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Differences in Explicit Stereotype Activation among Social Groups Based on the Stereotype Content Model: Behavioral and Electrophysiological Evidence in Chinese Sample

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Abstract: The stereotype content model (SCM; Fiske, Cuddy, Glick and Xu, 2002) identifies four basic categories of stereotyped social groups: high warmth-high competence (HW-HC), high warmth-low competence (HW-LC), low warmth-high competence (LW-HC), and low warmth-low competence (LW-LC). However, many of these groups have not been directly examined in stereotype activation research. The purpose of the present research was to extend stereotype activation research to groups that more fully represent those identified under the SCM. Employing explicit sequential priming task, participants responded to prime-target stimulus pairs that were either congruent or incongruent with stereotypes of social groups from all four SCM quadrants in two studies in the current investigation. Study 1 was to determine the behavioral pattern of explicit stereotype activation among four quadrants (the sample included 60 Chinese undergraduate students, 51%—female). Study 2 further employed event-related brain potentials (ERPs) technique to track the time course and electrophysiological underpinnings of explicit stereotype activation (the sample included 22 right-handed Chinese undergraduate students, 76%—female). In Study 1, participants responded more quickly and accurately on stereotype congruent trials than incongruent trials for all social groups except LW-LC groups. This reverse priming effect on LW-LC social groups in RTs was also replicated in Study 2. ERPs findings further showed that incongruent targets elicited larger N400 amplitudes than congruent targets for all four SCM quadrants. Moreover, congruent targets elicited larger P2 than incongruent targets, but only found for the LW-LC social groups. In addition, congruent targets elicited larger amplitudes of late positive component than incongruent targets for the low warmth (LW-LC and LW-HC) groups. Together, these results highlight the unique processing that LW-LC groups receive throughout the cognitive stream, ultimately manifesting in distinctive behavioral responses. Unconscious activation of egalitarian goals, disgust, and distrust accounts are discussed.

Keywords: stereotype activation; stereotype content model; N400; LPC; P2; event-related potentials; reverse priming effect

1. Introduction

In an effort to process and simplify a complex social world, people often rely on mental shortcuts and heuristics as they navigate their daily lives [1,2]. Stereotypes represent one of these mental shortcuts, and while their use can provide a sense of order and coherence, they can just as easily lead to misunderstandings and friction in one's social environment. The activation of stereotypes and their resulting impact on human behavior are seen as a ubiquitous part of being human, thus they have been the subject of intense research scrutiny for over half a century. Starting in the 1980s, researchers adapted response time paradigms to study stereotype activation (e.g., [3–6]). More recently, various neuroscience techniques have been used to further elucidate the cognitive processes involved in stereotype activation (see reviews [7–9]). This line of research has revealed a great deal about stereotype activation and the conditions under which it occurs (for review, see [10]), but the vast majority has focused on only one or two social groups (e.g., racial groups, gender groups). According to the stereotype content model (SCM [11,12]), there are many other groups in society that are consistently stereotyped, and these groups also require empirical attention. The primary purpose of the present research was therefore to investigate patterns of stereotype activation in both response times and neural activity for a wide range of social groups identified under the SCM.

1.1. The Stereotype Content Model (SCM) and BIAS Map

The SCM [11,13] organizes social and cultural groups along two universal and fundamental dimensions: perceived warmth and perceived competence. Warmth refers to the intent to help or harm others, and warmth judgments are dictated primarily by perceptions of competition (competing groups are perceived as less warm). Competence refers more specifically to the ability to help or cause harm, and judgments are based more on the perceived status of the group in society (lower status groups are perceived as less competent). Social and cultural groups in society are perceived as low or high on each of these dimensions, resulting in their placement in one of four different quadrants of the model. Some groups are perceived as high on both warmth and competence (HW-HC). These are typically groups that participants perceive as part of their in-group or are held in relatively universal high regard within society. On the other end of the spectrum, some groups are perceived as low on both warmth and competence (LW-LC). These groups are held in relatively universal low regard and include groups such as the homeless and drug addicts. Finally, there are groups in society that have mixed stereotype content, meaning they are perceived as high on one dimension, but low on the other. For example, some groups are perceived as high on warmth but low on competence (HW-LC) (e.g., elderly people, the disabled). Other groups are perceived as low on warmth but high on competence (LW-HC) (e.g., rich people). Research has confirmed that SCM patterns generalize across time, level of analysis, and measures (see reviews [14,15]). Additionally, the SCM has been validated in multiple countries [16–19]. To further develop the SCM, BIAS (behaviors from intergroup affect and stereotype) map [12,20] was proposed to capture the affect and action tendencies associated with stereotype. Besides the application in intergroup situations, SCM and BIAS map could also be employed in interpersonal perception [21–23].

1.2. Low Warmth—Low Competence (LW-LC) Social Groups

Among the four quadrants of the SCM, groups in the LW-LC quadrant might be processed differently from groups in the other three quadrants. According to the SCM and BIAS map, LW-LC social groups elicit contempt and disgust along with active harm behavioral tendencies (e.g., attacking or harassing) [11–13,20]. Social groups in the LW-LC (vs. HW-HC, HW-LC, LW-HC) quadrant fail to elicit brain activity associated with human social processing (medial pre-frontal cortex, mPFC) and instead elicit activity associated with disgust (insula and amygdala) [24,25] but these findings have not been replicated by others. In other words, it has been argued that members of social groups in the LW-LC quadrant are more likely to be dehumanized relative to social groups in the other

three quadrants (see [26,27] for a more complete discussion). Other research demonstrated that brain regions associated with the emotion of disgust (the left anterior insula) are more active when thinking about the homeless (LW-LC) than the elderly (HW-LC) [28]. Compared with other three quadrants, participants were more willing to sacrifice LW-LC group members in moral dilemmas [29]. Moreover, desirable events were anticipated to occur significantly more frequently than undesirable events for HW-HC and HW-LC group members while this social optimism biases were reversed for LW-LC groups [30–32]. Compared to HW-HC and HW-LC groups, the temporoparietal junction and right anterior temporal lobe were recruited when evaluating LW-HC and LW-LC groups, while thinking about LW-LC groups additionally involved the dorsomedial frontal cortex (stereotypical thinking and disgust), inferior frontal cortex (stereotypical thinking), and anterior insula (disgust and repulsion) [31].

1.3. Response Pattern of Stereotype Activation

Behavioral research on stereotype activation has relied heavily on priming and response time techniques (e.g., [33–36]). A common paradigm used in stereotype research is the sequential priming paradigm [37,38]. In this paradigm, participants view trials that each contains two stimuli (prime and target) with the meaning congruency between the stimuli varied across trials. For example, in stereotype priming, a congruent stimulus pair would be the prime “men” followed by the stereotypically congruent target “strong”. An incongruent stimulus pair would be the prime “women” followed by the stereotypically incongruent target “strong”. If participants respond more quickly to a target preceded by a stereotypically congruent prime than those preceded by a stereotypically incongruent prime, this is interpreted as evidence of stereotype priming/activation. The sequential priming paradigm has been used to examine stereotypes for a variety of different social groups [37,38] (such as gender [3,39–54], and race [52–67]) and the priming effect was repeatedly reported [1,68,69], but we are not aware of any research that examined groups from all SCM quadrants simultaneously and compared observed priming effects among them. Thus, the purpose of Study 1 in the present research was to investigate the pattern of stereotype activation in behavioral response for social groups that fall into the four different quadrants of the SCM. In line with previous research, we expected to observe lower accuracy and slower response times on stereotype incongruent trials than stereotype congruent trials, and that this pattern would be observed for social groups from all four SCM quadrants.

1.4. Electrophysiological Pattern of Stereotype Activation

Stereotype activation occurs rapidly and involves multiple cognitive processes [8,9,43,70,71]. Due to high temporal resolution (milliseconds), event-related potential (ERP) is optimal for studying the progress of stereotype activation as it unfolds in real-time [72,73]. The various ERP components are also sensitive to different types of cognitive processes, enabling researchers to disentangle the presence and impact of these processes. Thus, ERPs are better able to examine the time course of stereotype activation, and the cognitive processes that contribute to this activation, than either response times or fMRI data. Similar to response times research, however, ERP research on stereotypes and stereotype activation has focused on a limited number of social groups (e.g., men/women, black/white) [40,41,67,74,75]. The utility of ERPs to study all types of SCM groups therefore remains untested. Study 2 in the present research had two primary goals: (1) extend neuropsychological investigations of the SCM by using ERPs to elucidate the cognitive processing time-course for multiple social groups, and (2) extend previous ERP research on stereotype activation by identifying potential differences among groups in the four SCM quadrants. These goals were accomplished by examining ERP components at different time points in the information-processing stream.

1.4.1. Early ERP Component: P2

The P2 component has previously been connected with stereotype processing. While the P2 component appears to be modulated by a variety of cognitive tasks and conditions, it is generally thought to also reflect mechanisms of selective attention [76]. Previous research has found the P2 component to

be particularly sensitive to race and stereotypes. Specifically, larger P2 amplitudes were elicited by pictures of black faces (than white faces) among white participants (e.g., [77–80]), and larger P2 amplitudes have been observed on race stereotype congruent trials than incongruent trials in a sequential priming paradigm [67]. These results still need to be replicated for other stereotyped social groups in society. Given the uniquely stigmatized status of LW-LC groups, we expected these groups to attract greater attention early in the processing stream, which would be reflected in larger P2 amplitudes on stereotype-congruent trials for these groups.

1.4.2. Later ERP Components: N400 and LPC

Two later ERP components have been examined in research on stereotypes and stereotype activation—the N400 and the late positive component (LPC). The N400 component is a negative deflection that peaks around 400 milliseconds following stimulus exposure. It is thought to reflect the influence of both bottom-up and top-down neural processes in efforts to construct meaning, drawing on information from the multimodal long-term memory system [81]. The amplitude of the N400 is particularly responsive to the ease of integrating information into the preceding context, with larger amplitudes elicited when integration is more difficult. For example, larger N400 amplitudes would be elicited by the word “jelly” if preceded by the word “shoe” than if preceded by the word “grape” [82]. One potential explanation for these results is that exposure to the first word (“grape”) results in the activation of long-term memory information related to this concept as the system attempts to reconstruct the meaning of this concept. If the second word is related to the concept of “grape” (as would be the case for the word “jelly”), then the preactivation of this information would facilitate processing of the second word. Thus, differences in N400 amplitudes may reflect differences in the activation of multimodal information in long-term memory during the meaning-construction process [81].

Recent research extended earlier N400 findings to stereotypes, and consistently found the N400 to be sensitive to stereotype incongruities (e.g., [40,41,67,75,83]). This was first demonstrated by White and colleagues (2009) [40], who presented participants with prime-target stimulus pairs which were congruent or incongruent with gender stereotypes. In this study, stereotype incongruent trials (e.g., MEN: NURSE) elicited significantly larger N400 amplitudes than stereotype congruent trials (e.g., WOMEN: NURSE). Later studies replicated these results for gender stereotypes in a non-Western culture (i.e., Chinese culture [39,41–43]) and for other stereotype dimensions, such as race [67] and migrant workers [83]. This suggests that the N400 ERP component is sensitive to stereotype incongruities and may reflect differences in stereotype activation. However, whether these results could be replicated and generalized in social groups that represent all four quadrants of the SCM still remains unclear. Aligned with previous research, we expected that stereotype-incongruent targets would elicit larger N400 amplitudes than congruent targets for social groups in all four quadrants of the SCM.

Evidence for the sensitivity of the LPC to stereotypes is more mixed. The LPC is a positive deflection with typical onset around 300 milliseconds, extending for several hundred additional milliseconds. In one early study, participants read sentences that violated definitional (e.g., the mailman took a shower after she got home) or stereotypical (e.g., our aerobics instructor gave himself a break) noun-pronoun agreement [84]. Relative to sentences without a noun-pronoun violation, LPC amplitudes were enhanced for both definitionally and stereotypically incongruent sentences, suggesting that the LPC might be sensitive to stereotype incongruities. Other studies also found the LPC to be sensitive to pronoun incongruities within the context of social and nonsocial sentences [85,86]. In contrast to these results, the LPC was not modulated by stereotype incongruities in studies that employed a sequential priming paradigm (i.e., presented participants with word pairs rather than sentences) (e.g., [40,41,67]). Given these latter results, we did not expect stereotype congruity to modulate LPC amplitudes in Study 2.

1.5. Current Research

In the current research, we conducted two studies to explore the similarities and differences on explicit stereotype activation for HW-HC, HW-LC, LW-HC and LW-LC social groups based on the framework of SCM. Employing sequential priming paradigm, we investigated the behavioral pattern of explicit stereotype activation in Study 1 and further examined the electrophysiological pattern of explicit stereotype activation among four quadrants by using ERPs in Study 2.

2. Study 1: The Behavioral Pattern of Explicit Stereotype Activation for HW-HC, HW-LC, LW-HC and LW-LC Social Groups

2.1. Methods

2.1.1. Participants

Sixty Chinese undergraduate students (31 female, $M = 21.5$ years, range 19–25 years) participated in the study in exchange for 10 RMB. All participants signed an informed consent form approved by the Academic Ethical Committee of Ningbo University. Data from two participants (1 female and 1 male) were excluded due to excessive incorrect trials (greater than 30%), leaving a final sample of 58 participants.

2.1.2. Design

Group (HW-HC, HW-LC, LW-HC, LW-LC) \times congruency (congruent, incongruent) within-subject design was applied in the current study.

2.1.3. Stimuli

Stimuli were Chinese word pairs consisting of a prime word followed by a target word. Prime words were 24 social group labels, which were retrieved from Yang et al. (2019) [87], which were validated in Ji et al. (2020) [88] (see Appendix A). These social groups were divided into four categories, according to the two SCM dimensions of warmth and competence. Specifically, the six high warmth-high competence (HW-HC) groups were soldiers, firemen, professors, psychotherapists, air hostesses, and yoga instructors. The six high warmth-low competence (HW-LC) groups included elderly, farmers, housewives, migrant workers, left-behind children, and cleaning workers. The six low warmth-high competence (LW-HC) groups were businessmen, overseas returnees, government workers, government officials, stars in showbiz, and rich. Finally, the six low warmth-low competence (LW-LC) groups included criminals, unemployed, beggars, drug addicts, terrorists, and urban management officers.

Target stimuli were words stereotypically associated with one of the social groups. Target words were also retrieved from Yang et al. (2019) [87], which were selected through the classical method by Katz and Braly (1933) [89] (see [88] for details). For each quadrant of SCM, the 30 most stereotypic words were selected, totaling 120 target words (see Appendix A).

These 120 words were used to form both congruent and incongruent trials. When paired with their matching social group, the words formed congruent trials. Incongruent trials were then created by pairing each target word with a social group that was as different in stereotypes as possible. This resulted in 30 congruent and 30 incongruent target words for each social group category (see Appendix A). Thus, eight experimental conditions were established: stereotype congruent vs. incongruent for the HW-HC social group category, stereotype congruent vs. incongruent for the HW-LC social group category, stereotype congruent vs. incongruent for the LW-HC social group category, and stereotype congruent vs. incongruent for the LW-LC social group category. In total, there were 120 congruent prime-target trials and 120 incongruent prime-target trials. Each prime-target word pair was presented twice, thus there were 480 trials in the experiment.

All primes and targets (Chinese characters) were presented centrally on a white background in 60-point, black, boldface font. All stimuli were presented in the center of a 17 in. LCD (Liquid Crystal Display) monitor with a silver-gray background (resolution: 1024 × 768, refresh rate: 60 Hz) using E-Prime 2.0 (see Figure 1). The stimuli, seen from a distance of 120 cm, occupied a visual angle of 6.06° × 6.06°.

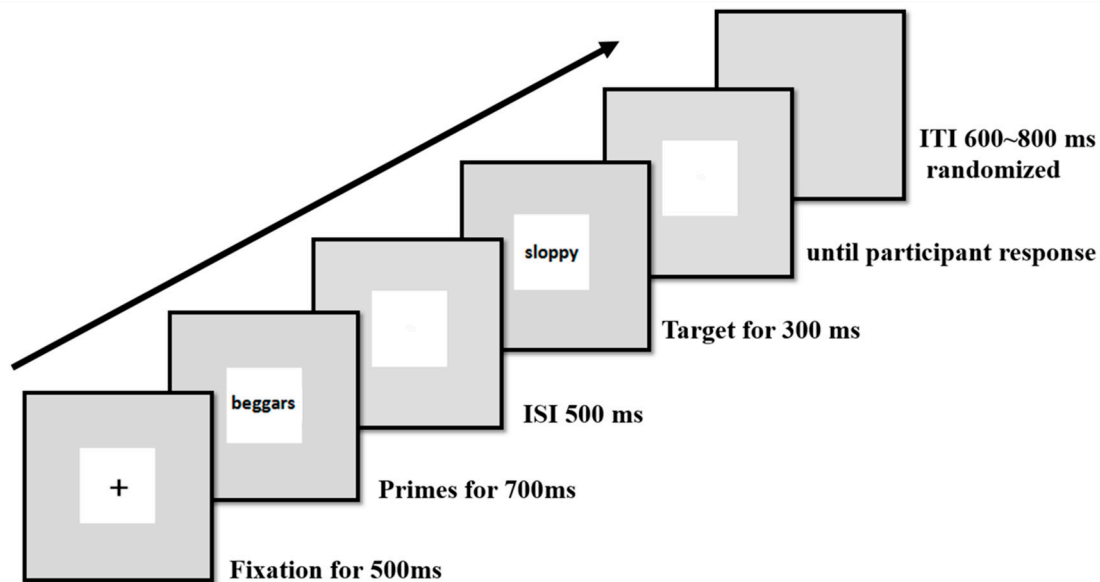


Figure 1. Example of the sequences of one trial. ITI: inter-trial interval; ISI: inter-stimulus interval.

2.1.4. Procedure

Upon arriving at the lab, participants read and signed an informed consent form. Each participant was escorted to a dimly lit, sound attenuated testing room and seated in a comfortable chair approximately 120 cm in front of a computer monitor. Participants were instructed to watch the center of the screen where a series of word pairs would be presented. It was explained that each trial would begin with a fixation point, then they would see a social group label (e.g., bagger), and the second word would sometimes be associated with the preceding social group (i.e., sloppy) and other times not associated with the preceding social group (i.e., pretty). Participants were instructed to verify as quickly and as accurately as possible whether or not the second word matched the priming word according to cultural stereotypes by pressing the “CONGRUENT” button on the response keyboard for matching words and the “INCONGRUENT” button on the response keyboard for non-matching words. The “CONGRUENT” and “INCONGRUENT” labels were pasted on the “Q” and “P” keys of the keyboard before the experiment and were counterbalanced across participants.

As presented in Figure 1, each trial began with the appearance of a fixation point for 500 ms. The fixation point was then replaced with a prime stimulus, which remained on the screen for 700 ms. After an inter-stimulus interval (ISI) of 500 ms (SOA (Stimulus Onset Asynchrony) = 1200 ms), the target stimulus was presented for 300 ms. The screen then went blank and remained blank until the participant responded. The inter-trial interval (ITI) was randomized between 600 and 800 ms.

Participants completed a total of 528 trials, 480 of which constituted the experimental trials (presented in 6 blocks of 80 trials). The first 48 trials were presented as practice trials to familiarize participants with the procedure. Six social groups (policemen, otaku, Tibetan girls, football players, models, and the mentally disabled) were used as practice primes. The 480 experimental trials were presented after these practice trials. Stimuli used in practice trials did not appear in the experimental trials and only data from the experimental trials was analyzed. Participants took a break (about 3 to 4 min in length) after each block of 80 trials.

2.1.5. Data Analyses

Accuracy rates and response times (RTs) were analyzed using two-way repeated measures ANOVAs, with both groups (HW-HC, HW-LC, LW-HC, LW-LC) and congruency (congruent, incongruent) as within-subject factors. For each participant, incorrect responses and response times that deviated ± 2 SD from each condition were removed before formal analysis [90]. Statistical analyses were conducted using SPSS 13.0. When the assumption of sphericity was violated, the Greenhouse–Geisser (G–G) adjustment, with the corrected significant levels and partial eta-squared (η^2) effect-size statistic, are reported. For simplicity, the uncorrected degrees of freedom are presented along with the G–G epsilon (ϵ). Post hoc comparisons were conducted using a Bonferroni correction to control for inflated family-wise error.

2.2. Results

2.2.1. Accuracy

The analysis revealed a significant main effect for group, $F(3, 171) = 93.58, p < 0.001$, partial $\eta^2 = 0.62$, but not for congruency, $F(1, 57) = 1.24, p = 0.270$, partial $\eta^2 = 0.02$. The main effect for group was qualified by a significant interaction with congruency, $F(3, 171) = 7.22, p < 0.001$, partial $\eta^2 = 0.11$. As presented in Figure 2A, simple effect analyses for the HW-HC group showed that accuracy on trials with congruent targets ($M = 0.972, SE = 0.005$) was significantly higher than for trials with incongruent targets ($M = 0.955, SE = 0.006$), $p = 0.002$. The difference in accuracy between congruent and incongruent trials was also significant for the LW-LC group, but in the opposite direction; accuracy on trials with congruent targets ($M = 0.864, SE = 0.012$) was significantly lower than trials with incongruent targets ($M = 0.901, SE = 0.008$), $p = 0.009$. There was no significant difference in accuracy between trials with congruent and incongruent targets for the HW-LC (for congruent targets: $M = 0.922, SE = 0.008$; for incongruent targets: $M = 0.934, SE = 0.007$; $p = 0.154$) or the LW-HC groups (for congruent targets: $M = 0.896, SE = 0.009$; for incongruent targets: $M = 0.900, SE = 0.009$; $p = 0.781$).

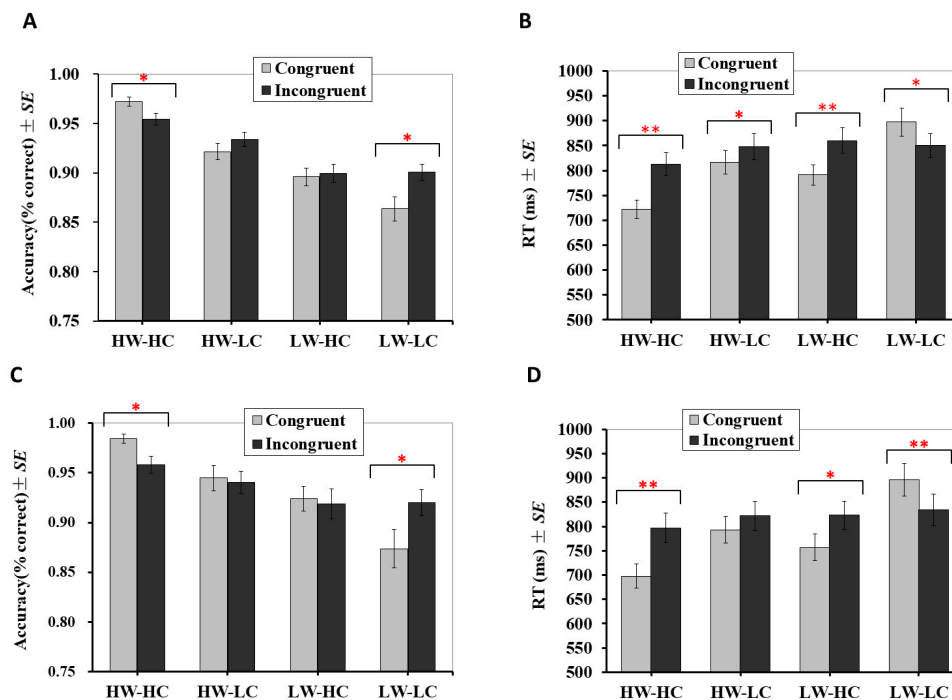


Figure 2. Behavioral results for Study 1 and Study 2. (A) Accuracy in Study 1; (B) mean reaction times in Study 1 ($n = 58$); (C) accuracy in Study 2; (D) mean reaction times in Study 2 ($n = 19$). Error bars indicate ± 1 standard error of the mean. RT: reaction time. SE: standard error. ** $p < 0.01$, * $p < 0.05$.

2.2.2. Response Times

Analysis of RTs revealed significant main effects for both *Group*, $F(3, 171) = 66.67, p < 0.001$, partial $\eta^2 = 0.54$, and congruency, $F(1, 57) = 13.34, p = 0.001$, partial $\eta^2 = 0.19$. The interaction between group and congruency was also significant, $F(3, 171) = 30.41, p < 0.001$, partial $\eta^2 = 0.35$. As presented in Figure 2B, participants responded significantly faster to congruent targets than incongruent targets for the HW-HC (for congruent targets: $M = 722$ ms, $SE = 18$; for incongruent targets: $M = 813$ ms, $SE = 23$; $p < 0.001$), HW-LC (for congruent targets: $M = 817$ ms, $SE = 23$; for incongruent targets: $M = 848$ ms, $SE = 27$; $p = 0.031$), and LW-HC groups (for congruent targets: $M = 791$ ms, $SE = 20$; for incongruent targets: $M = 860$ ms, $SE = 26$; $p < 0.001$). Conversely, participants responded significantly slower to congruent targets ($M = 898$ ms, $SE = 28$) than to incongruent targets for the LW-LC group ($M = 850$ ms, $SE = 24$), $p = 0.003$.

2.3. Discussion

Using a sequential priming paradigm, Study 1 examined the behavioral pattern of stereotype priming on accuracy rates and response times for the four quadrants (HW-HC, HW-LC, LW-LC, and LW-HC) identified under the framework of SCM. The typical stereotype priming pattern was observed (especially in RTs) for the HW-HC, HW-LC and LW-HC social groups. That is, congruent targets elicited significantly faster responses than incongruent targets for these social groups, replicating previous studies [3,6,40,42,47]. More importantly, a reverse stereotype priming pattern for LW-LC groups was revealed in Study 1. That is, congruent targets elicited significantly slower responses than incongruent targets, which indicated the robustness of reverse priming effect for LW-LC social groups.

Overall, the results from Study 1 replicate the typical stereotype priming pattern for HW-HC, HW-LC and LW-HC social groups, but reveal a decidedly reverse stereotype priming pattern for LW-LC social groups. Accuracy rates and response times may not be sensitive enough to adequately probe stereotype priming results, though. Behavioral RTs represent the outcome of a set of cognitive processes, and thus are limited to measuring a single conscious outcome of these processes [91]. For example, response times in sequential priming paradigms may reflect the influence of memory activation and response competition [92]. Distinguishing among these processes in behavioral results can be done using specific analyses and models (e.g., [93–95]), but an alternative approach is to measure stereotype activation more directly with event-related potentials (ERPs). This approach was adopted in Study 2, which used both behavioral and ERP measures to further examine patterns of stereotype activation.

3. Study 2: The Electrophysiological Pattern of Explicit Stereotype Activation for HW-HC, HW-LC, LW-HC and LW-LC Social Groups

The purpose of Study 2 was to explore potential neuropsychological differences in stereotype activation patterns among the four SCM clusters. Both early (P2) and later (N400, LPC) ERP components were examined to determine if stereotype activation patterns differ among four SCM quadrants, both in magnitude of activation and timing. The N400 ERP component was of primary importance, given that previous research has found it to be a reliable measure of stereotype activation [39–42,67,83], and it reflects a post-perceptual processing stage that involves the dynamic reconstruction of information from long-term memory [81]. In this way, Study 2 aimed to demonstrate the utility of the N400 ERP component as a measure of stereotype activation for a wide range of social groups identified under the framework of SCM. In addition to the N400, we also examined early ERP component (P2) at fronto-central regions to capture early perceptual processing stages and the late positive component (LPC), which reflects a later, decision processing stage.

Overall, we expected to replicate the results of Study 1, that is, a typical stereotype priming effect in response times for the HW-HC, HW-LC, and LW-HC groups, and reverse priming effect for the LW-LC groups. For the N400, we expected stereotype incongruent trials to elicit larger N400 amplitudes than stereotype congruent trials for all four SCM group clusters, but that this effect would be especially pronounced for the LW-LC social group cluster. Due to the attention-grabbing nature of

the LW-LC groups, we also expected these social groups to elicit larger P2 amplitudes than the other SCM clusters. No differences were expected for any of the remaining ERP components.

3.1. Methods

3.1.1. Participants

Twenty-two right-handed, Chinese undergraduate students (16 female, $M = 21.9$ years, range 19–25 years) participated in the study in exchange for 30 RMB. All participants reported normal or corrected-to-normal vision, had no history of current or past neurological or psychiatric illness, and took no medications known to affect the central nervous system. All signed an informed consent form approved by the Academic Ethical Committee of Ningbo University. Data from three participants (1 female and 2 male) were excluded due to excessive artifacts, leaving a final sample of 19 participants.

3.1.2. Stimuli and Procedure

The stimuli used in Study 2 were the same as those used in Study 1. The procedures used were also identical, except that participants were prepared for electroencephalogram (EEG) recording before the formal experiment.

3.1.3. EEG Recording

EEG data was recorded continuously using an electrode cap with 64 Ag/AgCl electrodes mounted according to the extended international 10–20 system. Electro-oculogram (EOG) data was recorded via two pairs of electrodes placed on the bilateral external canthi and left supraorbital and infraorbital areas to monitor eye movements and blinks. Both EEG and EOG were sampled at 500 Hz, with a bandpass of 0.05–100 Hz using NeuroScan Synamps2 Amplifier. The left mastoid served as a reference during recording and the right mastoid served as a recording electrode. Electrode impedances were kept below 5 k Ω .

NeuroScan 4.3 software (Compumedics Neuroscan, Charlotte, NC, USA) was used to analyze the data offline. The data was re-referenced offline to the algebraic average of the left and right mastoids. The raw EEG data were manually previewed to remove artifacts after merging with the behavioral data. Then an automatic eye-movement correction program corrected vertical eye movements and blinks [96]. Afterwards, the EEG was segmented in epochs of 1200 ms beginning 200 ms prior to the target stimulus onset and each epoch in all electrodes was then corrected to a 200 ms baseline. Segments contaminated with artifacts exceeding an amplitude of ± 80 μ V were automatically rejected from the averaging (9.7% artifacts were rejected). EEG data from correct trials were averaged separately for each of the eight conditions. After this procedure, averaged ERPs included at least 48 trials for each trial type. Finally, the averaged ERPs were low-pass filtered at 30 Hz (24 dB/Oct ave).

3.1.4. Data Analyses

Behavioral data were analyzed using the same method in Study 1. For ERPs data, mean amplitude of each ERP component (P2, N400, LPC) was subjected to two-way repeated measures ANOVA with both group (HW-HC, HW-LC, LW-HC, LW-LC) and congruency (congruent, incongruent) as within-subject factors. The analyses were conducted on ERP mean amplitudes of clusters of electrodes (regions of interest, ROI). The measurement windows and electrodes to be included in the ROIs were determined by visual inspection of the ERP waveforms and literature-based hypotheses (for exact time-windows and ROIs of each component please see the corresponding section in the results) [97]. All post-hoc tests were Bonferroni corrected for multiple testing. If necessary, the degrees of freedom were corrected using the Greenhouse–Geisser epsilon.

3.2. Results

3.2.1. Behavioral Results

Accuracy. Accuracy results mirrored those from Study 1. That is, the main effect was significant for group, $F(3, 54) = 23.55$, $p < 0.001$, partial $\eta^2 = 0.57$, but not for congruency, $F(1, 18) = 0.06$, $p = 0.809$, partial $\eta^2 = 0.003$. Additionally, the main effect for group was qualified by a significant interaction with congruency, $F(3, 54) = 4.88$, $p = 0.005$, partial $\eta^2 = 0.21$. As presented in Figure 2C, simple effect analyses for the HW-HC quadrant revealed that accuracy on congruent trials ($M = 0.984$, $SE = 0.005$) was significantly higher than incongruent trials ($M = 0.958$, $SE = 0.008$), $p = 0.002$. The difference in accuracy between congruent and incongruent trials was also significant for the LW-LC quadrant, but in the opposite direction; accuracy on congruent trials ($M = 0.874$, $SE = 0.019$) was significantly lower than incongruent trials ($M = 0.920$, $SE = 0.013$), $p = 0.012$. There was no significant difference in accuracy between congruent and incongruent trials for the HW-LC (for congruent targets: $M = 0.945$, $SE = 0.013$; for incongruent targets: $M = 0.940$, $SE = 0.011$; $p = 0.762$) or LW-HC groups (for congruent targets: $M = 0.924$, $SE = 0.012$; for incongruent targets: $M = 0.918$, $SE = 0.015$; $p = 0.819$).

Response times. Similar to Study 1, for HW-HC, LW-LC and LW-HC groups, analysis of RTs revealed significant main effects for both group, $F(3, 54) = 49.44$, $p < 0.001$, partial $\eta^2 = 0.73$, and congruency, $F(1, 18) = 9.45$, $p = 0.007$, partial $\eta^2 = 0.34$. The interaction between group and congruency was also significant, $F(3, 54) = 25.38$, $p < 0.001$, partial $\eta^2 = 0.59$. Simple effect analyses showed that, as presented in Figure 2D, participants responded significantly faster to congruent targets than incongruent targets for the HW-HC (for congruent targets: $M = 698$ ms, $SE = 25$; for incongruent targets: $M = 797$ ms, $SE = 31$; $p < 0.001$) and LW-HC groups (for congruent targets: $M = 757$ ms, $SE = 28$; for incongruent targets: $M = 823$ ms, $SE = 28$; $p < 0.001$). Although participants also responded faster to congruent targets ($M = 793$ ms, $SE = 28$) than incongruent targets ($M = 822$ ms, $SE = 30$) for the HW-LC groups, the difference did not reach a statistically significant level ($p = 0.122$). Conversely, participants responded significantly slower to congruent targets ($M = 896$ ms, $SE = 34$) than to incongruent targets ($M = 834$ ms, $SE = 32$) for the LW-LC group ($p = 0.001$).

3.2.2. ERPs Results

P2. For the P2 component, the ROI included 3 central electrodes (Fz, FCz, Cz) in the 150–250 ms time-window. Amplitudes were averaged across all electrodes within the ROI before submitting them to statistical analysis. Analysis of P2 mean amplitudes revealed significant main effect of group, $F(3, 54) = 10.14$, $p < 0.001$, partial $\eta^2 = 0.36$, but the main effect of congruency was not, $F(1, 18) = 1.47$, $p = 0.241$, partial $\eta^2 = 0.08$. The interaction between group and congruency was significant, $F(3, 54) = 2.78$, $p = 0.050$, partial $\eta^2 = 0.13$. Simple effect analyses revealed that the P2 amplitudes elicited by congruent targets ($M = 2.56$ μV) were significantly more positive than those elicited by incongruent targets ($M = 1.20$ μV ; $p = 0.002$), but only for the LW-LC social groups (see Figure 3).

N400. Similar to the statistical analyses of the P2 component, analyses of the N400 component were conducted on mean ERP amplitudes of the given ROI (FC1, FCz, FC2, C1, Cz, C2, CP1, CPz, CP2) in the 300–500 ms time-window. Analysis of N400 mean amplitudes revealed a significant main effect of group, $F(3, 54) = 9.23$, $p < 0.001$, partial $\eta^2 = 0.34$, as well as a significant main effect of congruency, $F(1, 18) = 164.93$, $p < 0.001$, partial $\eta^2 = 0.90$. Specifically, the N400 amplitude elicited by incongruent targets ($M = -0.69$ μV) was significantly more negative than that elicited by congruent targets ($M = 1.74$ μV). Moreover, the interaction between group and congruency was also significant, $F(3, 54) = 2.79$, $p = 0.049$, partial $\eta^2 = 0.13$.

Simple effect analyses for the group \times congruency interaction confirmed the main effect of congruency. As illustrated in Figure 4, the N400 amplitudes elicited by incongruent targets was significantly more negative than those elicited by congruent targets, for all four quadrants (for HW-HC quadrant: $M_{\text{incongruent}} = -0.06$ μV , $M_{\text{congruent}} = 2.36$ μV , $MD_{\text{incongruent-congruent}} = -2.42$ μV ,

SE = 0.37, $p < 0.001$; for HW-LC quadrant: $M_{\text{incongruent}} = -1.43 \mu\text{V}$, $M_{\text{congruent}} = 0.32 \mu\text{V}$, $MD_{\text{incongruent-congruent}} = -1.75 \mu\text{V}$, SE = 0.37, $p < 0.001$; for LW-HC quadrant: $M_{\text{incongruent}} = 0.20 \mu\text{V}$, $M_{\text{congruent}} = 2.28 \mu\text{V}$; $MD_{\text{incongruent-congruent}} = -2.08 \mu\text{V}$, SE = 0.59, $p = 0.002$; for LW-LC quadrant: $M_{\text{incongruent}} = -1.48 \mu\text{V}$, $M_{\text{congruent}} = 2.02 \mu\text{V}$, $MD_{\text{incongruent-congruent}} = -3.49 \mu\text{V}$, SE = 0.36, $p < 0.001$. However, as presented in the Figure 4, this tendency seems more obvious for the LW-LC quadrant.

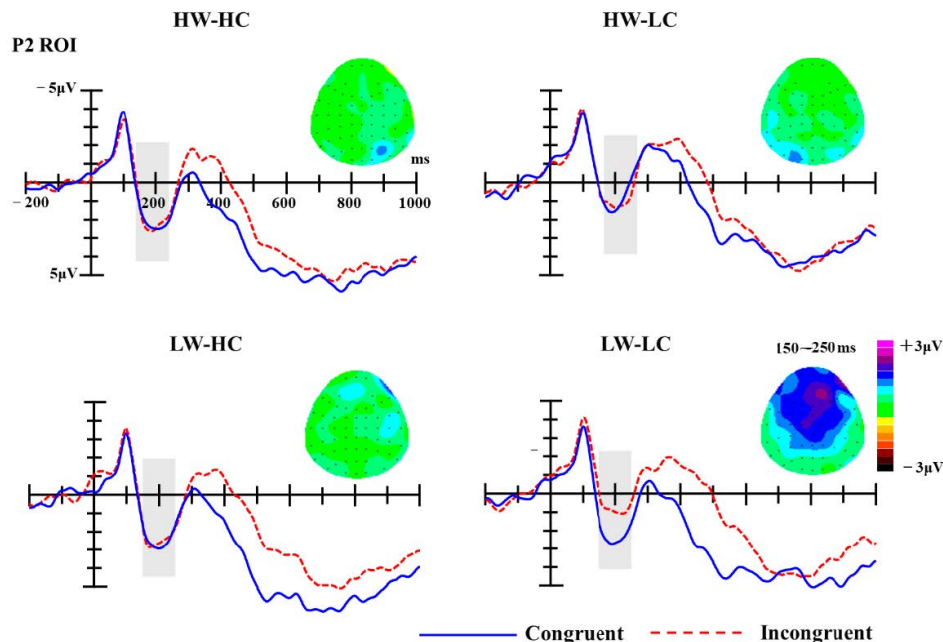


Figure 3. The grand-average event-related brain potentials (ERPs) at selected regions of interest (ROI) electrodes (Fz, FCz, Cz); the shaded areas mark P2 components (150–250 ms). Topographies of P2 difference waves (incongruent minus congruent trials) for four stereotype content module (SCM) quadrants.

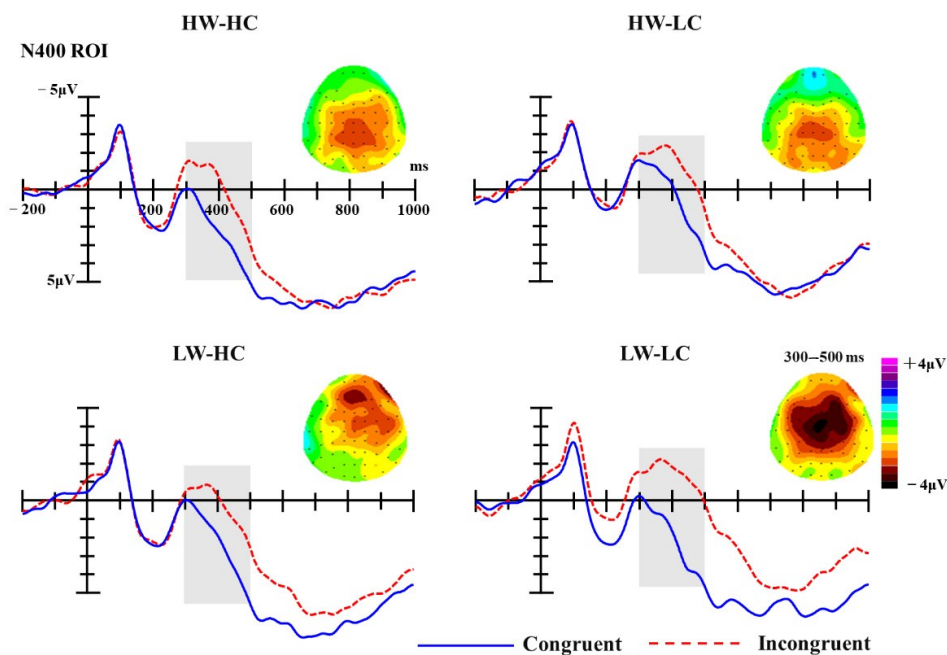


Figure 4. The grand-average ERPs at selected ROI electrodes (FC1, FCz, FC2, C1, Cz, C2, CP1, CPz); the shaded areas mark N400 components (300–500 ms). Topographies of N400 difference waves (incongruent minus congruent trials) for four SCM quadrants.

To further test the discrepancies on N400 component induced by different warmth-competence social groups, difference waves were calculated (subtracted the N400 amplitude elicited by congruent trials from the N400 amplitude elicited by incongruent trials within each social group) and analyzed using a one-way repeated measure ANOVA with group (HW-HC, HW-LC, LW-LC, LW-HC) as a within-subject factor. Results revealed a significant main effect for group, $F(3, 54) = 2.79, p = 0.049$, partial $\eta^2 = 0.13$. Multiple comparisons showed that the N400 difference waves elicited by LW-LC social groups were the largest ($M = -3.49 \mu\text{V}$) and were significantly more negative than those elicited by the HW-LC social groups ($M = -1.75 \mu\text{V}; p = 0.031$). The LW-LC N400 difference waves were also more negative than those elicited by HW-HC social groups ($M = -2.42 \mu\text{V}; p = 0.363$) and LW-HC social groups ($M = -2.08 \mu\text{V}; p = 0.233$), but differences did not reach significance. No other comparisons between social groups approached significance ($ps > 0.775$).

LPC. Similar to the statistical analyses of the P2 and N400 component, analyses of the LPC were conducted on mean ERP amplitudes of the given ROI (F1, Fz, F2, FC1, FCz, FC2, C1, Cz, C2, CP1, CPz, CP2) in the 500–700 ms time-window. The analysis of LPC amplitudes revealed a significant main effect of group [$F(3, 54) = 8.34, p < 0.001$, partial $\eta^2 = 0.32$] and congruency [$F(1, 18) = 19.24, p < 0.001$, partial $\eta^2 = 0.52$]. Moreover, the interaction between group and congruency was significant as well, $F(3, 54) = 2.88, p = 0.044$, partial $\eta^2 = 0.14$.

As presented in Figure 5, simple effect analyses for the interaction showed that LPC amplitudes elicited by congruent targets were significantly more positive than those elicited by incongruent targets for the LW-LC groups ($M_{\text{congruent}} = 5.32 \mu\text{V}$, $M_{\text{incongruent}} = 2.45 \mu\text{V}$, $MD_{\text{congruent-incongruent}} = 2.87 \mu\text{V}$, $SE = 0.59, p < 0.001$) and LW-HC groups ($M_{\text{congruent}} = 6.45 \mu\text{V}$, $M_{\text{incongruent}} = 4.51 \mu\text{V}$, $MD_{\text{congruent-incongruent}} = 2.04 \mu\text{V}$, $SE = 0.65, p = 0.006$). While the LPC amplitudes elicited by congruent targets were also more positive than those elicited by incongruent targets for the HW-HC ($M_{\text{congruent}} = 5.73 \mu\text{V}$, $M_{\text{incongruent}} = 4.92 \mu\text{V}$, $MD_{\text{congruent-incongruent}} = 0.81 \mu\text{V}$, $SE = 0.63, p = 0.216$) and HW-LC ($M_{\text{congruent}} = 4.14 \mu\text{V}$, $M_{\text{incongruent}} = 3.37 \mu\text{V}$, $MD_{\text{congruent-incongruent}} = 0.77 \mu\text{V}$, $SE = 0.69, p = 0.280$) social groups, these differences failed to reach significant.

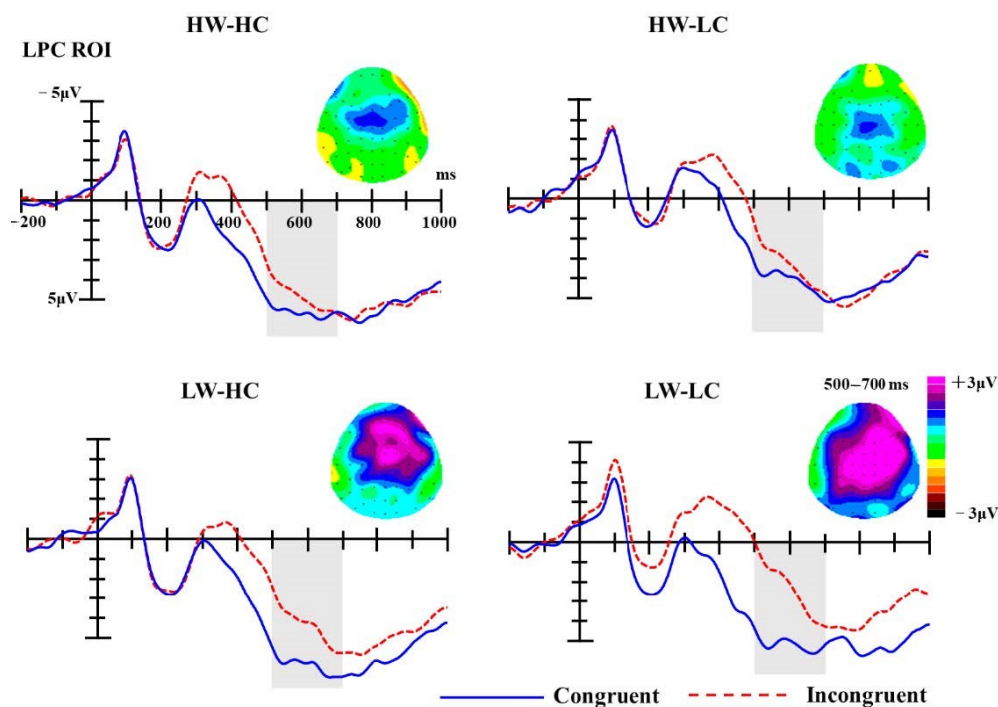


Figure 5. The grand-average ERPs at selected ROI electrodes (F1, Fz, F2, FC1, FCz, FC2, C1, Cz, C2, CP1, CPz, CP2); the shaded areas mark LPC components (500–700 ms). Topographies of late positive component (LPC) difference waves (incongruent minus congruent trials) for four SCM quadrants.

3.3. Discussion

Predictions for Study 2 were largely supported. Participants responded more quickly on stereotype congruent trials than incongruent trials for HW-HC, HW-LC, and LW-HC social groups. Replicating the results from Study 1, an opposite RT pattern was observed for LW-LC groups. Specifically, participants responded more quickly on incongruent than congruent trials for these groups. This highlights that LW-LC groups are perceived and processed differently than social groups from the other three SCM clusters. Results from the ERP data further support this conclusion. Replicating previous research [39–42,67,83], stereotype incongruent trials elicited more negative N400 amplitudes than congruent trials for all SCM quadrants. Extending this research and confirming predictions, the N400 effect was most pronounced for the LW-LC groups. Additionally, larger P2 amplitudes were elicited by stereotype congruent trials than incongruent trials, but only for the LW-LC groups, and LPC amplitudes were larger on congruent trials than incongruent trials, but only for the LW-LC and LW-HC groups.

4. General Discussion

The present research had two primary goals: (1) expand the investigation of stereotype activation/priming to social groups that represent all clusters under the framework of SCM, and (2) use event-related potentials (ERPs) to elucidate the timing and nature of stereotypical processing for these groups. A sequential priming paradigm was used to investigate stereotype activation in response times (Studies 1 and 2) and ERPs (Study 2) for a variety of social groups under the framework of SCM. Across both studies, response times revealed typical stereotype priming effects (faster RTs on stereotype congruent than incongruent trials) for HW-HC, HW-LC, and LW-HC social groups while a reverse priming pattern (slower RTs on congruent than incongruent trials) was observed for LW-LC social groups. ERP results from Study 2 further highlighted the unique processing of LW-LC groups. Amplitudes were larger on stereotype congruent than incongruent trials for P2 components, but only for the LW-LC groups. N400 amplitudes were larger on stereotype incongruent than congruent trials for all four SCM quadrants, while this difference on N400 was largest for LW-LC groups. Finally, LPC amplitudes were larger on stereotype congruent than incongruent trials, but only for the low warmth (LW-LC and LW-HC) groups. These results reveal a great deal about the way various SCM groups are processed, and provide further evidence that LW-LC quadrant are processed differently than other three SCM quadrants.

The unique status of LW-LC groups is evident very early in the stream of cognitive processing. P2 amplitudes elicited by stereotype congruent trials were greater than those elicited by stereotype incongruent trials, but only on trials that used a LW-LC group as the prime. Previous research demonstrates that larger P2 amplitudes are associated with perceptions of threatening and/or negative stimuli [78,98,99]. The heightened P2 amplitudes elicited on congruent trials for LW-LC groups thus indicates that these groups attract greater attention because they are perceived as more negative and/or threatening than other groups.

Additional evidence that LW-LC groups are processed uniquely was observed further down in the cognitive stream, in both N400 and LPC amplitudes. The N400 component is thought to reflect the dynamic activation of associations in long-term memory, in the sense that N400 amplitudes elicited by a given stimulus will be smaller when the associations typically activated by that stimulus are already partially or fully activated by other stimuli or experiences [81]. Applied to the current studies, exposure to a social category (prime stimulus) activates information about this group in long-term memory. When the category is followed by a stereotype congruent target, this pre-activation of information facilitates processing of the target stimulus, resulting in a smaller N400 amplitude than if the target stimulus is stereotypically incongruent with the primed social group. This was the case for all SCM groups in the present research, but the effect was particularly pronounced for the LW-LC groups. More specifically, the amplitudes of N400 difference waves for LW-LC groups are larger than those for the other SCM groups. This suggests that the semantic integration for LW-LC groups is harder than for the other groups. As a whole, these results replicate previous N400 stereotype research [39–41,67,83]

and extend it in two important ways—(1) they demonstrate that the N400 can be used to examine stereotypes for a wide range of social groups under the framework of SCM, and (2) they add to existing evidence for the unique status of LW-LC groups.

While the N400 results were expected, it was somewhat surprising that congruency also modulated LPC amplitudes for LW-LC and LW-HC groups. Specifically, congruent trials elicited larger LPC amplitudes than incongruent trials for low warmth (LW) groups. A potential explanation for these results comes from research that has connected the LPC to avoidance tendencies. In previous research, the LPC has been linked to the regulation of approach-avoidance tendencies, with larger amplitudes accompanying avoidance tendencies than approach tendencies [100]. Heightened LPC amplitudes on congruent trials for LW-LC and LW-HC groups may therefore reflect a general tendency to avoid LW groups. This aligns with previous research where approach-avoidance tendencies have been connected to warmth judgments (e.g., [101]). It also makes sense within the theoretical framework of the SCM. According to the SCM, the warmth dimension is prioritized over the competence dimension (receiving both earlier attention and greater weight) due to the evolutionary importance of discerning good or ill intentions in others [20]. This could explain why congruency modulated the LPC for both LW-LC and LW-HC groups—both groups are perceived primarily in terms of their warmth, and avoidance tendencies are correspondingly activated. The activation of avoidance tendencies might also explain the behavioral results observed in the present research.

The stream of unique processing for LW-LC groups culminate in a very distinct pattern for response times (RTs). Specifically, we observed typical RT priming effects for HW-HC, HW-LC, and LW-HC groups, but an opposite pattern (longer RTs on congruent trials than incongruent trials) for LW-LC groups. This reverse priming effect for LW-LC groups has been replicated in two additional experiments in Yang et al. [87], and reverse priming effects, in general, have been observed in a variety of conditions in past research. For example, reverse priming effects have been reported when a long SOA is used, when each trial contains two primes, when instructions emphasize accuracy over speed, and when primes are extreme (for review, see [102]). Of these conditions, only the condition employing extreme primes applies to the present research. Specifically, the LW-LC groups may be perceived as extreme with regard to their low warmth and low competence, relative to the other groups used as primes. Their extremity would cause these groups to stand out and subtly alert participants to their potentially biasing influence on responses [103]. This may, in turn, activate an unconscious goal to correct for this bias [103] (for review, see [104]), resulting in slowed responses on congruent trials. Considering the difference on P2 found on LW-LC groups, P2 might also be an indicator of unconscious activation of egalitarian goal or unconscious activation of motivation to correct bias [104–107]. However, this possibility needs further empirical support.

Alternatively, the reverse priming effect may reflect an avoidance behavioral tendency toward these groups, particularly since these groups elicit the emotion of disgust [12]. Previous research using disgust facial cues suggests that disgust strongly elicits avoidance tendencies, which ultimately diverts, rather than attracts, attention to stimuli [108,109]. In this line of research, dot-probe judgments were faster on validly cued trials than invalidly cued trials when fearful or angry facial cues were used. However, when disgust facial cues were used, judgments were slower on validly cued trials. In other words, the RT pattern was reversed on disgust facial cue trials [108,109]. Applied to the present research, LW-LC congruent trials might elicit disgust and attendant avoidance tendencies, significantly slowing responses on congruent trials relative to incongruent trials. Because disgust is not the dominant emotion elicited by other SCM groups [12], it would not interfere with responses on congruent trials for these groups. If the activation of disgust and avoidance explains the reversed RT pattern, we would see a significant slow-down on congruent trials for LW-LC groups, but much less or no difference in RTs between LW-LC and other SCM groups for incongruent trials. The difference in RTs between LW-LC and other SCM groups for incongruent trials was non-significant (Study 1) or relatively small (Study 2), meaning that participants responded to incongruent trials fairly similarly for all SCM groups. However, RTs were significantly longer for LW-LC groups for congruent trials in both

studies, meaning that participants responded much more slowly on congruent trials for LW-LC groups than for the other SCM groups.

One final possible explanation for the reverse priming effect involves distrust. According to the SCM and BIAS map, LW-LC groups can easily become a target of distrust [31,110,111], and previous research has found that distrust can facilitate processing of inconsistent information while inhibiting the processing of congruent information (e.g., [112]; for review, see [113]). Additionally, other research has found that distrust primarily affects stereotyping by reducing the application of stereotypes, as opposed to reducing the activation of stereotypes [114]. This could explain why a reverse-priming effect was observed in response times, but the anticipated pattern was observed for LW-LC groups for the N400 component. All these potential explanations, however, are speculative and require direct testing in future studies.

Taken as a whole, the results from the present research suggest that LW-LC groups may attract additional attention early in processing (as evidenced in P2 activity), but ultimately attention is repelled away from them as processing culminates in avoidance behavioral tendencies. Although share some common neural underpinnings (temporoparietal junction and right anterior temporal lobe [31]), results from the present research also highlight some important differences between LW-LC groups and LW-HC groups. LW-LC groups were immediately perceived as more negative or threatening (P2), activated avoidance predispositions (LPC), and ultimately elicited avoidance behavioral responses (RTs). LW-HC groups also appeared to activate avoidance tendencies (LPC), but they did not attract early attention, were not immediately perceived negatively, and did not elicit avoidance behavioral responses. According to the BIAS map [12], LW-LC groups elicit the emotion of disgust and both active and passive forms of harmful behavior (directed toward members of these groups). The BIAS map does not identify any general conditions when these groups would elicit facilitating (helpful/friendly) behavior from others. These groups may therefore be automatically and unconditionally perceived negatively, activating avoidance predispositions that are translated into action. This would explain their differential processing from perception to behavior in the present research.

Because of their mixed stereotype content (low warmth but high competence), LW-HC groups elicit the more ambiguous emotion of envy and either passive facilitation behavior or active harm behaviors. The BIAS map proposes that the type of behavior LW-HC groups elicit (facilitation or harm) depends on the situation and circumstances. In times of stability and success, people will passively facilitate (cooperate) with these groups because their high status makes it advantageous to do so. In times of instability and misfortune, however, people can turn on these groups as scapegoats and may actively try to harm them [12]. LW-HC groups would therefore not be automatically and unconditionally perceived negatively, hence the absence of differential processing of these groups in P2. Due to the primacy of the warmth dimension, it is reasonable to assume that LW-HC groups would elicit avoidance tendency, hence differential processing in the LPC occurred. However, absent any clear signals of instability or misfortune, it would be more advantageous to cooperate with, rather than avoid, these groups in LW-HC quadrant. Thus, these avoidance tendencies were not translated into avoidance behavioral tendencies in the present research. It is possible that an opposite RT pattern would be observed for these groups if signals of instability/misfortune were introduced into the experimental context. This is an interesting question to pursue in future research.

Some limitations and future directions should be mentioned in the current study. First of all, researchers should seek to replicate these results in other populations. Both of the current samples were composed of Chinese undergraduate students. In one sense, this helps improve the overall diversity of samples in psychological research, which tends to skew heavily toward Western cultures. On the other hand, the results may apply specifically to Chinese individuals. We consider this unlikely, though, given that the basic response time and N400 effects observed in the present research replicate past research conducted with Western samples. Even so, replications with other populations and non-student samples would increase confidence in the generalizability of the results. Moreover, the current findings were obtained at the intergroup level. Considered that SCM was also applied

in interpersonal perception [21–23], it would be interesting to explore the reverse priming effect and its mechanism at the inter-individual level. Recently, a framework [115] was proposed to integrate five different but connected models (including SCM [11], dimensional compensation model [116], dual perspective model [117], behavioral regulation model [118] and agency beliefs-communion model [119]). Four types of moderators (type of target, number of targets, perceiver-target relationship and context) were raised to explain contradictions among these models. The present results were obtained only under the framework of SCM, whether these results could be replicated under the newly integrated framework or other four models still remains unknown and the potential moderating role of these four kinds of moderators on reverse priming effect and traditional priming effect would be a fruitful field in the future. Lastly, the perceived warmth and competence for all four SCM quadrants fit SCM map well when checked individually, however, when validating the groups across SCM categories, the competence dimension did not fit perfectly while warmth dimension was balanced among four SCM quadrants in the current study. Specifically, the difference on competence ratings between LW-HC and HW-LC did not reach significant ($p = 0.225$) and HW-LC was perceived more competent than LW-LC ($p = 0.006$), even though they are both labeled as LC quadrants. Moreover, the SCM quadrants identified from pretest were the results of relative placement rather than the ideal absolute placement (see [88] for details). This limitation would be a potential confound and need addressed in future studies.

5. Conclusions

The present research makes several meaningful contributions to the literature. First, as far as we know, this is the one of the first studies to investigate the neural mechanism underlying reverse priming effect. Secondly, it verifies that the N400 ERP component can be used as a measure of stereotype activation for groups within all quadrants of the SCM. Thirdly, it adds to previous research evidence that suggests LW-LC social groups are processed differently than other SCM groups, and extends this research by elucidating the various time points when these groups are uniquely processed. Finally, it highlights the utility of ERPs for differentiating between the various SCM groups with regard to the sequence and timing of their processing. When combined with fMRI data, ERP data can provide a more complete and thorough understanding of the neural processes that give rise to biased/stereotypical processing of, as well as potentially discriminatory behaviors toward, these groups.

The present results demonstrate that the reverse priming effect is robust and exist among various LW-LC social groups. The underlying mechanism might involve early attention attraction (P2), followed by difficulty on semantic integration (N400) and avoidance behavioral tendency (LPC). Future studies are urgently needed to elucidate the moderators of the reverse priming effect and the mechanism underlying it.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. The prime words and target words for four SCM quadrants.

SCM Quadrants	Prime Words in Chinese	Prime Words in English	Stereotype Congruent Target Words in Chinese	Stereotype Congruent Target Words in English	Stereotype Incongruent Target Words in Chinese	Stereotype Incongruent Target Words in English
HW-HC	军人	soldiers	保家卫国 威严 坚毅 正义 正直	protect our homes and defend our country dignified fortitude righteous upstanding	重利益 欺软怕硬 瘦弱 可恶 爱唠叨	regard interests as highly important bully the weak and fear the strong thin and weak hateful nagging
	消防员	firemen	工作危险 行动迅速 灭火救人 令人尊敬 敬业 勇敢	dangerous work act quickly put out the fire and rescue people respectable dedicated brave	喊口号 行动缓慢 不办实事 唯利是图 凶残 无责任心	shout slogans slow movement don't get things done seek nothing but profits merciless without the sense of responsibility
	大学教师	professors	有学问 知识渊博 教书育人	scholarly knowledgeable imparting knowledge and educating people	狡猾 凶残 游手好闲	crafty cruel idle
	心理咨询师	psychotherapists	善于观察 懂人心 有耐心 温和 帮助他人	good at observing empathetic have much patience gentle helping others	没人性 缺少关爱 极端 没有同情心 凶狠	inhuman lack of love and care go to extremes without compassion fierce
	空姐	air hostesses	礼仪好 微笑服务 有气质 漂亮 美丽大方 举止优雅	good manners service with a smile graceful pretty beautiful and gracious elegant manner	威严 残暴 颓废 白发苍苍 心理扭曲 蛮横	dignified brute decadence grey-haired psychological distortion rude and unreasonable
	瑜伽教练	yoga instructors	柔韧性强 体形优美 身材好 健美 健康	great flexibility beautiful shape good figure well-built athletic	精神涣散 大腹便便 没有上进心 邋遢 脏	spiritless big-bellied no desire to advance slovenly dirty

Table A1. Cont.

SCM Quadrants	Prime Words in Chinese	Prime Words in English	Stereotype Congruent Target Words in Chinese	Stereotype Congruent Target Words in English	Stereotype Incongruent Target Words in Chinese	Stereotype Incongruent Target Words in English
HW-LC	老年人	elderly	需要照顾 需要关爱 爱唠叨 白发苍苍 行动缓慢 慈祥	need to be looked after need love and care nagging grey-haired slow movement kindly	体形优美 柔韧性强 身材好 残暴 行动迅速 挥霍	beautiful shape great flexibility good figure brutal act quickly spend extravagantly
	农民	farmers	辛苦 种田 勤劳 憨厚老实 收入低	laborious work farming industrious simple and honest low-income	知识渊博 私生活混乱 奢侈 懒惰 官腔官调	knowledgeable promiscuous spend extravagantly lazy bureaucratic
	家庭主妇	housewives	做饭带孩子 顾家 做家务 贤惠 勤劳	cooking and taking care of children value family keep house virtuous industrious	留学 保家卫国 贪污腐败 傲慢 形式主义	study abroad protect our homes and defend our country corrupt arrogant formalism
	农民工	migrant workers	辛苦 劳累 生活艰辛 弱势群体	laborious work overworked life is tough vulnerable group	有知识 工作清闲 工作稳定 官腔	educated work at leisure stable job official jargon
	留守儿童	left-behind children	渴望陪伴 缺少关爱 孤独 可怜	eager to be accompanied by parents lack of love and care lonely pitiful	见识广 有钱 美丽大方 外语好	well-informed wealthy beautiful and gracious good foreign language
	清洁工	cleaning workers	辛苦 早起 朴实 可敬 勤劳 工资低	laborious work early rising simple worthy of respect industrious low salary	有气质 有学问 收入高 铁饭碗 漂亮 待遇好	graceful scholarly high income has a stable lifelong job pretty well-paid

Table A1. Cont.

SCM Quadrants	Prime Words in Chinese	Prime Words in English	Stereotype Congruent Target Words in Chinese	Stereotype Congruent Target Words in English	Stereotype Incongruent Target Words in Chinese	Stereotype Incongruent Target Words in English
LW-HC	商人	businessmen	重利益 有钱 精明 唯利是图	regard interests as highly important wealthy shrewd seek nothing but profits	渴望陪伴 贫穷 憨厚老实 做家务	eager to accompany poor simple and honest keep house
	海归	overseas returnees	留学 外语好 见识广 有知识	study abroad good foreign language well-informed educated	监狱 萎靡 种田 工资低	prison flattened farming low salary
	公务员	government workers	工作稳定 铁饭碗 工作清闲 待遇好	stable job has a stable lifelong job work at leisure well-paid	绯闻多 需要照顾 堕落 工作危险	need more concern need to be looked after decadent dangerous work
	政府官员	government officials	官腔 形式主义 官腔官调 喊口号 不办实事 贪污腐败 大腹便便	official jargon formalism bureaucratic shout slogans don't get things done corrupt big-bellied	有耐心 敬业 孤独 弱势群体 朴实 做饭带孩子 骨瘦如柴	have much patience dedicated lonely vulnerable group simple cooking and taking care of children skinny
	演艺明星	stars in showbiz	收入高 绯闻多 光鲜亮丽 漂亮 私生活混乱 好看	high income more scandal glamorous pretty promiscuous good-looking	无所事事 啃老 衣衫褴褛 收入低 灭火救人 形容枯槁	slothful depend on parents for living shabbily dressed low-income put out the fire and rescue people haggard
	富人	rich	有钱 奢侈 傲慢 狡猾 挥霍	wealthy extravagant arrogant crafty spend extravagantly	生活艰辛 需要关爱 劳累 可怜 辛苦	life is tough need love and care overworked pitiful laborious work

Table A1. Cont.

SCM Quadrants	Prime Words in Chinese	Prime Words in English	Stereotype Congruent Target Words in Chinese	Stereotype Congruent Target Words in English	Stereotype Incongruent Target Words in Chinese	Stereotype Incongruent Target Words in English
LW-LC	罪犯	criminals	监狱 可恶 凶狠 残暴	prison hateful fierce violent and cruel	慈祥 令人尊敬 正义 教书育人	kindly respectable righteous imparting knowledge and educating people
	无业游民	unemployed	游手好闲 无所事事 无责任心 啃老 没有上进心	idle slothful irresponsible depend on parents for living no desire to advance	辛苦 早起 好看 勤劳 勇敢	laborious work early bird good-looking industrious courageous
	乞丐	beggars	脏 衣衫褴褛 邋遢 懒惰 贫穷	dirty shabbily dressed slovenly lazy poor	健美 光鲜亮丽 有钱 漂亮 勤劳	well-built glamorous wealthy pretty industrious
	吸毒者	drug addicts	颓废 堕落 萎靡 精神涣散 骨瘦如柴 形容枯槁 瘦弱	decadence decadent flattened spiritless skinny haggard thin and weak	健康 辛苦 勤劳 善于观察 坚毅 精明 顾家	fitness laborious work industrious good at observing fortitude shrewd value family
	恐怖分子	terrorists	极端 残暴 凶残 心理扭曲 没人性	go to extremes brutal cruel psychological distortion inhuman	帮助他人 微笑服务 正直 举止优雅 礼仪好	helping others service with a smile upstanding elegant manner good manners
	城管	urban management officers	欺软怕硬 蛮横 凶残 没有同情心	bully the weak and fear the strong rude and unreasonable merciless without compassion	温和 懂人心 贤惠 可敬	gentle empathetic virtuous worthy of respect

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