How do Asians perceive Caucasian eyes?

Electrophysiological correlates of perceiving racial differences from the eyes region of the face.

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Abstract

Past research has found that several brain event-related potentials (ERPs) are sensitive to the perception of ethnic differences displayed in human faces. This body of research suggests that race perception involves a cascade of cognitive processes that includes both automatic vigilance and familiarity processes, and overt attentional mechanisms. However, most of these studies used stimuli depicting *whole faces* rather than stimuli depicting separate facial features. Therefore, it is still largely unknown if ERP responses to racial differences rely on a holistic processing of the whole face, or whether they can be accounted for by the perception of single facial features. We examined whether the eyes region can provide sufficient information to trigger known ERP correlates of race perception such as the P2, the N400 and the Late Positive Complex (LPC). Specifically, we showed pictures depicting only the eyes region of Caucasian and Asian individuals to a sample of Asian participants living in an Asian country. We found that both the P2 and N400, but not the LPC were modulated by racial differences. The effects on the P2 may suggest an enhanced vigilance response to Other-Race eyes whereas the N400 effect could reflect a signal of familiarity triggered by Same-Race eyes. These results indicate that a specific facial feature, the eyes region, can account for known effects of race perception on early brain potentials. Our findings also indicate that well-known early neural correlates of race perception can be triggered in the absence of a holistic processing of the whole face.

Introduction

In the last two decades, significant progress has been achieved in understanding the neural mechanisms underlying the ability to perceive ethnic differences [1]. In particular, many studies using the event-related potentials (ERP) method have unveiled results suggesting that attentional and familiarity processes triggered by facial information plays an important role in race perception [2,3]. In this line of research, three ERP components have notably been associated to the perception of ethnic facial differences: The P2, the Late Positive Complex (LPC) and the N400 [4–6].

The association between the P2 and race perception was established by the finding that its amplitude tends to be larger for "Other-Race" (OR) compared to "Same-Race" (SR) facial stimuli [4–9]. The P2 is an early positivity occurring approximately between 100 and 250 ms post-stimulus onset, which can be observed both on frontal and posterior sites and it is often associated with a rapid and automatic allocation of attentional resources [10–12]. Its modulation by race perception has been interpreted as an initial vigilance response to outgroup (other-race) targets [2]. This interpretation is consistent with the well-known modulation of the P2 by stimuli that can convey threat-related information [10,11]. Further, many studies have found that a late positive deflection that typically peaks after 300 ms in posterior sites tends to be more positive for OR compared to SR faces [3–5,8]. This ERP has been labeled as a P300, or as a “late positive potential” (LPP) or “late positive complex" (LPC). The LPC is often seen as a neural marker of overt selective attention towards a specific stimulus or task [13–15]. In addition, Willadsen-Jensen and Ito [5] found that the N400, a mid-latency negativity peaking approximately between 300 and 400, was larger for SR compared to OR faces. The N400, which can be observed in centro-parietal or frontal sites, has been linked to the semantic processing of verbal materials [16] or to a signal of familiarity when face stimuli are used [17]. Interestingly, evidence suggests that the N400 reflects a relatively automatic signal of memory recognition [17]. Consistent with this literature, Willadsen-Jensen and Ito [5] interpreted their N400 effects as a manifestation of an effect of familiarity. Overall, the results reviewed above indicate that perceiving race-related information from faces is potentially associated to a diverse set of neural processes. Specifically, these studies have found that neural signals known to reflect early vigilance processes (e.g. the P2), overt attentional discrimination (the LPC) and familiarity processes (the N400) were associated with the perception of racial differences from face stimuli.

However, it remains unclear whether ERPs related to race perception are dependent or at least influenced by whole-face processing, rather than driven by specific facial features carrying race-related information. This issue is compounded by the fact that most ERP studies on this topic have used stimuli depicting whole faces, rather than single facial features. This issue is linked to two distinct conceptual frameworks [18]. First, a *holistic* approach of race perception would posit that an initial representation of a combination of several features of the human face is formed before racial information can lead to attentional and familiarity responses reflected by ERP correlates of race perception. This model is supported by behavioural evidence indicating that race perception is linked to a holistic or configural processing of the face [19]. This idea is also supported by an influential body of research that focuses on early ERPs related to specialized processes of face recognition. Some of these studies have found that the N170, a negative deflection often associated with the configural processing of faces [20] tends to be more negative for OR than SR faces [3,21–23].

Second, a *featural* approach of race perception could posit that specific facial features contain enough information to trigger differentiated attentional and familiarity responses. This approach is supported by a number of studies showing that the N170 is not sensitive to racial differences in faces [24,25]. Further, existing ERP evidence suggests that racial categorization can occur at latencies preceding typical neural correlates of whole-face processing [7]. In addition, substantial evidence suggests that a specific facial feature, the eyes region of the face, plays an important role in the perception of ethnic differences [26,27]. Consistent with this idea, a recent study found that P2 amplitudes tended to increase for OR faces when participants were instructed to fixate on the eyes of whole-face-stimuli [6]. However, given that this study was based on the manipulation of fixation instructions on whole face stimuli, it cannot be excluded that these results may have been influenced by a holistic form of processing of the face stimuli used in that experiment.

To address this question, we tested here whether stimuli depicting only the eyes region of the face (i.e. no other facial feature could be seen) can provide sufficient information to trigger known ERP correlates of race perception. If this possibility is true, it would indicate that a holistic processing of the whole face is not necessary for the attentional and familiarity processes commonly associated with these ERP effects. Specifically, we tested whether three ERP components linked to known early, mid-latency and late effects of race (the P2, N400 and LPC) were sensitive to the perception of ethnic differences from stimuli depicting only the eyes region of the face. We hypothesized that, if the eyes region of the face provides sufficient information to trigger typical ERP correlates of race perception, then a contrast between OR and SR eyes should lead to similar ERP patterns observed when whole face stimuli are used.

Our study had two additional methodological specificities. First, we were able to test our hypotheses on a sample of Asians living in a country where Asians are the major in-group (Malaysia), which contrasts with the majority of ERP studies of intergroup relations which are usually done in countries where Caucasians are the in-group (see [8,28] for notable exceptions) Second, we also avoided to explicitly ask our participants to make racial categorization judgments during the task, in order to avoid processes linked to the explicit search for social category information, or potential effects linked to individuation strategies [26]. Instead, we provided instructions directing our participants to pay attention to the stimuli (trying to detect the mental state experienced by the target) without explicit references to racial differences.

Methods

Participants

Forty young healthy right-handed adults (28 females, Mean age = 23.02, SD = 3.37) participated in this study. Nine participants were excluded because their EEG data was too noisy (see the "Methods" section), which resulted in a final sample of 31 individuals (20 females, Mean age = 23.18, SD = 3.33). Participants were all Malaysians from three major Asian ethnicities: Malays (N=11), Malaysian-Chinese (N=9) and Malaysian-Indians (N=7), and other Malaysian ethnic minorities (N=4). They were all living in the greater Kuala Lumpur Metropolitan and thus they were regularly exposed to a majority of ethnic Malays and Malaysian-Chinese. These two groups made up approximately 83% of the population living in the wider Kuala Lumpur in 2018 [29]. Both of these groups share similar facial traits [30] typical of East Asian types depicted in the Asian version of the RMET, and Caucasians are a very small minority in Kuala Lumpur. Participants signed an informed consent prior to the experiments, and they all received a token monetary reward for their participation.

Stimuli

We used the Reading the Mind in the Eyes task (RMET [31]), previously validated and extended to include Asian stimuli [32,33]. This stimuli set includes 72 gray-scale pictures depicting only the eyes region of the face, taken from 36 Caucasian and 36 Asian individuals. Each picture of the RMET (Asian or Caucasian) is linked to a specific mental state associated with a specific verbal label (e.g. "friendly", "worried", etc.). The RMET involves asking participants whether each pair of eyes matches a word describing the target state, compared to a number of other distractor words. This feature of the RMET enabled us to direct our participants to pay attention to pictures of two different ethnic groups without explicitly asking them to perform a race categorization task. A pilot study testing 20 Malaysian participants (mean age, = 20.4 years, SD = 1.23) established that the eye stimuli of the RMET could be accurately categorized as Asian or Caucasian eyes (mean accuracy; Asian eyes: M= .92, SD = 1.77; Caucasian Eyes: M=.93, SD=1.60; t = 0.66, p =0.52).

Procedure and design

Every participant was seated in an armchair placed within an electrically shielded cubicle where EEG recordings took place. Participants were given time to read the instructions of the experiment and read the glossary of the mental state words that was used in the RMET. The experiment included 288 experimental trials that followed the same structure: First, participants were presented with a fixation cross with a random duration ranging from 900ms to 1200ms. Second, a picture depicting the eyes region of either a Caucasian or an Asian individual was displayed for 2000ms. Third, a word describing a mental state (e.g. worried) was displayed for one minute. Participants responded with a keypress whether (yes/no) the word matched the state felt by the individual whose eyes had just been displayed. Participants were given unlimited time in between blocks to rest before completing the remaining blocks. Participants took about 30 minutes to complete the tasks. Each picture was shown four times corresponding to four different mental states described in the third stage. These mental states included the target mental state and three distractor states pertaining to the RMET task. The order of the pictures, whether Asian or Caucasian eyes were shown, and the order of the mental state words in the third stage were fully randomised. Participants took about 30 minutes to complete the tasks, and stimuli were presented visually against a white background on a screen located one meter away from participants, using E-prime 2.0TM (Psychology Software Tools, Pittsburgh, PA). Each RMET stimulus was standardised to a 14.5 (width) x 5.5 (height) cm format and presented on a 21” screen.

Electrophysiological data recording and processing

EEG data were recorded with a 128-channel net connected to a high-input amplifier (Electrical Geodesics, Inc. , EGI, Eugene, OR) at a rate of 500 Hz (0.01-200 Hz bandwidth), and an impedance ≤ 50 kΩ. In order to minimize signal noise, EEG recordings took place in a custom-made Faraday cage (IAC Acoustics, Smithfield NSW, Australia) and data were recorded using an online Cz reference. To conform with previous studies on race perception testing similar ERP components (e.g. [5]), Raw EEG data was converted offline to an average mastoids reference. EEG data was pre-processed using EEGLAB version 14.1.2b [34] and ERPLAB version 7.0 [35]. The data were filtered offline (0.1-40Hz), segmented into epochs between 200ms before and 2000ms after the onset of each picture depicting the eyes region (second stage of each trial) and baseline corrected.

Independent Component Analysis (ICA) was run on epoched data using the "Infomax" ICA decomposition method implemented in the "*runica*()" function of EEGLAB [34]. We next followed the guidelines of Jung, Makeig, Lee, and Sejnowski (2000) to detect and remove components accounting for ocular artifacts (eye-blinks and lateral eye movements) and muscular artifacts. Next, to minimize artifacts not captured by ICA, we rejected data epochs that had a difference between their maximum and minimum voltage amplitudes exceeding 100 μV in 1000-ms segments isolated in steps of 100 ms for every epoch. On average, 6.5 channels were found to be artifactual and were interpolated either through spherical spline interpolation or nearest-neighbor replacement. In line with recommended practice [37], nine participants were excluded from the sample because more than one third of their trials were rejected according to the criteria described above. The participants included in the final sample had an average rejection rate of 16.1% (max: 20.8%). The average number of accepted trials for the Caucasian eyes condition and the Asian eyes condition was 120 out of 144 trials (83.7%) and 121 out of 144 trials (84%) respectively. No participant had less than 114 artifact-free trials in either of the two conditions (Caucasian vs. Asian).

We quantified the P2, the N400 and the LPC by extracting peak amplitudes in specific a priori time windows defined on the basis of previous literature [4–10,12] and from a careful visual inspection of our waveforms. We extracted the most positive peak occurring between 100 and 250 ms (P2), and between 500 and 800 ms (LPC) and the most negative peak between 250 and 500 (N400). Given that the ERP effects that we targeted have been previously reported in both fronto-central and centro-parietal midline locations scalp locations [2], we adopted a regions of interest approach in which we selected four scalp regions surrounding midline areas and covering anterior-posterior (AP) and left-right axes. Using AP and left-right axes as factors in ERP analyses is an approach extensively used in ERP research [38,39]. Specifically, we selected a Left Anterior (EGI standard locations E7, E13, E12, E30, E20), Right Anterior (E5, E106, E112, E105, E118), Left Posterior (E60, E53, E54, E61, E67), and Right Posterior (E85, E86, E77, E78, E79) scalp regions. Next, similar to previous research [40], we averaged data for single electrodes inside each of these scalp regions. This practice has been recommended to address familywise errors in dense arrays of electrodes [41]. For each ERP of interest (P2, N400 and LPC), we computed a Race (Caucasian eyes vs. Asian eyes) X AP (Anterior vs Posterior) X Hemisphere (HEM, Right vs. Left) repeated-measures Analysis of Variance (ANOVA).

In order to enable a comparison with previous literature, we also analyzed ERP components typically associated with the configural processing of faces, the N170 and the occipito-temporal P2. For this aim, we followed standard practice of previous research on these components [42] by re-referencing our data to a common average reference, and we focused on electrodes E58 and E96 which in EGI nets correspond to electrodes P8 and P7 (also known as T6 and T5). For the N170, we extracted negative peak amplitudes in a 120-190 time window, and for the occipito-temporal P2 we extracted positive peak amplitudes between 150 and 250 ms.

For all the analyses, results were considered significant at $p < 0.05$, and partial eta-squares were reported in order to provide estimates of effect sizes.

Results

Behavioral results

Participants' accuracy in identifying mental states in the RMET task was not significantly different between Asian (68%) and Caucasian (70%) eyes, t=1.7, *ns,* in line with previous accuracy figures using the same materials [32]. Response times linked to the RMET did not significantly differ between Caucasian (M = 1.922 seconds, SD = 1.05) and Asian stimuli (M = 1.918 seconds, SD = 1.04), t (30) = .17, p = .86.

ERP results

A visual inspection of our ERP data depicted in Figure 1 indicated the existence of an early positive peak with a predominantly fronto-central topography which conforms to a P2 component, and a mid-latency negative deflection peaking at 300 ms in anterior and central sites, which conforms to the temporal characteristics of a N400/N3 component [16,43]. This N400 effect extends to posterior sites but with a slightly later peak latency around 340 ms (see supplementary Figure 1). ERP waveforms related to Caucasian and Asian eyes seem to be clearly differentiated for the P2 and N400, whereas no obvious differences can be seen in a typical LPC time window (500-800).

Insert Figure 1 here

Statistical analyses have largely confirmed these observations. A Race (Caucasian eyes vs. Asian eyes) X AP (Anterior vs Posterior) X Hemisphere (HEM, Right vs. Left) repeated-measures ANOVA computed on P2 peak amplitude scores revealed a significant main effect of Race, $F(1, 30) = 4.5$, $p=.04$, $\eta p^2 = .13$, indicating that P2 amplitudes were significantly larger for Caucasian than Asian eyes (*M*= 5.3, 5.0; *SEs*: 0.41, 0.36). This effect did not differ between electrode sites, as Race X AP, Race X HEM and Race X AP X HEM interactions were not significant (*Fs* = .20, 1.7, .34; *ps* = .66, .19, .56; ηp^2 = .007, .05, .01 respectively). A significant main effect of Race was found for the N400, $F(1, 30) = 7.3$, $p=.01$, $\eta p^2 = .20$, showing that N400 amplitudes were significantly larger for Asian than Caucasian eyes (*M*= -.39, .003; *SEs*: 0.36, 0.33). Similar to the P2 data, AP and HEM did not interact with Race in the N400 data (*Fs* = .04, 1.7. 1.04; *ps* = .85, .19, .32; ηp^2 = .001, .05, .03). This finding suggests that the effect of Race was broadly distributed across fronto-central and centro-parietal sites. In order to further test the reliability of these effects, we recalculated our main effects of race using a robust 10,000 samples bootstrapped t-test. This approach confirmed that the effects of Race were significant for both the P2 [*CI*: .03, .54, $p=.04$]

and the N400 [*CI*: .12, .67, *p*=.01]. Descriptive statistics of P2, N400 and LPC analyses are shown in Table 1.

Insert Table 1 here.

In order to ensure whether that N400 results were not masking two different effects with a distinct topography, we reanalyzed the N400 data separately for posterior and anterior electrodes. However, we found that effects of Race were significant and similar in both locations (see supplementary data, and supplementary Figure 1). In addition, given that the N170 and the occipito-temporal P2 are mainly associated to the configural processing of whole faces and other complex stimuli [3,20], we did not expect these components to be sensitive to our experimental manipulation. However, we performed supplementary analyses on both of them for the sake of completeness. As expected, we found no significant differences between Asian and Caucasian eyes for both of these components (see Supplementary data and supplementary Figure 2).

In summary, these results show that Asian participants who attended to both Asian and Caucasian eyes produced a larger P2 for Caucasian eyes, and a larger N400 for Asian eyes. Overall, these effects did not significantly interact with AP or HEM, which indicates that they are broadly distributed around the midline.

Discussion

This study is to our knowledge the first to show that two early brain potentials, the P2 and N400, are triggered by the perception of racial differences from the eyes region of the face even when other facial features cannot be seen. These results indicate that these two ERPs reflect processes involved in race perception that do not require a holistic processing of the whole face, which is compatible with a featural account of early neural responses to racial differences. In addition, we found that the late positive complex was not affected by ethnic differences displayed in eye stimuli. We discuss hereafter potential interpretations of these findings.

The finding that P2 amplitudes were larger for Caucasian compared to Asian eyes are in line with a vast amount of previous evidence obtained from whole-face stimuli in which OR faces lead to a more positive P2 than SR faces [4–9]. In particular, our results are consistent with Volpert et al. [6], although we showed that the link between race perception and the eyes regions can be observed even when other facial features cannot be seen, which excludes any whole-face processing effect. The P2 effects observed in our study were not modulated by the AP and HEM factors, implying that they were distributed broadly across fronto-central and centro-parietal sites. P2 effects are usually linked to very early processes of allocation of attentional resources that are often deemed to be automatic, and they may reflect the activity of an early vigilance system devoted to the detection of motivationally relevant stimuli [10–12]. Similar interpretations have been advanced in the literature of ERP correlates of race perception, where the P2 has been linked to an early vigilance system that detects outgroup-related information [2].

The second noticeable finding of our study is a significant effect of race on a negativity ranging from 250 to 500 ms and spanning over anterior and posterior sites. This negativity peaked at approximately 300 ms in fronto-central sites and 350 ms in left centro-parietal sites. This negativity conforms to an N400, which is typically observed in centro-parietal sites, but it can also be found in anterior sites, where it is called a frontal N400 or N3 [16,17,43]. Our findings on the N400 are consistent with the results that Willadsen-Jensen and Ito [5] obtained from Asian participants using whole-face stimuli.

There are at least two potential interpretations for this effect: First, the enhanced negativity for SR eyes may reflect a signal of familiarity. More specifically, a prior history of exposure to in-group eye regions would have created a memory representation that is activated when SR targets are met, resulting in a familiarity response. This interpretation would be consistent with the interpretation of Willadsen-Jensen and Ito [5] for their results with whole faces, and they are also consistent with known effects of face familiarity on the N400 [17].

The second potential interpretation of this result is that the N400 results might just reflect attentional effects caused by an effect of stimulus frequency. Given that Caucasian eyes are rarer in the Asian context where participants were tested, they would be likely to attract more attention, which could explain the results observed with the N400. Although this explanation appears to overlap with the explanation based on familiarity processes, it is important to stress that familiarity in this context refers to a memory process which relies on the activation of representations that may have been formed over a considerable amount of time. In contrast, the stimulus frequency explanation refers to an attentional effect modulated by differences in the frequencies of different categories of stimuli that can occur over a short period of time, similar to “oddball” tasks [15].

Although the stimulus frequency explanation cannot be fully ruled out, it has to be stressed that attentional effects to rare/frequent stimuli in oddball-type tasks are not typically indexed by the N400. Instead, the LPC is more widely known to be sensitive to such manipulations [15], and our observation that the LPC is not modulated by race perception in the current experiment is inconsistent with the hypothesis that attention to rare stimuli *per se* would have played a role in our results. Moreover, previous evidence shows that short-term repetition of stimuli is related to a *decrease* of N400 amplitudes [44], whereas our results show that SR stimuli are related to an *increase* of the N400.

Furthermore, the main goal of this study was to examine whether the eyes region of the face could provide sufficient information to trigger known effects of race perception on ERP activity. Our results show that this hypothesis is confirmed for the P2 and N400, which argues in favour of a featural explanation of these early effects. The P2 and N400 both refer to processes that are often thought to be relatively quick and automatic [10,12,17], such as an early vigilance response in the case of the P2, and an early familiarity response for the N400. This interpretation is consistent with evidence suggesting that quick, motivationally-relevant processes can be triggered with minimal information [45,46]. This explanation is also compatible with evidence suggesting that perceiving the eyes region of the human face can activate brain areas such as the amygdala and other subcortical structures [47,48], which are often associated with quick vigilance responses. It is important to note that these results do not contradict previous evidence showing a link between holistic facial processing and racial categorization [19]. Our results simply indicate that a subset of processes involved in racial categorization do not need whole-face processing. Given that a complex cascade of cognitive processes are involved in racial categorization, it is very likely that a number of processes happening after holistic processes of facial recognition exert a significant influence on racial perception. In addition, our results do not exclude the influence of any configural processing from racial categorization. Configural processing can in theory take place in the eyes region, as for instance the judgment of the distance between the eyes. Our results only indicate that configural processes involving the whole face are not needed for effects of race on the P2 and N400.

Finally, we did not observe significant effects of race on the LPC, contrary to studies using whole-face stimuli [3–5,8]. Although the absence of an effect can never be fully interpreted, it is possible that one of the reasons for an absence of LPC effects is that race perception from the eyes would rely mainly on quick, "obligatory" vigilance and familiarity processes. This potential phenomenon would be in contrast with race perception from whole faces, which seems to rely on a more complex cascade of neural processes reflecting both automatic and overt processes. This explanation would be compatible with evidence suggesting that the LPC reflects an overt allocation of attentional resources towards a specific category of stimuli or task [15] and with evidence indicating that the P2 and N400 can be linked to automatic attentional and recognition processes [11,12,17]. However, further research would be needed to test whether this assertion is true.

In summary, the present study found that ethnic differences displayed on the eyes region of the face were associated with differences on the P2 and N400 brain potentials. These results show that a specific facial feature - the eyes region of the face - can provide sufficient information for early "obligatory" neural processes of racial categorization. Our findings suggest that featural models may account for early attentional and familiarity processes contributing to the perception of ethnic differences from the human face.

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References

[1] P. Molenberghs, W.R. Louis, Insights From fMRI Studies Into Ingroup Bias, Front. Psychol. 9 (2018) 1868. doi:10.3389/fpsyg.2018.01868.

[2] T.A. Ito, B.D. Bartholow, The neural correlates of race, Trends Cogn. Sci. 13 (2009) 524–531. doi:10.1016/j.tics.2009.10.002.

[3] H. Wiese, J.M. Kaufmann, S.R. Schweinberger, The Neural Signature of the Own-Race Bias : Evidence from Event-Related Potentials, Cereb. Cortex. 24 (2012) 826–835. doi:10.1093/cercor/bhs369.

[4] C.L. Dickter, B.D. Bartholow, Racial ingroup and outgroup attention biases revealed by event-related brain potentials, Soc. Cogn. Affect. Neurosci. 2 (2007) 189–198. doi:10.1093/scan/nsm012.

[5] E.C. Willadsen-Jensen, T.A. Ito, Willadsen-Jensen, E. C., & Ito, T. A. (2008). A foot in both worlds: Asian Americans' perceptions of Asian, White, and racially ambiguous faces., Gr. Process. Intergr. Relations. 11 (2008) 182–200. doi:10.1177/1368430207088037.

[6] H.I. Volpert-esmond, E.C. Merkle, B.D. Bartholow, The iterative nature of person construal : Evidence from event-related potentials, Soc. Cogn. Affect. Neurosci. 12 (2017) 1097–1107. doi:10.1093/scan/nsx048.

[7] T.A. Ito, G.R. Urland, Race and Gender on the Brain : Electrocortical Measures of Attention

to the Race and Gender of Multiply Categorizable Individuals, J. Pers. Soc. Psychol. 85 (2003) 616–626. doi:10.1037/0022-3514.85.4.616.

[8] F. Sheng, S. Han, Manipulations of cognitive strategies and intergroup relationships reduce the racial bias in empathic neural responses, Neuroimage. 61 (2012) 786–797. doi:10.1016/j.neuroimage.2012.04.028.

[9] J.T. Kubota, T. Ito, Rapid race perception despite individuation and accuracy goals, Soc. Neurosci. 12 (2017) 468–478.

[10] S. Walker, D.B. O'Connor, A. Schaefer, Brain potentials to emotional pictures are modulated by alexithymia during emotion regulation, Cogn. Affect. Behav. Neurosci. 11 (2011) 463–475. doi:10.3758/s13415-011-0042-1.

[11] J.K. Olofsson, S. Nordin, H. Sequeira, J. Polich, Affective picture processing : An integrative review of ERP findings, Biol. Psychol. 77 (2008) 247–265. doi:10.1016/j.biopsycho.2007.11.006.

[12] L. Carretie, A. Hinojosa, M. Martı, F. Mercado, M. Tapia, Automatic Attention to Emotional Stimuli :, Hum. Brain Mapp. 299 (2004) 290–299. doi:10.1002/hbm.20037.

[13] H.T. Schupp, T. Flaisch, J. Stockburger, M. Junghofer, Emotion and attention : event-related brain potential studies, Prog. Brain Res. 156 (2006) 31–51.

[14] N. Goto, F. Mushtaq, D. Shee, X.L. Lim, M. Mortazavi, M. Watabe, A. Schaefer, Neural signals of selective attention are modulated by subjective preferences and buying decisions in a virtual shopping task, Biol. Psychol. 128 (2017) 11–20. doi:10.1016/j.biopsycho.2017.06.004.

[15] J. Polich, Updating P300 : An integrative theory of P3a and P3b, Clin. Neurophysiol. 118 (2007) 2128–2148. doi:10.1016/j.clinph.2007.04.019.

[16] M. Kutas, K.D. Federmeier, Thirty years and counting: Finding meaning in the N400 component of the event related brain potential (ERP), Annu. Rev. Psychol. 62 (2011) 621–647. doi:10.1146/annurev.psych.093008.131123.Thirty.

[17] M. Eimer, Event-related brain potentials distinguish processing stages involved in face perception and recognition, Clin. Neurophysiol. 111 (2000) 694–705.

[18] Z. Wang, P.C. Quinn, J.W. Tanaka, X. Yu, Y.P. Sun, C.M. Gaspar, An other-race effect for configural and featural processing of faces : upper and lower face regions play different roles, Front. Psychol. 6 (2015) 559. doi:10.3389/fpsyg.2015.00559.

[19] C. Michel, B. Rossion, J. Han, C. Chung, C. Michel, B. Rossion, J. Han, C. Chung, R. Caldara, Holistic Processing Is Finely Tuned for Faces of One's Own Race, Psychol. Sci. 17 (2006) 608–615.

[20] B. Rossion, I. Gauthier, M.J. Tarr, P. Despland, R. Bruyer, S. Linotte, M. Crommelinck, The N170 occipito-temporal component is delayed and enhanced to inverted faces but not to inverted objects: an electrophysiological account of face-specific processes in the human brain., Neuroreport. 11 (2000) 69–72.

[21] S. Caharel, B. Montalan, E. Fromager, C. Bernard, R. Lalonde, R. Mohamed, Other-race and inversion effects during the structural encoding stage of face processing in a race categorization task : An event-related brain potential study, Int. J. Psychophysiol. 79 (2011) 266–271. doi:10.1016/j.ijpsycho.2010.10.018.

[22] J. Stahl, H. Wiese, S.R. Schweinberger, Expertise and own-race bias in face processing: an event-related potential study., Neuroreport. 19 (2008) 583–587.

[23] P.M. Walker, L. Silvert, M. Hewstone, A.C. Nobre, Social contact and other-race face processing in the human brain., Soc. Cogn. Affect. Neurosci. 3 (2007) 16–25.

[24] R. Caldara, C.A.B. Rossion, P. Bovet, C. Hauert, Event-related potentials and time course of the 'other-race'face classification advantage., Neuroreport. 15 (2004) 905–910. doi:10.1097/01.wnr.00001.

[25] H. Wiese, J. Stahl, S.R. Schweinberger, Configural processing of other-race faces is delayed but not decreased., Biol. Psychol. 81 (2009) 103–109.

[26] K. Kawakami, A. Williams, D. Sidhu, B.L. Choma, R. Rodriguez-Bailón, E. Cañadas, D.

Chung, K. Hugenberg, An eye for the I : preferential attention to the eyes of ingroup members, J. Pers. Soc. Psychol. 107 (2014) 1–20.

[27] S.D. Goldinger, Y. He, M.H. Papesh, Deficits in Cross-Race Face Learning: Insights From Eye Movements and Pupillometry, J. Exp. Psychol. Learn. Mem. Cogn. 35 (2009) 1105–1122. doi:10.1037/a0016548.Deficits.

[28] F. Sheng, N. Du, S. Han, Degraded perceptual and affective processing of racial out-groups : An electrophysiological approach, Soc. Neurosci. 12 (2018) 479–487. doi:10.1080/17470919.2016.1182944.

[29] Department of Statistics, Malaysian government. Population by Ethnic group 2018., 2018. https://www.dosm.gov.my/v1/index.php?r=column/cone&menu_id=Nk1JZnJBMm1TdmRFS0xaTXZnanIrQT09.

[30] W.C. Ngeow, S.T. Aljunid, Craniofacial anthropometric norms of Malays, Singapore Med. J. 50 (2009) 525–528.

[31] S. Baron-cohen, S. Wheelwright, J. Hill, Y. Raste, I. Plumb, The '" Reading the Mind in the Eyes "' Test Revised Version : A Study with Normal Adults , and Adults with Asperger Syndrome or High-functioning Autism, J. Child Psychol. Psychiatry Allied Discip. 42 (2001) 241–251.

[32] R.B. Adams, N.O. Rule, R.G. Franklin, E. Wang, M.T. Stevenson, S. Yoshikawa, M. Nomura, W. Sato, K. Kveraga, Cross-cultural Reading the Mind in the Eyes : An fMRI Investigation., J. Cogn. Neurosci. 22 (2010) 97–108.

[33] W. Sato, T. Kochiyama, S. Uono, R. Sawada, Y. Kubota, O.D. Monte, Structural Neural Substrates of Reading the Mind in the Eyes, 10 (2016) 1–7. doi:10.3389/fnhum.2016.00151.

[34] A. Delorme, S. Makeig, EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis, J. Neurosci. Methods. 134 (2004) 9–21. doi:10.1016/j.cognition.2007.05.006.

[35] J. Lopez-Calderon, S.J. Luck, ERPLAB: an open-source toolbox for the analysis of event-

related potentials, Front. Hum. Neurosci. 8 (2014) 1–14. doi:10.3389/fnhum.2014.00213.

[36] T. Jung, S. Makeig, T. Lee, T.J. Sejnowski, Removing electroencephalographic artifacts by blind source separation, Psychophysiology. 37 (2000) 163–178.

[37] T.W. Picton, S. Bentin, P. Berg, E. Donchin, S.A. Hillyard, R. Johnson, G.A. Miller, W. Ritter, D.S. Ruchkin, M.D. Rugg, M.J. Taylor, Guidelines for using human event-related potentials to study cognition : Recording standards and publication criteria, Psychophysiology,. 37 (2000) 127–152.

[38] E.K. Bridger, J.E. Herron, R.L. Elward, E.L. Wilding, Neural Correlates of Individual Differences in Strategic Retrieval Processing, J. Exp. Psychol. Learn. Mem. Cogn. 35 (2009) 1175–1186. doi:10.1037/a0016375.

[39] S. Watts, L.G. Buratto, E. V Brotherhood, G.E. Barnacle, A. Schaefer, The neural fate of neutral information in emotion-enhanced memory., Psychophysiology. 51 (2014) 673–84. doi:10.1111/psyp.12211.

[40] F. Mushtaq, R.M. Wilkie, M.A. Mon-williams, A. Schaefer, Randomised prior feedback modulates neural signals of outcome monitoring, Neuroimage. 125 (2016) 868–879. doi:10.1016/j.neuroimage.2015.10.046.

[41] B.S. Oken, K.H. Chiappa, Statistical issues concerning computerized analysis of brainwave topography., Ann. Neurol. 19 (1986) 493–497. doi:10.1002/ana.410190511.

[42] B. Rossion, C. Jacques, Does physical interstimulus variance account for early electrophysiological face sensitive responses in the human brain? Ten lessons on the N170, Neuroimage. 39 (2008) 1959–1979.

[43] H.E. Schendan, G. Ganis, Electrophysiological potentials reveal cortical mechanisms for mental imagery, mental simulation, and grounded (embodied) cognition., Front. Psychol. 3 (2012) 329. doi:10.3389/fpsyg.2012.00329.

[44] M.D. Rugg, The effects of semantic priming and word repetition on event-related potentials., Psychophysiology. 22 (1985) 642–647.

[45] M. Mermillod, S. Droit-Volet, D. Devaux, A. Schaefer, N. Vermeulen, Are coarse scales sufficient for fast detection of visual threat?, Psychol. Sci. 21 (2010) 1429–37. doi:10.1177/0956797610381503.

[46] P. Vuilleumier, Y. Huang, Emotional Attention: Uncovering the Mechanisms of Affective Biases in Perception, Curr. Dir. Psychol. Sci. 18 (2009) 148–152. doi:10.1111/j.1467-8721.2009.01626.x.

[47] P.J. Whalen, J. Kagan, R.G. Cook, F.C. Davis, H. Kim, S. Polis, D.G. McLaren, L.H. Somerville, A.A. McLean, J.S. Maxwell, T. Johnstone, Human amygdala responsivity to masked fearful eye whites, Science (80-.). 306 (2004) 2061. doi:10.1126/science.1103617.

[48] K.E. Demos, W.M. Kelley, S.L. Ryan, F.C. Davis, P.J. Whalen, Human amygdala sensitivity to the pupil size of others., Cereb. Cortex. 18 (2008) 2729–34. doi:10.1093/cercor/bhn034.

Figure Legends

Figure 1. a) ERP waveforms plotted on the left anterior cluster for Asian and Caucasian stimuli. The left anterior cluster is shown because the N400 and P2 effects are maximal in this cluster. Amplitude in microvolts (μV) is on the *y* axis and time in milliseconds is on the *x* axis. b) Scalp maps of Caucasian-Asian difference scores of maximum peak amplitudes for the P2 (Map limits: -0.5/+0.5) and frontal N400 (Map limits: -0.8/0.8) time windows.

Figure 2. a) ERP waveforms plotted on the left posterior cluster for Asian and Caucasian stimuli. The left posterior cluster is shown to depict the centro-parietal N400. Amplitude in microvolts (μV) is on the *y* axis and time in milliseconds is on the *x* axis. b) Scalp map of Caucasian-Asian difference scores of maximum peak amplitudes for the N400 time windows in posterior sites (Map limits: -0.4/0.4).

Figure
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