Event-related potentials and time course of the 'other-race' face classification advantage

Roberto Caldara,[CA] Bruno Rossion,[1] Pierre Bovet and Claude-Alain Hauert

Faculté de Psychologie et des Sciences de l'Education, University of Geneva, 40, bd du Pont d'Arve, 1211 Geneva 4, Switzerland; [1]Unité de Neurosciences Cognitive et Laboratoire de Neurophysiologie, Université de Louvain, Belgium

[CA]Corresponding Author: roberto.caldara@pse.unige.ch

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Other-race faces are less accurately recognized than same race faces but classified faster by race. Using event-related potentials (ERPs), we captured the brain temporal dynamics of face classification by race processing performed by 12 Caucasian participants. As expected, participants were faster to classify by race Asian than Caucasian faces. ERPs results identified the occurrence of the other-race face classification advantage at around 240 ms, in a stage related to the processing of visual information at the semantic level. The elaboration of individual face structural representation, reflected in the N170 face-sensitive component, was insufficient to achieve this process. Altogether, these findings suggest that the lesser experience of other-race faces engender fewer semantic representations, which in turn accelerate their speed of processing. *NeuroReport* 15:905–910 © 2004 Lippincott Williams & Wilkins.

Key words: Event-related potentials; Face processing; Other-race effect; N170; Temporal segmentation

INTRODUCTION

Human adults are significantly more accurate at recognizing individuals of their own race than those of another race (the other-race effect; for a recent review see [1]). More recently, it has been shown that other-race (OR) faces are faster classified by race than same race (SR) faces [2,3]. Two hypotheses of the OR face classification advantage have been proposed in the literature. First, this advantage was explained in a theoretical framework: the face multidimensional space [2]. A small number of OR face exemplars are located in a high-density space compared to a large number of exemplars of SR faces. This particular representation of OR faces would produce a stronger activation that results in a faster classification. According to an alternative hypothesis, visual information indicating the race of OR faces is coded as a feature [3] and, as in pop-out studies, results in a faster detection and classification for those faces. Interestingly, these two hypotheses about the OR face classification advantage, involve qualitative differences in the stages of processing [2–4].

The present study was designed to explore and clarify this issue by investigating the cerebral dynamics of face classification by race, using event-related potentials (ERPs). Numerous ERP studies of face processing have reported an N170 component located at posterior temporal sites, peaking maximally between 150 and 180 ms following the presentation of faces and with a lower amplitude for non-face objects [5–9]. The N170 component is not influenced by face familiarity [8,10,11] (but see [12]) and it has been suggested that it represents a stage of processing allowing the elaboration of individual face structural representation [6,8,11]. We recently investigated the other-race effect using ERPs with a face passive viewing paradigm [7]. We found that the N170 was not sensitive to the race of the faces. However, the activity over medial occipital electrodes was larger for OR compared to SR faces, reflecting attentional processes associated to the relatively stronger unfamiliarity for OR faces rather than race detection through a face feature-positive [7]. Nevertheless, it is not yet established whether this activity, as well as the N170 component, can be modulated for the human within-face category class of stimuli when active paradigms involving the use of racial face-specific diagnostic information are used. Given these observations, the face multidimensional space representation hypothesis [2] would suggest a differential processing of SR and OR faces taking place after the construction of an individual face representation, i.e. after the N170. In contrast, the racial-feature coding hypothesis [3] postulates a faster detection of a racial-feature in the earlier stages of processing, and subsequent changes of face processing. Here we directly tested these hypotheses using ERPs while the participants performed a face classification by race task. The recorded brain electrical activity was submitted to classical waveforms analysis on selected electrodes coupled with recent data-driven spatiotemporal analysis that use the configuration of the electric field to define stable periods of functional processing [7,13–16].

MATERIALS AND METHODS

Subjects: Twelve right-handed Caucasian university students (six female, aged 18–30 years; mean 24.5 years) with normal or corrected-to-normal vision voluntarily participated in the study, which was conducted with the understanding and consent of each participant. None of the participants knew more than one Asian person at the individual level, namely their name and their associated semantic information (such as the age and the profession).

Stimuli and procedure: Participants were seated in a dimly lit, sound-attenuated electrically shielded room. A computer monitor was placed at a distance of 120 cm from the participants. Stimuli were composed by 288 greyscale photographs of Caucasian (72 male, 72 female) and Asian faces (72 male, 72 female) digitally scanned from a college yearbook. Male faces were clean-shaven and none had particular distinctive features. All images showed a frontal view, with eyes aligned on the horizontal midline of the image, and occupied a visual angle of $3.75 \times 4.25°$. Stimuli were randomly interspersed and sequentially presented for 100 ms at the center of the computer screen, with an interstimulus interval varying at random between 2500 and 3500 ms. Randomly, in 29% of the trials (n=48) and equally for both face races, 200 ms after the stimulus offset three question marks appeared on the center of the computer screen. Subjects were required to classify by race the previously seen face as quickly as possible by pressing the corresponding labelled key (Asian or Caucasian) of a two-key bottom box. The position of the labels was counterbalanced across subjects. These verification trials were excluded for ERPs analysis and were taken into account only for the behavioural performance. Two experimental sessions were conducted with 144 images each, with an equal number of Asian and Caucasian faces (n=72) and an equal number of verification trials (n=24) for each race.

Behavioural analysis: Mean reaction time for each participant was calculated for both face races from the verification trials. These measures were statistically compared using a two-tailed paired t-test.

ERP recordings and analysis: EEG was continuously recorded from 62 channel Ag/Ag Cl electrodes with a sampling rate of 500 Hz (band pass 0.15–70 Hz). Sixty of these were embedded in an elasticized cap montage (Easy-Cap, FMS, München, Germany), arranged according the International 10-20 system. An electrode was placed on the tip of the nose and used as a common reference for all the cap electrodes. Ocular artefacts were recorded and monitored by using bipolar electrodes on the outer canthus of each eye, and vertical EOG was recorded from bipolar electrodes placed above and below the dominant eye. Vertical blinks were corrected off-line by an automatic algorithm (Scan 4.2, Neuroscan Inc., USA). Electrode impedances were kept under 5 kΩ. The recorded signal was low-pass filtered at 30 Hz and rescaled across the average reference. EEG epochs extended from 200 ms before to 700 ms after stimulus onset and were baseline corrected to the first 200 ms. Finally, all the epochs were carefully scanned and remaining artefacts were rejected before averaged to individual ERPs and grand-means.

Data were subjected to two independent analyses procedures consisting of (1) ERP waveform analysis and (2) analysis of ERP map topography. First, N170 components elicited by Asian and Caucasian faces were compared by analyzing ERP peak amplitudes and peak latencies at P7/PO7 and P8/PO8 electrode sites between 140 and 200 ms post stimulus. A repeated measures ANOVA, using Greenhouse-Geisser adjusted degrees of freedom, was performed with race of the face (Caucasian *vs* Asian), electrode site (P *vs* PO) and hemisphere (left *vs* right) as factors in order to test for race-specific activation patterns. In order to investigate the other-race effect related to our previous findings, a repeated measures ANOVA was separately performed over medial occipital electrodes with the race of the faces (Caucasian *vs* Asian) and electrode site (O1, OZ *vs* O2) as factors.

Second, grand-mean ERP map series were submitted to a spatiotemporal segmentation procedure in order to define stable scalp electric field configurations, namely segment maps, each hypothesized to represent information processing of the brain by functional microstates [15,16]. Usually, periods of map stability are represented by high values of the global field power (GFP; the spatial standard deviation of the map's potential distribution) and low values of the global map dissimilarity (GMD; the square root of the mean of the squared differences) which is a measure inversely related to the spatial correlation coefficient between two successive maps (Fig. 1; for additional methodological details see [7,15]). Spatiotemporal segment maps and their time of occurrence were defined in the grand-mean ERP map series using a clustering procedure that determines the optimal number of maps [17]. The specificity of each topography for a given condition was assessed by calculating, in each individual subject, the spatial correlation coefficients between a given segment map and the successive ERP maps of both condition in the corresponding time intervals. This fitting procedure was conducted in order to assess how well a given segment map explains a given condition (goodness of fit=best explained variance). The ERP map fitting procedure described above also provides information about the time at which a given segment map is best represented (time point of best explained variance). The latter index may be considered as a peak value in terms of the electrical scalp topography distribution and was used to reveal differences in timing. Consequently, best explained variances and their time points of occurrence were compared for each segment map between conditions using two-tailed paired t-tests.

RESULTS

Behavioural results: Asian faces (mean 539 ms) were classified faster by race than Caucasian faces (mean 571 ms; t=3.63, $p < 0.01$).

ERPs: Figure 2 shows the time course of face classification by race processing on the N170 temporal electrode sites (P7/PO7 and P8/PO8) as well as in the medial occipital area (O1, OZ and O2). No significant differences were found between the N170 evoked by SR and OR faces ($F(1,11)=0.126$, $p=0.728$) and there were no significant interactions involving the race of the faces as a factor. The N170 was larger on the right than the left hemisphere ($F(1,11)=4.99$, $p=0.047$)

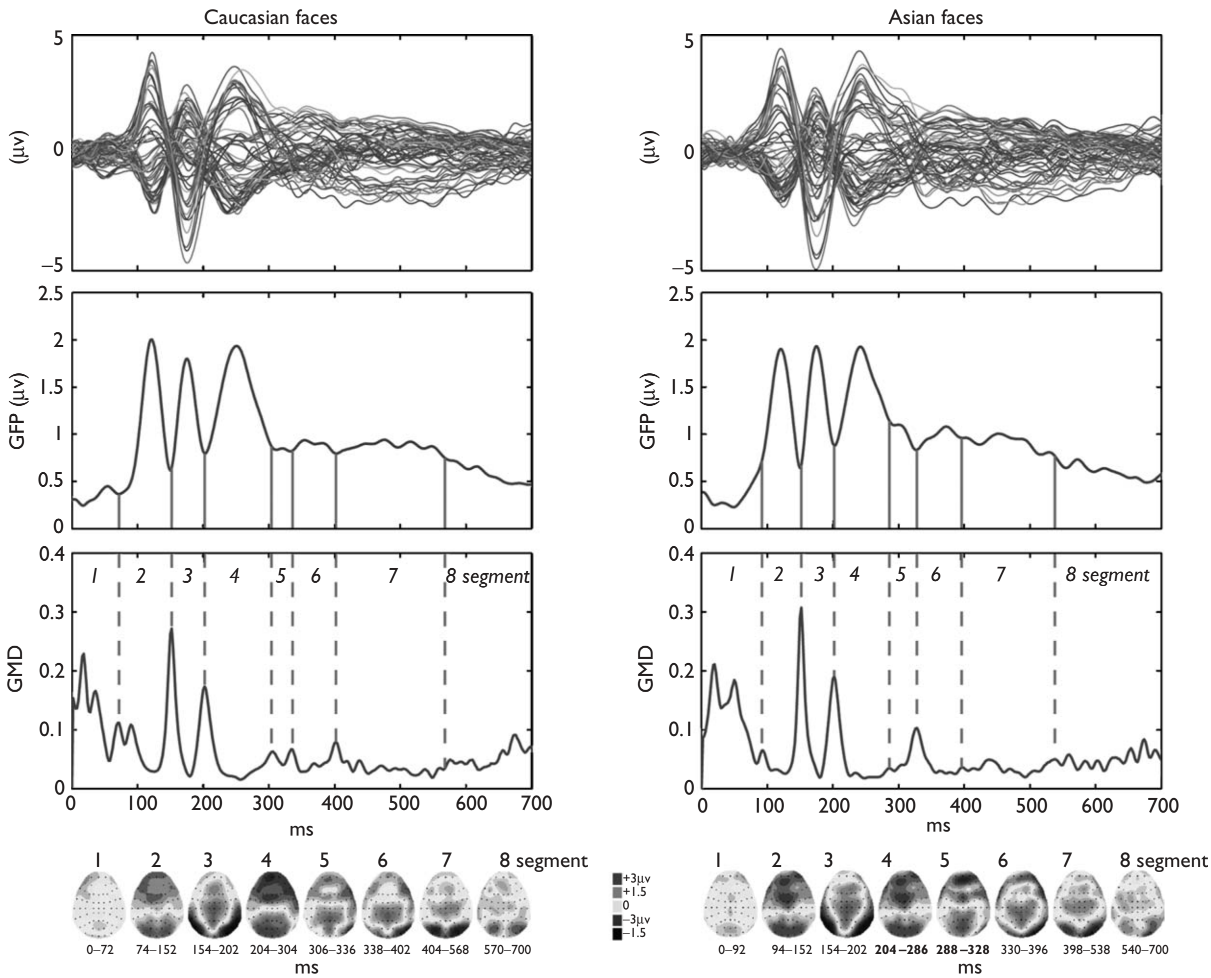

Fig. 1. First row: Grand-averaged ERP waveforms of all the electrode channels for Caucasians (left side) and Asian (right side) face conditions. Second row: The global field power (GFP) is the spatial standard deviation calculated over the time on the signal recorded on all electrode channels. Third row: The global map dissimilarity (GMD) is the square root of the mean of the squared differences between two successive maps. Segment periods (1–8) defined by the spatiotemporal segmentation procedure are displayed with vertical bars. Usually, low values of the GFP are accompanied by high values of the GMD and correspond to segment borders defining periods of map stability. Fourth row: Segment maps as defined by spatiotemporal segmentation of the grand-mean ERPs. Maps are represented in order of appearance (from left to right) for each condition separately. All maps are rescaled against the average reference. The maps are viewed from the top, with the nose up and the left ear left. Their onsets and offsets are given below. Note that maps of overlapping time periods are very similar in topography between conditions. Significant differences based on the time point of best explained variance analysis are highlighted in bold. These effects mark an advantage in the time course appearance of Asian compared to Caucasian maps occurring in similar time periods.

and on the parietal than on the parieto-occipital electrode site ($F(1,11)=7.81$, $p=0.017$). Regarding its latency, the N170 peaked earlier on the right compared to the left hemisphere ($F(1,11)=9.55$, $p=0.013$) and no statistical significant differences were found for the race of the faces. At medial occipital sites, no statistically significant differences were found for the race of the faces as a factor ($F(1,11)=0.002$, $p=0.962$), as well as in its interaction ($F(1.19,13.14)=1.51$, $p=0.245$).

Figure 1 illustrates the grand-mean signal on all of the electrodes for each condition as well as the GFP (=map strength) and the GMD over time. The borders of the eight stable functional microstates, namely segment maps (labelled with numbers), identified by the spatiotemporal segmentation analysis and their topography are also reported. Visual inspection of these topographies suggests a high similarity in the electrical configuration of both conditions for the maps occurring in similar time periods. This observation was statistically confirmed by the fitting procedure. As shown in Table 1, statistical analysis on the best explained variance showed that none of the maps' topography was specific to one condition. However, differences in the time course of such functional stages of processing were revealed by statistical analysis based on the time point of best explained variance (Table 2). Segments 4 (linked to the third peak of the GFP) and 5 occurred faster for the Asian rather than the Caucasian condition. Visual inspection of the waveforms revealed that this event is related to a component located on the POZ electrode (Fig. 3). Two separate two-tailed paired *t*-tests performed on the peaks' occurrence of the GFP and the POZ electrode, in the time window defined by the segmentation analysis, confirmed this observation. Processing of Asian faces (mean 239 ms) was about 13 ms faster than processing of Caucasian

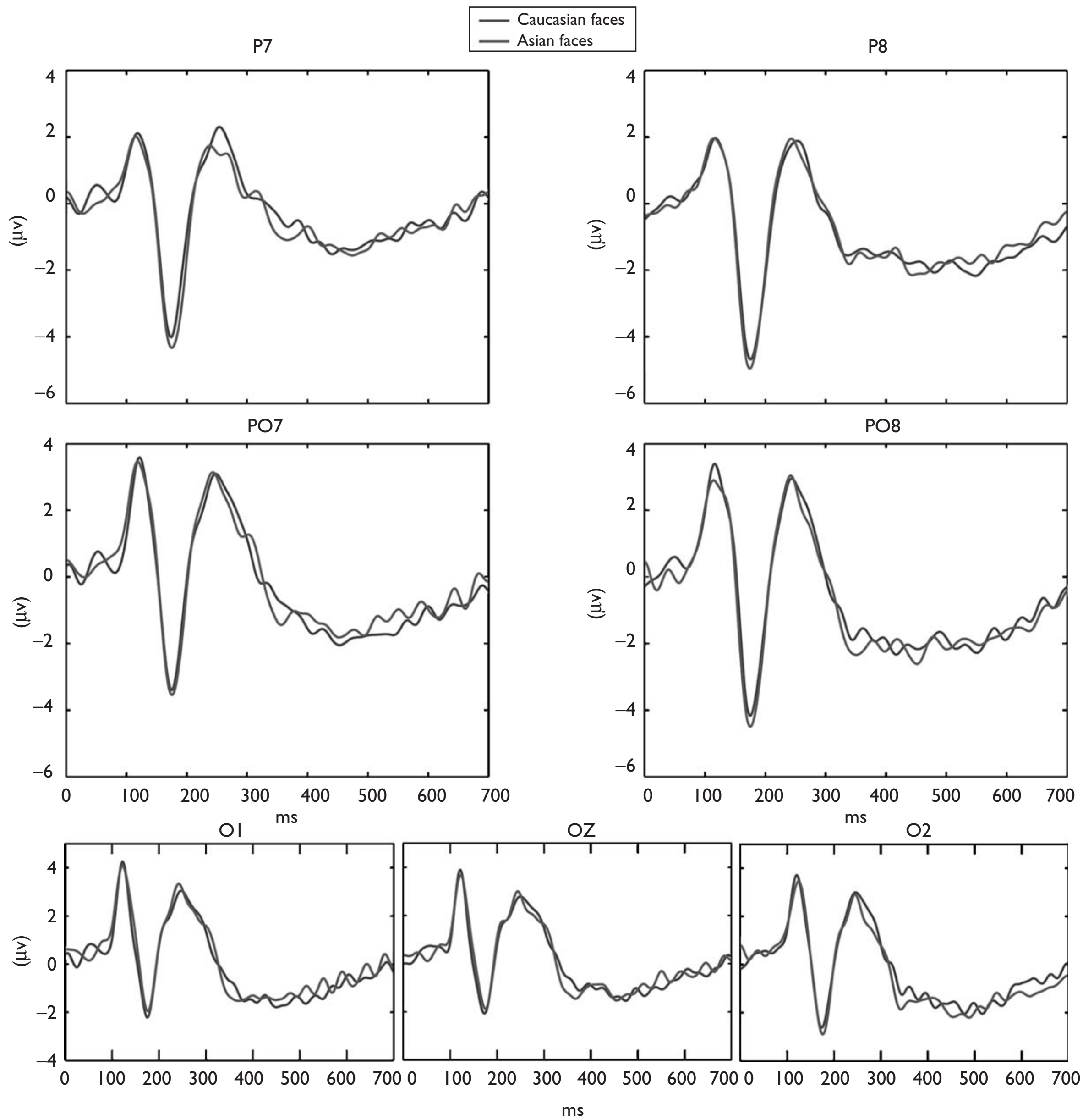

Fig. 2. Top and middle: Grand-averaged ERP waveforms recorded at lateral temporo-occipital electrodes (P7/8 and PO7/8) in response to Caucasian and Asian faces. Bottom: Grand-averaged ERP waveforms recorded over central occipital electrodes (O1, OZ and O2). Positive values are up.

Table 1. *t* and *p*-values for the comparisons on the best explained variance indexes (%).

	Segments							
	1	2	3	4	5	6	7	8
Caucasian faces	40.46	86.96	68.96	77.62	53.08	57.59	59.06	46.10
Asian faces	44.70	83.14	70.74	74.34	45.06	45.55	55.03	37.51
t	−0.496	1.603	−0.237	−0.860	1.028	1.700	0.640	1.566
p	0.630	0.137	0.817	0.408	0.326	0.117	0.535	0.146

Two-tailed *t*-tests were performed segment by segment (1–8) on the best explained variance for Caucasian and Asian face conditions. No significant differences were found.

faces (mean=252 ms; t=2.51, $p<0.05$) on the GFP, as well as on the POZ electrode (mean Asian 237 ms; mean Caucasian 250 ms; t=2.21, $p<0.05$). No significant differences were found for the amplitudes.

DISCUSSION

Behavioural results corroborated an OR face classification advantage [2,3]: Caucasian participants classified Asian faces by race faster than Caucasian faces. Regarding the

Table 2. *t* and *p*-values for the comparisons on time points of the best explained variance (ms).

	Segment							
	1	2	3	4	5	6	7	8
Caucasian faces	78	126	177	246	326	370	468	616
Asian faces	60	129	175	236	300	382	488	601
t	0.996	−0.568	0.328	−2.671	−4.563	−0.845	−0.770	0.704
p	0.340	0.581	0.748	**0.022**	< **0.001**	0.416	0.457	0.496

Two-tailed *t*-tests were performed segment by segment (1–8) on the best explained variance for Caucasian and Asian face conditions. Significant effects are indicated in bold.

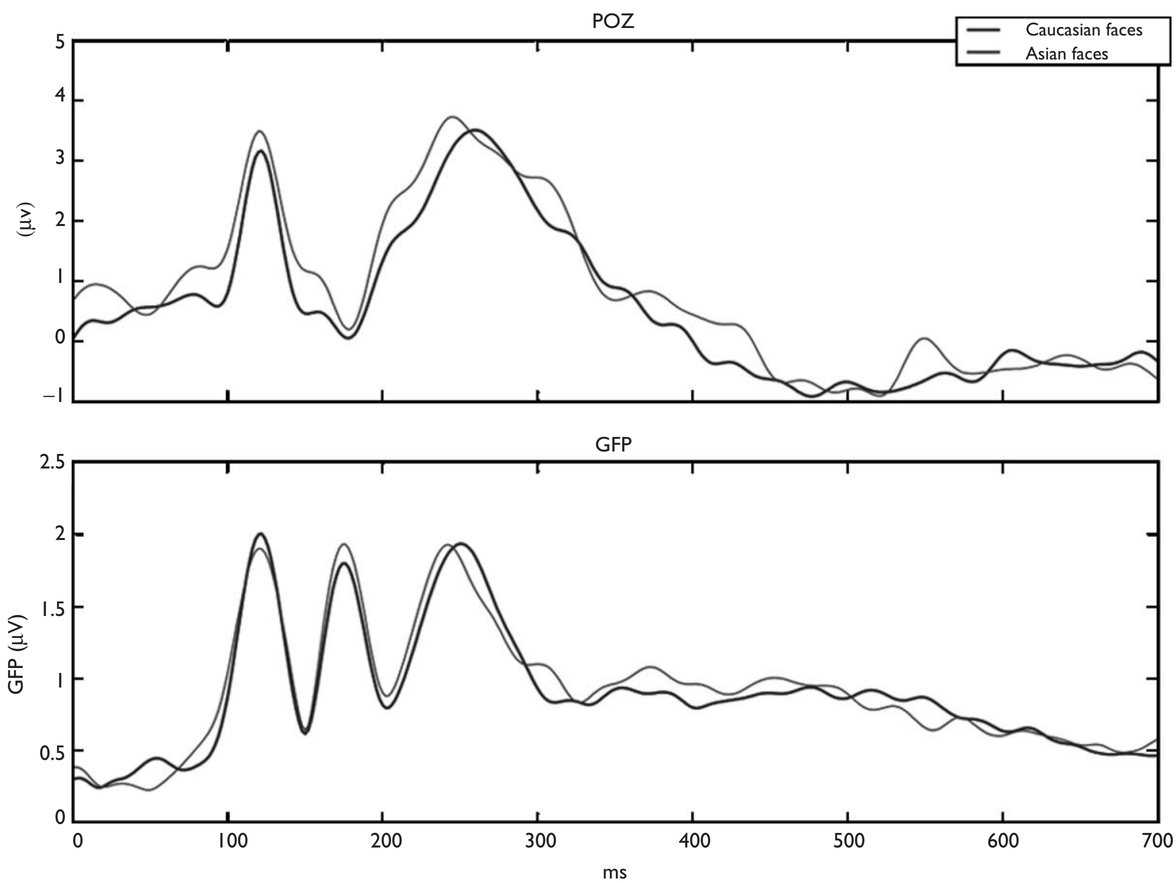

Fig. 3. Top: Grand-averaged ERP waveforms recorded at the central parieto-occipital electrode (POZ). Bottom: The Global Field Power for the Caucasian and Asian conditions. Note the time course synchronisation between the peaks of the GFP and the waveforms on the POZ electrode.

time course of face classification by race processing, three important results were established.

First, analysis based on segmentation analysis allowed the identification of differences in the temporal dynamics of the face classification by race. Asian faces were processed about 20 ms faster in segments 4 and 5. This advantage started around 240 ms and was identified in the time course of the GFP as well as in peak latency of the component located in the POZ electrode. This segment, that follows the structural encoding stage of the N170 component [6,8,11], seems to be related to the activation of the visually derived semantic information from images (faces and non-face objects) [7]. However, contrary to our previous results [7], GFP peaks showed that Asian faces were faster processed than Caucasian faces. Of particular interest, in an influential functional model of face recognition [18], identification of the race of the face, as well as gender and age, occurs at this stage of processing. Regarding the component located at the POZ electrode, its topography [10] and latency [19] suggests that it might be related to the P2 or the P250 [20] components, involved in more integrative stages of face processing [10] and changes in facial configuration [19,20]. However, in regard of all these findings, a clear-cut functional role of these components, and their relationship with the semantic level, can not yet be drawn. In addition, segment topographies were identical across the time course for both conditions and indicate that face classification by race processing involves the same functional pathways regardless of race.

Second, the N170 component was not sensitive to the race of the faces, even if active paradigms are used. Asian and Caucasian face features are approximately located in the same spatial configuration and drive a similar response at the level of the N170 component. This result reinforces the idea that the N170 component is not modulated by the level of visual experience within the class of human faces [7] and posit this component as a component that is sensitive to structural representation of facial configuration [6,8,9,11]. Finally, the previous ERP other-race effect [7], namely a stronger medial occipital activity for OR faces, was not replicated. This result suggests that the previous activity associated to other-race faces was task-related [7] and reinforces our previous interpretation in terms of attentional modulations. Altogether, our findings do not support the feature-positive explanation [3]. This hypothesis assumed a faster detection of the visual cue coding the racial information and predicted a difference in the following stage of processing for OR and SR faces. Our ERP data do not support neither the first nor the second of these assumptions. The OR face classification advantage takes place after the construction of an individual representation reflected by the N170 component. This findings are rather in favour of an exemplary density explanation [2] or a more elaborate processing based on the activation of the visually derived semantic information [7,18]. In fact, classification of OR faces might take less processing time in this stage, because such faces evoke lesser semantic representations due to the weaker experience that we have for OR faces.

CONCLUSION

The other-race face classification advantage was identified in stages of face processing related on the activation of the visually derived semantic information. This pattern of results is in line with Bruce and Young's [18] functional model of face recognition as well as a theoretical face multidimensional space representation proposed by Valentine [2]. Thus, the present ERPs study demonstrates that the simple extraction and integration of the face features are not sufficient to achieve the face classification by race, a process that requires semantic mechanisms to be completed.

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