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FACE GENDER CATEGORIZATION AND HEMISPHERIC ASYMMETRIES: CONTRASTING EVIDENCE FROM CONNECTED AND DISCONNECTED BRAINS

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Abstract—We investigated hemispheric asymmetries in categorization of face gender by means of a divided visual field paradigm, in which female and male faces were presented unilaterally for 150 ms each. A group of 60 healthy participants (30 males) and a male split-brain patient (D.D.C.) were asked to categorize the gender of the stimuli. Healthy participants categorized male faces presented in the right visual field (RVF) better and faster than when presented in the left visual field (LVF), and female faces presented in the LVF than in the RVF, independently of the participants' sex. Surprisingly, the recognition rates of D.D.C. were at chance levels – and significantly lower than those of the healthy participants – for both female and male faces presented in the RVF, as well as for female faces presented in the LVF. His performance was higher than expected by chance – and did not differ from controls – only for male faces presented in the LVF. The residual right-hemispheric ability of the split-brain patient in categorizing male faces reveals an own-gender bias lateralized in the right hemisphere, in line with the rightward own-identity and own-age bias previously shown in split-brain patients. The gender-contingent hemispheric dominance found in healthy participants confirms the previously shown right-hemispheric superiority in recognizing female faces, and also reveals a left-hemispheric superiority in recognizing male faces, adding an important evidence of hemispheric imbalance in the field of face and gender perception.

Key words: face gender categorization, hemispheric asymmetries, split-brain, own-gender bias.

INTRODUCTION

Humans are social animals, living in a social environment and interacting with each other for individual and group-related reasons. As social individuals, we are sensitive to our conspecifics, and the most informative cue exploited to recognize and categorize our conspecifics is their faces. The evolutionary basis of this extraordinary ability is confirmed by the evidence of a similar bias for conspecifics' face recognition in a number of species besides humans (see Leopold and Rhodes, 2010 for a review).

Decades of research have definitively confirmed a right-hemispheric superiority for face processing (Meadows, 1974), both at a neural level (e.g., Yovel et al., 2008), and at a behavioral level (e.g., Prete et al., 2015b), not only in humans, but also in other animals species (for reviews, see Rosa Salva et al., 2012; Rogers et al., 2013). The most agreed-upon explanation of this evidence is that of a right-hemispheric superiority in global shape processing – faces being processed as a global percept – as opposed to a left-hemispheric superiority in local processing (Yovel et al., 2001). Nevertheless, if the right-hemispheric lateralization for face processing appears unquestionable, hemispheric asymmetries are much more controversial when analyzed separately for the specific features of the face, such as gender, age, ethnical group, and so on. In humans, this issue has been explored by means of behavioral paradigms, neuroimaging studies, and neurological patients. A neurological condition which is still very informative about a possible cerebral imbalance is that of epileptic patients who underwent the surgical resection of the *corpus callosum* (CC), in an attempt to reduce the spread of epileptic activity between the hemispheres ("split-brain" patients). Although this surgical treatment is rarely used today, thanks to the development of more efficient pharmacological therapies than those available in the past years, the performance of such patients, in whom the left and right cerebral hemispheres are surgically disconnected, constitutes a milestone for the investigation of hemispheric abilities (e.g., Gazzaniga, 2005).

Using a divided visual field paradigm, Mason and Macrae (2004) asked a group of healthy participants and a male split-brain patient (J.W.) to carry out a face gender categorization task, and a face identity recognition task. The results revealed no cerebral asymmetries in gender recognition, but they showed a right-hemispheric

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Abbreviations: CC, corpus callosum; LVF, left visual field; ORB, own-race bias; OGB, own-gender bias; OAB, own-age bias; RVF, right visual field.

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superiority during identity recognition, both in healthy participants and in the patient. This superiority was also supported by functional magnetic resonance imaging (fMRI) results in healthy participants, showing that the right fusiform gyrus and the right temporal gyrus were more strongly activated in the identity recognition task than in the gender recognition task, during the central presentation of the faces (Mason and Macrae, 2004).

Even in the literature on split-brain patients, however, the evidence of hemispheric dominance is not consistent for different facial characteristics, such as identity. For instance, exploring the cerebral asymmetry for self-face recognition, Turk et al. (2002) found that the left disconnected hemisphere of the patient J.W. was dominant with respect to the right hemisphere, even if both hemispheres were able at recognizing faces. On the other hand, Keenan et al. (2003) found the opposite pattern of results: the right disconnected hemisphere of the patient M.L. was better than the left hemisphere in self-face recognition. This latter result is in line with a previously shown increased galvanic skin response when own face was presented to the right hemisphere of a split-brain patient (Preilowski, 1979). Keenan and Gorman (2007) explained the difference between the results of the patient M.L. (Keenan et al., 2003) and those of the patient J.W. (Turk et al., 2002) as possibly due to ''*pre-surgical condition, the nature of the surgery, post-operative response, a difference in testing methods, or perhaps an interaction between these variables*" (p. 1076). Moreover, a different study in which Turk et al. (2005) exploited a delayed match-to-sample task revealed that the patient J.W. showed a right-hemispheric superiority in recognizing faces of his own ethnicity. Specifically, the results confirmed the expected own-race bias (ORB), and revealed that the disconnected right hemisphere of the patient better recognized Caucasian than Japanese faces, showing that the ORB is right-lateralized. However, by administering the same task to nine healthy participants, the authors confirmed the ORB, but no hemispheric lateralization was found.

As regards cerebral asymmetries for face gender processing, Proverbio et al. (2010) recorded Event-Related brain Potentials (ERPs) in healthy participants during the passive viewing of female and male faces, and found that faces of the opposite gender than the participants' elicited a larger and earlier centro–parietal N400 compared to faces of their own gender (both in female and male participants), whereas a greater occipito–parietal late positive component was elicited when faces of the same-gender as the participants' were presented. Importantly, the results revealed that the N400 (the ''marker" of other-gender) mainly involved the left hemisphere, whereas the late positive component (the ''marker" of own-gender) was mainly lateralized to the right hemisphere. An unexpected hemispheric imbalance during face gender recognition was found in a behavioral study carried out by Parente and Tommasi (2008): the authors presented healthy participants with either female and male whole faces, or chimeric faces in which the left/right halves were of the same gender, or chimeric faces composed by two hemifaces of different gender (half female and half male). They found that male–male chimeric faces were recognized better than female–female faces, independently of the participants' gender. Importantly, they found that female–male chimeric faces were better recognized than male–female stimuli, showing a right-hemispheric superiority for female faces recognition, without differences between female and male observers. The authors explained the right-hemispheric superiority in recognizing female faces by referring to the lateralized bias in maternal cradling, that has been shown to occur preferentially on the left side of the body's midline, possibly attributable to the right-hemispheric superiority for (female) face processing (Todd and Banerjee, 2016). Finally, it has to be highlighted that Wright and Sladden (2003) confirmed the OGB both in female and male healthy participants, but they also showed that part of the bias was attributable to the hairstyle of the faces used as stimuli. In the study by Parente and Tommasi (2008) the hairstyle was hidden by enclosing faces in a white oval-shaped mask, and this could be one reason for the absence of an overall OGB. Moreover, Verdichevski and Steeves (2013) investigated the effect of face age and gender on the face identity recognition: the authors asked healthy participants to carry out a same/different task during the presentation of female/male, young/old faces. The results revealed an own-age bias (OAB), due to the better performance of older participants during the presentation of older faces (also a trend toward the OAB was found in younger participants for younger faces), together with an own-gender bias (OGB), at least in females, due to the fact that females outperformed males during the presentation of female faces. Since the results revealed an overall better performance by older than younger participants, the authors concluded that this finding could be ascribed to the more extensive experience that older people have with persons of all ages.

To summarize, the ERPs results by Proverbio et al. (2010) suggest a right-hemispheric superiority in the processing of faces containing the same characteristics as those of the observers, specifically the gender, whereas the behavioral results described by Parente and Tommasi (2008) suggest a right-hemispheric superiority for the recognition of female faces, independently of the participants' gender. Finally, Mason and Macrae (2004) failed in finding any cerebral asymmetry in a gender recognition task, both in healthy observers and in a split-brain patient. Thus, it seems to emerge that face gender is independent of other facial characteristics, such as identity or ethnicity, which appear to be a right-hemipsheric domain. In fact, apart from the evidence of a left-hemispheric superiority in the identification of own face found in a split-brain patient by Turk et al. (2002), the other findings reported above seem to suggest a right-hemispheric superiority in categorizing faces having the same characteristic as those of the patients tested (e.g., self-face: Preilowski (1979), Keenan et al. (2003); face ethnicity: Turk et al. (2005)). Results collected with healthy participants lead to a less clear hemispheric imbalance: for example, cerebral asymmetries were not found in the control group tested by Turk et al. (2005) for the ORB; similarly, Mason and Macrae (2004) failed