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One of us? how facial and symbolic cues to own- versus other-race membership influence access to perceptual awareness

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ABSTRACT

Information that conveys racial group membership plays a powerful role in influencing people's information processing including perceptual, memory and evaluative judgments. Yet whether own- and other-race information can differentially impact people's perceptual awareness at a preconscious level remains unclear. Employing a breaking continuous flash suppression (b-CFS) paradigm, we investigated whether compared with other-race stimuli, participants' own-race stimuli would be prioritized to gain privileged access to perceptual awareness. Across five experiments (N = 136), we firstly found that participants' own-race faces enjoyed privileged access to perceptual awareness (Experiment 1). In Experiments 2–5, we employed an associative training task to establish associations between otherwise arbitrary visual stimuli and own- vs. other-race) during the training, own- and other-race representing stimuli did not differ in their potency in entering perceptual awareness. This dissociation was further corroborated by Bayesian analyses and an internal meta-analysis. Taken together, our findings suggest that people's perceptual expertise with their own-race members' faces plays a determining role in shaping perceptual awareness. In contrast, newly learned race-representing stimuli did not influence early perceptual selection processes as indicated by the time they take to emerge into perceptual awareness.

1. Introduction

When people navigate the complex social world, a classic dilemma is how to resolve tensions between limited processing capacity and abundant social information. Thus, at any moment, an adaptive system would only extract a fraction of available information to receive prioritized processing. Understanding the mechanisms underlying such selective, prioritized processing is necessary to understand how the human mind works. Here, we aim to test the impact of an important social cue, namely racial group membership, on people's perceptual awareness. Research has provided strong evidence that racial group membership systematically influences our perceptual preferences, memory performance and evaluative judgments. For example, infants as early as three-month old preferentially look at faces of their own racial group (Kelly et al., 2005). Notably, daily exposure or familiarity with otherrace faces shaped such perceptual preferences: when infants grew up in frequent proximity to other-race members, this own-race perceptual preference disappeared. This finding suggests that familiarity and/or perceptual experience with own- and other-race faces plays a determining role in perceptual preferences even at an early developmental stage (Bar-Haim, Ziv, Lamy, & Hodes, 2006). Beyond perceptual

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preference, racial group membership also powerfully influences people's memory about others' faces: people generally show better face memories for their own-race or in-group members than for the otherrace or out-group members (for a review and its moderating factors, see Young, Hugenberg, Bernstein, & Sacco, 2012). Furthermore, people's attitudes and evaluations toward others are strongly biased by race: even 3-year and 6-year old preschool children already show in-group favoritism toward their own-race group members (e.g., Baron & Banaji, 2006). Among adults, considerable evidence also suggests that racial biases and attitudes can be manifested rapidly and spontaneously (Devine, 1989; Dovidio, Kawakami, Johnson, Johnson, & Howard, 1997: Fazio, Jackson, Dunton, & Williams, 1995: Kawakami, Dovidio, & Dijksterhuis, 2003; Todd, Simpson, Thiem, & Neel, 2016; Wittenbrink, Judd, & Park, 1997). Recently, using continuous flash suppression (CFS) to prevent faces from being perceived, we have demonstrated that even impercetible own- and other-race faces under interocular suppression could bias people's automatic evaluative judgments (Yuan, Hu, Lu, Bodenhausen, & Fu, 2017).

Despite this established evidence supporting the own-race advantage across various domains, we still lack answers for critical questions regarding how race-relevance shape our early perceptual awareness. Specifically, whether own-race information is prioritized to enter our perceptual awareness over other-race information, and if so, what is the driving mechanism? Particularly, when own- and other-race stimuli are suppressed from being visible and they need to compete with perceptual noise to gain access to perceptual awareness, would own-race stimuli be prioritized in this preconscious battle? A particularly suitable paradigm to answer this question is the breaking Continuous Flash Suppression (b-CFS) task, which allows researchers to measure the amount of time for visual stimuli to break perceptual suppression and emerge into consciousness (Jiang, Costello, & He, 2007; Stein, Hebart, & Sterzer, 2011; Yang, Zald, & Blake, 2007). In a typical CFS task, a high-contrast, contour-rich and fast-changing Mondrian pattern is projected into one's dominant eve, whereas the lowcontrast, static target stimuli (e.g., faces, words, figures) are projected to the other non-dominant eye (Fang & He, 2005; Tsuchiya & Koch, 2005). Such dichoptic presentation allows the Mondrian pattern to dominate people's subjective perceptual awareness and to suppress the target stimuli from being perceived. In the b-CFS task, however, the targets will gradually overcome interocular suppression and eventually gain access to perceptual awareness. By measuring the amount of time required for the stimuli to break suppression and become consciously reportable, i.e., breaking time, the b-CFS procedure is particularly suitable to assess certain stimuli's perceptual salience and detection threshold (Stein & Sterzer, 2014).

Here, we employed the b-CFS to assess whether and how own- vs. other-race stimuli are prioritized in gaining access to perceptual awareness. In the first experiment, we tested perhaps the most prototypical stimuli that guide racial group categorization: human faces. Previous research has investigated the factors that may influence people's perceptual awareness of face, such as upright vs. inverted orientation (Jiang et al., 2007; Zhou, Zhang, Liu, Yang, & Qu, 2010; Stein et al., 2011), different facial expressions (Yang et al., 2007; Stein and Sterzer, 2012; Stein, Seymour, Hebart, & Sterzer, 2014), and faces that convey social evaluative information (Stewart et al., 2012; Abir, Sklar, Dotsch, Todorov, & Hassin, 2017). Surprisingly, so far very few studies examined how social group membership may modulate people's perceptual awareness of faces. One exception is Stein, End, and Sterzer (2014) in which they examined the face-inversion effect in contexts of race and age. Specifically, the face-inversion effect was more evident for participants' own-race and own-age faces as measured by the breaking time from b-CFS, which was explained by people's intensive perceptual experiences with their own-race/age faces that render such faces more potent to emerge from interocular suppression (Stein, Seymour, Hebart, & Sterzer, 2014; Stein, End, & Sterzer, 2014).

reflect distinctive neural and psychological processes (Koch & Tsuchiya, 2007), heightened attention to other-race faces may nevertheless boost their potency to emerge from interocular suppression. Second, regarding the underlying mechanisms, although perceptual expertise or familiarity may well explain the own-race awareness advantage (Jiang et al., 2007; Stein, Reeder, & Peelen, 2016; Stein et al., 2016), it remains unclear to which extent top-down factors such as race-relevance, social categorization and/or social evaluative processes contribute to own-race faces' prioritized perceptual awareness. Specifically, categorizing others into own- and other-racial group members can automatically activate knowledge scripts (e.g., social stereotypes) and affective responses (e.g., in-group favoritism and out-group derogation) associated with racial groups (for reviews, see Macrae & Bodenhausen, 2000; Kawakami, Amodio, & Hugenberg, 2017). Most importantly, such social categorization can occur rapidly, i.e., within hundreds of milliseconds (Dickter and Bartholow, 2007; Ito & Urland, 2003); and the affective responses can occur even when the faces were subliminally presented or imperceptible under interocular suppression (Dovidio et al., 1997; Fazio et al., 1995; Yuan et al., 2017). Relatedly, b-CFS studies have shown that face evaluations (e.g., dominance, trustworthiness) can reliably modulate faces' potency in entering perceptual awareness (Abir et al., 2017; Stewart et al., 2012). Thus, it is possible that top-down factors such as automatic social categorization/evalua-

advantage effect and the possible explanation of perceptual expertise,

both the phenomenon and the underlying mechanism require further

investigation. First, previous studies examining face processing in an

interracial context have repeatedly found that compared with own-race

faces, the other-race faces can more likely to capture early attention as reflected by both electrophysiological and behavioral data (Dickter and

Bartholow, 2007; Ito & Urland, 2003; Trawalter, Todd, Baird, &

At a broader level, addressing this question can possibly make a meaningful contribution to a hotly debated question: to what extent can top-down social/cognitive factors influence low-level, early perceptual selection processes that determine our conscious awareness (Firestone & Scholl, 2016)? In particular, although top-down social/cognitive factors such as expectations/stereotypes/attitudes can interact with bottom-up face perception to influence people's social judgments (Freeman & Ambady, 2011; Freeman & Johnson, 2016), whether top-down factors such as race-relevance can influence our very early perceptual experience, e.g., how quickly we become aware of own-race stimuli, remains unknown.

tive processes can contribute to low-level perceptual experiences (Xiao,

Coppin, & Van Bavel, 2016).

Here, we aimed to investigate whether own vs. other-race stimuli would modulate the early perceptual selection processes that determine our conscious awareness, and to scrutinize the underlying mechanisms. Specifically, following Experiment 1 that used different racial faces as stimuli, Experiments 2-5 investigated whether visual stimuli that were newly associated with racial group memberships would modulate early perceptual selection processes. We employed a race version of associative training task adapted from Sui, He, and Humphreys (2012) to establish novel associations between otherwise arbitrary visual stimuli (e.g., polygon, gabor gratings) and own-/other-race labels. Employing similar associative training tasks, it has been repeatedly shown that otherwise arbitrary visual stimuli are prioritized during matching judgments even when these stimuli are newly associated with participants' in-groups or themselves (Enock, Sui, Hewstone, & Humphreys, 2018; Stein et al., 2016; Sui et al., 2012; Moradi, Sui, Hewstone & Humphreys, 2015, 2017). Beyond matching judgments, people also quickly imbue positive evaluations to visual stimuli that become newly associated with themselves (e.g., Gawronski, Bodenhausen, & Becker, 2007). These findings suggest that otherwise arbitrary visual stimuli can rapidly gain perceptual and evaluative salience even when they are newly associated with self or in-groups. Thus, it is plausible that even with visual stimuli that are newly associated with racial group

Despite this initial finding supporting the own-race awareness

membership, these own- and other-race representing stimuli will differ in their potency to enter perceptual awareness in a subsequent b-CFS task. Importantly, because these visual stimuli were counterbalanced and were equally exposed to participants in the associative training, we can effectively control familiarity/perceptual experience and rule out unexpected influence from stimuli-level factors (e.g., contour, spatial frequency, or other idiosyncratic features, see Stein and Sterzer, 2012; Stein et al., 2014). Most importantly, such a manipulation would allow us to disambiguate the mechanisms underlying own-race awareness advantage: if the own-race awareness advantage effect is specifically due to observers' perceptual expertise with their own-race members' faces but not other stimulus categories, then such newly learned stimuli should not modulate breaking time. However, if own-race awareness advantage effect is determined by top-down social cognitive processes (e.g., acquired social salience and own-race relevance), then newly learned race-representing stimuli should gain salience and function similarly to human faces in modulating the breaking time. For an overview of the five experiments and experimental characteristics, see Table 1. Data for all studies are publicly available at https://osf.io/ dcjm3/.

2. Experiment 1

2.1. Method and material

2.1.1. Participants:

Forty-eight participants (24 females, all Chinese) were recruited and received monetary compensation for their time. We randomly assigned 24 participants (12 females, 22.5 \pm 2.2 years) to the breaking-CFS (b-CFS) group, and the remaining 24 participants (12 females, 22.7 \pm 3.5 years) to a monocular control group that mimicked perceptual experience as in the b-CFS group, but no interocular suppression was involved (see Gavet, Paffen, Belopolsky, Theeuwes, & Van der Stigchel, 2016; Jiang et al., 2007; Stein et al., 2011). We chose this sample size to be consistent with previous studies on a highly similar topic (Stein et al., 2014), and such a sample size is consistent with most prior b-CFS studies. All participants were right-handed, had normal or corrected-to-normal vision. Before the experiment began, we measured their eye dominance and stereotypic vision (details in measuring eye dominance can be found in Supplementary Materials). The experiment was approved by the ethics committee at the Department of Psychology, Tsinghua University.

2.1.2. Stimuli and procedure

All stimuli were presented on a Samsung 19-inch SyncMaster 988 MB Plus monitor (1024*768, with a refresh rate at 60 Hz). Experimental scripts were written using the Psychophysics Toolbox (Brainard, 1997). Participants wore prism goggles to induce dichoptic presentation. Viewing distance was set to be 58 cm.

Face stimuli were sixteen Chinese faces (i.e., own-race) and sixteen European White (i.e., other-race) faces. Across both racial groups, half of the faces were male and half of the faces were female. All faces were made black and white and were equalized for global contrast and luminance and were balanced in spatial frequency by a low-pass filter (see Yuan et al., 2017). All stimuli were presented against the gray background of the monitor. Each of these 32 faces was presented 10 times, resulting in a total of 320 trials. These 320 trials were equally divided into eight blocks.

In the b-CFS group, via dichoptic presentation, a high-contrast, contour-rich, colorful Mondrian pattern with a refreshing rate of 10 Hz was presented to the participant's dominant eye, whereas a face was presented to the participant' non-dominant eye (see Fig. 1). At the beginning of each trial, contrast of the faces was increased gradually from 0 to 100% within the first 1000 ms, and then remained at the 100% contrast until participants made a button response or for 10 s if no response was registered. On each trial, participants were required to make a left vs. right location judgment depending on which side of the monitor they perceived a face coming out of the perceptual noises. Accuracy and speed were equally emphasized. A response window was set to 10 s. If no response was registered within this 10 s time window, the next trial would begin.

The control group aimed to mimic perceptual experience of the b-CFS group and to control for the influence of non-CFS factors (e.g., ownvs. other racial faces' structural differences) on participants' performance. Here the same faces were embedded within the Mondrian pattern and were presented to both of the participant's eyes. Thus, no interocular suppression was involved. Contrast of the faces increased gradually from 0% to 100% within 5 s. Participants completed the same location judgment task as in the b-CFS group.

2.2. Results and discussions

Participants were highly accurate in the location judgment task (b-CFS group: 97.9%; control group: 98.8%). Trials that yielded no response within the response window (b-CFS group: 0.4%; control group: 0.3%) were recoded as the length of the response time window because these trials reflected the longest responses (i.e., 10 s in the b-CFS group; 5 s in the control group, see Gayet & Stein, 2017). To test our primary hypothesis that own-race faces would gain privileged access to perceptual awareness, we performed a paired-sample t-test on participants' location judgment RTs to own- and other-race faces. In the b-CFS group, participants were significantly faster to detect own-race faces than other-race faces, mean \pm SEM: 1546 \pm 15 vs. 1716 \pm 15 ms (SEMs were reported to remove participant's variability, see Loftus & Masson, 1994), t(23) = 5.50, p < 0.001, Cohen's d = 1.123 (Fig. 2 left panel). The same test in the control group failed to reveal any significant difference between own- and other-race faces (1589 \pm 4 vs. $1595 \pm 4 \text{ ms}, t(23) = 0.829, p = 0.415$, Cohen's d = 0.169, see Fig. 2 right panel). Furthermore, we have conducted a 2 (race, own- vs. otherrace) by 2 (task, binocular suppression vs. monocular no suppression) mixed ANOVA on the breaking time, with the first race variable as a within-subject factor and the second group variable as a between-subject factor. Confirming results from these separate t-tests, we found a significant interaction effect: F(1, 46) = 26.67, p < 0.001, ${\eta_p}^2 = .367^1.$

While Experiment 1 successfully established the own-race awareness advantage effect, this effect could be due to (1) people's higher perceptual expertise with their own-race members' faces or (2) own- vs. other-race faces eliciting different social-evaluative processes. To further investigate this own-race awareness advantage and to disambiguate the underlying mechanisms, we conducted subsequent experiments with otherwise arbitrary visual stimuli that were recently learned to represent own-/other-race group memberships (see Table 1 Experiments. 2–5). If otherwise arbitrary visual stimuli that were recently learned to represent racial group membership could modulate breaking time, then it is the social salience acquired by visual stimuli plays a determining role in influencing early perceptual selection processes. However, as will be presented below, data across four experiments failed to support this hypothesis.

3. Experiments 2-5

3.1. Method and materials

3.1.1. Participants

Because Experiments 2-5 followed the same rationale and employed

¹ Participants' RT distributions are right skewed. We then repeated the same analyses with log-transformed RTs and obtained highly consistent results. RT distributions and these additional analyses can be found in the Supplementary Materials.

Table 1

An overview of Experiments 1-5 and the stimuli, experimental hypotheses, sample sizes and designs in each experiment.

Experiment/Condition	Own- vs. Other-race Stimuli	Primary Hypothesis	Sample Size	Experimental Design
Experiment 1/bCFS	Chinese and Caucasian faces	Own-race Face Advantage	24	Within-subject design
Experiment 1/Control	Chinese and Caucasian faces	Own-race Face Advantage	24	Within-subject design
Experiment 2	Black/White bars	Own-race Symbol Advantage	16	Within-subject design
Experiment 3	Black/White bars	Own-race Symbol Advantage	24	Replication of Experiment 2
Experiment 4	Gabor Gratings	Own-race Symbol Advantage	24	Within-subject design
Experiment 5	Irregular Polygons	Own-race Symbol Advantage	24	Within-subject design

A **bCFS Experiment**

B Control (no CFS) Experiment



Fig. 1. Experiment 1, task flows of the b-CFS group and the control group.



Fig. 2. Results from Experiment 1. As can be inspected, own-race faces enjoyed more efficient detection time from binocular suppression in the b-CFS group.



Fig. 3. The b-CFS tasks used in Experiments 2–5. This figure illustrates an exemplar trial flow from Experiment 2.

highly similar procedures, we report these four studies together. In total eighty-eight Chinese participants were recruited for Experiments 2-5 and they received monetary compensation for participation (n = 16 in Experiment 2: 8 females, 20.7 ± 1.8 years; n = 24 in each of Experiment 3, 4 and 5: 12 females, 23.4 ± 3.4 years; 11 females, 23.3 \pm 2.7 years; 9 females, 21.6 \pm 2.8 years). Sample size in each individual experiment is either consistent with Experiment 1 or similar to previous b-CFS studies (because Exp.2 employed a smaller sample n = 16, we conducted Exp. 3 as a direct replication n = 24). The specific visual stimuli used in each experiment are presented in Fig. 3. Given our within-subject design, this sample size (n = 88) allows us to detect a small effect size of Cohen's dz = 0.3 with 80% power with $\alpha = 0.05$ with two-tails tests, using G-power's sensitivity power analysis (Faul, Erdfelder, Lang, & Buchner, 2007). All participants were all right-handed, and were pre-screened for neurological disorders. Participants provided consent forms prior to the experiment. The experiments were approved by the ethics committee at the Department of Psychology, Tsinghua University.

3.1.2. Procedure

Participants completed three sessions in order: (1) a baseline b-CFS to ensure that there were no pre-existing differences between two arbitrary visual stimuli (see Fig. 3); (2) an associative training task in which participants learned to match visual stimuli with own- and otherrace labels respectively (see Fig. 4); and (3) a post-learning b-CFS to assess whether stimuli that were recently learned to represent own- or other-race could modulate breaking time.

Baseline b-CFS: Participants were presented with otherwise arbitrary stimuli in a b-CFS setting just as in Experiment 1. Again, the same Mondarin pattern was presented to participants' dominant eyes at 10 Hz, and one of the two figures was presented to participants' nondominant eyes. Participants' task was to make a left-right location judgment whenever they perceived the stimulus coming out of the perceptual noise.

Associative training task: The task structure followed Sui et al. (2012), Stein et al. (2016) and Macrae, Visokomogilski, Golubickis, Cunningham, and Sahraie (2017). Participants were given instructions on match vs. nonmatch pairings between arbitrary visual stimuli and own-/other-race labels. For own-race labels, we used a word phrase 中国人 (meaning "Chinese"); for other-race labels, we used a word phrase 西方人 (meaning "Westerners"). The associative training task thus employed a 2 (own vs. other-race labels) by 2 (match vs. nonmatch) within-subject design. Specifically, participants were instructed to discriminate among four types of pattern-label pairings: own-race-match, own-race-nonmatch, other-race members were counterbalanced

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Fig. 4. Experiments 2–5, stimuli pairings used in the associative training tasks.

between participants. In each pair, the pattern was always presented on the left side while the label was always presented on the right side. Participants were told that they should make a match/mismatch judgment by pressing one of two buttons. Button press was counterbalanced across participants, and speed and accuracy were equally emphasized. Participants were given 20 practice trials before the main task.

The main task contained 240 trials, with 60 trials in each of the four conditions. These 240 trials were equally divided into three blocks. Each trial started with a fixation cross that last for 500 ms, followed by the pairing that was presented for 100 ms. All stimuli were presented against a grey background. A response window of 1000 ms was set up to register participants' button press. Performance feedback was provided to participants for correct, incorrect and missed responses. After an inter-trial-interval (0, 100 or 200 ms), the next trial began.

Post-training b-CFS: Following the associative training task, participants completed the same b-CFS as in the baseline session.

3.2. Results

Because each study of Experiments 2–5 yielded highly consistent results for both the training and the post-training b-CFS tasks, we have summarized and presented all statistics from each experiment in Tables 2 and 3.

Associative training task: Following previous research (Sui et al., 2012), we employed a signal detection approach to conduct statistical analyses on the accuracy data. Specifically, for each of the own-race and other-race conditions, we calculated a *d'* value based on participants' accuracy from match (hit rate) and nonmatch (false alarms) trials. We then conducted paired-sample *t*-tests comparing own- and other-race pairings, which revealed that participants were more sensitive in discriminating match vs. nonmatch pairings in the own-race condition than in the other-race condition (for statistics from each experiment, see Table 2). RTs from correct responses similarly showed that participants were significantly faster in judging own-race match pairings than judging other-race match pairings.

B-CFS task: Given the pre-post within-subjects experimental design,

Table 2

Across experiments 2–5, race-relevance significantly modulated participants' performance in the associative training task: participants demonstrated an own-race matching advantage effect in sensitivity (own-race d' minus other-race d'). BF factors were derived from the corresponding paired-sample *t*-tests, and were calculated with JASP version 0.9.0.1.

Experiment	Sample Size	Sensitivity Difference	95% CI	<i>p</i> -value	Cohen's d	BF10
2	16	1.25	[0.846, 1.66]	< 0.001	1.64	2415
3	24	0.935	[0.602, 1.267]	< 0.001	1.187	3310
4	24	0.357	[-0.066, 0.78]	0.094	0.356	0.797
5	24	0.607	[0.228, 0.987]	0.003	0.676	13.3
Combined Samples	88	0.746	[0.551, 0.941]	< 0.001	0.810	> 10,000

we conducted a 2 (time, baseline vs. post-training) by 2 (race, own- vs. other-race stimuli) within-subject ANOVA on participants' detection time to test our hypothesis. Specifically, a significant interaction from the ANOVA would indicate that own- and other-race stimuli differentially influenced breaking time following the associative training task. However, as can be seen, all experiments consistently showed non-significant interactions (ps > 0.10, for statistics from each individual experiment, see Table 3, and Fig. 5).

3.2.1. Bayesian analyses

We subsequently conducted Bayesian analyses with participants' b-CFS performance to assess how strongly the data would support the alternative hypothesis H1 relative to the null hypothesis H0 as reflected by Bayes Factor BF_{10} . Results showed that the data from each of the four experiments consistently supported the null hypothesis, with BF_{10} ranging from 0.235 to 0.847 (see Table 3 for BF_{10} from each individual experiment). In sharp contrast, participants' performance in the associative training task strongly support an own-race advantage effect, with BF_{10} ranging from 0.797 to 2415 supporting an own-race matching advantage effect (see Table 2).

3.2.2. An internal meta-analysis

Lastly, we conducted an internal meta-analysis (Goh, Hall, & Rosenthal, 2016) employing the Comprehensive Meta Analysis (CMA, 3.3.070, Borenstein, Hedges, & Higgins, 2014) software to quantitatively synthesize the b-CFS effect sizes across Experiments 2–5. Because each of the experiments employed the same protocol and only differed in terms of the visual stimuli used, effect sizes across experiments are highly homogenous: Cochran Q(3) = 2.115, p = 0.549. Both fixed- and random-effects model analyses revealed a non-significant, small effect size, Hedge's g = 0.159, 95% CI: [-0.053, 0.372], p = 0.14.

For the purpose of direct comparisons between the associative training task and the b-CFS tasks, we then conducted the same internal meta-analysis with the sensitivity *d*′from the associative training tasks. The analysis revealed a large effect size Hedge's g = 0.658, 95% CI: [0.456, 0.860], p < 0.001. The non-overlapping 95% CIs of the b-CFS detection performance and the training suggests that race-relevance plays a significant role in own-race matching judgments at a conscious level, but not in preconscious or near-threshold perceptual detection judgments.

Thus, employing otherwise arbitrary visual stimuli that were recently learned to represent own- and other-racial groups, Experiments 2–5 provided novel evidence regarding the boundary conditions of the own-race awareness advantage observed in Experiment 1 and in previous studies (Stein et al., 2014). Even though we have established a robust own-race advantage effect in matching judgments at a conscious level, visual stimuli that newly associated with racial group membership did not modulate perceptual selection processes in terms of their potency in entering perceptual awareness.

4. General discussion

Understanding how social stimuli gain access to perceptual awareness is central to the question of how the mind organizes multitudinous social information. Here, we examined how facial and symbolic stimuli representing own- and other-race would be prioritized to gain privileged access to perceptual awareness. Employing the breaking continuous flash suppression (b-CFS) paradigm that provides unparalleled indicators to assess stimuli's perceptual salience (Stein et al., 2011), we found that only own-race faces, but not otherwise arbitrary visual stimuli that were recently learned to represent one's own race, are prioritized to enter people's perceptual awareness. Overall, our findings suggest that perceptual expertise in own-race face processing contributes to the own-race awareness advantage effect.

Racial group membership strongly influences our perceptual preferences, memory performance as well as social evaluative judgments. Here, we provide novel evidence that the own-race faces were prioritized in the information-processing stream at an early, preconscious perceptual selection stage: own-race faces broke interocular suppression faster and gained privileged access to perceptual awareness than other-race faces. Importantly, this own-race face awareness advantage effect is generalizable across different populations with different experimental materials: Stein et al. (2014) recruited European White participants and employed African American faces as the other-race faces, and found that the own-race face inversion effects were larger than the other-race face inversion effects in a b-CFS task. Indeed, effect sizes associated this own-race face awareness advantage effect are highly comparable across these two studies: Cohen's d = 0.964 in Stein et al., 2014 vs. 1.123 in our Experiment 1 (for more detailed comparisons, see Supplementary Materials). These consistent findings also suggest that although other-race faces may rapidly capture people's attention deployment at an early, conscious level (Ito & Urland, 2003; Dickter and Bartholow, 2007); own-race faces can gain an advantage at a preconscious level in being prioritized to emerge into perceptual

Table 3

Across experiments 2–5, race-relevance did not modulate participants' perceptual detection efficiency of visual stimuli that were newly associated with own- and other-racial groups. The breaking time difference is calculated as below: own-race stimuli's breaking time_{baseline minus post-training} -minus- other-race stimuli's breaking time_{baseline minus post-training}. Thus, larger values indicate that the own-race stimuli will be preferentially detected than the other-race stimuli.

Experiment	Sample Size	Breaking Time Difference	95% CI	<i>p</i> -value	Cohen's d	BF10
2	16	33.1	[-8.03, 74.2]	0.107	0.429	0.847
3	24	17.9	[-29.5, 65.4]	0.442	0.16	0.283
4	24	34.3	[-39.9, 109]	0.348	0.195	0.324
5	24	-25.7	[-146, 95]	0.664	-0.09	0.235
Combined Samples	88	13.0	[-26, 53]	0.506	0.071	0.146



Fig. 5. Results from experiments 2–5. Here we plotted facilitation scores (y-axis) for otherwise arbitrary visual stimuli that were recently associated with own- and other-racial groups. The facilitation scores are calculated as the baseline b-CFS detection time minus the post-learning b-CFS detection time for own- and for other-race stimuli, respectively. Thus, a larger facilitation scores will indicate more efficient perceptual detection due to previous associative training.

awareness.

Despite this robust finding across participant population and stimulus sets, the underlying mechanism has been unclear. Particularly, such an own-race face awareness advantage effect can be explained by two possible mechanisms, namely perceptual expertise or social-cognitive factors. Supporting the perceptual expertise account, it has been repeatedly demonstrated that in b-CFS tasks, people are faster in detecting stimuli with high levels of perceptual expertise or familiarity from interocular suppression (Gobbini et al., 2013; Jiang et al., 2007; Stein et al., 2014; Steinet al., 2016). Supporting the social-cognitive account, it has been found that socially salient information, including self-referential information and information that signals threat/danger/ dominance/trustworthiness, can systematically modulate their breaking time in the b-CFS task because they are important for survival and for successful social interactions (Abir et al., 2017; Gayet et al., 2016; Geng, Zhang, Li, Tao, & Xu, 2012; Schmack, Burk, Haynes, &

Sterzer, 2016; Stewart et al., 2012; Yang et al., 2007).

To disambiguate these two accounts, we employed an associative training task in Experiments 2–5 to imbue otherwise arbitrary visual stimuli with race-relevance. This associative training task has been repeatedly employed in previous self- and ingroup-prioritization research (Enock et al., 2018; Stein et al., 2016; Sui et al., 2012; Macrae et al., 2017; Moradi et al., 2015; 2017). Specifically, otherwise arbitrary visual stimuli, once were learned to represent self or ingroup concepts, would enjoy prioritized processing in such training tasks. Thus, this training task provides an effective manipulation to establish strong associations between otherwise arbitrary visual stimuli and social concepts. Moreover, employing otherwise arbitrary visual stimuli is important here because we could effectively control for low-level stimulus features and participants' familiarity/perceptual experiences with these stimuli. Thus, if recently learned race-representing stimuli could still modulate breaking time in the b-CFS, then it will provide the

most compelling evidence supporting the social-cognitive account of the own-race awareness advantage effect.

We obtained two key findings: First, participants clearly showed an own-race advantage in the associative training, such that they made quicker and more accurate judgments for own-race match vs. nonmatch pairings than for other-race match vs. nonmatch pairings (see also Enock et al., 2018; Moradi et al., 2015; 2017). Second, this own-race matching advantage did not lead to an own-race perceptual awareness advantage in the subsequent b-CFS task, during which own- and otherrace stimuli need to compete with perceptual noises to gain access to perceptual awareness. Both Bayesian analyses and an internal metaanalysis provided convergent support for this result; and the magnitude of effect size is much smaller compared to the effect obtained from the associative training tasks. Thus, our data suggest that although racial group membership can exert a significant impact on matching decisions at a conscious level, it fails to influence early perceptual decisions at a preconscious level. Such a dissociation is meaningful because it illustrates at which stage will newly learned race-relevant information be prioritized along the information processing stream.

Overall, the data suggest that it is people's perceptual expertise with own-race faces that determines their privileged access to perceptual awareness (see also Stein et al., 2014, p.6). More specifically, face perception literature suggests that people process own-race or in-group members' faces in a more holistic manner (Hugenberg & Corneille, 2009; Michel, Rossion, Han, Chung, & Caldara, 2006; Tanaka, Kiefer, & Bukach, 2004), and people are superior even at recognizing components of own-race faces (Hayward, Rhodes, & Schwaninger, 2008). With a holistic processing style for own-race faces and superior recognition with even own-race faces from perceptual noises and interocular suppression.

At a broader level, the current research joins recent efforts in investigating how top-down factors such as self-relevance may influence early perceptual selection processes (Geng et al., 2012; Macrae et al., 2017; Stein et al., 2016). Similar to own-race, self-referential information enjoys preferential processing across perceptual, memory and executive control tasks (Hu, Wu, & Fu, 2011; Symons & Johnson, 1997; Sui et al., 2012; for a recent review, see Sui & Humphreys, 2015). For instance, Geng et al. (2012) reported that participants' own faces would break interocular suppression faster than others' faces. Employing a similar associative training task as in our Experiments 2-5, Stein et al. (2016) reported that otherwise arbitrary visual stimuli (e.g., Gabor gratings) that were recently learned to represent the self did not gain privileged access to perceptual awareness. However, a subsequent study by Macrae and colleagues found that self-representing geometric shapes were identified faster than other-representing shapes in the b-CFS. Unlike most previous b-CFS tasks that require participants to make a spatial location judgment regardless of stimuli' identity (e.g., Stein et al., 2016), participants in Macrae et al. (2017) made a target vs. nontarget identification judgment that may tap into post-perception judgments of specific shapes. Such post-perception processes may account for the superior identification of self-representing shapes among interocular suppression. Indeed, their drift diffusion model analyses showed that self-relevance influenced the starting point of decision, i.e., decisional processes, rather than information uptake, i.e., perceptual processes.

Although our data favor the perceptual expertise account over the social/cognitive account, we consider it is premature to completely reject the idea that top-down social/cognitive processes could not contribute to perceptual selection of racial- or group-relevant stimuli at a preconscious level. Specifically, the current experiments focused on visual stimuli that are *newly learned* to represent racial group memberships. Although the associative training task was successful in imbuing visual stimuli with race-relevance and the effect sizes were robust and large (see also Enock et al., 2018; Macrae et al., 2017; Stein et al., 2016; Sui et al., 2012; Moradi et al., 2015, 2017), it is still possible that

existing symbols (e.g., national flags, cultural landmarks) that have been long associated with racial or group concepts would influence preconscious perceptual selection processes. Thus, future studies are warranted to employ different stimuli, such as existing cultural symbols, or use minimal group paradigms with human faces (Bernstein, Young, & Hugenberg, 2007; Van Bavel, Packer, & Cunningham, 2008), to further test to which extent will top-down social/cognitive/motivational factors influence people's early perceptual awareness of own- vs. other-race, and in- vs. out-group stimuli.

Taken together, this research suggests that along the informationprocessing stream, our own-race members' faces are preferentially selected to gain access to perceptual awareness. Such priority is likely face-specific and is based on people's intensive perceptual experience with their own-race members. While visual stimuli that are newly associated with one's own racial group are prioritized during perceptual matching judgments at a consciously level; they are less likely to influence people's early, preconscious perceptual selection processes (cf. Firestone & Scholl, 2016).

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cognition.2018.12.003.

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