

Race perception and gaze direction differently impair visual working memory for faces: An event-related potential study

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Humans are amazingly experts at processing and recognizing faces, however there are moderating factors of this ability. In the present study, we used the event-related potential technique to investigate the influence of both race and gaze direction on visual working memory (i.e., VWM) face representations. In a change detection task, we orthogonally manipulated race (own-race vs. other-race faces) and eye-gaze direction (direct gaze vs. averted gaze). Participants were required to encode identities of these faces. We quantified the amount of information encoded in VWM by monitoring the amplitude of the sustained posterior contralateral negativity (SPCN) time-locked to the faces. Notably, race and eye-gaze direction differently modulated SPCN amplitude such that other-race faces elicited reduced SPCN amplitudes compared with own-race faces only when displaying a direct gaze. On the other hand, faces displaying averted gaze, independently of their race, elicited increased SPCN amplitudes compared with faces displaying direct gaze. We interpret these findings as denoting that race and eye-gaze direction affect different face processing stages.

Keywords: Race; Eye-gaze direction; Face processing; Visual working memory; Event-related potentials.

Faces of conspecifics are stimuli of the utmost significance for humans: They convey a large amount of social and emotional information and represent the main source in order to identify other individuals. Each encountered face is quickly categorized in a social group by a variety of stable (i.e., structural) face cues, such as race, age and sex (e.g., Crisp & Hewstone, 2007; Tajfel, 1981; Tajfel, Billig, Bundy, & Flament, 1971; Taylor, Fiske, Eto, & Ruderman, 1978). Along with categorizations on these cues, humans quickly process also transient face dimensions that may provide critical information on others' mental states and intentions, such as emotional expression and eye-gaze direction (e.g., Bruce &

Young, 1986; Haxby, Hoffman, & Gobbini, 2002). Notably, a huge body of work has established that both stable and transient face dimensions influence face processing in cascade.

Although humans are incredibly experts at processing and recognizing faces, there are moderating factors of this ability, such as race and eye-gaze direction. In the present study, we used the event-related potential (i.e., ERP) technique while focusing on a specific stage of face processing, namely face representations in visual working memory (i.e., VWM), to investigate the influence of both race and eye-gaze direction on face representations. Indeed, both race and eye-gaze direction, have been shown to modulate memory, such

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that other-race faces on one side (e.g., Hancock & Rhodes, 2008; MacLin & Malpass, 2001, 2003; Meissner & Brigham, 2001; Sessa et al., 2012), and faces displaying averted gaze on the other (Adams, Pauker, & Weisbuch, 2010; Hood, Macrae, Cole-Davies, & Dias, 2003; Mason, Hood, & Macrae, 2004; Smith, Hood, & Hector, 2006), are more poorly recognized than own-race faces and faces displaying direct gaze, respectively.

One singular aspect of processing of face stimuli when compared with the processing of other object stimuli, is that faces are recognized by the use of a form of configural processing, as opposed to feature-based processing, which results in the whole face being recognized without any explicit recognition of face parts (e.g., Tanaka & Farah, 1993). Maurer, Le Grand, and Mondloch (2002) distinguish three different types, or levels, of configural processing: One type would allow to detect first-order relations characteristics of a face, namely two eyes above a nose and mouth; a different type, termed holistic processing, is characterized by the glueing of the features together into a Gestalt; the last type consists in the processing of second-order relations, that is, the spacing among features. To note, when all of these types of configural processing are performed, this would very likely lead to higher resolution face representations relative to when only one or two types are at work, that is, when configural processing is less efficient.

In the past 15 years, two streams of research dominated in the field of studies on race processing by using neuroimaging and ERP methods, one focusing on differences that appear directly related to race evaluation (e.g., Amodio, Harmon-Jones, & Devine, 2003; Cunningham et al., 2004; Hart et al., 2000; Phelps et al., 2000; Wheeler & Fiske, 2005), and the other focusing on differences in face processing as a function of race (e.g., Caldara et al., 2003; Golby, Gabrieli, Chiao, Eberhardt, 2001; Golarai, Ghahremani, Eberhardt, Grill-Spector, & Gabrieli, 2004; Ito & Urland, 2005; Vizioli, Foreman, Rousselet, & Caldara, 2010). Consistent with decades of research showing that race can trigger the automatic activation of stereotypes and negative affective responses (e.g., Devine, 1989), a branch of studies using functional magnetic resonance imaging and ERP technique highlighted the impact of race evaluation on emotion (e.g., Phelps et al., 2000), cognitive control (e.g., Richeson et al., 2003), attention (e.g., He, Johnson, Dovidio, & McCarthy, 2009), VWM representations (Sessa et al., 2012) and, more recently, empathy toward other-race individuals (Avenanti, Sirigu, & Aglioti, 2010; Sessa, Meconi, Castelli, & Dell'Acqua, 2014; Sheng & Han, 2012; Xu, Zuo,

Wang, & Han, 2009). On the other hand, the large body of neuroimaging studies examining face processing in cross-racial contexts have consistently shown that race processing is associated with differences in activity of a brain region notoriously involved in face processing, namely the face fusiform area such that it exhibits greater blood oxygen level dependent activity to own-race faces than to other-race faces (Golby, Gabrieli, Chiao, & Eberhardt, 2001; Golarai et al., 2004; see also Brosch, Bar-David, & Phelps, 2013; see Ito & Urland, 2005; for similar results using ERP). All of these observations are of particular importance in the context of the so-called other-race effect (i.e., ORE; known also as own-race advantage or cross-race effect; see Meissner & Brigham, 2001, for a review), namely the poor recognition of faces from an unfamiliar racial group. Recently, Hugenberg, Young, Bernstein, and Sacco (2010) proposed a Categorization–Individuation Model of the ORE that integrates these factors and asserts that the ORE has its roots in both visual expertise and motivated processing.

Eye-gaze orientation is a relevant face cue as much as race. Indeed, meeting the eyes of others can lead to profound consequences in an observer. For instance, faces displaying direct gaze, compared to averted gaze, are generally judged as more likable and attractive (e.g., Mason, Tatkov, & Macrae, 2005; see also Jones, DeBruine, Little, Conway, & Feinberg, 2006), facilitate categorical responses, for instance by gender (Macrae, Hood, Milne, Rowe, & Mason, 2002), tend to increase arousal (e.g., Hietanen, Leppänen, Peltola, Linna-Aho, & Ruuhiala, 2008), capture attention more easily (e.g., Senju & Hasegawa, 2005; but see for instance also Pavan, Dalmaso, Galfano, & Castelli, 2011), and are associated with approached-oriented emotions (Slepian, Weisbuch, Adams, & Ambady, 2011) and feelings related with social inclusion (e.g., Wirth, Sacco, Hugenberg, & Williams, 2010). Importantly, eye-gaze orientation, similarly to racial group, has also been shown to influence facial identity recognition, with averted eye-gaze reducing memory accuracy (e.g., Adams et al., 2010; Conty & Grèzes, 2012; Hood et al., 2003; Mason et al., 2004; Smith et al., 2006; see Emery, 2000; Frischen, Bayliss, & Tipper, 2007; for reviews concerning eye-gaze processing).

To note, processing style differences (configural vs. featural encoding) have been posited to play a causal role in face memory, with configural encoding hypothesized to undergird accurate face memory (e.g., Maurer et al., 2002; Tanaka, Kiefer, & Bukach, 2004).

As expounded in the following paragraphs, despite compelling evidence showing that either different race from that of the observer and averted gaze negatively

influence memory, at the present it is not understood which aspect of face processing is impaired so that memory is compromised. We were precisely interested in understanding the ‘nature’ of these deficits in recognition at the stage of VWM representations of faces. To this aim, by using the ERP technique, we manipulated the direction of the gaze (i.e., direct or averted) of White (i.e., own-race) and Black (i.e., other-race) faces in order to examine the mechanism (s) underlying detrimental face recognition in a VWM task for other-race faces and faces displaying averted gaze. We monitored the amplitude of a well-known electrophysiological index of VWM called sustained posterior contralateral negativity (SPCN; Luria, Sessa, Gotler, Jolicœur, & Dell’Acqua, 2010; Sessa et al., 2012; Sessa, Luria, Gotler, Jolicœur, & Dell’Acqua, 2011; Meconi, Luria, & Sessa, 2014; also called contralateral delay activity, Vogel, McCollough, & Machizawa, 2005). In particular, the SPCN is an electrophysiological index of the maintenance of representations in VWM, such that the amplitude of the SPCN increases with the amount of visual information maintained in VWM. Notably, compelling evidence indicates that objects, and not features, are the building blocks of VWM (i.e., the integrated object account of VWM; e.g., Luria & Vogel, 2011; Marshall & Bays, 2013) such that VWM performance (Luck & Vogel, 1997; see also Awh, Barton, & Vogel, 2007; Duncan, 1984; Gajewski & Brockmole, 2006) and the amplitude of the SPCN (Luria & Vogel, 2011) has been shown to be identical for objects that have only a single feature (e.g., a color) relative to objects that have multiple features (e.g., color and orientation). This evidence strongly suggests that the SPCN amplitude should increase from conditions in which a face is perceived in a configural fashion (i.e., one object—the face—composed by multiple features) to conditions in which a face is perceived in a featural, analytic, piecemeal fashion (i.e., many objects, for instance eyes, nose and mouth). Furthermore, on the basis of the distinction between the three different types of configural processing discussed above (see Maurer et al., 2002), even when a face is processed configurally, the SPCN would be sensitive to the quality of this processing, since low-quality configural processing would result in low-resolution face representation, that is, reduced SPCN amplitude, compared to high-quality configural processing leading to high-resolution face representation.

In the present design, we monitored the SPCN component while participants performed a change detection task—which is a well-known paradigm appropriate to elicit a reliable SPCN (e.g., Vogel et al., 2005)—that required encoding and maintaining

for a short interval the identity of one face lateralized in the visual field, either White (i.e., own-race) or Black (i.e., other-race) with either direct or averted gaze. The SPCN time-locked to the onset of the face was used to index the VWM resources allocated to the face. Our rationale was that, on the one hand, if averted gaze and/or other-race induce feature-based processing, the SPCN amplitude elicited by faces displaying averted gaze and/or other-race faces should be increased compared to that elicited by faces with direct gaze and/or own-race faces as well, because of featural, piecemeal processing leading to multiple representations (i.e., eyes, nose and mouth) in VWM rather than a unique face representation. On the other hand, if configural processing of other-race faces and/or of faces displaying averted gaze is not completely disrupted but only impaired, such that low-quality configural processing is performed, this would result in reduced SPCN amplitudes elicited by these faces as compared to that elicited by own-race and direct gaze faces (i.e., low-resolution face representations). To note, to both of these ERP scenarios would correspond a deterioration of behavioral performance in face recognition, that is behavioral measures are not appropriate to disentangle between them. The more interesting possibility, explored by the present study, was that averted gaze and race might impact different types of face processing, leading to different SPCN modulations: In particular, previous studies seem to suggest that averted gaze may dramatically disrupt face processing, inducing a feature-based analysis of the face (Young, Slepian, Wilson, & Hugenberg, 2014); this would manifest at the level of the SPCN as larger amplitudes for averted gaze faces than for direct gaze faces. On the other hand, both other-race and own-race faces might involve configural processing but this could work less efficiently for other-race faces compared with own-race faces (as supported, e.g., by an ERP study by Wiese, Stahl, & Schweinberger, 2009); this would manifest at the level of the SPCN as reduced amplitude for other-race faces compared with own-race faces. In general, we expected interactive effects of race and gaze, supporting the view that race perception and gaze direction differently impair VWM for faces.

METHOD

Participants

Twenty-seven White students ($M = 24$ years, $SD = 2.22$; 13 females; two left-handed) from the University of Padova took part in this study on a

voluntary basis. All reported normal or correct-to-normal vision and were naïve to purpose of the experiment. Informed consent was obtained from all of them. The local ethic committee approved the study. Data from two participants were excluded because of excessive electroencephalogram (EEG) artifacts, leaving 25 participants in the final sample ($M = 24$ years, $SD = 2.29$; 12 females; two left-handed).

Stimuli, apparatus and procedure

Face stimuli were taken from the Minear and Park (2004) database. We selected 12 White and 12 Black male faces (aged 18–29 years) with neutral expression. For each face there were two versions, the original version depicting faces with direct gaze, and a new version depicting faces with averted gaze rightwards or leftwards. This new version was created ad hoc by moving the irises about 0.25° to the right or to the left from the original central position using Photoshop CS5. All faces were then converted in a grey-scale, resized to 3.3° wide \times 4.5° height from a viewing distance of approximately 70 cm, normalized for contrast and luminance and cropped with an ovoid mask in order to omit extraneous cues such as ears, neck and hairline. The memory and test arrays were

composed by two faces of the same race with both direct or averted gaze that were located at the corners of an imaginary rectangle centered around fixation. The faces were horizontally aligned and occupied either the upper or the lower two quadrants of the visual field. The horizontal distance between the center of two faces was 7° and the distance between the center of each face and the fixation cross was 4.9° .

Examples of trials are depicted in Figure 1. A centrally placed black fixation cross remained on the screen throughout the trial (Fixation cross frame, Figure 1). After trial initiation, 500 ms elapsed before the presentation of two arrow cues, one above and one below the fixation cross, both pointing rightwards or leftwards (Predictive cue frame). The two arrow cues were displayed for 200 ms and were followed, after a variable interstimulus interval (ISI) of 200–400 ms (ISI frame), by the memory array of faces, which was displayed for 200 ms (Memory array frame). The memory array was composed of two faces. Following the memory array, a blank interval of 900 ms (Retention interval frame) preceded the onset of the test array, which was exposed until the response (Test array frame). Each memory and test array contained faces of the same race, and trials with White faces and Black faces were presented in separate blocks.

Participants were instructed to maintain fixation throughout the trial and to memorize only the face in

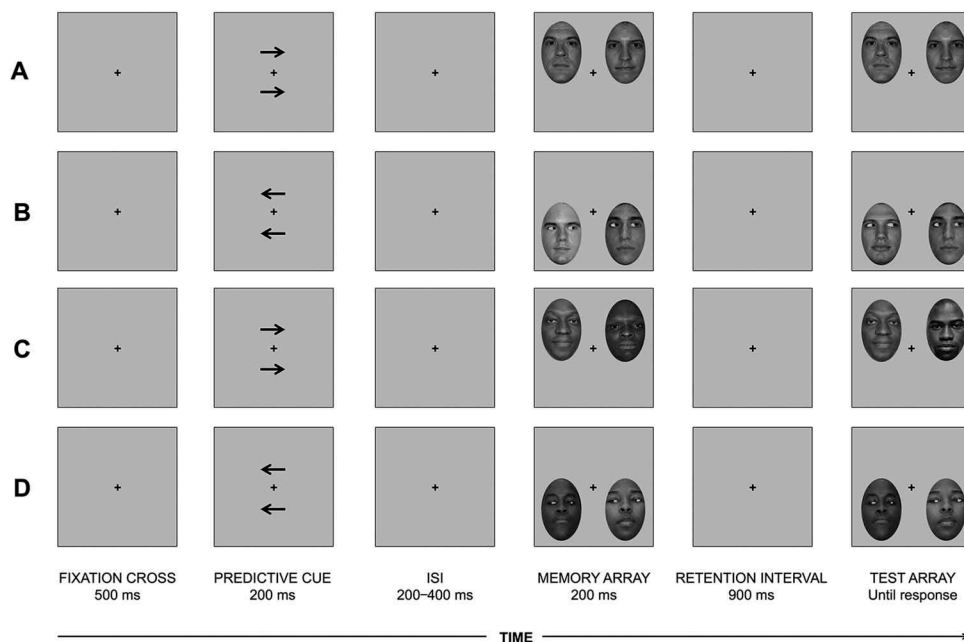


Figure 1. Illustration of the procedure and examples of White (A and B) and Black (C and D) face-stimuli with direct (A and C) and averted (B and D) gaze. Arrows indicated the to-be-memorized face during the memory array, that in the test array could remain the same (A and D) or change (B and C) with same probability. The faces used in this article are from the published Center for Vital Longevity Face Database, by Minear and Park (2004), available for researchers and their publications.

the memory array displayed on the side indicated by the arrow cues, and were explicitly informed that the face displayed on the opposite side were of no importance for the response they had to make at the end of the trial. Importantly, no information about race and gaze direction of face stimuli were given to participants. The task was to compare the cued side of the memory array and test array in order to indicate whether the identity of the face had changed. On 50% of the trials, the memory array and the test array were identical. On the other 50% of trials, the face on the arrow-cued side of the memory array was replaced with a different face in the test array. When a change occurred, one face was replaced with a different face. Half of the participants pressed the 'F' key to indicate that the face had changed between the memory array and the test array and the 'J' key to indicate that the memory array and the test array were identical. The other half of the participants responded using the opposite mapping. The response had to be made without speed pressure and participants were explicitly informed that speed of response would not be considered to assess their performance. Following the response, a variable inter-trial interval of 1510 – 1600 ms elapsed before the presentation of the fixation cross indicating the beginning of the next trial.

Face stimuli of same race and gaze direction (i.e., White face, direct gaze; White face, averted gaze; Black face, direct gaze; Black face, averted gaze) were presented separately in four distinct blocks selected in a random order. There were 4 practical blocks each composed by 16 trials followed by 4 experimental blocks each composed by 96 trials for a total of 384 experimental trials.

ERP recording and analysis

EEG activity was recorded from 64 standard electrodes distributed over the scalp according to the international 10/20 system referenced to the left earlobe. The EEG was re-referenced offline to the average of the left and right earlobes. Trials associated with horizontal eye movements exceeding $\pm 60 \mu\text{V}$ and eye blinks or any other artifact exceeding $\pm 80 \mu\text{V}$ were discarded from analyses. Incorrect responses in the change detection task were also discarded from analysis. We computed contralateral waveforms by averaging the activity recorded at right hemisphere electrodes when participants were cued to encode the face stimulus on the left side of the memory array with the activity recorded from the left hemisphere electrodes when they were cued to encode the face

stimulus on the right side of the memory array. SPCN was quantified at posterior electrode sites P7/P8 (temporo-occipital lobe) as the difference in mean amplitude between the ipsilateral and contralateral waveforms in a time window of 300–950 ms relative to the onset of the memory array.

RESULTS

SPCN

Figure 2 displays SPCN (contra-minus-ipsi waveforms) recorded at electrode sites P7/P8 time-locked to memory arrays of faces for each cell of the present experimental design (race: White vs. Black, gaze direction: direct vs. averted). SPCN was quantified at posterior electrode sites (P7/P8) as the difference in mean amplitude between the contralateral and the ipsilateral waveforms in a time window of 300–950 ms relative to the onset of the memory array.

Mean SPCN amplitudes were submitted to a repeated-measures ANOVA that considered gaze direction (direct vs. averted) and race (White vs. Black) as within-subject factors. The main effect of gaze direction was significant, $F(1, 24) = 10.799$, $MSE = .653$, $p = .003$, owing to a greater amplitude of SPCN for averted ($M = -1.205 \mu\text{V}$, $SE = .170$) than

Contra-minus-ipsilateral waveforms (SPCN) recorded at P7/P8

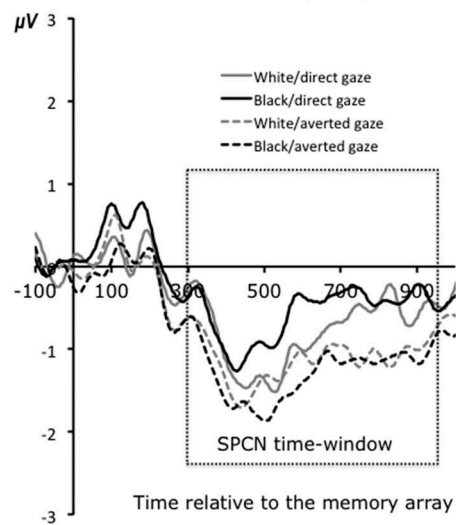


Figure 2. SPCN (contra-minus-ipsilateral waveforms) recorded at P7/P8 electrode sites, plotted as a function of race (White/own-race vs. Black/other-race) and gaze direction (averted vs. direct) and time-locked to the memory array of faces. The rectangle indicates the SPCN time-window (i.e., 300 – 950 ms). Waveforms were filtered with a high cutoff filter of 10 Hz (slope 24 dB/oct) for visual inspection only.

TABLE 1
Behavioral data for each condition presented in the experiment

	<i>White faces</i>		<i>Black faces</i>	
	<i>Direct gaze</i>	<i>Averted gaze</i>	<i>Direct gaze</i>	<i>Averted gaze</i>
Hit rate	.856 (.102)	.777 (.115)	.842 (.102)	.776 (.084)
False alarm rate	.125 (.093)	.094 (.075)	.123 (.087)	.113 (.091)
d'	2.45 (.731)	2.23 (.606)	2.34 (.518)	2.17 (.619)
RT (ms)	954 (193)	951 (252)	947 (227)	982 (247)

Note: Values in brackets are standard deviations.

for direct ($M = -.674 \mu\text{V}$, $SE = .200$) gaze, whereas the main effect of race was not significant, $F(1, 24) < 1$, $MSE = .168$. The interaction Gaze direction \times Race was, however, significant, $F(1, 24) = 4.346$, $MSE = .231$, $p = .048$. Paired t -tests indicated that the SPCN amplitude differed between White (own-race) and Black (other-race) faces only when those faces displayed direct gaze, such that the SPCN tended to be smaller for Black faces ($M = -.556 \mu\text{V}$, $SE = .218$) than for White faces ($M = -.793 \mu\text{V}$, $SE = .200$), $t(24) = -1.917$, $p = .067$, whereas no differences emerged between White ($M = -1.128 \mu\text{V}$, $SE = .170$) and Black ($M = -1.282 \mu\text{V}$, $SE = .191$) faces displaying averted gaze, $t(24) = 1.221$, $p = .234$.

For completeness we conducted the same analysis considering mean SPCN amplitude values recorded at P3/P4 (parietal lobe) and at O1/O2 (occipital lobe). The degree with which SPCN was reflected on different posterior electrodes sites could provide insights concerning its modulation over space. For the SPCN recorded at P3/P4, the main effect of gaze direction tended to be significant, $F(1, 24) = 3.561$, $MSE = .271$, $p = .071$, reflecting greater amplitude of SPCN for averted ($M = -.300 \mu\text{V}$, $SE = .109$) than for direct ($M = -.103 \mu\text{V}$, $SE = .104$) gaze, as well as the main effect of race, $F(1, 24) = 3.132$, $MSE = .097$, $p = .089$, reflecting greater amplitude of SPCN for white ($M = -.257 \mu\text{V}$, $SE = .101$) than for black ($M = -.146 \mu\text{V}$, $SE = .095$) faces. At O1/O2, the main effect of gaze direction was significant, $F(1, 24) = 9.321$, $MSE = .095$, $p = .005$, owing to a greater amplitude of SPCN for averted ($M = -.427 \mu\text{V}$, $SE = .106$) than for direct ($M = -.239 \mu\text{V}$, $SE = .113$) gaze. No other significant results emerged ($ps > .327$).

Behavior

VWM performance was quantified using a standard index of sensitivity (d' ; Green & Swets, 1974) calculated as following:

$$d' = H - FA,$$

where H is the hit rate and FA is the false alarm rate, both transformed in z -scores. In so doing, larger d' indicate greater recognition performance. This was a critical control to identify how sensitive the participants were to changes between the memory and test arrays independent of possible response biases. We submitted d' values to a repeated-measures ANOVA that considered Gaze direction (direct vs. averted) and Race (White vs. Black) as within-subjects factors. The main effect of Gaze direction approached statistical significance, $F(1, 24) = 4.130$, $MSE = .229$, $p = .053$, reflecting greater d' values in response to direct ($M = 2.395$, $SE = .109$) than averted ($M = 2.200$, $SE = .107$) gaze. No other results were significant ($ps > .345$). Finally, for completeness, a second repeated-measures ANOVA with the same factors as above was conducted on median reaction times (i.e., RT) of correct trials (84.94% of total trials). We used medians instead of means because they reduce the effect of outliers without removing any trials (see also Dalmaso, Galfano, Coricelli, & Castelli, 2014). No significant results emerged ($ps > .427$; see Table 1). This is not surprising since participants were required to respond accurately without speed pressure.

DISCUSSION

We used the ERP approach to investigate the temporal locus of the impairment in face representations at the stage of VWM of either other-race faces and faces displaying averted gaze compared with own-race faces and faces displaying direct gaze, respectively. We adapted a change detection task in which race and direction of the gaze were orthogonally manipulated while monitoring a *direct* measure of the amount of information maintained in VWM, namely, the SPCN component of the ERP (Dell'Acqua, Sessa, Jolicœur,

& Robitaille, 2006, 2006b, Jolicœur, Sessa, Dell'Acqua, & Robitaille, 2006a; Sessa et al., 2011, 2012; Vogel & Machizawa, 2004). The advantage of monitoring the SPCN in the present paradigm was that differences in face processing as a function of gaze and race during early stages would have led to different VWM face representations, and then, to differences in SPCN modulations.

The electrophysiological results of the present investigation provide the first evidence that brain responses related to VWM maintenance of faces are modulated both by race (i.e., own-race vs. other-race faces) and by gaze direction (direct gaze vs. averted gaze) simultaneously. Indeed, other-race faces elicited reduced SPCN amplitudes compared with own-race faces only when displaying a direct gaze. On the other hand, faces displaying averted gaze, independently of their race, elicited increased SPCN amplitudes compared with faces displaying direct gaze. Behaviorally, a detriment in face recognition was observed only for faces displaying an averted gaze, independently of their race. These findings strongly support the view that the *temporal loci* of the interplay between race and face perception on one side, and between gaze direction and face perception on the other, are different. In particular, the present investigation provides evidence that this impairment in recognition, at least at the stage of VWM, depends on disruption of different face processing stages, with averted gaze having an earlier effect inducing featural processing of faces—and leading to increased SPCN amplitudes compared with faces with direct gaze—and other race having a later effect during configural processing stages, causing low-quality configural processing (see Maurer et al., 2002) and reduced SPCN amplitudes compared with own-race faces (for similar findings of race effects on VWM see also Sessa et al., 2012). In other words, when a face is displayed with averted gaze, this information would be prioritized, and would induce feature-based processing that would nullify any influence of race. Instead, when a face is displayed with direct gaze, the race of the face would be fully processed modulating face processing at a later stage compared to the gaze (see, e.g., Maurer et al., 2002).

Our findings related to the influence of gaze direction on VWM representations of faces fit nicely with a recent study by Young and colleagues (2014) that has suggested, indeed, the disruption of configural processing as the perceptual mechanism through which averted eye-gaze impairs face memory. In two experiments, these authors implemented two paradigms known to disrupt holistic processing of faces, that is,

composite face (Young, Hellawell, & Hay, 1987) and face-inversion (Yin, 1969) paradigms, while manipulating also eye-gaze direction (i.e., direct vs. averted). To note, faces characterized by averted gaze were less affected by these manipulations than faces characterized by direct gaze indicating that faces displaying an averted gaze are processed less holistically and in a more feature-based fashion. In this vein, our findings together with those by Young et al. (2014) strongly suggest that gaze direction has a very early effect in face processing causing analytic processing of separate features. One may object that an alternative interpretation of this increased SPCN amplitude for faces with averted gaze (compared with faces displaying direct gaze) may rely on the additional maintenance of gaze direction information at the level of VWM rather than reflecting featural processing of those faces. However, we note that this interpretation is incongruent with the pattern of interaction observed in the present study between race and gaze, and that this interpretation would have been consistent with an additive effect of race and gaze direction, that is other-race faces displaying averted gaze should have elicited reduced SPCN amplitude compared with own-race faces displaying averted gaze.

With regard to race-driven modulations on SPCN amplitude, a study by Wiese et al. (2009) is particularly critical in the context of the present investigation. These authors implemented a design in which participants were exposed to own-race faces and other-race faces as well as to two categories of control stimuli, that is, ape faces, and house fronts, all of these presented both in upright and inverted orientations. Notably, the N170 ERP component (e.g., Bentin & Deouell, 2000; Eimer, 2000) was delayed but not decreased in amplitude for other-race faces compared with own-race faces suggesting that the processes involved for both classes of faces are not qualitatively different but that these processes work less efficiently for other-race faces compared with own-race faces (but see also Caldara et al., 2003; Herrmann et al., 2007; Ito & Urland, 2005; Stahl, Wiese, & Schweinberger, 2008; Vizioli et al., 2010). In line with our findings of reduced SPCN amplitudes for direct-gaze other-race faces compared with direct-gaze own-race faces (see also Sessa et al., 2012, for similar findings), this study suggests that configural/holistic processing is not disrupted for other-race faces but rather that it is less efficient (see also Maurer et al., 2002). To note, however, the dominant view on the functional significance of N170 ERP component is that it reflects structural face encoding for input to

other higher level brain regions involved in face identification (e.g., Bentin & Deouell, 2000; Eimer, 2000), rather than indexing, per se, face identity representation, which is in fact a critical stage for the study of the characteristic impairment in recognition of other-race faces. We overcame such limitation by implementing a design in which participants were explicitly required to encode face identities, and in this vein SPCN reflected the efficiency of such encoding. Our findings further corroborate the view that representations of direct-gaze other-race faces are of lower resolution compared with representations of direct-gaze own-race faces, likely as a consequence of less efficient configural processing. Even though the SPCN amplitude was sensitive to both gaze direction and race, a more accurate identification of faces was documented in the present study only when faces with direct gaze had to be memorized, independently of their race, that is behavioral performance was not modulated by the race of the faces (although a trend in the same direction of SPCN modulations was observed, see Table 1). We note that brain responses may be more sensitive to tiny processing differences than behavioral measures, as shown by previous studies where modulations of neural activity were not complemented by behavioral effects (e.g., Heil, Rolke, & Pecchinenda, 2004; Luck, Vogel, & Shapiro, 1996; see also Wilkinson & Halligan, 2004).

The whole pattern of ERP findings is also congruent with the behavioral study by Adams et al. (2010) who implemented a design in which both race (i.e., own-race vs. other-race faces) and gaze direction (i.e., direct gaze vs. averted gaze) were orthogonally manipulated in order to study long-term memory impairments in face recognition of other-race faces and faces displaying an averted gaze. Similarly to the findings reported here, these authors found that such impairments as a function of race were manifest only for faces making direct eye contact. Our findings may help explaining such interesting empirical scenario by suggesting that gaze direction and race perception differently affect face processing. We propose that averted gaze has an earlier impact on face processing, before race-driven modulations may take place, causing own- and other-race faces to be subject to the same kind of disruption of configural processing in favor of feature-based processing. On the other hand, for faces making direct eye gaze, race may affect the quality of configural processing, which is not a single-step process but rather a multi-step process (Maurer et al., 2002). Providing an answer to whether this race-driven modulation of face processing originates from observers' motivation, visual expertise or related

factors is beyond the scope of the present investigation.¹ The debate around the causes of race-driven modulations in general, and on the causes of interferences in memory recognition in particular, has been very hot for decades (e.g., Meissner & Brigham, 2001); with regard to this debate, we embrace the recent model proposed by Hugenberg and colleagues (2010; 2013; Categorization–Individuation Model) that in our view provide a very plausible account on how these factors, that is, motivated processing and visual expertise, integrate in generating race-driven modulations including interferences in memory recognition of other-race faces. In this vein, both of these factors may have contributed in interfering with processing of other-race faces compared with own-race faces leading to low-resolution other-race faces representations, but only when making direct eye contact.

Taken together, these results corroborate the interplay between face memory processes and individuals differences. Moreover, they provide both theoretical and practical insights for future research aimed to uncover modulations of cognitive mechanisms when individuals of different race interact with each other.

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¹Embracing a more socially connoted view, it is important to note that faces with direct gaze may communicate the intention to establish an approach with an observer. Interestingly, a recent study showed that other-race faces with direct gaze were rated as more threatening than own-race faces with direct gaze, whereas there were no differences when these facial stimuli were displayed with averted gaze (Richeson, Todd, Trawalter, & Baird, 2008). These results emerged, reasonably, because the intentions communicated by other-race faces with direct gaze were perceived by participants as more negative. In our view, this is perfectly congruent with both the model proposed by Hugenberg et al. (2010, 2013) and with our findings.

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