

ERP Evidence for Cognitive Modulation of Face-Race Classification

Xun Zhu

Shihezi University Normal College
Shihezi University Psychological Application Research Center
Shihezi, China

Zehai Mao

Shihezi University Normal College
Shihezi University Psychological Application Research
Center
Shihezi, China

Jiao Chen

Shihezi University Normal College
Shihezi University Psychological Application Research
Center
Shihezi, China

Abstract—This paper explores the cognitive factors that can adjust the other-race classification advantage (ORCA). 26 Han people and Uygur ethnic people were selected to complete the event-related potential (ERP) experiment on different ethnic race classifications. In the experiment, the participants were required to classify a group of randomly selected target race faces to introduce cognitive factors into the task. Over the experiment, it is found that faces of non-target races can be classified faster. When the target race is inconsistent with the race of the participant, larger amplitude of P1 component can be observed. The components of N170 and thereafter are not regulated by cognitive needs, no matter which race of face is observed by the participant. The experimental result confirms the competition hypothesis of recognition/classification, predicting that the “race classification advantage” is driven by the different allocations of the processed resources rather than being decisive by the actual facial attributes.

Keywords—face classification; cognitive adjustment; ERP; race

I. INTRODUCTION

Studies have shown that people can more quickly and accurately identify the faces of their own race than other race of people. This phenomenon is known as the "Other Race Effect" (ORE, Messner & Brigham, 2001; Sporer, 2001). However, some researchers have come up with another idea, the "Other-race Classification Advantage" (ORCA). That is, people can classify the faces of other race of people more quickly. The phenomena reflected by those two effects are very obvious, but ORE has been extensively studied, while the ORCA has been paid less attention. In some literature and studies on the ORCA, two hypotheses are proposed. H1: people have initial classification marks on the faces of their race and other race when identifying faces of people; they are prone to getting the members who have faces of their race classified as subordinate level of individual (such as Bob, Joe), and classifying the members of other race on a racial level (e.g., Caucasian, Asian). Therefore, when the

level of classification is different races, participants will show a corresponding racial superiority (Bernstein, et al., 2007; Levin, 2000; MacLin & Malpass, 2003; Shutts & Kinzler, 2007; Caldara, Et al., 2004). The racial classification and individualized differences were supported by researches of Levin et al. (Levin, 2000). This research shows that people do not have any difference in ORE and ORCA, compared with the control group. H2: the personalization and classification process may interact with each other and are processed in the same mechanism (Gerlach, 2015). According to this view, the ORE of those two kinds of faces (identification and classification) reflects the competition in dealing with individual identities and classifying facial information. In other words, ORE and ORCA are mainly driven by the processing resources allocated in the identification process and classification process. This hypothesis is mainly supported by processing of secondary configuration, namely analyzing the characteristic relationships between partial structures within the contour of face (Zhao, 2011).

This study uses event-related potential (ERP) technology to deeply explain the internal brain mechanism of face recognition and classification. Most of the previous studies required the participants to judge whether the face given by the experiment belongs to a particular race (for example, whether it was the face of a Caucasian). In contrast, this experiment first showed the participants a specific race of face (target race, TR). This task requires the participant to classify whether a face is a target race of face, rather than judging whether a face is his/her race or not. In this way, the participant is required to match the target race instead of matching the participant's own race to manipulate the participant's cognitive process. If the ORCA is mainly driven by sensory information processing, the expected experimental result should be that different cognitive needs will not affect the brain mechanism. If the main internal cause of ORCA is driven by the competition in different processing resources allocated between the identification

process and the classification process, the experimental results of the ORCA may show that there is significant difference between the target race and the tested race.

In this study, two races with small differences in skin color but different facial details were selected as the participants to further reduce the effect of skin color on racial face classification. Bar-Haim (2009) mentioned in his study that skin color plays an important role in race classification;

but the effect is relatively small in face recognition, and skin color may increase the allocation processing of facial features or resources. Uyghur ethnic people live in western China and are mixed race of 55% Western European and 45% Eastern European subsistence (Liu, 2015). In China, their skin color is not significantly different from that of the Han people, but the structural features of their faces are very distinctive (see "Fig. 1").



Fig. 1. Comparison of the average faces of Han people and Uyghur ethnic people.

II. METHOD

A. Participants

The participants in this experiment was composed of 16 Han ethnic college students (8 female students, 8 male students, with ages ranging from 18 to 27; average age: 19 years old) and 17 Uyghur ethnic college students (9 female students, 8 male students, with ages ranging from 18 to 21 years old; average age: 20.5 years old. All participants were voluntary to participate in this experiment and signed an informed consent. All participants had not been diagnosed as having neurological or psychiatric diseases, and were given certain experimental reward after ending the experiment. Among all the participants in the experiment, the experimental data of 3 Han ethnic participants and 4 Uyghur ethnic participants showed that they were not fully involved in the task because of their eye tracking data (total fixed time <25%), and thus was not incorporated into the data analysis.

B. Experimental Design

This study adopts a 2*2 two-factor experimental design; the independent variables are the target race (it decides whether a face is the face of Han people or Uyghur people) and the presented race (it is a processed picture presented to the participant and containing more than one face of Han people or Uyghur people); and the dependent variables are the behavior data (reaction time) and ERP data (P1, N1, P2) of the participant.

C. Experimental Procedures

First, participant was asked to take part in and complete a short experimental task in a well-lit, sound-proof room, to get familiar with the entire experimental process flow and ensure that the experiment can be completed without errors. After completing the task, wear an electrode cap on the participant, and ask the participant to sit 80 cm away from

the screen. The experimental materials are the previously processed average faces of Uyghur people and Han people. All faces are presented at a ratio of 3:4 on the center of a 19-inch display screen. There are a total of 60 trials for the experimental stimulation and a 5-min break time in the middle of the task. In each trial, the following steps should done: first let the participant watch the average face of a Uyghur people or the average face of a Han people ("target race") for 10 s, then randomly select a synthetic face (the average face of the same gender), and ask the participant to determine whether the presented face is the same as the previously presented target face. There are three feedback buttons (number keys 1 — the same, 2 — not sure, 3 — different). The picture of each stimulating face will be presented for 1500ms, and the participant is required to make a judgment as soon as possible within the 1500ms. If the participant does not give respond within 1500ms, the next trial will be entered still. There is a 500ms time interval between each stimulating face. At the same time, the SMI RED 500 system was used to track the remote contactless eye movement data of participant during the experiment.

D. ERP Records and Analysis

Electrophysiological signals were recorded by using the Neuro Scan ERP record and analysis system, the 64-electrode cap recording EEG extended by the International 10-20 system, and a high-resolution NuAmps 2 amplifier. The impedance in the experimental record is maintained below 5 k, and the A/D sampling frequency is set to 1000 Hz. Offline processing was performed by using a Curry Neuroimaging Suit (version 7.07, Compumedics Neuroscan Ltd, USA) and baseline correction method; the filtration between 0.5 and 30 Hz is conducted by using a digital filter. Continuous EEGs are recorded from the 100 ms before the stimulation until the 500 ms after the stimulation. All experimental data generated by eye movements not within the required scope of the experiment, or by any other technical problems are excluded and not incorporated in the

analysis. In order to obtain more complete ERPs data, the EEG data of all valid trials were analyzed based on the 100 ms before stimulation.

Consistent with most previous studies, this study focuses on analyzing the N170 (the electrode at lateral temporal part (P8, PO8) of the electrodes (P7, PO7) at the right temporal part of brain, and the homologous regions (P7, PO7) and (P8, PO8) of the left hemisphere of brain). The peak analysis is mainly concentrated in three partial bands: P1 (up to approximately 115 ms), N170 (up to approximately 170 ms), and P2 (up to approximately 235 ms). The peak amplitude and delay at the electrodes (P7, PO7) and (P8, PO8) are measured in a 50 ms window centered on the time over 50 ms. Although there are 7 faces with different proportions of facial deformation, in order to simplify the ERP analysis, they are divided into three types: face of Han people (including at least 70% of the face of Han people) and face of Uyghur people (including at least 70% of the face of Uyghur people), face of mixed races (all others). Spss22.0 is used for analyzing the repeated measurement variance of four factors (left/right hemisphere of brain, race of the

participant, target race, race of the presented face). In order to highlight the impact, it also analyzes the repeated measurement variance of three factors (race of the participant, target race, race of the presented face).

III. EXPERIMENTAL RESULTS

By preliminary analysis, it is shown that the gender of the participant and the gender of the face presented have not significant influence on the experimental result. Therefore, those two factors are excluded from further analysis.

A. Behavior Results

Compared with the target face (average: 757 ms), both Uyghur and Han participants were able to fast classify the non-target faces (average 693 ms), $F(1, 6) = 6.81, p < 0.001$. There was no significant difference between the faces of the participant race and target race. The main effect of the target race has a significant effect, $F(1, 2) = 4.12, p = 0.044$, but the main effect of the participant race is still not significant (see "Fig. 2").

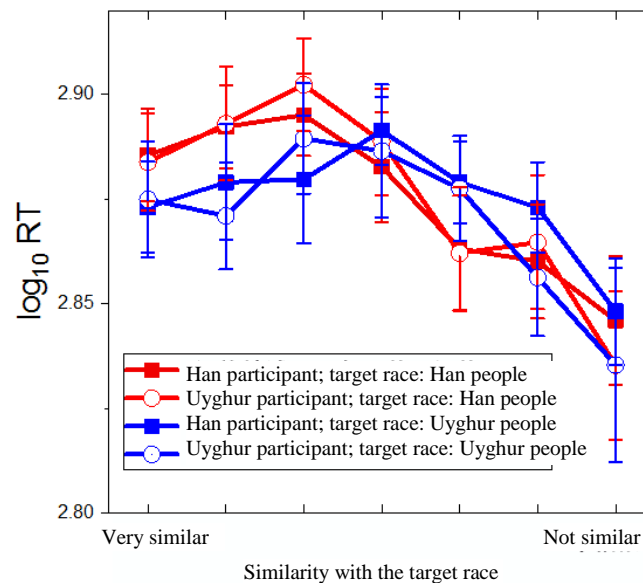


Fig. 2. Time difference diagram of different participants' classification on different tasks.

B. ERP Amplitude

In terms of the participant race and target race, no significant effects were observed on the waveforms of the components P1 and N170.

1) P1: The P1 waveforms in the analysis of the variances of the left and right hemispheres of brain are significantly different; and there is a larger amplitude appearing on the electrodes in the right hemisphere of brain, $F(1, 24) = 21.3, p < 0.001$. No other significant interaction effect was found in the experimental results. The double interaction between the left and right hemispheres of brain and the participants' race, $F(1, 24) = 4.12, p = 0.053$. The triple interaction among the

left and right hemispheres of brain, the target race, and the participants' race, $F(1, 24) = 2.975, p = 0.097$ has significant margins ($p < 0.10$). Over an analysis on the repeated measurement variance of three factors (the participants' race, the target race, and the presented race), the result shows that the main effect margin of the right hemisphere of brain is significant, $F(1, 24) = 3.022, p = 0.095$. Importantly, the interaction between the target race and the participants' race, $F(1, 24) = 3.954, p = 0.058$, reflects that participants of the two races both had a more positive P1 amplitude response on the face of other race (see "Fig. 3").

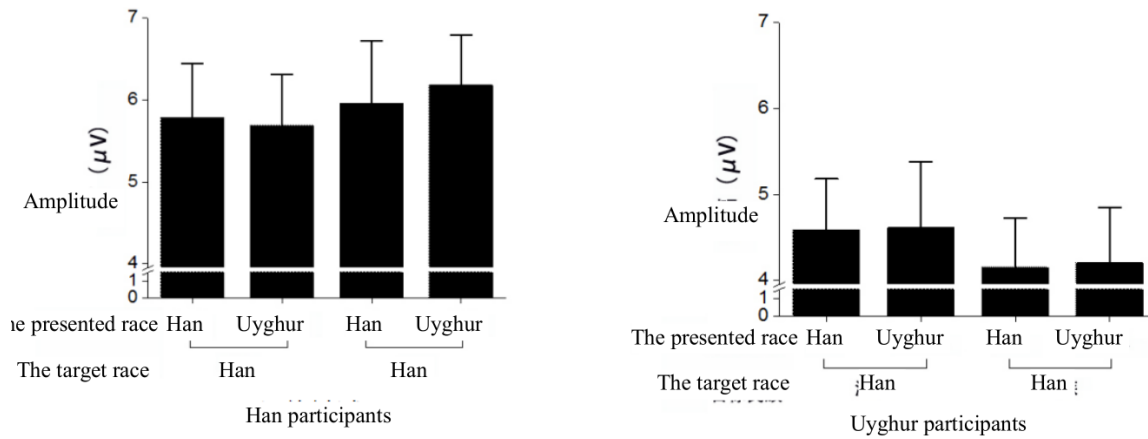


Fig. 3. Comparison of different participants' P1 wave amplitude response on different classification tasks (at P8).

2) *N170*: The analysis results of multi-factor variance on the P1 amplitude does not reveal significant main effects (all *F*s are greater than 0.1), and significant differences are observed in the left and right hemispheres of brain and the presented races, $F(1, 24) = 5.013, p=0.035$. In the right hemisphere of brain, there is a main effect of significant margin in terms of the race of the presented picture, $F(1, 24) = 3.503, p=0.074$. Both the Han and Uyghur participants' recognition on the face of Uyghur people reflect a U170 negative wave with larger amplitude, while the left hemisphere of brain does not have corresponding significant effect and all *F*s were greater than 0.2.

3) *P2*: By analyzing the repeated measurement variance of multiple factors, the result shows that the main effect of component P1 at the left and right hemispheres of brain is significant, $F(1, 24) = 9.413, p=0.005$; and the amplitude of the electrode on the right hemisphere of brain is larger. The interaction between the left and right hemispheres of brain and the participants' race is significant, $F(1, 24) = 6.150, p=0.021$. On the component P2, the right hemisphere of brain of Uyghur participants shows a more significant positive wave, $F(1, 24) = 4.920, p=0.036$. Other than that, no other significant difference was found (see "Fig. 4").

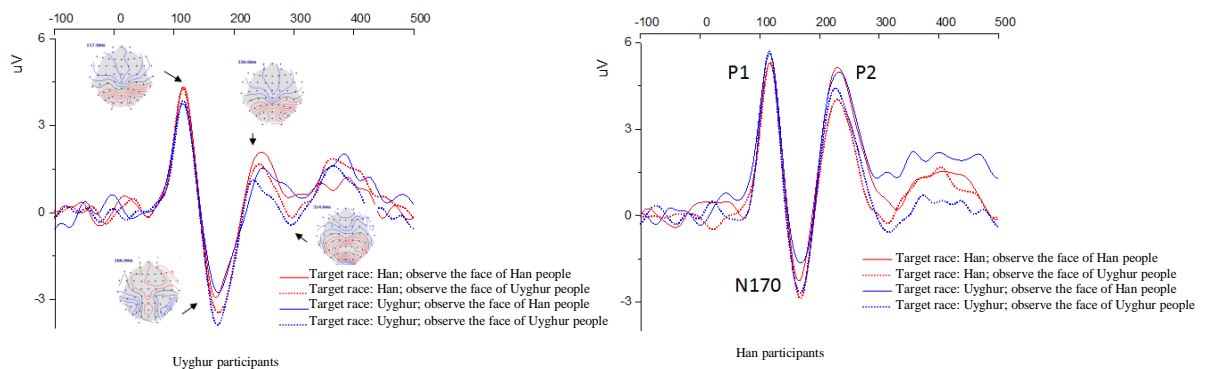


Fig. 4. Time course diagram of the processing of different ethnic faces at electrode P8.

IV. DISCUSSION

This study explores the role of cognitive needs in the classification of ethnic faces, and found that non-target faces can be classified faster. More importantly, when the face of the target race is not the race of the participant, a larger P1 positive wave can be observed. In addition, regardless of the face actually seen by the participant, the N170 and later components are not regulated by cognitive needs. In general, the experimental result confirms the recognition/classification competition hypothesis. It is predicted that ORE and ORCA are driven by the processing resources allocated and are not decided by the actual facial

attributes. This result was found in the early visual component P1 of ERP.

The behavior result shows that both Han and Uyghur participants can distinguish non-target faces from the target faces more quickly. The results of response time show that the interaction between the participants' race and the presented race is not obvious. When the faces of the participants' race were slightly synthesized with some other ethnic faces (other ethnic faces accounted for 30%), the participants' response time is significantly longer. This conclusion is consistent with the results of previous studies. Zhao & Bentin (2011) found that when the overall structure or local features of people's faces were changed, the

"interracial classification advantage" of the faces would be significantly enhanced. This result indicates that there will be some delay in the processing of the changed native face, but there will be no delay in processing the changed face of other race. They believe that this experimental phenomenon also proves that configuration analysis is applied in face recognition and is also the source of the ORCA in racial face recognition.

The experimental record shows the ERP components in different stages of face classification recognition.

P1 (also known as P100 in some studies) is a peak EEG 100 ms after a stimulation. This component is mainly sourced from the electrodes in the posterior region of brain (Di Russo et al., 2002).

N1 (also known as N170 in some studies) is a negative wave from the posterior electrode of brain and reaches its maximum peak between 130ms and 200ms. The distribution and waveform characteristics of this component have large relation with the nature of the presented visual material (Bentin, McCarthy, Perez, Puce, & Allison, 1996).

P2 (after N2), is found on the occipital lobe and temporal lobe of brain. Compared with the face of other race, P2 will produce larger amplitude for the face of native race (Stahl et al. 2010). Some studies also found that the amplitude of P2 is significantly reduced due to racial effects (Stahl et al. 2008), so this may reflect the typicality of a particular face. P2 is also related to the so-called second-order configuration processing; that is, it is related to the distance between the internal features of the faces (Latinus & Taylor 2006).

N250 is discovered after P2. For its own race, P2 produces larger amplitude of negative wave for faces of other races (Stahl et al. 2010). Although the N250 also reflects the process of face learning (Tanaka et al. 2006; Kaufmann et al. 2009), the subsequent studies made by Tanaka and Pierce (2009) showed that the N250 only increases the individualization of face recognition, without training on classification for the faces of other races. This suggests that face classification recognition of different races should be mainly related to the first previously mentioned ERP components.

In some studies, the P1 component mentioned visual ability has larger amplitude for the face picture than for the object picture. (e.g., Eimer, 1998; Goffaux, Gauthier, & Rossion, 2003; Herrmann, Ehlis, Muehlberger, & Fallgatter, 2005; Itier & Taylor, 2004a, 2004b). Despite the evidences from fMRI studies, P1 amplitude is associated with the facial sensitive nerve activation in the occipital cortex below the right hemisphere of brain (Sadeh, Podlipsky, Zhdanov, & Yovel, 2010). In addition, the race-related intra-brain studies made on patients with epilepsy have shown that relevant electrophysiological evidence can still be observed in the ventral region of brain from the 100 ms after receiving the visual material stimulation from face and object images (Liu, Agam, Madsen, & Kreiman, 2009). Therefore, some researchers believe that this is caused by low-level visual clues and has nothing to do with the specific perception of human ethnic faces (Rossion, 2011). Most studies have

shown that visual P1 component can be regulated by attention and may reflect the distribution of attention on specific regions or target stimuli. Over this study, it is found that if a face does not belong to the participants' race, then the participants of both races showed higher P1 amplitude when being asked to classify the face. That is to say, if a face is the face of the participant's race, the participant may pay more attention to processing other tasks when being asked to distinguish whether the face is the face of his/her native race. Since the visual P1 component is mainly related to the processing of low-level visual information, rather than dealing with the specific internal structure of the face, the racial effect, especially the "interracial classification advantage", may not be affected by what kind of face actually seen. It is controlled by the top-down process of processing resource allocation. The results of the ERP study showed that when participants were asked to distinguish faces that were not their own race, the participants may allocate more processing resources to the face that was not their own race. So, this phenomenon supports the experimental hypothesis, namely the main driving force for ORE and ORCA may be the competition between processing individual face characteristics and distinguishing whether the face is their own race.

For N170, the experimental results showed that the amplitude of the two races of participants toward the Uyghur face U170 is greater. The interaction between the races of the participants and the race of face to be distinguished was not significant. Many studies have mentioned that a larger negative wave may appear when people are stimulated by other race of faces than their own race of faces (Herrmann et al. 2005; Gajewski et al. 2008; Walker et al. 2008; Caharel et al. 2011; Wiese 2012). Some researchers believe that this is just a low-level visual stimuli (such as brightness or contrast), and not caused by the differences in different races (Vizioli, Foreman, et al. 2010; Vizioli, Rousselet, et al. 2010). When the participants watched the Uyghur face, the N170 in ERP component showed a larger negative wave. The results at the time of the reaction showed that participants of the two races both need a shorter time to judge a Uyghur face. Based on those experimental results, it is believed that for the processing, the internal structure of a Uyghur face may be more complicated; so when distinguishing whether a face structure is the native race or not, it will lead to a larger N170 amplitude and faster reaction time. This is consistent with previous studies. The higher the complexity is, the more difficult it is to identify, but it reduces the difficulty for classification (Gerlach, 2015). In the racial classification experiment task, the N170 component also shows that when people classify the target faces, they may not be affected by the specific information of the face itself.

V. CONCLUSION

To sum up, current studies show that cognitive need may have influence on the facial classification process, more on the attention or processing resource allocation level (reflected in the P1 component), rather than on stimulation processing level of the face itself (such as the N170 component). This indicates that ORCA is more likely to be

driven by the competition for resource allocations between classification and identification, rather than being driven by the classification process prior to identification. One of the shortcomings of the study is that, just as Woodman (2010) pointed out, the P1 component should be measured by 300-1000 valid trials; and in this study, the number of trials is small. In terms of the experimental results, it is only available to observe the significant effect of the margin. Therefore, in order to get more accurate and effective experimental result, it is necessary to carry out a deeper study on the relevant experiments.

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