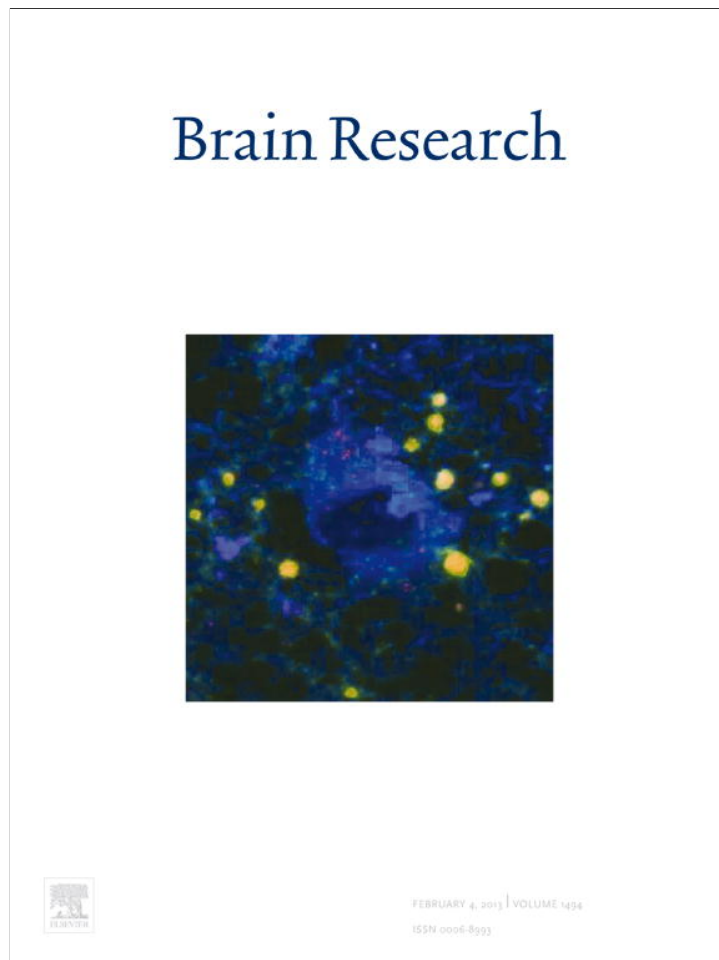


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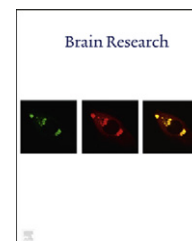
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## Research Report

## Race, emotion and trust: An ERP study

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## ABSTRACT

Faces contain certain cues that can be used to infer the intentions of other people and to formulate beliefs about them. The present study explored the extent to which the race of the partners and their emotional facial expressions influenced participants' decision-making in a Trust Game where race and emotional expression had no actual predictive value regarding the partners' reciprocation rate. Behaviourally, participants shared more money with happy than with angry partners. In two separate experiments, electrophysiological results showed an early interaction between race and emotion in the N170 potential and also in the subsequent P200, which suggests inter-dependent processing of those cues in a social context. Overall, our results indicate that racial and emotional cues exert both independent and also interacting effects in the processing of faces in an interpersonal context.

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## 1. Introduction

Social interactions play a pivotal role in our lives. Humans have developed efficient abilities that use social features, such as race and emotional facial expressions, to forecast in a direct or indirect way the actions of other people. These could activate stereotypes and may influence the formulation of beliefs that could be used to generate initial trust and to plan subsequent actions toward others (e.g., Gaertig et al., 2012). Much research in social cognitive neuroscience has focused on social perception and how automatic biases drive people's impressions of others. In this sense, evaluations are relatively automatic and might occur without conscious monitoring (Cunningham and Zelazo, 2007; Bargh and Williams, 2006). Many of the cues used to trigger evaluative processes and impressions of others come from their faces. Both race and emotional facial expressions have been thoroughly investigated in social cognition. The current study focuses on these

two features to investigate whether and how they modulate cooperative behaviour in social interactions.

Racial information easily activates stereotypes and prejudices. Research using implicit measures of prejudice such as the Implicit Association Test (IAT; Greenwald et al., 1998) has shown that positive and negative attitudes can be activated implicitly, which biases social interactions. However, at the same time interactions with minority-group members may also lead to the activation of egalitarian motives, which could inhibit the influence of the stereotypes on judgments and behaviour (see Bargh and Williams, 2006, for a review). For example, Moskowitz et al., 1999 used implicit measures of activation and posited that holding a goal to be egalitarian toward a particular group prevented the activation of stereotypes. Emotional facial expressions, on the other hand, are immediate indicators of behavioural dispositions in people (Darwin, 1872). Since this information is highly relevant to adapt our social behaviour to the tendencies of others,

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we have developed efficient mechanisms for detecting their emotional states.

Racial and emotional information is mainly extracted from faces, which are processed in fusiform brain regions through fast and efficient brain mechanisms (Haxby et al., 2000; Frith and Frith, 2012). Electrophysiological studies of face processing have shown that the first electrophysiological potentials to be sensitive to these cues are the P1 and N1 deflections. Both coloured and gray-scaled black vs. white faces already differ around 120 ms after face onset (e.g., Ito and Urland, 2003), although these differences are most likely due to low-level physical differences between racial categories (e.g., Tanskanen et al., 2005). On the other hand, faces also elicit rapid brain responses depending on their specific emotional expression. The categorization of facial emotions can occur at latencies as short as 100 ms. For example, Eimer and Holmes (2007) showed that fearful vs. neutral faces generated significant electrophysiological differences in frontal channels as soon as 120 ms after stimulus onset. Other studies have shown that fearful facial expressions elicit a more pronounced negative N100 component than happy and neutral faces as well as enhanced positive P1 amplitudes (e.g., Luo et al., 2010).

The N170, a negative deflection that peaks later in time at bilateral occipito-temporal sites, has larger amplitude for faces than for other stimulus categories. Electrophysiological (Bentin et al., 1996) and fMRI studies of face processing have shown greater activation at right than at left hemisphere sites, as well as more extensive fusiform gyrus activation in the right hemisphere (Puce et al., 1996; Kanwisher et al., 1997). Several reports have studied the sensitivity of the N170 to the structural encoding of faces, facial identification (Bentin et al., 1996; Bentin and Deouell, 2000), and emotional expression (Eimer and Holmes, 2002, 2007; Herrmann et al., 2002). Nevertheless, the relation of this potential to race and emotion is far from settled. Although some authors have reported that it is not sensitive to these cues, others have shown modulations in either or both directions (see Ito and Bartholow, 2009, for a review).

Similarly, another ERP deflection that occurs during the same temporal window as the N170, the anterior face-sensitive vertex positive potential (VPP), has been described as sensitive to facial stimuli (Jeffreys, 1989). A recent study (Wiese, 2012) examined the influence of race on the VPP and reported larger amplitudes for other-race faces. The VPP also appears to be enhanced for emotive (happy and sad) versus neutral expressions (Luo et al., 2010; Jaworska et al., 2012).

In addition, other studies including participants of two races, black and whites, looking at black and whites faces, have reported modulations in the fronto-central N200 potential as a function of the race of the participant (Dickter and Bartholow, 2007). The N200 has been specifically associated with deeper processing of faces, and is typically larger to faces of one's own race than to other races (Ito et al. 2004; Ito and Urland, 2003). Emotion modulates the amplitude of the N200 in fronto-central channels, which is typically larger to neutral than fearful faces and for happy than angry facial expressions (Eimer and Holmes, 2002; Kubota and Ito, 2007; Ruz et al., in press).

In a similar time range of processing, some authors have explored how race modulates the P200 at occipito-temporal

sites<sup>1</sup> (Stahl et al., 2008, 2010; Wiese, 2012). In these studies, P200 amplitudes were larger for same as compared to other-race faces. Research looking at the modulation by valence of the occipital P200 has reported an enhanced deflection for negative emotional stimuli (Dennis and Chen, 2007). For example, in an affective evaluation task the P200 related to unpleasant stimuli was more positive than for pleasant stimuli (Delplanque et al., 2004). On the other hand, the amplitude of the P200 is reduced following the presentation of angry, compared to neutral facial expressions (Horley et al., 2001).

Finally, the modulation in the P300 component by race depends mainly on the task and relies on contextual updating of existing content or on a motivated attempt to resolve inconsistent information (Ito and Bartholow, 2009; Nieuwenhuis, et al., 2005). On the emotion realm, the P300 has been linked to motivationally significant events and it typically reflects the arousing content of stimuli (Keil et al., 2002). It is often conceptualized as indexing attention to motivationally relevant stimuli (Kubota and Ito, 2007), with a larger P300 for positive and negative valences compared to neutral stimuli (Keil et al., 2002).

Despite the fact that under normal circumstances race and facial emotion displays are combined to shape the perception of a single entity, a person, research has scarcely investigated the simultaneous perception of these social cues. As an exception, Kubota and Ito (2007) studied the time course of their processing in a task where people made either racial or emotional explicit categorization judgments (the other dimension being task irrelevant). Based on the lack of evidence of interactions between race and emotion in the electrophysiological components analysed, the authors concluded that both cues are processed quickly, independently and in parallel.

Although previous research has considered task and context effects on ethnicity processing (Wiese et al., 2009; Caharel et al., 2011) they have, however, not explored a crucial context in which the race and emotional expression of others are usually processed, that is, social interactions. As mentioned in previous paragraphs, we often evaluate those pieces of information trying to predict the beliefs and proximate behaviour of others. Thus, adding a social context to the task performed by participants in which predicting the behaviour of others is relevant may affect the way their race and emotional expression are processed, and the interactions between them. Our studies emphasize the social interaction with a partner, which might make both emotion and ethnicity implicitly salient.

Therefore, the main goal of the current study was to explore how the brain processes race and facial emotional expression within a classic inter-personal economic setting, by investigating how the electrophysiological potentials were modulated by these social cues. With this purpose we adapted

<sup>1</sup> However, other studies have localized this potential as the positivity occurring at fronto-central sites before the N200 (Ito and Urland, 2003, 2005; Kubota and Ito, 2007; Ito and Bartholow, 2009). In this case, the P200 is considered the same as the VPP potential.

the Trust Game paradigm (Berg et al., 1995; Camerer, 2003), in which participants had to choose whether to cooperate or not with black and white unknown partners who displayed different emotional states. Importantly, in our studies the two types of cues were incidental to the primary task, in the sense that they did not carry information regarding the partner's cooperation rates. This feature allowed us to examine their automatic effect on trust behaviour, unbiased by strategic factors introduced by the task contingencies. Nevertheless, in spite of being incidental, we expected race and emotional face features to have an effect on the early processing of faces, and affect the cooperation rate of the observers, at least for emotional features (Eckel and Wilson, 2003; Averbach and Duchaine 2009; Tortosa et al., in press).

We performed two separate experiments, which were almost identical. The second one had the main purpose of replicating the finding in Experiment 1 of a previously unreported interaction between race and emotion in the N170 potential, which was sustained in the P200 (thus minimizing the risk of a Type I error). Participants from both experiments also performed an Implicit Association Test (Greenwald et al., 1998) after the Trust Game, which helped to evaluate whether they had implicit negative biases toward black people.

## 2. Results

### 2.1. Behavioural performance

Omission trials, those trials where participants answered late (1.9% on average) and reactions times shorter than 200 ms (0.38%) were excluded from the analysis. Cooperation Rates were introduced into an ANOVA with Race (black, white) and Emotion (angry, happy, neutral) as within-subjects factors, and Experiment as between-subject factor. The rate of cooperation was larger in Experiment 1 than in Experiment 2,  $F(1,43)=18.21$ ,  $p=.001$ . Participants cooperated, i.e., shared at least some of the money, in 78% of the trials in Experiment 1 and in 61% of the trials on Experiment 2. There was a main effect of Emotion on Cooperation Rates,  $F(2,86)=49.17$ ,  $p<.001$ . Participants cooperated less for angry (51.7%) than for neutral (75.4%) emotional expressions,  $F(1,43)=53.53$ ,  $p<.001$ , and more for happy (82.5%) than for neutral expressions,  $F(1,43)=12.26$ ,  $p=.001$ . This effect of Emotion was independent of Experiment ( $p>.3$ ).

However, there was a significant interaction between Race and Experiment,  $F(1,43)=5.96$ ,  $p<.05$ . Whereas in Experiment 1 the race of the partners did not affect cooperation rates ( $F<1$ ), in Experiment 2 participants cooperated more with black (64.4%) than with white (57.5%) partners,  $F(1,23)=12.11$ ,  $p<.01$ .

Results of the IAT task revealed that participants showed an implicit negative bias towards black partners, which was evident in both experiments. The size of the bias was equal across experiments,  $F(1,43)=164.232$ ,  $p>.2$ , and the average score was 0.82. This value was significantly higher than zero ( $t=6.40$ ,  $df=44$ ,  $p<.001$ ), and means that participants took more time to respond to the inconsistent than to the prejudice-consistent condition.

### 2.2. ERP results

Data from one participant from each experiment had to be removed due to excessive artefacts. Data from these participants were also omitted from the behavioural analyses.

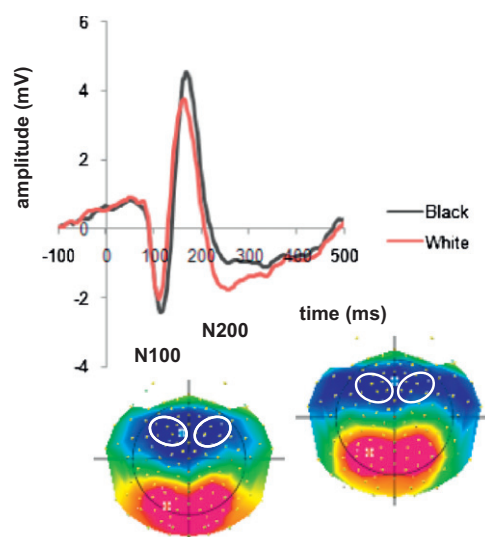
### 2.3. N100 and P100

The N100 potential peaked at 115 ms over frontal and midline sites in Experiment 1 and was analysed in a 95–135 ms time window. It peaked at 130 ms over the same sites in Experiment 2 and was analysed in a 110–150 ms time window. The amplitude of the N100 was modulated by the Race of the partner,  $F(1,43)=30.67$ ,  $p<.001$ , with a larger N100 for black ( $-1.01 \mu\text{V}$ ) than for white faces ( $-0.68 \mu\text{V}$ ). There was a significant Race X Hemisphere interaction,  $F(1,43)=5.29$ ,  $p<.05$ . The difference in amplitude among races was greater in the right hemisphere ( $0.45 \mu\text{V}$ ) than in the left ( $0.25 \mu\text{V}$ ). The factor Emotion did not reach significance levels,  $F(2,86)=2.54$ ,  $p=.08$  (see Fig. 1A, and Tables 1 and 2 for all the means and standard deviations for the two experiments separately).

The P100 peaked at the same latencies over occipital sites. The amplitude of the P100 was also only modulated by the Race of the partner,  $F(1,43)=49.47$ ,  $p<.001$ , with a larger P100 amplitude for black ( $1.96 \mu\text{V}$ ) than for white faces ( $1.16 \mu\text{V}$ ).

### 2.4. N170

The N170 potential peaked at around 170 ms in Experiment 1 and around 200 ms in Experiment 2, at the same temporo-occipital electrode locations. The analysis of the N170 amplitude, in the 150–190 ms time window in Experiment 1 and in the 190–220 ms time window in Experiment 2 revealed a



**Fig. 1 – Face-locked ERPs for whites and blacks displaying the N100 and N200 potentials in a frontal channel (F3). The topographies associated to each potential are also displayed, and the white circles within the maps highlight the location of the electrodes used for the amplitude analyses.**

**Table 1 – Mean amplitudes and standard deviations in each condition and for each potential in Experiment 1.**

	Emotion	Angry				Happy				Neutr			
		B		W		B		W		B		W	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
N100	Hem												
	left	-1.80	1.56	-1.30	1.85	-1.65	1.69	-1.34	1.80	-1.50	1.56	-1.19	1.72
	right	-1.36	1.88	-0.94	2.11	-1.48	2.04	-1.02	2.05	-1.39	1.67	-0.83	2.11
P100		2.84	2.80	1.74	3.10	2.84	2.83	1.87	3.14	2.56	2.73	1.85	2.93
N170	left	-2.51	2.27	-1.80	1.86	-2.56	2.25	-2.02	1.75	-2.54	2.00	-2.22	1.89
	right	-2.52	1.22	-2.06	1.13	-2.66	1.57	-1.54	1.06	-2.26	1.46	-1.82	1.48
VPP		2.55	1.33	1.76	1.31	2.91	1.33	1.78	1.43	2.85	1.44	1.68	1.44
N200	left	-0.44	1.46	-1.28	1.73	-0.64	1.39	-1.70	1.88	-0.96	1.28	-1.57	1.34
	right	-0.66	1.81	-1.62	1.61	-0.75	1.65	-1.36	1.71	-0.91	1.72	-1.46	1.36
P200	left	1.82	2.50	2.59	2.17	2.08	2.04	2.74	2.06	2.27	2.32	2.84	2.22
	right	0.97	2.27	1.87	2.05	1.16	1.98	2.64	2.03	1.93	2.01	2.57	2.24
P300		3.38	2.17	2.93	2.37	2.88	2.35	2.38	2.24	2.21	2.12	2.26	2.21

**Table 2 – Mean amplitudes and standard deviations in each condition and for each potential in Experiment 2.**

	Emotion	Angry				Happy				Neutr			
		B		W		B		W		B		W	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
N100	Hem												
	left	-0.61	0.74	-0.25	0.75	-0.37	0.71	-0.35	0.92	-0.29	0.81	-0.29	0.68
	right	-0.51	0.80	-0.20	0.96	-0.68	0.86	-0.30	0.88	-0.53	0.75	-0.14	0.78
P100		1.81	1.60	0.53	1.67	1.21	1.71	0.55	1.64	1.12	1.42	0.39	1.38
N170	left	-2.34	2.23	-2.11	2.03	-2.51	2.31	-2.10	1.80	-2.14	2.10	-1.98	1.79
	right	-2.40	1.79	-2.41	1.75	-2.61	2.05	-2.02	1.84	-2.11	1.88	-1.85	1.98
VPP		2.13	2.04	1.80	1.97	2.42	2.22	1.75	1.86	1.96	2.08	1.45	1.82
N200	left	0.41	1.93	0.16	1.59	0.60	1.83	0.04	1.60	0.20	1.72	-0.30	1.57
	right	0.38	2.04	-0.19	2.07	0.60	2.03	-0.03	1.89	-0.01	1.80	-0.29	1.87
P200	left	-0.51	3.53	0.07	2.98	-0.65	3.33	0.35	2.97	0.25	3.12	0.85	2.75
	right	-0.84	2.97	-0.05	2.94	-0.81	3.02	0.38	2.78	0.27	2.82	0.74	2.72
P300		5.07	1.78	4.62	1.83	4.72	1.64	4.73	1.90	4.23	1.51	4.00	1.77

significant Emotion X Race X Hemisphere interaction,  $F(2,86)=3.70, p<.05$ . Analyses on each hemisphere revealed that the interaction between Emotion and Race was only significant at the right hemisphere,  $F(2,86)=8.19, p<.001$  (see Fig. 1B; at the left hemisphere,  $p>.2$ ). On the right hemisphere angry and happy expressions showed larger amplitudes ( $-2.46 \mu\text{V}$  and  $-2.63 \mu\text{V}$ , respectively) than neutral expressions ( $-2.18 \mu\text{V}$ ,  $F(1,43)=9.17$  and  $F(1,43)=18.47$ , respectively,  $ps<.01$ ) when displayed by black faces. On the other hand, angry expressions showed larger amplitudes ( $-2.24 \mu\text{V}$ ) than happy ( $-1.78 \mu\text{V}$ ;  $F(1,43)=16.94, p<.001$ ) and neutral faces ( $-1.84 \mu\text{V}$ ,  $F(1,43)=7.83, ps<.01$ ) when displayed by whites. There was no difference between happy and

neutral faces ( $F<1$ ).<sup>2</sup> There was also a main effect of Race, with larger N170s for blacks ( $-2.43 \mu\text{V}$ ) than for whites ( $-1.99 \mu\text{V}$ ,  $F(1,43)=28.89, p<.001$ ), and an interaction of Emotion X Hemisphere,  $F(2,86)=6.37, p<.01$ . While in the left hemisphere there was no effect of emotion,  $p>.3$ , in the right hemisphere angry ( $-2.35 \mu\text{V}$ ,  $F(1,43)=13.55, p<.001$ ) and happy expressions ( $-2.21 \mu\text{V}$ ,  $F(1,43)=6.09, p=.01$ ) showed

<sup>2</sup> The interaction of race and emotion at right-hemisphere electrodes was significant in both Experiment 1 and 2 ( $F(2,40)=5.15, p=.01, F(2,46)=3.59, p<.05$ , for Experiment 1 and 2, respectively). Relevant interactions were also all significant in both experiments (all  $ps<.05$ ).



larger amplitudes than neutral expressions ( $-2.01 \mu\text{V}$ ). In addition, the Emotion X Experiment interaction was also significant. While the amplitude of the N170 was the same for all emotions in Experiment 1, ( $F < 1$ ), it was modulated by this factor in Experiment 2,  $F(2,46) = 7.61$ ,  $p = .001$ . Planned comparison revealed that angry and happy faces ( $-2.32 \mu\text{V}$  and  $-2.31 \mu\text{V}$ , respectively) elicited larger N170 amplitudes than neutral faces ( $-2.02 \mu\text{V}$ ;  $F(1,23) = 8.66$  and  $11.13$ , respectively,  $ps < .01$ ).

### 2.5. VPP

The VPP potential peaked at 170 ms in Experiment 1 and at 200 ms in Experiment 2 at the same centro-medial electrodes. The ANOVA performed on the average voltages across conditions in these electrodes during the 150–190 ms and 190–220 ms time windows, respectively, revealed a significant main effect of Race,  $F(1,43) = 56.11$ ,  $p < .001$  due to a larger VPP amplitude for black ( $2.47 \mu\text{V}$ ) than for white faces ( $1.70 \mu\text{V}$ ). The interaction Race X Experiment,  $F(1,43) = 6.51$ ,  $p = .01$ , showed that the difference in amplitude between races was greater in Experiment 1 ( $1.03 \mu\text{V}$ ), than in Experiment 2 ( $0.51 \mu\text{V}$ ). There was also a significant main effect of Emotion,  $F(2,86) = 3.45$ ,  $p < .05$ . Happy faces ( $2.21 \mu\text{V}$ ) elicited larger VPP amplitudes than neutral ones ( $1.98 \mu\text{V}$ ;  $F(1,43) = 7.12$ ,  $p = .01$ ), whereas angry expressions ( $2.06 \mu\text{V}$ ) did not differ from happy or neutral faces ( $ps > .1$ ).

### 2.6. N200

This potential peaked at approximately 248 ms in Experiment 1 and at 300 ms in Experiment 2 after target presentation over bilateral frontal sites. It was analysed in the 228–268 ms time window for the former and in the 280–370 ms for the latter. There was a main effect of Race,  $F(1,43) = 44.19$ ,  $p < .001$ , with more negative amplitudes for white ( $-0.80 \mu\text{V}$ ) than for black faces ( $-0.18 \mu\text{V}$ ).

There was also a main effect of Emotion,  $F(2,86) = 9.02$ ,  $p < .001$ , with more negative amplitudes for neutral ( $-0.66 \mu\text{V}$ ) than for angry and happy expressions ( $-0.40 \mu\text{V}$  for both emotions: both  $ps < .001$ ). There was also a significant interaction between Emotion and Hemisphere,  $F(2,86) = 4.27$ ,  $p = .01$ . Specifically, N200 amplitudes were larger for neutral ( $-0.65 \mu\text{V}$ ) than for angry ( $-0.28 \mu\text{V}$ ,  $F(1,43) = 18.61$ ,  $p < .01$ ) and happy ( $-0.42 \mu\text{V}$ ,  $F(1,43) = 5.25$ ,  $p < .05$ ) expressions in the left hemisphere and larger for neutral ( $-0.67 \mu\text{V}$ ) than for happy expressions ( $-0.38 \mu\text{V}$ ,  $F(1,43) = 15.68$ ,  $p < .001$ ), in the right hemisphere.

### 2.7. P200

This potential peaked over bilateral occipito-temporal sites at approximately 240 ms in Experiment 1 and at 290 ms in Experiment 2. It was analyzed in the 220–270 ms time window in Experiment 1 and in the 260–310 ms in Experiment 2. It showed a main effect of Race  $F(1,43) = 27.70$ ,  $p < .001$ , with more positive amplitudes for whites ( $1.46 \mu\text{V}$ ) than for blacks ( $0.66 \mu\text{V}$ ), and a main effect of Emotion,  $F(2,86) = 37.54$ ,  $p < .001$ , with a more positive amplitude for neutral ( $1.47 \mu\text{V}$ ) than for happy ( $0.99 \mu\text{V}$ ;  $F(1,43) = 34.13$ ,  $p < .001$ ), and for the later than for

angry expressions, ( $0.74 \mu\text{V}$ ;  $F(1,43) = 7.90$ ,  $p < .01$ ). We also obtained a three-way interaction between Emotion, Race and Hemisphere,  $F(2,86) = 4.08$ ,  $p < .05$ . This interaction showed a pattern similar to the N170. Separate ANOVAS for each hemisphere showed that the interaction Emotion X Race was only significant at the right hemisphere, ( $p > .3$  at the left location). The P200 was larger for neutral ( $1.10 \mu\text{V}$ ) than for angry ( $0.06 \mu\text{V}$ ;  $F(1,43) = 61.12$ ,  $p < .001$ ) and happy expressions ( $0.18 \mu\text{V}$ ;  $F(1,43) = 47.83$ ,  $p < .001$ ) for black partners. On the other hand, neutral and happy expressions ( $1.66 \mu\text{V}$  and  $1.51 \mu\text{V}$ , respectively) showed larger amplitudes than angry ( $0.91 \mu\text{V}$ ;  $F(1,43) = 17.65$  and  $20.41$ , respectively,  $ps < .001$ ) when displayed by white faces. There was no difference between happy and neutral faces ( $F < 1$ ).

### 2.8. P300

This potential was analysed in the 428–560 ms and in the 490–570 ms time windows over centro-medial electrodes, for Experiments 1 and 2, respectively. There was a main effect of Emotion on its amplitude,  $F(2,86) = 29.42$ ,  $p < .001$ . Planned comparison revealed that angry faces ( $4.00 \mu\text{V}$ ) elicited larger P300 amplitudes than happy expressions ( $3.68 \mu\text{V}$ ;  $F(1,43) = 8.18$ ,  $p < .01$ ), and the latter elicited larger amplitudes than neutral ones ( $3.17 \mu\text{V}$ ;  $F(1,43) = 20.30$ ,  $p < .001$ ).<sup>3</sup>

## 3. Discussion

The present studies explored how we extract information from other people based on both inherent (race) and variable (emotional expressions) facial characteristics and the extent to which the ERP correlates of face processing in a social decision-making task are modulated by these characteristics. We found previously unreported interactions in the processing of race and emotion on the N170 and P200 potentials, focused on the right hemisphere, which we replicated in a second experiment.

Behavioural data showed higher rates of cooperation with smiling and neutral partners compared to angry ones. The long-lasting effect of emotion even when it was not related to the partner's response of cooperation, replicates previous findings (Scharlemann et al., 2001; Eckel and Wilson, 2003; Tortosa et al., in press) and points out that facial expressions are strong predictors of others' behaviour and bias our responses even when our expectations are not matched by evidence (see also Ruz and Tudela, 2011; Ruz et al., in press).

While race did not affect cooperation rates in the first experiment, the second revealed a bias in favour of black people, and this is so despite the fact that participants showed an IAT effect indicative of a racial bias that favoured whites in both cases. The asymmetry between the effects

<sup>3</sup> Additionally, we introduced the variable Gender in all behavioral and ERP analyses of the Experiment 2 to test for potential modulation of this factor. There were no significant effects involving this variable (all  $ps > .1$ ). Nevertheless, given that only 14 female and 10 male participants were examined, this null result should be taken with caution as it may reflect insufficient statistical power.

of race on the two experiments might be related to the change in the response options, which were dichotomous in Experiment 2 and thus, may have favoured the expression of compensatory behaviour in cooperation rates. This same reason could explain the highest cooperation rate in Experiment 1, where participants had three options of cooperation (1,2,3) vs. one of no-cooperation (0), in comparison to Experiment 2, where the dichotomy in the response options (1–0) made the probability of both choices potentially equal (50%). Nevertheless, the size of the effect of race observed in Experiment 2 is small compared to the effect of facial expression observed in the two experiments, (7% vs. 26% or 36%).

The modulation of racial characteristics on cooperation behaviour in favour of black partners in Experiment 2 could be also explained by the fact that people tend not to show their prejudice-related biases in explicit tasks that manipulate race (Allport, 1954; Monteith et al., 2002), and even tend to compensate it by appearing more “giving” to the exogroup. An alternative explanation could be that the particular black faces selected for the experiment appeared more trustworthy than the white faces used. However, results from the trustworthiness evaluation that participants performed on the faces at the end of the experimental session (see Section 4) rule out this explanation, as ratings were equated across categories. Implicit tasks, however (e.g., the IAT, the “Affective Lexical Priming Score” or ALPS), have shown evidence of race response-bias even among those who claim to be non-prejudiced (Amodio et al., 2004). IAT scores in our participants showed the existence of such race response-bias in the two samples (Experiments 1 and 2). This positive result in the implicit test might indicate that the way in which our brain initially processes emotional and racial cues escapes conscious control, whereas cooperation responses towards other-race people could be easily controlled to avoid showing non-popular racial biases, as occurs in fact in the cooperation rates participants showed in the Trust Games.

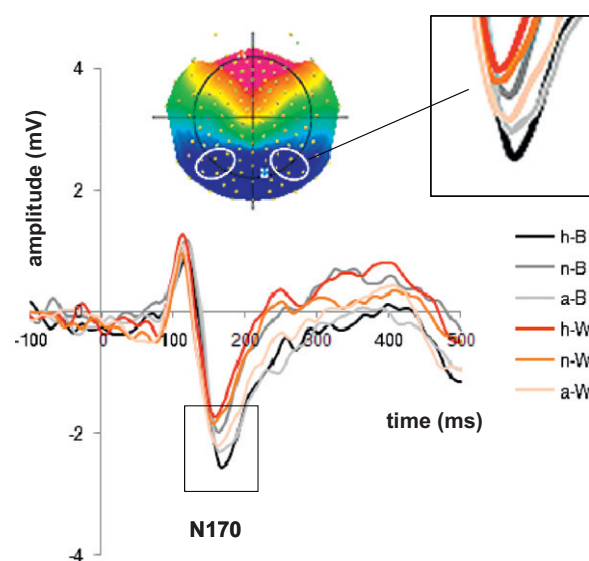
Turning to the electrophysiological results, an unexpected observation was the delay in the latencies of the peaks of all potentials in the second experiment compared to Experiment 1. This consistent delay was most likely due to uncontrolled differences in background luminance between the two experiments (Wijers et al., 1997). As explained in Section 4, we tuned the analysis by adapting the temporal windows to the latency of the peaks in each experiment. By using this approach we were able to observe the same pattern of results across experiments, which constitutes a replication of our main findings.

In the two studies, ERP results are consistent with past research on the perception of race and emotion, showing initial modulations of ERP components by race and slightly later by emotional expression. These replications validate the utility of our paradigm in measuring the electrophysiological processing of racial and emotional characteristics of facial displays. Race differentially affected early ERP responses on the fronto-central N100, which had larger amplitude for blacks than for whites. This effect may well resemble polarity-reversed effects in the occipital P100, which is known to be sensitive to physical low-level characteristics (Heinze et al., 1994), and thus both potentials may reflect similar processes. We cannot rule out an explanation of our

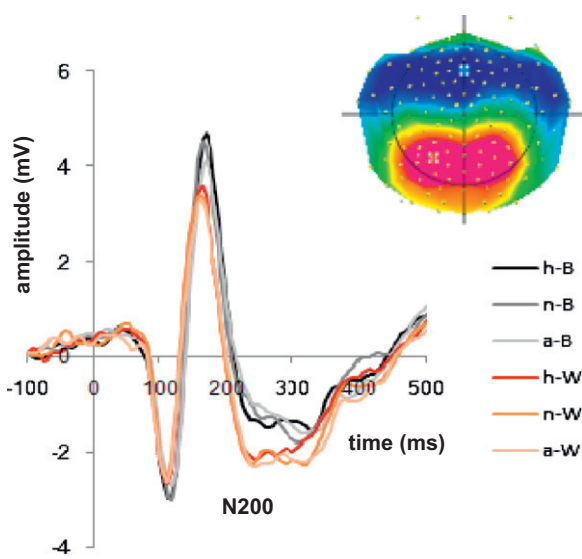
N100 and P100 racial effects in terms of the differences in physical characteristics that naturally occur between the two race categories. Although other studies have reported effects in the same direction as ours even when using grey-scaled stimuli (see Ito and Urland, 2003, 2005) it is relevant to note that grey scale images do not a priori diminish low-level differences. It has been suggested that, in the context of race, these effects are boosted by early orientation to more novel targets, as a form of rapidly occurring vigilance or greater attention to the racial group (see Ito and Bartholow, 2009; Kubota and Ito, 2007). There is no conclusive research about this issue to date though.

As in the case of the N100, the N170 potential had larger amplitudes for blacks than for whites. This type of modulation could reflect increased demands placed upon the extraction of configural features of other-race faces (Walker et al., 2008). Walker et al. (2008) investigated face-related neural activity and its modulation by race. Participants with greater social contact with the other race showed a diminished difference in N170 mean amplitudes during the structural encoding of whites vs. blacks. It could also reflect an enhanced configural processing for own-race faces (Stahl et al., 2008), as the N170 showed more negative amplitudes for other-race faces. A larger and delayed N170 has also been reported for inverted compared with upright faces (Eimer, 2000; Rossion et al., 2000). Thus, it could also be possible that other-race people might have caused a disruption of configural processing and hence an increase in the amplitude of this potential (Figs. 2–4).

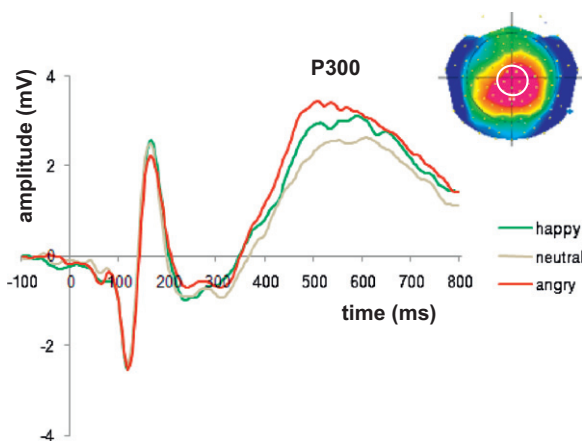
Most importantly, we found a previously unreported interaction in the processing of race and emotion in the N170, which was focused on the right hemisphere and was replicated in a second experiment, with a different sample. The results of our two experiments contradict previous



**Fig. 2 – Face-locked ERPs from a posterior-temporal electrode showing the interaction between race and emotion on the N170 potential. The topography during this temporal window is also displayed, together with white circles highlighting the location of the electrodes used for the amplitude analyses.**



**Fig. 3** – Face-locked ERPs from a frontal (F2) electrode showing the N200 potential. The topography during this temporal window is also displayed, together with white circles highlighting the location of the electrodes used for the amplitude analyses.



**Fig. 4** – Face-locked ERPs from a central (Cz) electrode showing the effect of emotion on the P300. The topography during this temporal window is also displayed, together with white circles highlighting the location of the electrodes used for the amplitude analyses.

reports of no interactions between these two social cues (Kubota and Ito, 2007), as well as some models of facial processing which propose that invariant and variable face dimensions are processed through parallel and different brain routes (e.g., Haxby et al., 2000). In addition, the subsequent P200 potential displayed the same interactive pattern between racial and emotional facial features. Our results show larger N170s for both angry and happy expressions than for neutral facial expressions of black partners, whereas the display of white partners generated N170s of larger amplitudes for angry than for happy expressions. Thus, it seems that in our task, the amplitude of this potential was heightened by displays of positive and negative emotions

of black people, whereas only the anger of white partners had the same effect. Given that the N170 seems to reflect the categorical processing of faces (Campanella et al., 2000; Aranda et al., 2010), our results suggest that the faces of black people displaying emotions in a social context, regardless of their valence, may receive heightened processing. This increase in resources would be limited to negative emotions in the case of white partners. The reason for such asymmetry may lie in the differences in familiarity that participants had with people from their own vs. a different race (Scott and Nelson, 2006). The larger amplitude of the N170 for blacks' angry and happy emotional expressions could also be due to increased attention (Holmes et al., 2003; Olofsson et al., 2008) or deeper processing (Stahl et al., 2008) to emotional in contrast to neutral expressions. According to previous studies showing a modulation of the N170 by facial expression (Batty and Taylor, 2003; Blau et al., 2007), the increased N170 to angry and happy blacks might be caused by the emotional valence of these stimuli (see also Herrmann et al., 2007). It could be the case that participants were more cautious for emotional expressions of black people, regardless of its type. For whites, this enhanced processing would only be linked to partners displaying anger, which is a truly threatening expression. In this case, attention might be oriented towards events that might pose a threat to the perceiver (Öhman and Mineka, 2001).

In addition, and given that the modulation of the N170 appears to be highly task-dependent (Walker et al., 2008; see also Ito and Bartholow, 2009), additional factors for this divergence between the interaction reported here and previous findings could be due to the differences between earlier investigations and the current paradigm. Previous research showed no interaction between emotion and ethnicity of faces, but those results were observed in contexts in which either none of these factors or only one of them were task-relevant (Kubota and Ito, 2007). In contrast, the current task employed a social interaction game in which participants may have used emotional and racial information as relevant sources of information to try to predict the trustworthiness of their partners, and this process may have been different across races. Nevertheless, further research would be needed to clarify the nature of this interesting interaction between emotion and ethnicity in the processing of faces in social contexts.

Similar but attenuated effects were found in the fronto-central VPP, with higher amplitude for black than for whites, in accordance with the study of Wiese (2012), and also for happy emotional expressions. The VPP is a positivity that earlier studies have proposed to show identical response properties to the N170 (Joyce and Rossion, 2005). Although this matter is far from settled (see Ibáñez et al., 2010 for a dissociation between the N170 and VPP), in the current study both potentials indeed reflected the same patterns in the main effects, as well as some of the interactions (Table 3).

The N200 was modulated by both race and emotion, with larger amplitudes for whites than for blacks and also for neutral expressions compared to the other two (but see Ruz et al., in press). The occipito-temporal P200 potential seems to mirror the effects of the N200. The P200 had larger amplitudes for white than for black partners, its amplitude



**Table 3 – Electrodes used for the ERP analyses in Experiments 1 and 2. LH: Left Hemisphere; RH: Right Hemisphere.**

	EXP 1	EXP 2
N100		
LH	19, F1, FC1, 23, AF3, F3, 26, AF7, F5, 29, FC3, 33, F7, FC5	F1, FC1, AF3, F3, F5, 29, FC3, F7, FC5
RH	1, AF8, AF4, F2, 8, 9, 10, FC4, FC6, 118, FC2, F8, F6, F4	AF4, F2, FC4, FC6, 118, FC2, F8, F6, F4
P100	P1, PO7, 67, POz, 70, 71, O1, 73, 75, 76, O2, 78, P2, 83, 84, PO8, 90	P1, PO7, 67, POz, 70, 71, O1, 73, 75, 76, O2, 78, P2, 83, 84, PO8, 90
N170		
LH	47, 50, TP7, 56, TP9, P9, 63	47, 50, TP7, 56, TP9, P9, P7, 64
RH	P10, TP8, 100, TP10, 102, 103, 108	P8, 96, P10, TP8, TP10, 102, 103, 108
VPP	5, FCz, 7, VREF, 12, 13, FC1, FC3, C1, C2, 107, FC4, 113, FC2	5, FCz, 7, VREF, 12, 13, FC1, FC3, C1, C2, 107, FC4, 113, FC2
N200		
LH	19, F1, FC1, 23, AF3, F3, 26, AF7, F5, 29, FC3, 33, F7, FC5	F1, FC1, AF3, F3, F5, 29, FC3, F7, FC5
RH	1, AF8, AF4, F2, 8, 9, 10, FC4, FC6, 118, FC2, F8, F6, F4	AF4, F2, FC4, FC6, 118, FC2, F8, F6, F4
P200		
LH	P9, P7, 64, 65, PO7, 70, 71, O1	P9, P7, 64, 65, PO7, 70, 71, O1
RH	O2, 84, PO8, 90, 91, P8, 96, P10	O2, 84, PO8, 90, 91, P8, 96, P10
P300	VREF, 7, C1, 32, CP1, 54, CPz, Pz, 80, 81, CP2, C2, 107	VREF, 7, 32, 54, CPz, Pz, 80, 81, CP2, 107

was also larger for neutral than for angry and happy expressions (see Lucas et al., 2011, for further discussion about the P200 and N200). Those results are not in the same direction as the literature on emotional processing reviewed in the introduction (see Dennis and Chen, 2007; Delplanque et al., 2004); however to date this potential has not been explored in this type of paradigms and effects may depend on several parameters, including the task and the stimuli employed.

The effects of emotion were sustained over the P300, with emotional expressions, both angry and happy, eliciting larger amplitudes than neutral ones. The amplitude of this potential, however, did not vary as a function of the race of the game partners (see Kubota and Ito, 2007). In contrast to early perceptual potentials, the P300 has been mostly linked to decision-making and/or response selection stages of processing (Rugg and Coles, 1995). A number of studies have examined the effects of ethnicity on the P300 and the late positive complex (LPC), which are closely linked (Stahl et al., 2010; Ito and Urland, 2003, 2005). This potential appears to be sensitive to the context, reflecting context-updating processes that occur in response to explicit attention to task-relevant stimulus features, so that the race effect in those late potentials seems to depend on task and context factors (see also Ruz et al., in press). Thus, the sensitivity of the P300 to emotion could be related to the influence that this factor exerted on participants' explicit cooperation rates. An additional factor could be the arousing nature of faces displaying emotional expressions, as previous results have shown that P300 amplitudes are enhanced by motivationally significant events (Olofsson et al., 2008), whereas at this late stage of the processing the automatic race bias has been bypassed already.

Overall, electrophysiological results suggest that face processing at early stages is not independent from the emotion and race of partners in a social context. These cues, however, do not exert parallel effects on behavioural responses. Our results highlight the marked effect of emotional facial expressions on cooperation responses, and the inter-wired electrophysiological correlates of race and emotion in early

stages of face processing. Further research would be needed to explore the conditions in which the race and emotional expression of faces modulate, in an interactive or independent way, face-related early ERPs components like the N170, and the factors determining whether the race of the partner does or does not modulate overt social behaviours in interpersonal interactions.

## 4. Experimental procedures

### 4.1. Participants

Participants were all white students from the University of Granada, who received course credits in exchange and signed a consent form approved by the local Ethics committee. Twenty-two (one left-handed, 20 female; 20 years old in average) participated in Experiments 1 and 25 (two left-handed, 14 female; 22 years old in average) in Experiment 2.

### 4.2. Experimental tasks

#### 4.2.1. Trust Game task

In the two experiments, participants performed a Trust Game task with a multi-round design. In this game there are two players. One player, the *trustor*, is given a fixed amount of money, which s/he can keep or invest with a player s/he does not know (the *trustee*, e.g., the face displayed in the computer monitor). If an investment is made, the amount is multiplied and then the trustee supposedly decides how to share the amount with the investor. The trustee can either reciprocate the investment (returning a part of it to the trustor) or fail to reciprocate. In the latter case, the trustor obtains nothing from that exchange. Participants always played as trustors in the game and their 12 game partners (i.e., the 12 faces) were the trustees. These partners were represented by photos and nothing was said about their different races and the emotions they would display.

The experimental task in Experiments 1 and 2 was the same except for the options of response cooperation. In Experiment 1 participants received a fixed amount of 3 Eur in each trial, and then they could decide either to share it all, part of it (1, 2 or 3 EUR), or not to share it with the partner. In each trial of Experiment 2, participants received a fixed amount of 1 EUR and responses were dichotomous: they either cooperated sharing the full amount (1 EUR) or they did not cooperate by not sharing anything with the partner. The decision to keep the money ended the trial. If the participant shared anything, the partner received the triple of the shared amount (the quintuple in Experiment 2). Then the partner could either keep the entire multiplied amount or give half of it back (thus corresponding the trust of the participant). Feedback about this decision was presented on the computer screen, which concluded the trial. Trials were independent from each other; they always started with the same endowment regardless of the gains or losses in the previous rounds or the identity of the partner.

Participants were informed that they were not playing against real people on-line, but they were told that the behaviour of their partners mimicked responses given by real trustors in previous games. They were also told that beneficial outcomes were more likely if both they and their partners were cooperative and shared the money, and were encouraged to maximize their outcomes. Nevertheless, the partners' responses were random and therefore not predictable from the decisions of the participants.

#### 4.2.2. Stimuli and procedure

In the Trust Game, participants viewed faces of 12 distinct people: 6 photographs of black faces (3 female) and 6 photographs of white faces (3 female), each portraying angry, happy and neutral facial expressions, resulting in a total of 36 different face stimuli. Images were selected from the NimStim Set of Facial Expressions (Tottenham et al., 2009). This standardized set (NimStim) lacks trustworthiness ratings; however, participants completed a questionnaire after the task and rated the trustworthiness of every face in a 1–7 point scale. We performed a t-test comparing white and black faces, which did not show differences between the two.<sup>4</sup> All images were presented upright in frontal view at the centre of the computer screen over a silver background.

Each trial started with a display of a Eur symbol for 200 ms ( $2.1 \times 1.6^\circ$  visual angle) to indicate the endowment of money to the participant. It was then replaced by a fixation point (+,  $0.7 \times 0.7^\circ$ ) for 500 ms, which was followed by a picture of the partner for that trial ( $6.2 \times 8.3^\circ$ ) for 1500 ms. During this interval, participants had to give a response with their dominant hand by pressing on the response pad the keys 1, 2 or 3, depending on how much they wanted to share, or the 0 key in case they chose to keep their endowment. Afterwards, another fixation point appeared for 500 ms, and then it was replaced by a symbolic feedback symbol ( $1.0 \times 1.0^\circ$ ) in the centre of the screen that indicated the partner's decision for that trial. In order to minimize saccadic eye movements, three possible symbols displayed in three different colours

were used as feedback: a green "o", a navy "#" and a maroon "x". Their meaning was: "You have decided to keep the money. You receive 3 EUR. Your partner receives 0 EUR."; "You have decided to share and your partner has decided to correspond"; "You have decided to share and your partner has decided not to correspond". The association between specific symbols and their meaning was counterbalanced across participants. On trials where participants did not enter their decision on time (1.5 ms), they saw the message "¡tarde!" (late!). At the end of the trial a larger ( $1.0 \times 1.0^\circ$ ) fixation point (+) remained on the screen for a random duration between 2000 and 3000 ms. During this interval participants could blink if they needed so. The task consisted of 5 blocks with 108 trials each (plus 12 practice trials performed at the beginning of the session). Every participant saw each identity with the 3 emotional expressions, for an approximate task duration of 50 min.

#### 4.2.3. Implicit association task (IAT)

A Black–White IAT (Greenwald et al., 1998) was administered to each participant after they performed the Trust Game. Their task was to categorize animals either as pleasant or unpleasant, and faces as white or black. Participants responded by pressing the "e" and "i" keys with their left and right hands. The IAT had two blocks: prejudice-consistent and prejudice-inconsistent (their order of presentation was counterbalanced). In the consistent condition, responses for black (faces) and unpleasant (animals) were associated with the same key-press, while white and pleasant were associated with the other key-press. Left and right key-presses were counterbalanced for black/white responses while the pleasant/unpleasant responses remained constant. In the inconsistent condition the opposite key assignments were used. Incorrect responses were indicated with an "X" in the centre of the screen following the response.

Accuracy and reaction times were recorded and used to compute IAT scores for each participant. The IAT test is based on the hypothesis that people respond faster when stimuli that are similar in valence are assigned to the same response key in comparison to when stimuli differ in valence (Devine et al., 2002). Thus, to obtain these indexes, we subtracted the average RT in the congruent block from the average RT in the incongruent block, standardized according to the standard deviation (see the algorithm proposed by Greenwald et al., 2003; see also Ibáñez et al., 2010). An IAT score near zero supposedly reflects a neutral implicit racial association, whereas a positive score indicates more positive evaluative associations for whites than for blacks.

#### 4.2.4. Stimuli and procedure

In the IAT, the stimuli used were neutral facial coloured pictures of four black and four white faces (in each case, two male and two female faces) from the NimStim Set of Facial Expressions (Tottenham et al., 2009) database. These were the same as the ones employed in the Trust Game. The animals were 8 full-colour pictures from the IAT-set, half of which were unpleasant (mean  $M=3.62$ ;  $SD=0.36$ ), and the other half pleasant, ( $M=7.70$ ;  $SD=0.52$ ; in a range of the scale of 1–10).

Participants completed 64 trials divided in two blocks (each containing 32 consistent and 32 inconsistent trials). Before

<sup>4</sup> T-test for Experiment 1:  $t=-0.34$ ,  $df=5$ ,  $p=0.75$ ; Experiment 2:  $t=1.00$ ,  $df=5$ ,  $p=0.36$ .

every block, participants performed 32 practice trials (16 consistent and 16 inconsistent) where they could see above and below the picture a label with a reminder of the correct key-press response. The order in which the pictures were presented within each block was randomized for each participant.

#### 4.3. Electrophysiological recordings and analysis

Presentation of stimuli was controlled via PC running Biological E-prime software (Schneider et al., 2002) connected to a 17-inch monitor. This computer was connected to a Macintosh, which recorded continuous EEG. Electrophysiological data were collected from AgCl electrodes placed on the scalp using a 128-channel Geodesic Sensor Net, connected to a high-input impedance amplifier (200 M $\Omega$ ). Eye movements were monitored by horizontal and vertical electro-oculogram (EOG) electrodes lateral to and below both eyes. Impedance was measured for all channels and was maintained below 50 k $\Omega$  as recommended for the Electrical Geodesics high-input impedance amplifiers. Gain and zero calibration were performed prior to the start of every recording. EEG was recorded continuously with a sampling frequency of 250 Hz using the vertex channel as the online reference. The amplifier band-pass was set at 0.1–100 Hz.

##### 4.3.1. Topographical analysis

Prior to voltage analysis, we used Cartool software (developed by Denis Brunet: <http://sites.google.com/site/fbmlab/>) for studying the spatial distribution of brain electrical activity at successive time points across conditions. This technique is informative regarding differences between conditions in terms of likely underlying neurophysiologic sources. Using a spatio-temporal cluster analysis of the ERP normalized group-averaged data, Cartool provides different maps (topographies) that reflect time periods of stable electric field configurations and dissociable functional states of the brain, or microstates (Murray et al., 2008).

In our experiment, face stimuli ERPs were summarized by a limited number of scalp potential fields. The choice of the optimal number of topographies that best explained each data set was based on a cross-validation criterion (Pascual-Marqui et al., 1995). The output of this segmentation analysis consisted of a sequence of different scalp-topography configurations or template maps for each segmentation and condition, Black/White and Angry/Happy/Neutral. This procedure served to guide the selection of the optimal temporal windows for the ERP waveform analysis.

##### 4.3.2. Event-related potentials (ERP) analysis

Continuous raw data were filtered offline using a 40 Hz low-pass filter. The EEG was segmented 200 ms before the face onset and 800 ms after it to obtain face-locked ERPs. After segmentation the EEG was submitted to software algorithms for identification of artefacts. Artefact rejection criteria were defined as 70  $\mu$ V for eye blinks and eye movements' channels, and as voltage exceeding  $\pm 80 \mu$ V at any other electrode. Each segment was then visually inspected to remove remains of ocular or other artefacts. In addition, trials that did not meet the criteria set for behavioural analysis were rejected. ERPs were baseline-corrected 200 ms prior to the presentation of the targets. Data from individual channels that were consistently bad (more than

20% of the trials) for a specific subject were replaced using a spherical interpolation algorithm (Perrin et al., 1989). After rejections, the mean number of trials per experimental condition and participant was 53.9, with a minimum criterion of 25 artefact-free trials per condition and participant. These artefact-free epochs were then averaged separately for each experimental condition and participant, and then re-referenced off-line to the average (Dien, 1998; Tucker et al., 1994).

The average amplitudes for particular ERP components were compared across stimulus conditions over the time windows revealed by the Cartool segmentation process. Face-locked ERPs were explored focusing on the N100-P100, N170, VPP, N200, P200 and P300, given their relevance in the study of the electrophysiological correlates of race and emotion facial processing (Ito and Bartholow, 2009; Kubota and Ito, 2007). Electrodes where the potentials of interest were maximal were selected, and the mean amplitude of the peak averaged over the selected channels during the established time windows for each experimental condition was computed and entered in the analyses.

Repeated-measures ANOVAs with the factors Race (2: black, white), Emotion (3: angry, happy, neutral), and Hemisphere where relevant (2: left, right) were conducted for the mean amplitude of each potential for the face analysis. In the first place, analyses were conducted separately for Experiments 1 and 2. However, as most of the effects were replicated across them and to facilitate readability, we present combined analyses with Experiments (1, 2) as a between-subject factor, in both the behavioural and electrophysiological sections. Results that are significant in both experiments and in which there is no interaction of Experiment with any other factor are presented collapsed across experiments. In the cases of interaction, on the other hand, results are reported separately for each experiment. Where relevant, effects were evaluated using a Greenhouse-Geisser (1959) correction, although uncorrected degrees-of-freedom for these contrasts are reported in the text (Jennings, 1987).

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