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Invisible own- and other-race faces presented under continuous flash suppression produce affective response biases

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ABSTRACT

One triumph of the human mind is the ability to place the multitudinous array of people we encounter into in- and out-group members based on racial characteristics. One fundamental question that remains to be answered is whether invisible own- and other-race faces can nevertheless influence subsequent affective judgments. Here, we employed continuous flash suppression (CFS) to render own- and other-race faces unperceivable in an affective priming task. Both on-line and off-line awareness checks were employed to provide more stringent control of partial awareness. Results revealed that relative to own-race faces, imperceptible other-race faces significantly facilitated participants' identification of negative words, suggesting an other-race derogation bias. When faces were presented consciously, we found that not only other-race faces facilitated detection of negative words, but also own-race faces facilitated detection of positive words. These findings together provide novel and strong evidence suggesting that invisible racial faces can bias affective responses.

1. Introduction

People have a natural tendency to categorize others into social groups, even when such groups are formed based on minimal and ostensibly arbitrary information (Tajfel, 1970). Indeed, one triumph of the human mind is an ability to manage multitudinous social information via social categorization (Allport, 1979; Fiske & Neuberg, 1990; Macrae & Bodenhausen, 2000). Categorizing the social world into "us" and "them" provides a basis upon which people form and honor cooperative coalitions with some people while remaining vigilant for potential threats from others (Allport, 1979). In this way, social categorization not only divides the social world into us and them but also attaches presumptions of alliance versus (potential) enmity on these groupings, triggering associated affective responses. These affective responses may serve a basis for intergroup biases such as prejudice, stereotyping, and even discriminatory behavior toward out-group members (Allport, 1979; Banaji & Hardin, 1996; Bodenhausen, Kang, & Peery, 2012; Fiske & Neuberg, 1990; Hilton & Von Hippel, 1996; Macrae &

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Bodenhausen, 2000; Tajfel, 1970). One salient factor that supports social categorization is known as race. Indeed, three-month old infants begin to preferentially look at their own-race faces over other-race faces (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005, 2007). Beyond this race-based perceptual bias, 4- and 5-year old children start to show an evaluative bias to other-race members (Qian et al., 2016), and particularly to low-status other-race members (e.g., Dunham, Chen, & Banaji, 2013; for a review, see Dunham, Baron, & Banaji, 2008).

This evidence from developmental psychology strongly supports the idea that even at a very early developmental stage, infants and pre-school children showed race-based perceptual and evaluative biases. Moreover, this evidence indicates that high-level cognitive processes such as reasoning and language that are supported by developed prefrontal cortices may not be necessary for perceptual/evaluative biases to occur. However, it remains unclear whether awareness of own- and other-race faces is necessary to generate affective response bias. This is also the primary goal of the current study: can invisible own- and other-race faces bias evaluative judgments in an affective priming task.

Voluminous studies have demonstrated that inter-group prejudice and stereotyping can be manifested efficiently and spontaneously. Specifically, a briefly presented social prime such as an other-race face will facilitate judgments of subsequent prejudice- and stereotype-congruent words in a sequential priming task (e.g., Banaji & Hardin, 1996; Couto, Pinheiro, & Wentura, 2012; Dovidio, Evans, & Tyler, 1986; Dovidio, Kawakami, Johnson, Johnson, & Howard, 1997; Fazio, Jackson, Dunton, & Williams, 1995; Gaertner & McLaughlin, 1983; Kawakami, Dovidio, & Dijksterhuis, 2003; Lowery, Hardin, & Sinclair, 2001; Wittenbrink, Judd, & Park, 1997; for reviews, see Greenwald & Banaji, 1995; Greenwald et al., 2002). Although evidence from implicit or indirect tasks clearly suggests the unintentional and efficient nature of such biases, it remains ambiguous whether awareness of the primes is necessary for such biases to occur (Bargh, 1994; Gawronski, Hofmann, & Wilbur, 2006; Moors & De Houwer, 2006; Moors, 2016).

A direct test of whether interracial affective bias depends on consciousness would be to manipulate participants' awareness of the primes. Traditionally, researchers have relied on a masking approach to render stimuli invisible to study unconscious processing. Specifically, briefly presented primes (typically <30 ms) are masked by forward/backward noise patterns so as to manipulate awareness of primes (e.g., 80 ms forward mask +27 ms prime +13 ms backward mask in Couto et al., 2012; 75 ms prime +250 ms backward mask in Dovidio et al., 1997; 17 ms prime +225 ms backward masking in Study 3 of Kawakami et al., 2003; 100 ms forward mask +17 ms prime +200 ms backward mask in Study 4 of Lowery et al., 2001; 15 ms prime +2000 ms backward masking in Wittenbrink et al., 1997). As a manipulation check, participants were probed awareness of the primes following the primary priming tasks using either subjective self-reports or objective two-alterative forced-choice tasks (e.g., Couto et al., 2012). Although this masking approach has been widely used to demonstrate a range of unconscious processing effects, recent empirical data suggest that many previous findings that support the automatic or unconscious emotional processing can actually be attributed to non-automatic processing features such as attentional demand and awareness (Pessoa, 2005; Pessoa, McKenna, Gutierrez, & Ungerleider, 2002; Pessoa, Padmala, & Morland, 2005; Pessoa, Japee, Sturman, & Ungerleider, 2006). Specifically, regarding unconscious processing, Pessoa (2005) argued that previous evidence that seems to support unconscious visual processes mostly relies on imprecise awareness checks (e.g., subjective report or off-line awareness assessments). Moreover, Kouider and Dupoux (2004) showed that even partial awareness of the primes in a subliminal priming task could drive the priming effects. Lastly, it should be noted that in Weisbuch and Ambady (2008) Study 2, when 12 ms backward masked white and black neutral faces were used as primes, these faces did not produce the basic affective priming effects as in Fazio et al. (1995). Therefore, employing a paradigm other than masking to manipulate awareness and adopting both on-line and off-line, performance-based awareness checks will provide novel and stronger evidence regarding whether interracial affective bias can occur without awareness.

Here we employ continuous flash suppression (CFS; Fang & He, 2005; Tsuchiya & Koch, 2005), a relatively new variant of binocular rivalry and flash suppression, to prevent presentations of own- and other-race faces from entering into awareness and to investigate whether these invisible faces can produce affective bias. Unlike the masking approach that relies on short presentation time of primes and forward/backward masking to render primes invisible, CFS relies on dichoptic presentation and can effectively induce a prolonged state of unconscious stimulus presentation (Fang & He, 2005; Tsuchiya & Koch, 2005; Tsuchiya, Koch, Gilroy, & Blake, 2006). Specifically, during CFS, participants are presented with dynamic noise images (e.g., Mondrian) to their dominant eyes whereas primes are presented to their non-dominant eyes. Participants' conscious perceptual experience will be captured by the dynamic noise image, due to its high contrast, rich contours, and dynamic change. One notable difference between masking and CFS is the duration of unconscious presentation they can sustain: masking can render primes invisible for tens of milliseconds, whereas CFS can suppress primes from being perceived for seconds and even up to minutes (Tsuchiya & Koch, 2005; Tsuchiya et al., 2006).

Moreover, there is evidence suggesting that CFS and masking may tap into different neural mechanisms in unconscious processing. Specifically, it has been shown that invisible, masked stimuli still engage the ventral occipital-temporal cortex pathway (Dehaene et al., 2001; Liddell et al., 2005). Note activity along this pathway is tightly linked with fine-grained perceptual analyses, face/object recognition and thus rich awareness (Grill-Spector, 2003). On the other hand, it has been shown that the primes under CFS largely abolish this ventral pathway activity (Fang & He, 2005; Pasley, Mayes, & Schultz, 2004; Troiani & Schultz, 2013; Williams, Morris, McGlone, Abbott, & Mattingley, 2004, for a review, see Sterzer, Stein, Ludwig, Rothkirch, & Hesselmann, 2014). Given these behavioral and neural mechanisms differences associated with masking and CFS, previous studies also reported different priming patterns when masking and CFS were directly compared to study unconscious processing (Almeida, Mahon, Nakayama, & Caramazza, 2008; Almeida, Pajtas, Mahon, Nakayama, & Caramazza, 2013).

Given CFS's advantage in creating sustained period of unconsciousness and its possible different neurocognitive mechanisms than masking, CFS has recently been employed to answer many fundamental questions regarding (un)conscious processing, such as (un)conscious object categorization (Almeida et al., 2008; Fang & He, 2005), (un)conscious semantic/affective processing (Almeida et al., 2013; Anderson, Siegel, White, & Barrett, 2012; Kang, Blake, & Woodman, 2011; Lapate, Rokers, Li, & Davidson, 2014; Sklar et al., 2012; Yang, Zald, & Blake, 2007), and whether simple math operations can be performed unconsciously (Sklar et al., 2012).

Regarding unconscious affective processing, it has been repeatedly shown that when under CFS, invisible emotional faces can bias subsequent affective responses to neutral faces or characters (Almeida et al., 2013; Anderson et al., 2012; Lapate et al., 2014). Specifically, perceptually suppressed fearful faces reliably activated the amygdala (Jiang & He, 2006; Pasley et al., 2004; Troiani, Price, & Schultz, 2014; Troiani & Schultz, 2013; Williams et al., 2004; for a recent review, see Johnson, Senju, & Tomalski, 2015). Interestingly, the amygdala has also been found to be involved in intergroup affective biases (e.g., Cunningham et al., 2004; Wheeler & Fiske, 2005; Hart et al., 2000; Phelps et al., 2000; Van Bavel, Packer, & Cunningham, 2008; for recent reviews, see Amodio, 2014; Kubota, Banaji, & Phelps, 2012), and the differential level of amygdala activity to black and white faces was associated with one's anti-black racial bias measured in implicit association tests (Cunningham et al., 2004; Phelps et al., 2000).

Based on these lines of evidence, we hypothesized that interracial affective bias can indeed occur without conscious awareness. In particular, we examined whether own-/other-race faces under CFS could influence affective judgments differentially in an affective priming task. In addition to this novel awareness manipulation, we employed both on-line and off-line performance-based awareness checks to control for possible influences of partial awareness. Specifically, *during* the priming task, participants were asked to press a button to abort a trial when they saw any face or part of a face (for similar on-line awareness checks, see Tao, Zhang, Li, & Geng, 2012). Moreover, a control group was also tested with supraliminally presented own-/other-race faces as primes to establish affective response biases at a conscious level.

2. Method

2.1. Participants

Seventy Chinese participants were recruited from the campus and received monetary compensation for their participation. Upon random assignment, thirty-three participants (21.3 ± 2.5 years old, 14 females) were assigned to the unconscious affective priming group, and another thirty-three Chinese participants (20.7 ± 2.5 years old, 17 females) were assigned to a conscious affective priming group. Four participants from the unconscious affective priming group were excluded because of equipment or recording errors ($n = 3$) and for not following speed-accuracy instructions ($n = 1$). This study was approved by the Institutional Review Board of Tsinghua University.

2.2. Stimuli

Face stimuli consisted of 16 Chinese (8 males) face pictures (used as own-race faces here), and 16 European White (8 males) face pictures (used as other-race faces here). There was an additional set of 32 scrambled faces that were made using both Chinese and White faces. All face stimuli were black and white and were equalized for global contrast and luminance and were balanced in spatial frequency by a low-pass filter. Chinese and White faces did not differ on perceived attractiveness based on subjective ratings from an independent group of participants ($n = 12$, mean ± S.D., 2.73 ± 0.66 vs. 2.74 ± 0.63, based on a 5-point scale, $t(11) = -0.276$, $p = 0.788$). In addition, we employed an implicit association test (IAT), one of the most widely used indirect tests in implicit social cognition (Greenwald, McGhee, & Schwartz, 1998; Greenwald, Poehlman, Uhlmann, & Banaji, 2009), to assess participants' implicit intergroup bias. For the IAT, a different set of Chinese and White faces was used.

In the affective priming task, ninety-six words (half positive, half negative) were used as target words. In the IATs that followed the affective priming task, another sixteen words (half positive, half negative) were used.

All stimuli were presented on a Samsung 19in SyncMaster 988 MB Plus monitor (1024 ∗ 768, with a refresh rate at 100 Hz). Experimental scripts were written using the Psychophysics Toolbox (Brainard, 1997). To induce CFS, participants wore prism goggles to induce dichoptic presentation. They were seated 76 cm from a CRT monitor.

2.3. Procedure

We first measured each participant's eye dominance using a hole-in-the-card test. A central cross was always presented to each eye, serving as a fixation point. A high-contrast, contour-rich, colorful Mondrian pattern with a changing rate of 10 Hz was presented to the participant's dominant eye, whereas the target face (either a Chinese or a White face) was presented to the non-dominant eye.

Fig. 1 shows a trial structure used in the unconscious affective priming task. A Mondrian figure changing at a rate of 10 Hz was presented to each participant's dominant eye whereas a face was presented to each participant's non-dominant eye. To ensure the suppression time was equal for the faces of each race, the contrast value of the target face was adjusted for each

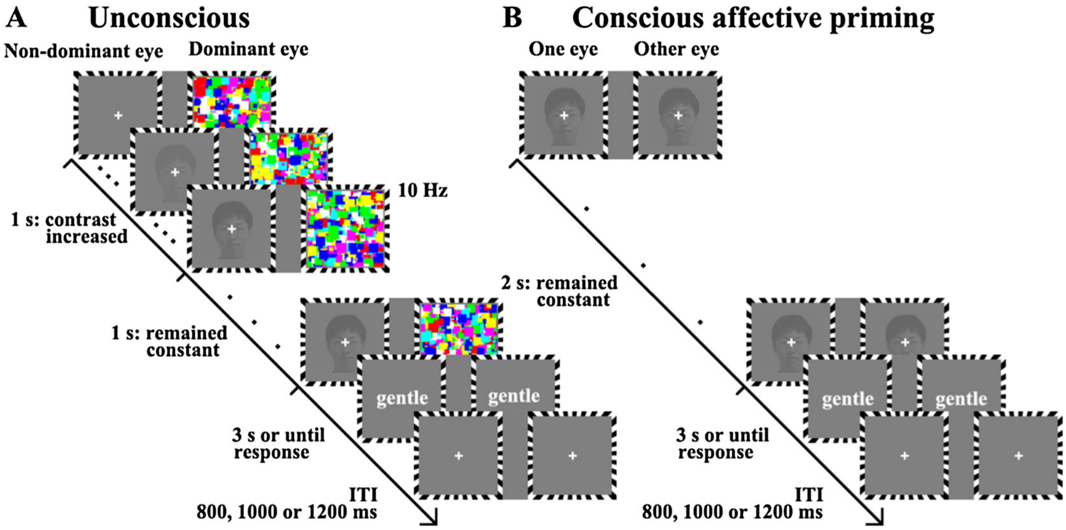

Fig. 1. Trial structures in the affective priming tasks. An exemplar trial from the unconscious affective priming group is presented in A; an exemplar trial from the conscious affective priming group is presented in B.

participant before the main task to ensure that the faces were completely suppressed during the full session (2000 ms; Tao et al., 2012).

Two hundred and eighty-eight trials, divided equally into six blocks, were presented to each participant. There were 48 trials in each block, with 16 trials in each of the three within-subject conditions: own-race Chinese face prime, other-race White face prime and scrambled face prime condition. Specifically, at the beginning of each trial, the contrast of the priming faces was increased gradually from 0 to the pre-determined contrast level within the first 1000 ms. After this first 1000 ms, the contrast of the priming faces remained constant for another 1000 ms, resulting in a total of 2000 ms face presentation time (Tao et al., 2012). A high-contrast, contour-rich, colorful Mondrian pattern with a changing rate of 10 Hz was presented to the participant's dominant eye during this 2000 ms window to render the priming face invisible. Immediately following the faces and the Mondrian images, the target words were presented in the center of the monitor to both eyes. We chose this relatively long stimulus onset asynchrony (SOA) to take advantage of CFS's prolonged suppression time and to increase the chances that the primes were processed unconsciously (a similarly long SOA was also employed in Wittenbrink et al., 1997). Participants were instructed to discriminate the target word as either a positive or a negative word. Speed and accuracy were equally emphasized. Participants were given a 3000 ms time window to give their responses. If a response was registered within 3000 ms, the next trial began at an interval of either 800, 1000 or 1200 ms. If no response was detected within 3000 ms, the next trial began with either 800, 1000 or 1200 ms interval.

In the conscious affective priming group, participants completed the same affective judgment task, except that the prime faces (Chinese, White and Scrambled faces) were presented to both dominant and non-dominant eyes with a constant contrast for 2000 ms. Therefore, participants were fully aware of the primes. The response time window and the ITI were the same as in the unconscious affective priming task. In both the conscious and the unconscious affective priming task, the response keys for positive and negative word judgment were counterbalanced across participants.

Following the priming tasks, participants from both groups completed an evaluative IAT. Stimuli consisted of Chinese/White faces that were not used in the previous priming task, and good/bad words such as *honor*, *success*, *cancer*, *poison*, etc. Here, the IAT consisted of five blocks with 176 trials in total. The ITI was 400 ms. Blocks 1, 2 and 4 (16 trials in each block) were simple categorization blocks in which participants used two buttons to categorize two types of stimuli. The critical blocks were double-categorization blocks 3 and 5 (64 trials in each block) in which participants used two buttons to categorize four types of stimuli. Specifically, in the congruent double-categorization block, participants press a button for either good words or Chinese faces and they press another button for either bad words or White faces. In the incongruent double-categorization block, participants press a button for either good words or White faces and they press another button for either bad words or Chinese faces. The order of double-categorization blocks was randomly decided for each participant (no order effect was observed). Across all blocks, participants were presented with error feedbacks (500 ms) following incorrect responses.

2.4. Unconsciousness manipulation check

We employed both on-line and off-line, performance-based awareness checks to ensure that the priming effects in the unconscious affective priming task were due to unconscious processing rather than partial awareness of the primes. First, before the priming task, participants finished 64 trials of two-alternative forced-choice (2AFC) judgments for the suppressed faces. Participants were asked to decide whether the stimulus was a human face or a scrambled face within 2000 ms when the stimulus was under CFS. Participants' performance was at chance level (49.19%, $p > 0.38$), suggesting that participants were not aware of the faces. Second, during the unconscious affective priming task, participants were instructed that they should press a third button if they ever perceived a face or any part of the face during the task. Trials including partial awareness were excluded from further analyses (~2.0% of the trials were excluded due to this reason).

2.5. Pre-analyses data exclusion

First, error trials were excluded (3.0%, 2.8% respectively for the unconscious and the conscious affective priming group). Moreover, RTs that exceeded 2 S.D. were excluded (5.1%, 4.9% respectively). For the unconscious affective priming group, we also excluded the trials in which participants reported perceiving the face (2.0% of the trials was excluded, see above for lack of consciousness confirmation).

3. Results

3.1. Data preparation

Our primary research question concerns whether imperceptible own- and other-race faces can influence participants' identifications of positive or negative target words following these faces. Based on Wentura and Degner (2010) and Wittenbrink (2007)'s recommendation in analyzing priming data, we calculated affective priming scores as described below. We first subtracted RTs for positive words following own-/other-race faces from RTs for positive words following scrambled faces (e.g., as baseline stimuli), as higher values indicate facilitated detection of positive words for own- and other-race faces compared to scrambled faces. We then subtracted RTs for negative words following own-/other-race faces from RTs for negative words following scrambled faces, as higher values indicate facilitated detection of negative words for own- and other-race faces compared to scrambled faces. Employing scrambled faces as baselines allows us to extract evaluation scores to estimate own-race favoritism or other-race derogation effects (Wentura & Degner, 2010; Wittenbrink, 2007).

3.2. Unconscious affective priming effect

A 2 (primes: own- vs. other-race faces) by 2 (valence facilitation: positive vs. negative words) within-subjects repeated measures ANOVA revealed a significant prime by valence interaction ($F(1,32) = 9.456$, $p = 0.004$, $\eta_p^2 = 0.228$). Decomposing this interaction suggests that invisible own- and other-race faces did not influence the speed of detecting positive words (own- vs. other-race faces, 0.73 vs. −7.79 ms, $F(1,32) = 1.898$, $p = 0.178$, $\eta_p^2 = 0.056$), whereas other-race faces significantly facilitated people's detection of negative words compared to own-race faces (own- vs. other-race faces: −4.34 vs. 18.52 ms, $F(1,32) = 8.686$, $p = 0.006$, $\eta_p^2 = 0.213$), i.e., an other-race derogation bias, see Fig. 2A. No other main effects or interactions were significant (all *F*s < 3, *p*s > 0.14).

3.3. Conscious affective priming effects

An ANOVA using the same factors revealed a significant prime by valence interaction ($F(1,32) = 25.787$, $p < 0.001$, $\eta_p^2 = 0.446$) among participants who could consciously see the face primes. Here, we found that own-race faces significantly facilitated detection of positive words compared to other-race faces (own- vs. other-race faces: 23.12 vs. 1.80 ms, $F(1,32) = 12.894$, $p = 0.001$, $\eta_p^2 = 0.287$). Moreover, similar to the unconscious affective priming effect, the other-race faces significantly facilitated detection of negative words compared to own-race faces (own- vs. other-race faces: 3.17 vs. 18.37 ms, $F(1,32) = 4.677$, $p = 0.038$, $\eta_p^2 = 0.128$). In other words, when participants were aware of the primes, people showed both own-race favoritism and other-race derogation (Fig. 2B). No other main effects or interactions were significant (all *F*s < 1, *p*s > 0.57).

3.4. Consciousness as a modulator of the affective priming effect

We then investigated whether the affective priming effects were modulated by awareness. A 2 (between-subject, consciousness vs. unconsciousness) by 2 (within-subject, own- vs. other-race- face) by 2 (within-subject, valence facilitation, positive vs. negative) mixed ANOVA was conducted. Consistent with prior analyses, we found a significant race by valence interaction ($F(1,64) = 29.582$, $p < 0.001$, $\eta_p^2 = 0.316$): own-race faces significantly facilitated the detection of positive words ($F(1,64) = 6.633$, $p = 0.012$, $\eta_p^2 = 0.094$) whereas other-race faces significantly facilitated the detection of negative words ($F(1,64) = 10.87$, $p = 0.002$, $\eta_p^2 = 0.145$). Moreover, the higher order three-way interaction was far from significant ($F(1,64) = 0.169$, $p = 0.682$), suggesting the being aware or not did not modulate inter-racial affective priming effects. No other main effects or interactions were significant (all *F*s < 2, *p*s > 0.16).

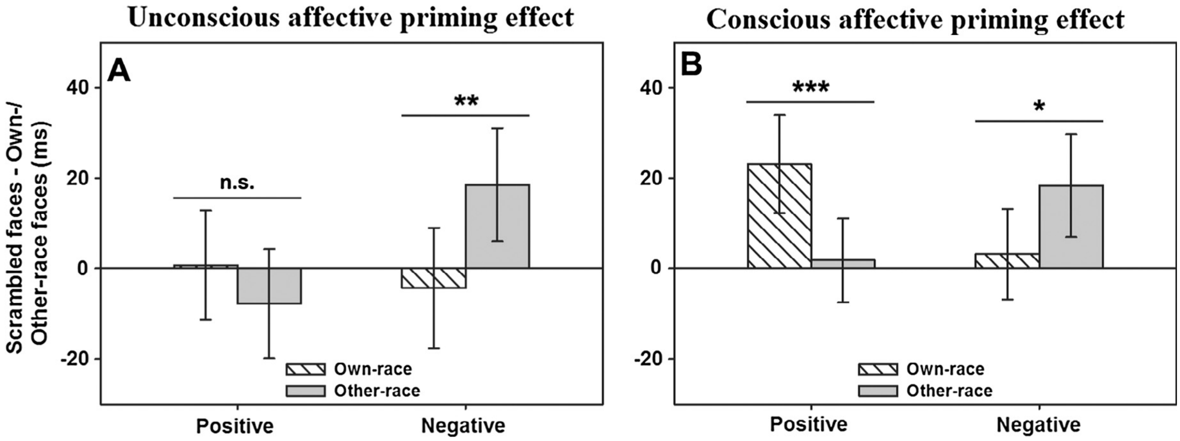

Fig. 2. The affective priming effect (in ms.) for positive vs. negative target words following own- and other-race faces (with RTs to target words following scramble faces as baselines). Results from the unconscious affective priming group were presented in A, results from the conscious affective priming group were presented in B. Error bars show 95% confidence intervals. Significance level: * indicates $p < 0.05$, ** indicate $p < 0.01$, *** indicate $p < 0.001$.

3.5. Implicit interracial bias from the IAT

We used D-scores as the dependent measure for the IAT. The D-scores were calculated based on the algorithm proposed in Lane, Banaji, Nosek, and Greenwald (2007, p.92). Results showed that participants had a stronger bias to associate pleasant words with own-race faces than with other-race faces. Specifically, in both unconscious and conscious affective priming group, participants' D-scores were significantly above zero (one-sample t-test, mean ± S.D., unconscious group, 0.29 ± 0.30, $t(32) = 5.483$, $p < 0.001$; conscious group, 0.34 ± 0.37, $t(32) = 5.223$, $p < 0.001$). We then conducted a correlation analysis between participants' D-scores and their affective priming scores. Here, each participant's affective priming effect was calculated as the positivity facilitation score minus the negativity facilitation score for own-race faces and other-race faces separately. Then the other-race evaluative bias scores were subtracted from the own-race evaluative bias scores to form a single value, a higher value would indicate a higher positive evaluation toward own-race relative to other-race faces. Results showed that there was a marginally significant (though negative) correlation between participants' D-scores and their performance from the conscious affective priming task ($r(33) = -0.336$, $p = 0.056$). In the unconscious affective priming group, this correlation was far from significant ($r(33) = -0.046$, $p = 0.801$).

4. Discussion

The present study provides novel and strong evidence that inter-racial affective biases can occur without consciousness. Critically, imperceptible other-race faces that were under interocular suppression biased later affective judgments, as evidenced by facilitated detection of negative target words following other-race faces, i.e., an other-race derogation effect. On the other hand, when participants were fully aware of the primes, we observed both own-race favoritism and other-race derogation effects.

Most previous research employs masking to render primes near or below perceptual threshold, and this research shows that the affective priming effects induced by racial faces are automatic, i.e., they are spontaneous, efficient, not dependent on awareness (e.g., Dovidio et al., 1986, 1997; Fazio et al., 1995; Gaertner & McLaughlin, 1983; Greenwald et al., 2002; Lowery et al., 2001; Wittenbrink et al., 1997). Despite this masking approach's success in demonstrating automatic interracial affective processing, recent research calls for more stringent control of awareness. Specifically, even for a brief prime presentation time (e.g., 17 ms), there existed large individual differences in the ability to detect so-called "subliminal" faces (Pessoa, Japee, & Ungerleider, 2005). Moreover, partial awareness of the primes could also contribute to the priming effects (Kouider & Dupoux, 2004). These methodological concerns necessitate awareness manipulation other than masking. Moreover, an on-line awareness check would be preferred so as to provide more stringent control for possible influence of partial awareness.

This is precisely what the current study achieved. First, we employed a relatively new variant of binocular rivalry and flash suppression known as continuous flash suppression (CFS). Compared with traditional masking approach that usually renders primes invisible up to tens of milliseconds, CFS can induce a sustained period of unconsciousness that lasts for seconds and even minutes (Tsuchiya & Koch, 2005; Tsuchiya et al., 2006). Moreover, at the neural level, research suggests that masking and CFS engage different neural mechanisms: whereas primes under masking still activate the ventral occipital-temporal pathways that allow for fine-tuned analyses and object recognition, primes under CFS largely abolish this ventral pathway or the inferior temporal cortex (Fang & He, 2005; Pasley et al., 2004; Troiani & Schultz, 2013; Williams et al., 2004, for a review, see Sterzer et al., 2014).

In addition to employing a different procedure to manipulate awareness, we adopted both on-line and off-line performance-based awareness checks. Specifically, our on-line awareness check required participants to abort trials in which they saw any part of a face during the task. This on-line awareness check can effectively reduce the concern that partial awareness of the faces may influence the priming effects. Thus, if evidence from this CFS task that incorporates on-line awareness checks still converges with data using masking, then we will have stronger confidence that people can indeed extract affective tones from inter-racial faces even without awareness.

Our study also extended previous research on own- and other-race face processing under CFS. For instance, Stein, End, and Sterzer (2014) employed CFS and measured the amount of time that own- and other-race faces take to break perceptual noise and enter awareness. Their results suggest that own-race faces were more readily to be perceived than other-race faces, probably because of people's expertise in processing own-race faces. The present study extended this research from perceptual judgments to affective judgments, and suggested that under CFS people could extract affective tones from imperceptible other-race faces as evidenced by an other-race derogation effect. Our result is also consistent with a larger background literature suggesting that negative valence may be processed more efficiently under unconscious condition. Specifically, Nasrallah, Carmel, and Lavie (2009) found that people could extract negative, but not positive valence, of subliminally presented emotional words. Similarly, when rendered invisible under CFS, only angry faces but not happy faces biased subsequent judgments of neutral, unfamiliar targets (Almeida et al., 2013). Notably, when awareness was manipulated with backward masking, both angry and happy faces influenced subsequent affective judgments. This again highlights the possibility that different neurocognitive mechanisms underlying CFS and backward masking may drive different affective processes (see also Almeida et al., 2008).

The present study also complements recent CFS research that investigates unconscious affect misattribution in person judgment and first impression (e.g., Anderson et al., 2012; Lapate et al., 2014). For instance, Anderson et al. (2012) showed that unseen affective faces (e.g., smiling, scowling faces) symmetrically biased judgments of subsequent neutral faces. More recently, it has been shown that one's autonomic physiological activity (e.g., skin conductance responses) induced by unseen fearful faces can predict later negative impression to a neutral face (Lapate et al., 2014). Thus, evidence from different lines of research (affect misattribution, affect priming, emotional faces, own- and other-race faces) converges that people can process affective information in the absence of awareness, and such processing biases subsequent affective judgments.

Previous research has provided a candidate neural pathway that may explain this unconscious face processing and affective priming effect (for recent reviews, see Johnson et al., 2015; Sterzer et al., 2014). As mentioned before, it has been shown that the activity of the ventral temporal pathway, which carries high spatial-resolution visual information and is tightly linked with object awareness, is largely abolished under CFS (e.g., Fang & He, 2005; Pasley et al., 2004; Troiani & Schultz, 2013; Williams et al., 2004). On the other hand, invisible emotional faces that are under interocular suppression can still modulate amygdala activity (Jiang & He, 2006; Pasley et al., 2004; Troiani & Schultz, 2013; Troiani et al., 2014; Williams et al., 2004). Therefore, it has been proposed that biologically significant stimuli such as (emotional) faces would modulate amygdala responses via a subcortical pathway that involves the superior colliculus (SC), pulvinar, and amygdala (Almeida et al., 2013; Anderson et al., 2012; LeDoux, 2003; Pasley et al., 2004; Troiani & Schultz, 2013; Williams et al., 2004; for a recent review, see Johnson et al., 2015).

Although this subcortical pathway hypothesis gains empirical support, other evidence casts doubts into this assumption. Specifically, even invisible faces under CFS dramatically reduced activity along the ventral pathway such as the fusiform face areas, there were still measurable brain activity (e.g., Jiang & He, 2006; Troiani et al., 2014), especially when multivoxel pattern analysis was employed (Sterzer, Haynes, & Rees, 2008). Furthermore, in an intracranial event-related potentials study, the amygdala responded to perceptually suppressed emotional faces around 140 ms (Willenbockel, Lepore, Nguyen, Bouthillier, & Gosselin, 2012). This response latency seems too slow if invisible faces were processed purely along the subcortical pathway (e.g., Pessoa & Adolphs, 2010, see also de Gelder, van Honk, & Tamietto, 2011 for this subcortical vs. multiple wave pathway theoretical debate).

The present behavioral study cannot shed direct light into the exact neural pathway underlying unconscious face processing. However, the unconscious other-race derogation effects suggest that the amygdala probably plays a central role here, considering that other-race faces are perceived as potentially threatening (e.g., Trawalter, Todd, Baird, & Richeson, 2008). Previous research in racial prejudice has linked implicit prejudice with the activity of the amygdala when perceiving other-race faces (e.g., Cunningham et al., 2004; Phelps et al., 2000; for reviews, see Amodio, 2014; Kubota et al., 2012). And it has been repeatedly shown that the amygdala is involved in unconscious (fearful) face processing (e.g., Jiang & He, 2006; Pasley et al., 2004; Troiani & Schultz, 2013; Troiani et al., 2014; Williams et al., 2004). Future research is warranted to directly investigate the neurocognitive processes associated with invisible racial faces processing and the elicited affective responses.

The IAT provided us with a measure of automatic intergroup biases (Greenwald et al., 1998). Replicating prior findings, we found that our Chinese participants hold implicit racial biases against white people (see also Luo et al., 2015; Wang et al., 2014). However, participants' implicit racial biases were not associated with the affective priming effects when primes were presented below consciousness. It is logical to infer that in the unconscious affective priming group, if participants cannot perceive the primes, there is neither motivation nor opportunity for them to control their performance. Unexpectedly, in the conscious group, we observed a marginally significant, negative correlation: larger affective priming effects were associated with smaller IAT effects. One possibility is that in the conscious priming group, our prolonged SOA (2000 ms) may allow participants to strategically control their performance (see also Degner, 2009), thus generating this unexpected negative correlation. Regardless of the possible reasons, this marginally significant negative correlation should be treated cautiously.

It should also be noted that our observed affect priming effects might be modulated by task instructions: here participants categorized whether target words were positive or negative. The extraction of affective tones from imperceptible primes may have been facilitated by such explicit evaluative judgments. Indeed, a recent meta-analysis on evaluative priming tests suggests that priming effects are significantly larger when participants' tasks involve affective judgments than when participants' tasks do not involve such judgments (Herring et al., 2013). Thus, it remains to be an open question that whether this unconscious affective priming effect can still be observed in other priming tasks such as in the lexical judgment tasks (e.g., Wittenbrink, Judd, & Park, 2001; Wittenbrink et al., 1997).

Although the present data provided novel and strong support for unconscious affective priming induced by own- and other-race faces, a further question that would be worthwhile investigating is how group membership and facial expression will modulate this affective priming effect. For instance, Weisbuch and Ambady (2008) reported that affective priming effects induced by emotional facial expressions depended on participants' group membership: while happy own-race faces facilitated positivity judgments, happy other-race faces facilitated negativity judgments, i.e., an affective divergence effect. Given that social categorization can influence many down-stream cognitive and affective processes (Macrae & Bodenhausen, 2000), one interesting future direction will be to manipulate participants' group membership and the prime faces' emotional expressions to investigate how social categorization and emotion interactively influence unconscious affective priming effects.

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