

The *other-race* effect does not apply to infant faces: An ERP attentional study

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ABSTRACT

It is known that pedomorphic characteristics, called “baby schema” by Lorenz, trigger an orienting response in adults, are judged as attractive and stimulate parental care. On the other hand, it is known that ethnicity may influence face encoding, with an advantage in recognizing faces of their own ethnicity (called own-race effect). Some have argued that this effect holds also for infant faces, which conflicts with the “baby schema” phenomenon. The aim of the study was to investigate the possible presence of the own-race effect on infant vs. adult face processing. Seventeen Caucasian students participated to the study. Their EEG/ERPs were recorded as they watched 400 pictures of adult and infant faces of different ethnicity (half Caucasian, half non-Caucasian), and subsequently responded to a target orientation. The behavioral results showed that responses were faster when the target was preceded by a child face, which enhanced the arousal level, regardless of ethnicity. The electro-physiological results showed an enhanced anterior N2 response to infant than adult faces, and a lack of ORE effect only for infant faces. Overall, the data indicate that baby faces automatically attract the adult viewer's attention and that face ethnicity has no effect on this innate response.

1. Introduction

The aim of this study was to investigate the neuroanatomical and temporal correlates of brain processing of faces to test the existence of face age differences in the so called *other race* effect (ORE). The ORE effect, also called *cross race* effect, is the well-known and documented phenomenon for which own-race faces are recognized more accurately and rapidly than other-race faces (Bothwell et al., 1989; Malpass e Kravitz, 1969). One of the hypothesis advanced to explain this effect is the *Contact* or *experience hypothesis* (Valentine and Endo, 1992; Chiroro and Valentine, 1995). The contact hypothesis predicts that people who report greater levels of other-race contacts are less likely to show an ORE effect in face recognition, and this is supported by empirical evidence (Brigham et al., 1982; Carroo, 1987; Cross et al., 1971; Lavrakas et al., 1976). On the other hand, other studies have failed to find this effect (Brigham e Barkowitz, 1978; Malpass e Kravitz, 1969; Ng e Lindsay, 1994), or have found ambiguous results (Platz e Hosch, 1988).

The contact hypothesis seems to hold also for children observing child faces. For example, Feinman and Entwisle (1976) tested the face discrimination ability in Caucasian and African American children,

some of them attending integrated and others segregated schools. Children were shown pictures of both Caucasian and African American children and were instructed to carry out an old/new recognition task. The results indicated a recognition bias due to ethnicity greater in children coming from segregated schools.

Chance et al. (1982) tested the developmental course of ORE from 6 to 20 years of age, with a recognition task involving Caucasian and Asian faces and found that there was no ORE effect during infancy (till about 10 years), while afterward it increased substantially. However, a number of other studies reported an ORE effect with recognition tasks in infancy (e.g., Sangrigoli and De Schonen, 2004, Kelly et al., 2007). Moreover, supporting the contact hypothesis, numerous studies demonstrated the influence of exposure to other-race faces on the ORE in infancy and in childhood (e.g., Anzures et al., 2012; de Heering et al., 2010; Heron-Delaney et al., 2011; Sangrigoli et al., 2005). Again, also children as young as 3 months of age (but not newborns, for reasons related to the lack of experience and immaturity of their visual system) would show a spontaneous preference for own-race faces (Bar-Haim et al., 2006; Kelly et al., 2005).

The “attentional hypothesis” of ORE postulates instead that other-race faces would engage attentional resources less effectively

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than same-race faces (Palermo and Rhodes, 2007). An indirect evidence in favor of the attentional hypothesis comes from Cao et al.'s (2013) study applying the eye-tracker method to an involuntary attentional orienting task in which subjects were asked to make a speeded eye movement to the location indicated by a central arrow, which was preceded by task-irrelevant faces. Due to the inhibition of return effect (IOR, e.g., Posner and Cohen, 1984; Dodd and Pratt, 2007; Samuel and Kat, 2003), caused by a long inter-stimulus-interval (ISI) between face and target (600–800 ms), they showed that saccade latencies towards the location that previously contained the own-race faces were significantly longer than that of other-race faces. In their hypothesis own-race faces had stronger attentional relevance therefore producing an involuntary attentional orienting toward their field, resulting in a robust IOR effect.

In terms of its neural mechanism the ORE effect might depend on differences in visual familiarity or attentional relevance involving the activity of brain regions such as the fusiform face area (FFA). And indeed fMRI studies have shown an increased FFA activation during own-race face perception (Golby et al., 2001). In terms of ERP responses the literature is not unanimous: some studies have not found a modulation of face-specific N170 ERP response (Caldara et al., 2003; James et al., 2001; Tanaka and Pierce, 2009) while others have found such a modulation (Stahl et al., 2008; Walker et al., 2008), with a larger and later N170 in response to other-race faces.

Overall, it is assumed that own-race faces are recognized more easily than other-race faces, both in adults, as well as in children and infants (observing kids their age). However, the existence of the ORE effect for infant faces in adults has not been demonstrated (Proverbio et al., 2011a). However, in a behavioral study by Hodsoll et al. (2010) it was shown that infant faces had attentional capturing effects (for the adult viewers) only when of their own race. In their study faces of different ages (infant and adult) were flashed simultaneously on the computer screen, each flanking a centrally placed fixation cross. Faces were South Asian or Caucasian and were viewed by South Asian or Caucasian participants, engaged in reporting the orientation of a probe shape that appeared at either the location previously occupied by the infant face or the location previously occupied by the adult face. According to the authors, own-race baby faces did attract attention, but other-race infants did not, which is a quite a strong conclusion that contradicts other literature on “baby schema” showing how the human child's face (independent of ethnic group) acts as attentional priming, spontaneously capturing the viewer's spatial attention (e.g., Brosch et al., 2007). Indeed, the whole set of paedomorphic characteristics typical of an infantile face called “baby schema” includes a round face, high forehead, big eyes, small nose and mouth, chubby cheeks, and a large head as compared to the baby's shoulder (Lorenz, 1971; Sternglanz et al., 1977). Baby faces are perceived as cute and this is thought to increase the adult motivation to take care of infants (Hahn and Perrett, 2014; Alley, 1981; Glocker et al., 2009; Kringelbach et al., 2008; Leibenluft et al., 2004; Nitschke et al., 2004; Proverbio et al., 2011b). Some findings indicate that the special response to baby faces is limited to infants and toddlers, while it significantly decreases as children age increases. For example, a reduction in the amplitude of reward related orbito-frontal N2 ERP response to faces of pre-pubertal children (as compared to infants) (Proverbio et al., 2011b) was recently demonstrated. Again, it has been estimated that the perceived child cuteness diminished after the age of 4.5 years (Luo et al., 2011) when the consistent baby growth significantly alters the infant face proportions. The assumption underlying the concept of “baby schema” is that the adults' releasing response is regulated by a universal instinct devoted to the human species preservation, with the evolutionary function of enhancing offspring survival, although it also extends to juvenile animals and puppies. Therefore it shouldn't be diminished by the

diversities of facial characteristics typical of distinct human ethnic groups.

And indeed Proverbio et al. (2011a) demonstrated that infant faces automatically attract the adult visual attention, regardless of their ethnic group. In their study 30 Caucasian University students had to decide whether a lateralized target (a little tree) was upright or inverted. Targets were preceded by 400 baby or adult (Caucasian vs. non-Caucasian) faces shortly flashed in the same location, thus acting as spatial cues (valid/invalid). Results showed no effect of the ethnic group but of face age in speeding up RTs to targets preceded by baby faces. Significant costs for invalid locations cued by baby faces were also found (difficulty in disengagement). The data were interpreted as showing how visual attention is literally captured by baby schema, independent of baby race.

To further shed some light on this matter, and especially to uncover the neural underpinnings of this phenomenon, in the present study brain electric activity was measured in healthy participants engaged in the same attentional paradigm described above.

The presence of an ORE effect in adults for infant faces would demonstrate that the “baby schema” theory is wrong and incorrectly assumed, at least for spatial orienting. On the other hand the lack of ORE effect for infant faces (both in terms of accuracy or response speed (Brosch et al., 2007) and in term of amplitude of orbitofrontal reward-related N2 response (Proverbio et al., 2011b) would be interpreted in terms of their powerful orienting capabilities and collative properties. Since faces were task irrelevant and had to be ignored, an effect of race or age on their processing (or target detection) would indicate an automatic attentional orienting due to collative stimulus properties. Previous electrophysiological literature have shown how anterior N2 is sensitive to face's age (being larger to infant than child faces, and to child than adult faces, Proverbio et al., 2011a, 2011b), is larger to pictures of persons in positive than negative emotional contexts (Proverbio et al., 2009) and to persons than to inanimate scenarios (Proverbio et al., 2008). Its neural generators include the orbitofrontal cortex (BA10/BA11). Some studies have shown the existence of an orbitofrontal pleasure circuit that is active in the adult brain when viewing lovable conspecifics (children, partners, etc.) (Bartels and Zeki, 2004; Leibenluft et al., 2004; Nitschke et al., 2004). This circuit would allow privileged and accurate processing of positive social stimuli. Bartels and Zeki (2004) have proposed a relation between so-called “maternal love” or parental love with positive emotions and activation of the pleasure circuit. In this view we would expect a lack of ORE effect in the amplitude of N2 component reflecting baby schema processing. In order to investigate whether the possible N2 modulation (or lack of it) was based on the orbitofrontal generator described above source reconstructions (namely: Low-resolution electromagnetic tomographies, LORETTAs) were performed on the ERP waveforms at the N2 latency stage (300–400 ms), as a function of face's age.

2. Material and methods

2.1. Participants

Seventeen right-handed University student (14 women, 3 men) whose mean age was 24.69 years (min = 20; max = 41; SE = 0.32). They were recruited through SONA system and received academic credits for their participation. They were all Caucasian, had normal or corrected-to-normal vision and reported no history of neurological illness or drug abuse. Handedness was assessed by Edinburgh laterality preference inventory. The experiments were conducted with the understanding and written consent of each participant and in accordance with ethical standards (Helsinki, 1964) and were approved by the University of Milano-Bicocca ethical committee. The data of three participants were

discarded for excessive EEG artifacts. Therefore, ERP averaging and analyses were performed on a final group of 14 participants.

All participants had a little familiarity with infants (although none of them had children their own, nieces or nephews, nor had a specific familiarity/skill with neonates or pre-school age children acquired through professional activities). None of them had a specific familiarity with other ethnic groups, nor relatives or closest friends among them. In Italy the incidence of non-Caucasian ethnic groups among the population is very low: (e.g., African 1.5%, Latin American = 0.47%, Chinese 0.28%, according to *National Institute of Statistics* (ISTAT) data).

2.2. Stimuli

The stimulus set consisted in 400 color pictures of infant faces (200) and male and female adult faces (200) of comparable luminance. Because all infants were anonymous, their age was actually unknown but, on the basis of infant appearance, it was estimated as being lower than 24 months. Except for the infant category (for which sex was sometimes indistinguishable), adult faces depicted an equal number of females (100) and males (100). All people were smiling or showing a neutral facial expression. Stimuli were downloaded from copyright-free image sets from the internet.

Half individuals (200) had Caucasian somatic traits, whereas the other half (200) were non-Caucasian people (Black or Afro-American, American Indian, Asian, etc.). Besides gender and ethnicity faces were also matched for facial expression. For each category 52 open smiles, 16 close smiles and 32 neutral expressions were selected. Images were downloaded from Google Images and royalty-free internet databases. Stimulus size was 7.5x9 cm that is 3°46'17" x 4°31'32" of visual angle (193x225 pixels). Faces of various sex, age and ethnic group were presented randomly mixed to the left or the right of the fixation point (along the horizontal meridian), at the eccentricity of 3 cm: 1.5° to the left or right of fixation point. Each face was presented for 500 ms with an ISI of 200 ms between the face and the target. A very short ISI was used to avoid the IOR effect (e.g., Posner and Cohen, 1984). The colored drawing of a little tree (same size and spatial distribution of face stimuli) was used as target stimulus. The tree could be presented in its standard orientation (upright) or downward (inverted orientation) for 200 ms. The inter-trial interval was 1300 – 1500 ms. The outer background was dark gray. The timeline of experimental procedure is described in Fig. 1.

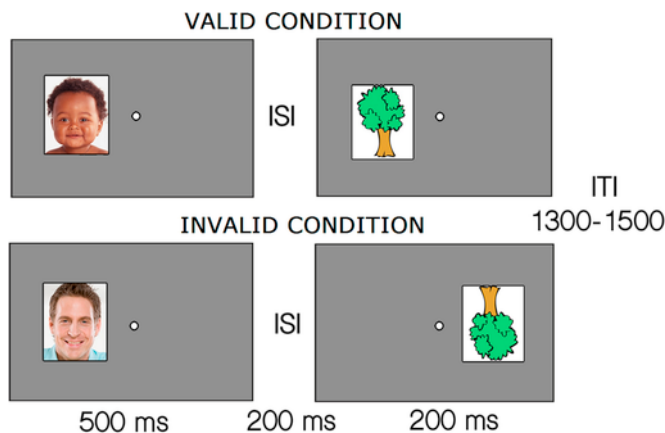


Fig. 1. Sketchy representation of experimental paradigm. An example of faces of different age and ethnic group is provided. The face immediately preceding the tree presentation acted as a valid or invalid exogenous cue for the target orientation task, by attracting attention on the visual field of presentation.

2.3. EEG recording and analysis

EEG was continuously recorded from 128 scalp sites according to the 10–5 International System (Oostenveld and Praamstra, 2001) at a sampling rate of 512 Hz. Horizontal and vertical eye movements were also recorded. Linked ears served as the reference lead. The EEG and vertical and horizontal electro-oculogram (EOG) were filtered with a half-amplitude band pass of 0.016–100 Hz. Electrode impedance was kept below 5 k Ω . EEG epochs were synchronized with the onset of face presentation. Computerized artifact rejection was performed to discard epochs in which eye movements, blinks, muscular artifacts or amplifier blocking occurred. The artifact rejection criterion was peak-to-peak amplitude exceeding 50 μ V, and the rejection rate was ~5%. ERPs were averaged offline from –100 ms before face onset to 900 ms after face onset. Topographical voltage maps of ERPs were made by plotting color-coded isopotentials obtained by interpolating voltage values between scalp electrodes at specific latencies.

Low-resolution electromagnetic tomographies (LORETA) were performed on the ERP waveforms at the N2 latency stage (300–400 ms). LORETA is an algorithm that provides discrete linear solutions to inverse EEG problems. The resulting solutions correspond to the 3D distribution of neural electrical activity that has the maximally similar orientation and strength between neighboring neuronal populations (represented by adjacent voxels). In this study, an improved version of this algorithm, the standardized weighted (sw) LORETA was used (Palmero-Soler et al., 2007). This version, referred to as swLORETA, incorporates a singular value decomposition-based lead field-weighting method. The source space properties included a grid spacing (the distance between two calculation points) of 5 points (mm) and an estimated signal-to-noise ratio, which defines the regularization where a higher value indicates less regularization and therefore less blurred results, of 3. The use of a value of 3–4 for the computation of the SNR in Tikhonov's regularization produces superior accuracy of the solutions for any inverse problem that is assessed. swLORETA was performed on the grand-averaged group data to identify statistically significant electromagnetic dipoles ($p < 0.05$) in which larger magnitudes correlated with more significant activation. The data were automatically re-referenced to the average reference as part of the LORETA analysis. A realistic boundary element model (BEM) was derived from a T1-weighted 3D MRI dataset through segmentation of the brain tissue. This BEM model consisted of 1 homogeneous compartment comprising 3446 vertices and 6888 triangles. *Advanced Source Analysis* (ASA) employs a realistic head model of three layers (scalp, skull, and brain) and is created using the BEM. This realistic head model comprises a set of irregularly shaped boundaries and the conductivity values for the compartments between them. Each boundary is approximated by a number of points, which are interconnected by plane triangles. The triangulation leads to a more or less evenly distributed mesh of triangles as a function of the chosen grid value. A smaller value for the grid spacing results in finer meshes and vice versa. With the aforementioned realistic head model of three layers, the segmentation is assumed to include current generators of brain volume, including both gray and white matter. Scalp, skull, and brain region conductivities were assumed to be 0.33, 0.0042, and 0.33, respectively. The source reconstruction solutions were projected onto the 3D MRI of the Collins brain, which was provided by the Montreal Neurological Institute. The probabilities of source activation based on Fisher's *F*-test were provided for each independent EEG source, whose values are indicated in a "unit" scale (the larger the value, the more significant). Both the segmentation and generation of the head model were performed using the ASA software program (Zanow and Knosche, 2004).

Response times exceeding the mean ± 2 standard deviations were excluded. To gain a sufficient number of EEG trials per condition the target orientation was not considered as a factor, but only the response correctness. As a record, RTs were on average 544 ms to upright trees and 551 ms to downward trees.

The mean area amplitude of N170 response was measured at PO9, PO10 (occipito/temporal sites) in between 150–200 ms. The mean area amplitude of anterior N2 was measured at AF3/AF4, AFp3h/AFp4h sites in between 300 and 400 ms. The mean area amplitude of centro-parietal P300 was measured at CPZ-PZ-POZ sites in between 350 and 450 ms. Repeated measures ANOVAs were applied to individual amplitude values of ERP potentials. Within-groups factors were: age (infants, adults); ethnic group (Caucasian, non-Caucasian), electrode (depending on the ERP component of interest), hemisphere (left, right).

Two repeated measures ANOVA were applied to correct response times and error percentages (arc-sine transformed, in order to undergo ANOVA). Factors of variability were, age (infant, adults); ethnic group (Caucasian, non-Caucasian), cue validity (valid, invalid).

2.4. Procedure

Participants were comfortably seated in a darkened, acoustically and electrically shielded cubicle, facing a computer screen located 120 cm from their eyes. Their task was to decide whether the tree presented right after the face was upright or inverted in orientation by pressing a joystick key with the index finger (of either the left or right hand) to answer yes and with the middle finger to answer no. All faces had to be ignored. The two hands were used alternately during the recording session. The order of the hand and task conditions was counterbalanced across subjects. Participants were instructed to fixate on the center of the screen, where a small circle served as fixation point, and to avoid any eye or body movements during the EEG recording session. The experimental session was preceded by a training session that included two runs, one for each hand.

3. Results

3.1. Behavioral data

The ANOVA performed on mean RTs yielded significant results for the age factor [$F(1, 13) = 9.253, p < 0.00945, \eta^2 = 0.416$], with faster responses to targets when they were preceded by infant (545 ms, $SE = 15.95$) vs. adult (550 ms, $SE = 16.00$) faces. The factor ethnic group was not significant ($F(1,13) = 0.27, p = 0.61$), neither was the age \times ethnic group interaction ($F(1,13) = 2.16, p = 0.2$). No significant effect was found for error percentages (children = 10.18, $SE = 0.82$; adults = 11.10, $SE = 1.24$) or for cue validity factor (see Fig. 2 for a summary of behavioral data and Table 1 for a list of mean confidence intervals).

3.2. Electrophysiological data

3.2.1. N170 (150–200 ms)

The ANOVA performed on N170 amplitude values recorded at occipito/temporal sites did not show any statistical significance (age factor: $p = 0.4$; age \times ethnic group interaction: $p = 0.55$; age \times ethnic group \times hemisphere: $p = 0.77$). This result indicate an optimal perceptual balance across stimuli.

3.2.2. N2 (300–400 ms)

The ANOVA performed on N2 amplitude values recorded at anterior frontal sites yielded the significance of age factor [$F(1, 13) = 7.27, p < 0.018, \eta^2 = 0.4$], with a much larger N2 to infant ($-3.31 \mu V, SE = 1.91$) than adult ($-2.66 \mu V, SE = 1.91$) faces. Fig. 3 show the grand-average ERPs while the topographical scalp distribution of this response, as a function face age, is displayed in Fig. 4.

The interaction of age \times ethnic group \times electrode [$F(1, 13) = 10.83, p = 0.0058, \eta^2 = 0.5$] was proved significant. According to post-hoc comparisons (see Table 2 for a complete summary) this deflection was more positive to Caucasian (AF3/AF4 = $-2.61 \mu V, SE = 1.01$; AFp3h/AFp4h = $-2.34 \mu V, SE = 0.99$) than non-Caucasian

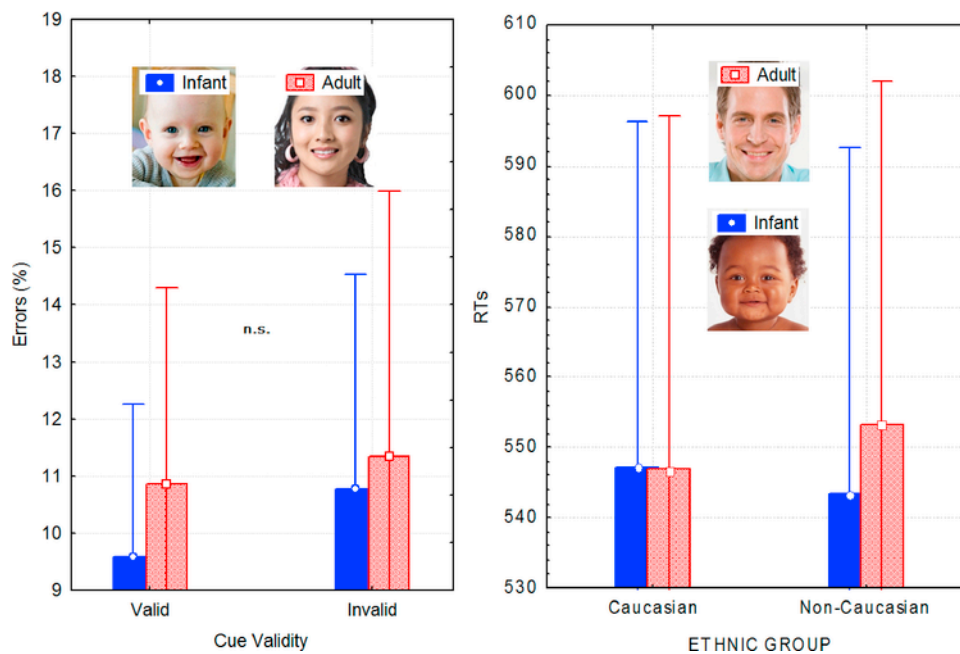


Fig. 2. Mean error percentages (left) and response times relative to correct target categorizations (index finger for upright and middle finger for upside down targets). Tree orientation discrimination was fastened when preceded by an infant face.

Table 1

Mean values of response times (in ms) or brain potential amplitude (in μV) relative to statistical significant factors, along with confidence intervals. Ethn = ethnic group, Ele = electrode, Cauc = Caucasian, NonC = Non Caucasian.

RTs						
Age	Mean	S.E.	- 95%	+ 95%		
Infant	545.33	15.954	510.86	579.80		
Adult	550.06	16.005	515.48	584.64		
N2 amplitude						
Age	Mean	S.E.	- 95%	+ 95%		
Infant	- 3.313	1.9116	- 7.443	0.8166		
Adult	- 2.664	1.9068	- 6.783	1.4557		
Age	Ethn	Ele	Mean	S.E.	- 95%	+ 95%
Infant	Cauc.	AF34	- 3.2290	0.9025	- 5.1787	- 1.2793
Infant	Cauc.	AFp34h	- 3.3096	0.9270	- 5.3124	- 1.3069
Infant	NonC.	AF34	- 3.3463	1.1176	- 5.7608	- 0.9317
Infant	NonC.	AFp34h	- 3.3680	1.0490	- 5.6343	- 1.1017
Adult	Cauc.	AF34	- 2.6062	1.0145	- 4.7979	- 0.4144
Adult	Cauc.	AFp34h	- 2.3386	0.9925	- 4.4827	- 0.1945
Adult	NonC.	AF34	- 2.8041	0.9754	- 4.9113	- 0.6968
Adult	NonC.	AFp34h	- 2.9059	0.9884	- 5.0411	- 0.7706
P300 amplitude						
Age	Ele	Mean	S.E.	- 95%	+ 95%	
ADU	Cz	- 4.3915	1.0608	- 6.6833	- 2.0998	
ADU	CPz	- 3.7781	1.0087	- 5.9573	- 1.59898	
ADU	Pz	- 2.8587	1.0108	- 5.0424	- 0.6750	
INF	Cz	- 4.7022	0.9579	- 6.7718	- 2.6326	
INF	CPz	- 3.8875	0.9133	- 5.8605	- 1.9144	
INF	Pz	- 2.7244	0.9377	- 4.7501	- 0.6987	

adult faces (AF3/AF4 = -2.80 μV , SE = 0.97; AFp3h/AFp4h = -2.90 μV , SE = 0.98), especially at AFp3h/AFp4h sites. This effect is depicted in Figs. 5 and 6. No effect whatsoever of ethnic group was found for infant faces (Caucasian: AF3/AF4 = -3.23 μV , SE = 0.90; AFp3h/AFp4h = -3.31 μV , SE = 0.93. Non-Caucasian: AF3/AF4 = -3.34 μV , SE = 1.11; AFp3h/AFp4h = -3.37 μV , SE = 1.04).

3.2.3. P300 (350–450 ms)

No effect of ethnic group $F(1, 13) = 3.6$, $p = 0.08$] was found over parietal area and centro/parietal area, but a strongly significant age x electrode interaction factor [$F(2, 26) = 6.43$, $p = 0.005$, $\eta^2 = 0.33$]. Tukey post-hoc comparisons showed larger P300 responses to adult (-4.39 μV , SE = 1.06) than infant faces (-4.7 μV , SE = 0.96) as predicted by current ERP literature, especially at centroparietal sites ($p < 0.001$) (see also Table 1 for all confidence intervals).

3.2.4. Source reconstruction

To identify the neural generators of the face age effect and of the possible attentional facilitation, 2 inverse solutions (for the two age types) were applied to the scalp potentials recorded at anterior N2 level (300–400 ms), and another swLORETA was applied to the difference-wave obtained by subtracting ERPs to infant from ERPs to adult faces. The list of active electromagnetic dipoles (provided in Table 3) shows a complex circuits of regions involved in face processing, including the superior temporal gyrus (rSTG) bilaterally, the superior frontal and rectal gyri (BA10 and BA11) and the Pulvinar thalamic nucleus. The major difference between the 2 source reconstructions was a particularly enhanced orbitofrontal activation during perception of infant faces. To better investigate this issue a further swLORETA was applied to the difference-wave as described above. A list of significant electro-

magnetic dipoles is reported in Table 4. The strongest neural sources specifically stimulated by infant paedomorphic facial features were the left orbitofrontal cortex (BA10), face devoted brain areas: such as the fusiform face area (BA20/37), the occipital face area (BA18), face specific rSTG (BA38/22), which exhibited a left hemispheric asymmetry, and affective limbic areas (right cingulate gyrus, BA23). Fig. 7 shows the swLORETA inverse solution displayed in 3 different sagittal, axial and coronal sections.

4. Discussion

The analysis of behavioral response clearly showed an effect of attentional priming for infant faces: participants were significantly faster in deciding about the target orientation when it was preceded by an infant face, regardless of their ethnic group. These results are in full agreement with those obtained in other studies showing an attentional orienting toward a space location primed by an infant, as opposed to an adult face (Brosch et al., 2007; Proverbio et al., 2011a). Accuracy data showed a trend toward the presence of attentional benefits only for the spatially cued location. The lack of significance might be interpreted as due to a slight IOR effect (e.g., Posner and Cohen, 1984; Dodd and Pratt, 2007; Samuel and Kat, 2003), which typically occurs if ISI is longer than 500 ms (Posner et al., 1995) acting on exogenous attention, but not on the arousal level. Indeed, while ISI was actually very short in the present study (200 ms), faces were presented for 500 ms (as opposed to 200 ms, as done in Proverbio et al., 2011a). This was made necessary by the need to observe face-related ERP responses at least for half a second, in absence of pattern-offset evoked responses.

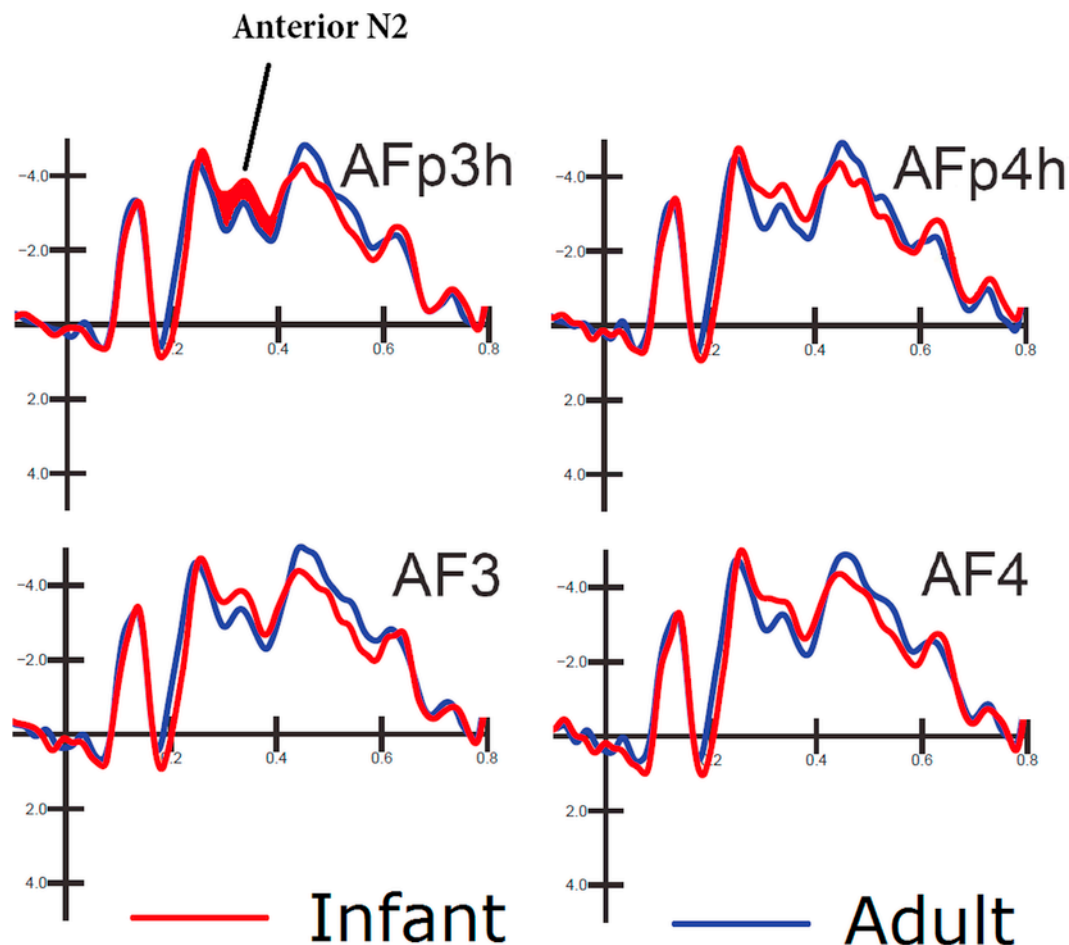


Fig. 3. Grand average ERP waveforms recorded from left and right anterior frontal sites, as a function of face age.

In the present study, independent of prime spatial validity, performance in an orientation decision task was fastened by the appearance of an infant face, and this was accompanied by an increase in N2 reward-related response over the anterior frontal area. This effect can be interpreted as a result of increased attentional arousal. Alerting (readiness to receive information) and subsequent activation (readiness to respond) is thought to be modulated by a noradrenergic mechanisms which from locus coeruleus, through reticular formation would activated the thalamus (and especially pulvinar) and parietal and frontal cortices, to enable an alert response (Rajkowski et al., 1994; Tracy et al., 2000). In this hypothesis the increased general arousal level would optimizing attentiveness. Its activation by a non-specific warning cue such as faces would promote and improve preparation for detecting and responding to targets (Aston-Jones, 2005; Geva et al., 2013; Howells et al., 2012; Petersen and Posner, 2012). Interestingly the thalamus, and particularly its Pulvinar nucleus (devoted to attentional orientation, e.g.: Fischer and Whitney, 2012) was found to be more active during processing of infant than adult faces, in the present study, which suggests a greater attentional orienting response.

The analysis of electrophysiological data showed an enhancement in the amplitude of N2 component response (300–400 ms) recorded over anterior frontal sites to infant, as compared to adult faces. No ethnicity effect was shown for infant but only for adult faces, with greater positivities for own-race faces.

These results are in agreement with previous findings in the literature of a larger anterior frontal N2 to infant than adult faces (Proverbio et al., 2011b) and can be interpreted in the light of the “baby schema” hypothesis. Other ERP evidences have demonstrated an increase in the

amplitude of early and late ERP responses to infants than adult faces independent of the esthetic quality of the face or observer sex, providing additional evidence for a “baby-specific” neural response (Hahn et al., 2016). The neural generators of the differential activity (obtained by subtracting ERPs to adult from that to infant faces in the N2 latency range) comprised the orbitofrontal cortex (OFC, BA10), the right superior temporal gyrus (BA22), the right fusiform gyrus (fusiform face area, FFA) and the posterior cingulate cortex (BA22). This circuit has been found to be involved in the affective processing of faces (e.g., Proverbio and Galli, 2016). While a stronger activation of FFA during perception of infant faces has been widely documented Leibenluft et al. (2004), Luo et al. (2015), Kringelbach et al. (2008) and Stoessel et al. (2014) many evidences indicate how OBC is involved in the brain response to the faces of infants, or “baby schema” response (Glocker et al., 2009; Kringelbach et al., 2008; Proverbio et al., 2011b; Luo et al., 2015; Parsons et al., 2013). Interestingly, the OFC is supposed to be engaged in processes integrating affective information with visual information such as faces and facial expressions in the right STS (Said et al., 2011; Flack et al., 2015; Candidi et al., 2015; Puce et al., 1998; Lahnakoski et al., 2012, Baseler et al., 2014) and FFA.

ERP data recorded between 300 and 400 ms indicated no effect of ethnicity (ORE) for baby faces, but a strong increase in positivity (P300) to own-race (Caucasian) than other-race (non-Caucasian) adult faces. This piece of data strongly supports previous psychophysiological literature showing larger P3 responses to own-race than other-race adult faces. (Lv et al., 2015; Sun et al., 2014; Liu et al., 2014). In the present study, the presence of an ORE effect for the adult faces corroborates the hypothesis that the experimental paradigm is indeed valid,

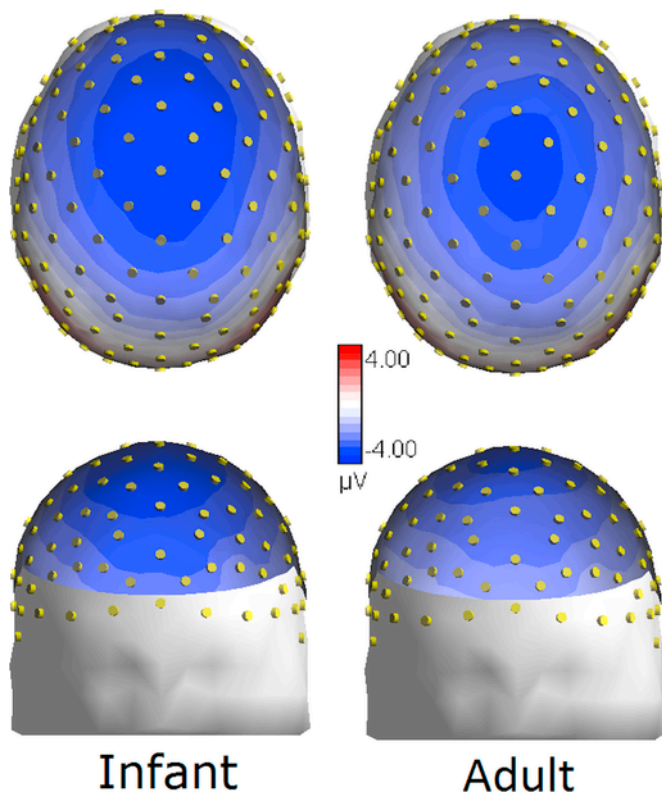


Fig. 4. Isocolour topographical maps of surface voltage recorded in between 300 and 400 ms (corresponding to anterior N2) in response to infant and adult faces. Upper: top view; lower: front view.

but that the ORE effect does not hold for infant faces because of their pedomorphic features that stimulates the baby-schema innate response in the adult brain.

Table 2

Post-hoc comparisons among means relative to the significant triple interaction of age \times ethnicity \times electrode according to Tukey test. Inf=infants, Adu=adults, Cau=Caucasian, Non=non Caucasian, AF=AF34 sites, AFp=AFP34h sites. The value indicate the p value obtained. No effect whatsoever of ethnicity was found for infant faces, while N2 significantly differed as a function of adult face ethnicity.

Stimulus type and electrode sites			INF	INF	INF	INF	ADUCAU AF	ADU	ADU	ADU
			AF	CAU AFp	NON AF	NON AFp		CAU AFp	NON AF	NON AFp
			CAU							
INF	CAU	AF		0.9057	0.6297	0.4422	0.0002	0.0002	0.0005	0.0047
INF	CAU	AFp	0.9057		0.9988	0.9811	0.0002	0.0002	0.0002	0.0007
INF	NON	AF	0.6297	0.9988		0.9999	0.0002	0.0002	0.0002	0.0004
INF	NON	AFp	0.4422	0.9811	0.9999		0.0002	0.0002	0.0002	0.0003
ADU	CAU	AF	0.0002	0.0002	0.0002	0.0002		0.0198	0.1207	0.0085
ADU	CAU	AFp	0.0002	0.0002	0.0002	0.0002	0.0198		0.0003	0.0002
ADU	NON	AF	0.0005	0.0002	0.0002	0.0002	0.1207	0.0003		0.7620
ADU	NON	AFp	0.0047	0.0007	0.0004	0.0003	0.0085	0.0002	0.7619	

Overall the present findings indicate a general prime effect of infant faces on visual processing, possibly attracting attention and increasing alertness and response readiness. This effect was not modulated by the ethnicity of infants (while an effect of ethnicity was found in the frontal response to adult faces). This data contradicts previous reports (Hodsoll et al., 2010) suggesting that spatial benefits for attentional orienting are observable only when infants share the ethnic groups with the observer. It cannot be excluded that differences in babies cuteness (for example an emaciated look), or other methodological causes might be the reason for such an inconsistency across studies. Instead, are fully in agreement with previous findings (Proverbio et al., 2011) showing how the ORE effects does not hold for infants faces, by virtue of their pedomorphic universal facial features.

In conclusion, based on these results it can advanced that the perceptual other-race effect (indicating a more accurate easier processing/recognition of familiar than unfamiliar ethnic traits in faces) does not exists for infant faces (in the brain of adults), since race-related facial features are overwhelming less relevant that baby-schema features of infant faces (e.g, large head and eyes, round chicks, small nose, etc...) acting as a universal trigger for instinctual caregiving, attention allocation and cuteness sensation regardless of human race (Kringelbach et al., 2016).

Conflict of interest statement

The authors declare that the research was conducted in the absence of any real or perceived conflict of interest.

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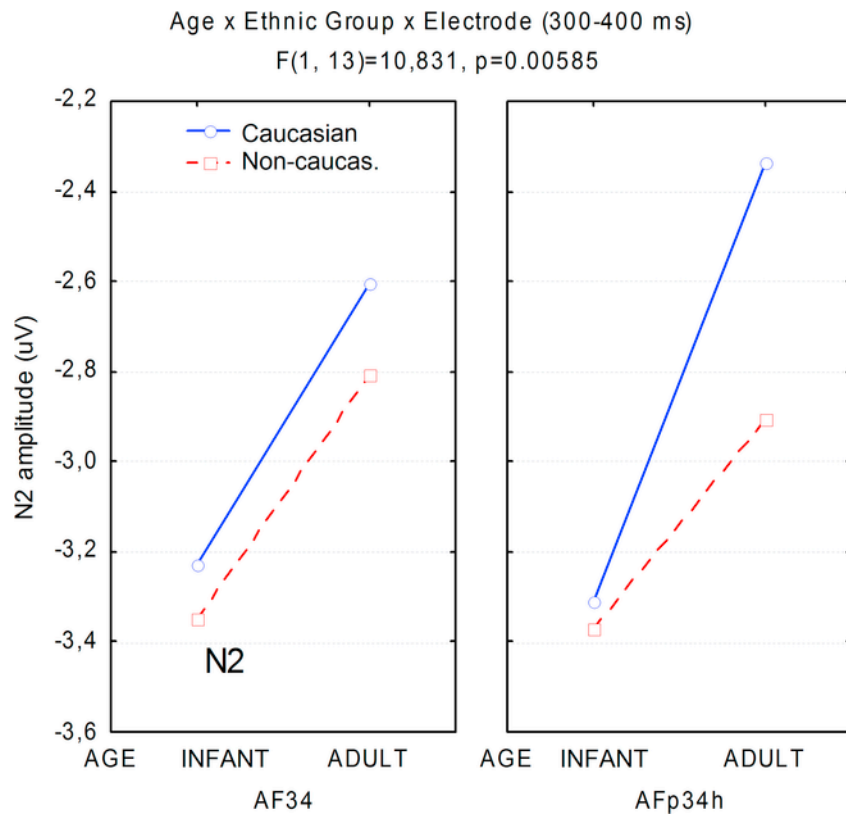


Fig. 5. Mean amplitude values of brain responses recorded in the 300–400 time window over left and right prefrontal sites, as a function of face age and ethnic group. It can be observed that baby faces elicited a much larger N2 to response regardless of ethnic group, while Caucasian (own-race) adult faces elicited larger P3 responses than other-race faces.

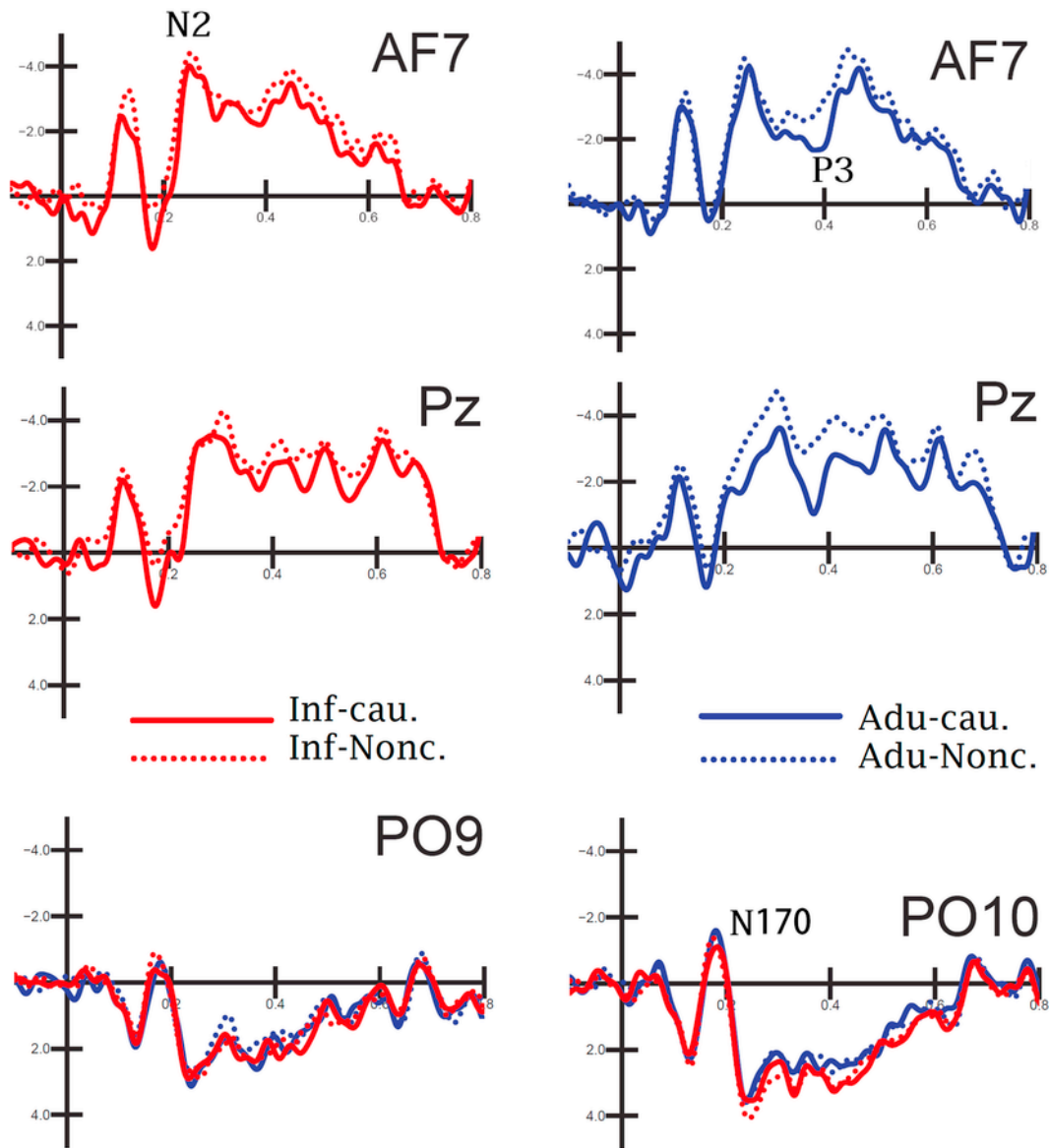


Fig. 6. Grand average ERP waveforms recorded from left anterior frontal, midline parietal and left and right occipito/temporal as a function of face age and ethnic group. Note the presence of an ORE effect for adult faces and the lack of it for infant faces. Also is notable the lack of N170 modulation at posterior brain sites, thus suggesting a perceptual matching between the two faces categories.

Table 3

Talairach coordinates corresponding to the intracranial generators explaining the scalp voltage measured in response to infant (Top) and adult faces (Bottom) in the 300–400 ms time window, according to swLORETA. Grid spacing = 5; estimated SNR = 3; Magn. = magnitude; T = Talairach; Hem. = hemisphere. Highlighted (in bold) are the activations recorded.

Magn.	T-x [mm]	T-y [mm]	T-z [mm]	Hem.	Lobe	Gyrus	BA
Infant faces							
13.82	50,8	-47,8	6,4	R	T	Superior Temporal Gyrus	22
13.24	-48,5	-47,8	6,4	L	T	Superior Temporal Gyrus	22
12.43	21,2	-27,5	8,2	R	Sub-lobar	Thalamus, Pulvinar	
11.56	-28,5	53,4	24,8	L	F	Superior Frontal Gyrus	10
11.00	-8,5	38,2	-17,9	L	F	Rectal Gyrus	11
9.39	1,5	64,4	16,8	R	F	Medial Frontal Gyrus	10
8.95	21,2	53,4	24,8	R	F	Superior Frontal Gyrus	9
7.35	-8,5	57,3	-9	L	F	Superior Frontal Gyrus	10
Adult faces							
13.45	50,8	-47,8	6,4	R	T	Superior Temporal Gyrus	22
12.88	-48,5	-57,9	5,6	L	T	Middle Temporal Gyrus	39
12.07	21,2	-27,5	8,2	R	Sub-lobar	Thalamus, Pulvinar	
9.99	-28,5	53,4	24,8	L	F	Superior Frontal Gyrus	10
9.45	11,3	64,4	16,8	R	F	Superior Frontal Gyrus	10
9.03	-8,5	38,2	-17,9	L	F	Rectal Gyrus	11

Table 4

Talairach coordinates corresponding to the intracranial generators explaining the difference voltages Infant – Adult faces in the 300–400 ms time window, according to swLORETA. Grid spacing = 5; estimated SNR = 3; Magn. = magnitude; T = Talairach; Hem. = hemisphere.

Magn.	T-x [mm]	T-y [mm]	T-z [mm]	Hem.	Lobe	Gyrus	BA
5.85	-28,5	53,4	24,8	L	F	Sup. Frontal Gyrus	10
4.37	40,9	-24,5	-15,5	R	T	Fusiform Gyrus	20
4.28	40,9	-87,3	-4,9	R	O	Inferior Occipital Gyrus	18
4.24	-58,5	-45,8	-9,5	L	T	Middle Temporal Gyrus	37
4.06	-48,5	8,2	-20	L	T	Sup. Temporal Gyrus	38
3.90	21,2	-18,9	9	R	Sub-lobar	Thalamus	
3.86	-58,5	5,3	2,7	L	T	Superior Temporal Gyrus	22
3.44	31	56,3	-1,6	R	F	Superior Frontal Gyrus	10
3.34	1,5	-13	27,7	R	Limbic	Cingulate Gyrus	23

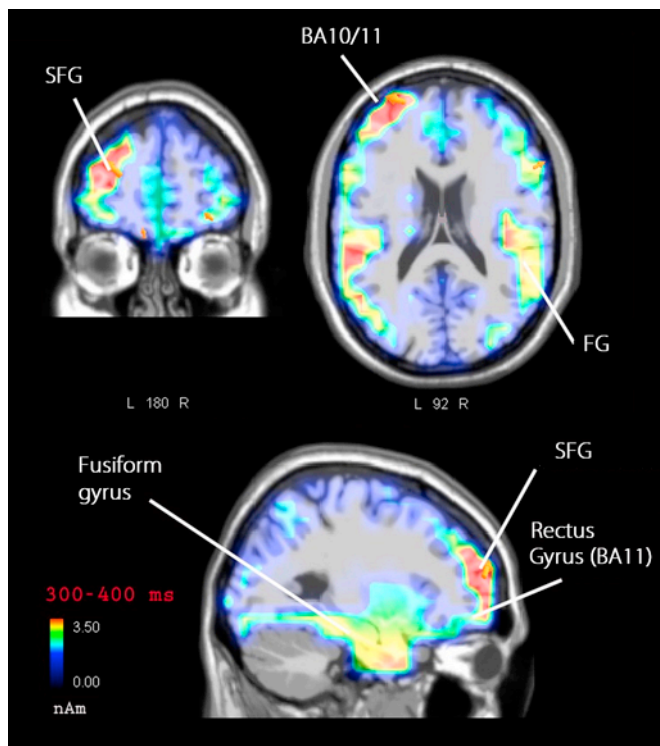


Fig. 7. The inverse solution was applied to the grand average signals. The different colors represent differences in the magnitudes of the electromagnetic signals (in nA m). The electromagnetic dipoles are shown as arrows and indicate the position, orientation and magnitude of the dipole modeling solutions that were applied to the difference ERP waveforms in between 300 and 400 ms. The numbers refer to the displayed brain slice in the axial view: L = left, R = right.

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