XJK0150XL002),湖南省教育厅科学研究优秀青年项目(15B152),湖南师范大学博士启动基金(2014BQ31),中国科学院心理健康重点实验室开放课题(KLMH2014K04),教育部人文社会科学研究规划基金项目(13YJA190001),湖南省自然科学基金(2015JJ2097,2015JJ2101)资助

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accurately reported at which point this rapid and unconscious activation of stereotype happened. Explorations on processing of stereotype using behavioral methods could only reflect integrated processing results rather than elaborate processing.

Event-related potentials(ERPs) has high time resolution, and it could not only provide instantaneous evaluation on neural activities in cognitive processes, but also identify and separate cognitive processes. So it could well explore the time process and cognitive mechanism of stereotype-activated effect[4]. On account of this, some researchers have begun to try to use ERPs to investigate the stereotype-activated effect. Osterhout and his colleagues used ERPs to study gender stereotype originally. Their study revealed P600 amplitudes elicited by reflexive pronouns inconsistent with antecedents were significantly larger than consistent condition. ERP effect scaused by sentences inconsistent with occupational gender stereotype were similar to those caused by sentences inconsistent with syntaxes[5]. Lattner and Friederici investigated influences that gender stereotypes had on sentence comprehension. The results showed P600 amplitudes eliciting in inconsistent condition were significantly larger than consistent condition, while P600 amplitudes of male and female were not significantly different[6]. Ma and his colleagues found ERN amplitudes elicited by "female faces--kitchen appliances" pictures were significantly smaller than "male faces--kitchen appliances" pictures. It revealed that gender stereotypes were automatically activated and affected follow-up information processing[7]. White and his colleagues found N400 amplitudes elicited by words inconsistent with gender stereotypes were significantly larger than those consistent with gender stereotypes. While in inconsistent condition, response time was longer and accuracy was lower than consistent condition[8]. Wang et al adopted semantic/association priming paradigm to study gender stereotype-activated effect and in-group bias effect. Their results showed that compared with the consistent condition, response time was longer in inconsistent condition and all subjects showed in-group bias effect. Namely, response time was shorter in in-group category words priming condition. N400 amplitudes elicited in inconsistent condition were larger than in consistent condition. P600 amplitudes elicited by in-group category words were larger than out-group category words. Furthermore, both the gender stereotype-activated effect and the in-group bias effect started at the post-perceptual stage[9]. Hehman and his colleagues indicated that the N400 could indeed function as an index of stereotype accessibility in an interracial domain, as greater N400 reactivity was elicited by trials in which the face prime was incongruent with the target trait than when primes and traits matched[10]. Anna et al examined the brain response to third-person pronouns that were implicitly primed by definitional or stereotypical antecedents. An N400-like effect on the pronoun emerged when it was preceded by a definitional incongruent prime, and a stereotypically incongruent prime for masculine pronouns only[11]. Leynes and his colleagues indicated that the late posterior negativity effect(LPN) was diminished and a novel, frontal-negative ERP with left-central topography was observed when stereotypes aided source judgments[12]. Jia et al provided strong evidence that the categorization processes of stereotype activation vary from the categorization processes of stereotype application, and that in-group and out-group status could have implications for those categorization processes. It appeared that implicit stereotype activation might be facilitated by later social expectancy violation to in-group and out-group information as assessed by LPP[13].

According to analyses of previous researches, we can conclude that investigated gender stereotypes and occupational gender stereotypes using ERPs, stimuli can mainly divided into three types: pictures, sentences and words. In terms of information bearing, if experimenters adopted pictures as stimuli, then those stimuli couldn't stand for rich and diverse contents of that group's stereotype. Thus, if pictures were adopted as stimuli to investigate stereotype-activated effect, results would inevitably have limitations to interpret stereotype. Hamilton and Trolier pointed out stereotype was perceived as knowledge and cognitive structures on human group, core contents were abstract semantic information standing for typical characteristics and behaviors of that group[14]. The perceiver often adopted

words and sentences to communicate with others. So compared with pictures, experimenters using words or sentences as stimuli to study stereotype-activated effect could reveal the processing and cognitive mechanism of stereotype better. To our regret, using sentences as stimuli also had inevitable disadvantages: so complicated stimuli made it difficult for experimenters to explain stereotype-activated effect; paradigm adopted sentences as context and pronouns as target stimuli largely reflected syntactic violations rather than semantic processing on stereotype representation. So it was difficult to reveal the nature of stereotype-activated effect.

In summary, compared with pictures and sentences, it would be better to use words as stimuli to study stereotype. According to the previous research, both the gender stereotype-activated effect and the in-group bias effect started at the post-perceptual stage. When the gender stereotype was activated, it always elicited N400 amplitudes, and when the in-group effect occured, it always elicited larger P600 amplitudes[6-10,15].

Importantly, the innovation of this study is that although occupational gender stereotypes belonged to gender stereotypes, its cognitive mechanism was different from gender stereotype. And we can investigate which stage occupational gender stereotype-activated effect and in-group bias effect started further. We assumed that occupational stereotype-activated effect on employment also had a gender difference; occupational gender stereotype-activated effect and in-group bias effect started at the post-perceptual stage; male and female subjects showed the occupational gender stereotype-activated effect in behavioral results and N400 amplitudes and showed the in-group bias effect in behavioral results and P600 amplitudes.

2 Method

2.1 Participant

Thirty undergraduate or postgraduate students(15 females, 15 males) aged 19-24 years participated in the experiment. All subjects were healthy, right-handed, had normal or corrected vision, and reported no history of brain injury.

2.2 Materials

In the experiment, we adopted the semantic/associative priming paradigm. The stimuli consisted of priming words and target words. Priming words(masculinize and feminine) belong to abstract category words, which stand for man or woman social groups. Target words consisted of male and female stereotyped occupational words. At first, 100 male and 100 female stereotyped occupational words were obtained by searching the previous research[3]. Then a 7 point scale was adopted to assess occupational words, (1=very suitable for women, 4=both suitable for men and women, 7=very suitable for men). 42 males(M=6.32, SD=0.23) and 42 females(M=1.75, SD=0.26) stereotyped occupational words were selected by assessments of 50 subjects(25 male and 25 female), undergraduate and graduate students coming from Hunan Normal University. Then 1 to 7 of 7 point scale was converted into -3 to 3 of 7 point scale and recalculated scores of male and female stereotyped occupational words. Results showed scores of male stereotyped occupational words(M=2.32, SD=0.23) had no significant difference with female stereotyped occupational words'(M=2.25, SD=0.26), [$T_{(81)}$=1.41, P>0.05]. 2 male and 2 female stereotyped occupational words were selected as practical stimuli and the remaining 80 words were selected as experimental stimuli.

The priming words--target words had 4 association types: man--male occupational words, woman--female occupational words, man--female occupational words and woman--male occupational words. The two former types were consistent conditions(stereotype contents activated by priming words were consistent with target stimuli) and the two latter types were inconsistent conditions(stereotype contents activated by priming words were inconsistent with target stimuli).

2.3 Experimental procedures

Stimuli were presented by E-prime 2.0 in the center of screen. The background was gray and font was 40, black italics. Subjects were seated in a quiet room approximately 70cm from a computer screen with horizontal and vertical visual angles all less than 5°. For the main experiment, each trial was initiated by a 200 ms presentation of a small white cross on the black

computer screen. Then, a blank screen of which duration varied randomly from 500 ms to 1000 ms was followed by 300 ms presentation of a priming stimulus. And then, a blank screen whose duration varied randomly from 400 ms to 500 ms was followed by 500 ms presentation of a target stimulus. After stimulus presentation, a blank screen was presented for 1000 ms. Participants' task was to judge whether target stimuli was consistent with priming stimuli according to occupational gender stereotype. If they were consistent, subjects pressed "1" key; if they were inconsistent, subjects pressed "4" key. The sequence of pressing keys balanced among subjects. If subjects didn't press keys within 1500ms, it would be regarded as wrong reaction. In the experiment, subjects should complete 3 blocks and each block contained 160 trials. Each block was divided into 4 experimental conditions. Each experimental condition contained 40 trials. The pseudo-random treatment had been taken among trails, and the same occupational stereotypes words would not appear. Subjects could have one minute's rest among blocks.

2.4 EEG recording and statistics

The electroencephalogram(EEG) was continuously recorded from 64 scalp silver/silver- chloride electrodes located according to international 10-20 system. The left mastoid as reference electrode, and the contra lateral mastoid as recording electrode in online record, forehead linked ground. The HEOG was recorded bipolar manner from electrodes placed 1.5cm lateral to the left and right outer canthi, the VEOG from electrodes below and above the left eye. The impedance for each electrode was kept below 5 KΩ. EEG was amplified (filter band pass 0.05-70 Hz) and digitized at a sampling rate of 500 Hz. ERPs recorded under each set of stimulus conditions were averaged separately off-line with epochs beginning an average of 200 ms prior to and ending 800 ms after the onset of the stimulus (target stimulus pre-presented 200ms and after the target stimulus presented 800ms, the target stimulus pre-presented 200ms as the baseline). Trials affected by eye blinks(VEOG exceeding ± 80 μV relative to baseline) or other artifacts(a voltage exceeding ± 80 μV at any electrode location relative to baseline) were considered contaminated and excluded. We superimposed and averaged each brainwaves of subject under four categories treatment in correct response, and then male and female subjects whose brainwaves were tested in four categories with correct responses are superimposed average.

According to images of ERPs and purposes of this study, the following 15 electrodes were selected for statistical analyses: F3, FC3, C3, CP3 and P3 on the left brain; Fz, FCz, Cz, CPz and Pz along the midline; F4, FC4, C4, CP4 and P4 on the right brain. The peak amplitudes and latencies of N1(50- 150ms)、P2(150-300ms)、N400(300-500ms) and average amplitudes of P600(500-700ms) were measured. A three-way repeated measures analysis of variance(ANOVAs) was conducted for behavioral data: response time and accuracy. The factors were subjects' gender(male and female), priming words(man and woman) and target words (male occupational words and female occupational words). A five-way ANOVAs were conducted for ERP data. The factors were subjects gender, priming words, target words, laterality(left, midline and right sites) and caudality(front, front-central, central, central-parietal and parietal sites). The degrees of freedom of *F*-ratio were corrected according to Greenhouse-Geisser method.

3 Results

3.1 Behavioral results

For accuracy, results of ANOVAs revealed that subjects gender and priming words had a very significant interaction[$F(1, 28)=22.26$, $P<0.01$]. Simple effects analysis revealed for female subjects, accuracy in "woman" priming condition(M=0.94) was significantly higher than "man"priming condition(M=0.85)[$F(1,28)=30.27$, $P<0.01$]. ANOVAs revealed that priming words and target words also had a very significant interaction [$F(1, 28)=20.85$, $P<0.01$]. Simple effects analysis revealed when priming words were "man", accuracy of male occupational words(M=0.93)was significantly higher than female occupational words(M=0.81), [$F(1, 28)=34.45$, $P<0.01$]; when priming words were "woman", accuracy of female occupational words(M=0.94) was significantly higher than male occupational words (M=0.87), [$F(1,28)=15.65$, $P<0.05$].

As to response time, results of ANOVAs revealed that subjects gender and priming words had a significant interaction[$F(1, 28)=24.53$, $P<0.01$]. Simple effects analysis revealed for female subjects, response time in "woman" priming condition(M=760.76ms) was significantly shorter than that in "man" priming condition(M=803.58 ms), [$F(1, 28)=18.59$, $P<0.01$]. ANOVAs revealed that priming words and target words also had a very significant interaction[$F(1, 28)=102.58$, $P<0.01$]. Simple effects analysis revealed when priming words were "man", response time of male occupational words(M=715.47 ms) was significantly shorter than that of female occupational words(M=830.23 ms), [$F(1, 28)=131.35$, $P<0.01$]; when priming words were "woman", response time of female occupational words(M=722.06 ms)was significantly shorter than that of male occupational words(M=802.42 ms), [$F(1, 28)=62.55$, $P<0.01$].

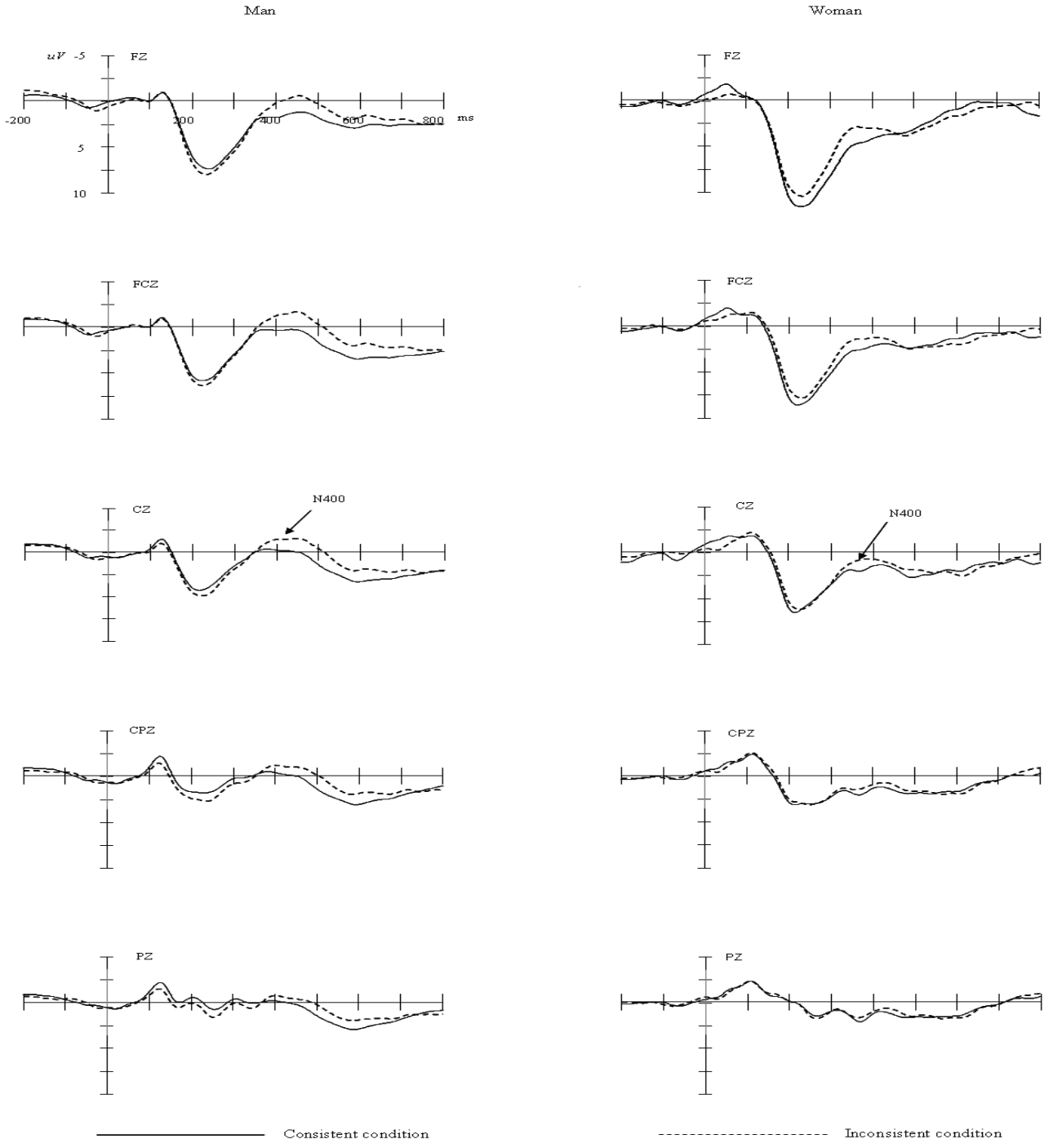

Fig.1. Men and women's grand average of ERPs at Fz, FCz, Cz, CPz and Pz in consistent and inconsistent conditions

3.2 ERP results

As for N400 average amplitude, results of ANOVAs revealed that target words had a significant main effect[$F(1, 28)=15.75$, $P<0.01$]; Post hoc test revealed N400 amplitude elicited by male occupational words (M=−1.69 *uv*) was significantly larger than that elicited by female occupational words(M=− 1.04 *uv*), $P<0.05$. Repeated measures ANOVA results also found that the priming word and target stimulus has an extremely significant interaction[$F(1, 28)=10.46$, $P<0.01$]. Simple effects analysis revealed when priming words were "man", N400 amplitude elicited by male occupational words(M=−1.44 *uv*) was significantly smaller than that elicited by female occupational words(M=−1.93 *uv*), [$F(1, 28)=6.57$, $P<0.05$]; when priming words were "woman", N400 amplitude elicited by female occupational words(M=−0.66 *uv*) was also significantly smaller than that elicited by male occupational words(M=−1.85 *uv*), [$F(1, 28)=32.95$, $P<0.01$].

As for P600 average amplitude, results of ANOVAs revealed that laterality had a very significant main effect[$F(2, 27)=22.59$, $P<0.01$]. Post hoc test revealed P600 average amplitude in midline sites(M=1.37 *uv*) was largest, then that in right sites(M=0.8 *uv*) and that in left sites(M=0.34 *uv*), Between each two of these, differences were significant (all $P<0.05$). Repeated measures analysis of variance demonstrated that subjects gender and priming words had a significant interaction [$F(1, 28)=6.63$, $P<0.05$]. Simple effect analysis showed that for female subjects, P600 average amplitude elicited by "woman" priming words(M=0.87 *uv*) was significantly larger than that elicited by "man" priming words (M=0.14 *uv*), [$F(1, 28)=8.35$, $P<0.05$].

4 Discussion

In this study, the semantic/associative priming paradigm was adopted to investigate occupational gender stereotype−activated effect. Behavioral results revealed that compared with the congruent condition, responses were slower and less accurate in incongruent condition. These results were consistent with previous research. White and his colleagues found that in inconsistent condition, response time was longer and accuracy was lower than consistent condition[6]. And Wang and his colleagues adopted semantic/association priming paradigm to study gender stereotype−activated effect and in−group bias effect, and the results showed that compared with the consistent condition, response time was longer than inconsistent condition[7]. One explanation may be that when the occupational gender stereotype was activated in consistent condition of the priming words and target words, the response time of target stimuli was shorter and the accuracy was higher. While when the priming words and target words were not consistent, subjects needed more attention resource to judge, so the response time was longer and the accuracy was lower.

Importantly, we found that there was a significant interaction of priming words and target words at N400 amplitude. Compared with the inconsistent condition, the elicited N400 amplitude was more significant than consistent condition. These results were also consistent with previous research. Ma et al found ERN amplitudes evoked by "female faces−− kitchen appliances" pictures was significantly smaller than those evoked by "male faces−− kitchen appliances" pictures. It revealed gender stereotypes were automatically activated and affected follow−up information processing[5]. White et al found N400 amplitudes induced by words inconsistent with gender stereotypes was significantly larger than those consistent with gender stereotypes[6]. Wang and his colleagues found that N400 amplitudes elicited in inconsistent condition were larger than consistent condition. Because of the priming words and target words were not consistent, which was in conflict with the existing occupational gender stereotype of subjects, and that led to larger N400 amplitude. In addition, we found the interaction of priming words and target words was only significant at N400 amplitude but not in other ERP indexes. So we could infer that N400 amplitude may be viewed as ERP index of occupational gender stereotype−activated effect.

According to the previous research, N400 effect meant N400 amplitude in consistent condition had significant difference with that in inconsistent condition due to the different connected extents of priming words and target words[14]. At present, the production mechanism of N400 effect mainly contained two viewpoints:

spreading activation and semantic matching. Spreading activation meant a fast processing that didn't need involvement of attention and consciousness and only needed to consume little cognitive resources[14,15]. Different memory spreading activation produced N400 effect [2,16-18]. The N400 is a negative ERP deflection over the centro-parietal scalp, which specifically reflects semantic processing. The N400 has been shown to be sensitive to semantic deviations with larger have frequently failed to obtain semantic brain activation N400 amplitudes for semantically incongruent words elicited by unconsciously perceived or unattended words compared to congruent words at both the sentence. For example, Michael Niedeggen and Frank Rösler(1999) use the Event related potential to investigate the whether the N400 component is sensitive to unconscious automatic priming mechanisms, they used the word-word combinations. The word-word combinations consisted of 160 semantically related pairs ('hen'-'egg') and 160 semantically unrelated pairs ('car'-'leaf'). Subjects were told to decide as fast and as accurately as possible whether the target was a real word or not, and they found that the N400 component is sensitive to semantic matching[19]; Chiara Avancini, Fruzsina Soltész, Dénes Szücs(2015) believed that in ERP studies, N400 amplitude to targets is upon observations that conscious or attentive processing of attenuated for semantically related word pairs compared to the prime is a prerequisite for N400 priming effects[20]. Semantic matching meant, according to semantic connection, subjects matched priming words and target words at post-lexicon level. Compared with consistent condition,subjects handling target words would spend more time and cognitive resources when they were semantically inconsistent[14]. Semantic matching was a fast processing and it could happen even if intervals between priming words and target words were very short[21,22]. Different extents of semantic matching between priming words and target words produced N400 effect[15,23,24]. So the current study found that the N400 effect may be explained by semantic matching.

In addition, the results also revealed that the interaction of subjects' gender and priming words was significant at P600 average amplitude. As to female subjects, P600 average amplitude,which was elicited by "woman" priming words was significantly larger than "man"priming words. These results were similar to previous research. One explanation of these results was offered by identity fusion theory, which referred to the convergence process in the emotion and psychology of individual and others or the groups and other groups. This process could lead to oneness of individuals in groups and activate automatic recognition level, which helped to organize the consistency of members and groups, and then to maintain the group behavior and improve self-esteem[25-27]. Gómez et al suggested that individual and group identity were equally important. When the individual identity and group identity were influenced by negative stereotypes, individuals of identity integration would use the way of self-verification to maintain their group identity[28]. This may result from the fact that the female subject showed a preference for cognitive processing to the information of in-group. That was to say, female subjects displayed in-group bias effect in P600 indexes. In addition, we also found the interaction of subjects gender and priming words were only significant at P600 average amplitude but not in other ERP indexes. So we could infer that P600 average amplitude may be viewed as ERP index of in-group bias effect.

In summary, the N400 amplitude may be viewed as ERP index of occupational gender stereotype-activated effect, while the P600 average amplitude may be viewed as ERP index of in-group bias effect. According to the previous research, N400 and P600 were started at the post-perceptual stage, which were viewed as the index of semantic processing and syntactic processing, respectively[14]. So we could infer that both the occupational gender stereotype-activated effect and the in-group bias effect started at the post-perceptual stage. The results showed that all subjects displayed the occupational gender stereotype-activated effect. And the production mechanism of N400 effect that belonged to occupational gender stereotype-activated effect was semantic matching. Furthermore, female revealed the in-group bias effect. In addition, both the occupational gender stereotype-activated effect and in-group bias effect started at the post-perceptual stage.

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(收稿日期:2015-11-12)