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Research report

Seeing the eyes in acquired prosopagnosia

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ABSTRACT

Case reports have suggested that perception of the eye region may be impaired more than that of other facial regions in acquired prosopagnosia. However, it is unclear how frequently this occurs, whether such impairments are specific to a certain anatomic subtype of prosopagnosia, and whether these impairments are related to changes in the scanning of faces.

We studied a large cohort of 11 subjects with this rare disorder, who had a variety of occipitotemporal or anterior temporal (AT) lesions, both unilateral and bilateral. Lesions were characterized by functional and structural imaging. Subjects performed a perceptual discrimination test in which they had to discriminate changes in feature position, shape, or external contour. Test conditions were manipulated to stress focused or divided attention across the whole face. In a second experiment we recorded eye movements while subjects performed a face memory task.

We found that greater impairment for eye processing was more typical of subjects with occipitotemporal lesions than those with AT lesions. This eye selectivity was evident for both eye position and shape, with no evidence of an upper/lower difference for external contour. A greater impairment for eye processing was more apparent under attentionally more demanding conditions. Despite these perceptual deficits, most subjects showed a normal tendency to scan the eyes more than the mouth.

We conclude that occipitotemporal lesions are associated with a partially selective processing loss for eye information and that this deficit may be linked to loss of the right fusiform face area, which has been shown to have activity patterns that emphasize the eye region.

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1. Introduction

Acquired prosopagnosia is a selective visual agnosia in which the ability to recognize familiar faces or to learn new faces is lost (Barton, 2003). The nature of the impairment that leads to problems recognizing faces remains a topic of investigation. As with all complex processes, face recognition involves several cognitive operations (Bruce & Young, 1986) and an extensive cerebral network (Fox, Iaria, & Barton, 2009). Hence acquired prosopagnosia is likely a family of disorders with variants that differ in their functional and structural bases (Barton, 2008; Davies-Thompson, Pancaroglu, & Barton, 2014).

In some, particularly those with fusiform lesions, the impairment is likely perceptual, a difficulty in perceiving the subtle differences that distinguish one face from another (Barton, 2008). However, there is considerable debate about what this apperceptive defect entails. Some suggest that holistic face processing is lost for some parts of the face (Bukach, Bub, Gauthier, & Tarr, 2006; Busigny & Rossion, 2011; Kimchi, Behrmann, Avidan, & Amishav, 2012), with the possible consequence of reliance on a local feature-by-feature strategy (Bukach et al., 2006; Levine & Calvanio, 1989). Others have demonstrated an inability to process the configuration of facial features (Barton, 2008; Barton, Press, Keenan, & O'Connor, 2002; Joubert et al., 2003).

Another interesting aspect is the possibility that the prosopagnosic impairment may affect the processing of some parts of the face more than others. There is evidence that not all aspects of the face contribute equally to face identification. The eye region contain the most diagnostic information for face identification (Sadr, Jarudi, & Sinha, 2003; Vinette, Gosselin, & Schyns, 2004) and can be used to discriminate faces (Sekuler, Gaspar, Gold, & Bennett, 2004). Behavioral performance in face identity tasks most reliably correlates with horizontal contour information from the eye region (Pachai, Sekuler, & Bennett, 2013). Healthy subjects look most at the eyes when recognizing faces and scan the upper face-half more than the lower half (Barton, Radcliffe, Cherkasova, Edelman, & Intriligator, 2006; Henderson, Williams, & Falk, 2005), and studies of cue saliency show that the eye region is particularly emphasized (Shepherd, Davies, & Ellis, 1981). Models of face scanning suggests that looking near the eyes is optimal for face recognition (Peterson & Eckstein, 2012).

Ironically, the early seminal description of prosopagnosia (Bodamer, 1947) recounted the anecdotal observation of the two patients that they were attracted to the eyes (Ellis & Florence, 1990). Likely the first experimental observation of disproportionate difficulty perceiving the eyes in acquired prosopagnosia was that of two prosopagnosic subjects who had more trouble matching eyes than mouths to whole faces (Gloning & Quatember, 1966; Gloning, Gloning, Hoff, & Tschabitscher, 1966). This issue was not examined further until recently. One study of four prosopagnosic subjects with fusiform lesions found that discrimination of facial configuration was more consistently impaired in the eye than the mouth region (Barton et al., 2002). Subjects LR and HH were impaired in perceiving changes of the eyes but not the mouth, whether those were changes in spatial position, a feature swap or a change in feature size (Bukach et al., 2006; Bukach, Le Grand, Kaiser, Bub, & Tanaka, 2008). Subject PS had difficulty discriminating changes in eye brightness or spatial position (Ramon & Rossion, 2010; Rossion, Kaiser, Bub, & Tanaka, 2009) and the Bubbles technique showed that she relied more on the mouth and external contours than the eyes for facial identity (Caldara et al., 2005). Subject GG was studied with the same perceptual discrimination tests, with similar findings (Busigny, Joubert, Felician, Ceccaldi, & Rossion, 2010). Also, in developmental prosopagnosia there is some evidence that impaired holistic processing is more severe for the eye than the mouth region (DeGutis, Cohan, Mercado, Wilmer, & Nakayama, 2012).

These cases raise several issues. The first is how common or uniform is this apparent selectivity of impaired eye processing in prosopagnosia. A review of 10 cases, including the four previously reported (Barton et al., 2002), noted impaired perception of eye configuration and normal perception of mouth configuration in three subjects (Barton, 2008). All three had right occipitotemporal lesions, as did all the cases above, with the exception of LR. Given that a variety of lesions can cause prosopagnosia (Barton, 2008), one question is whether impaired eye perception is specific to right occipitotemporal lesions. Indeed, a neuroimaging study of regional saliency in healthy subjects found that the fusiform face area showed a feature–salience hierarchy that emphasized the eyes and correlated with human perceptual efficiency, which was best for the eyes (Lai, Pancaroglu, Oruc, Barton, & Davies-Thompson, 2014).

A second question concerns the type of information processing that shows a selective vulnerability in the eye region. While most reports show that the processing of the spatial position of the eye is impaired, a number also show that ocular feature properties are affected. Subjects do not perceive changes from swapping of the eyes (Bukach et al., 2006), altering eye brightness (Busigny et al., 2010; Ramon & Rossion, 2010) or eye size (Bukach et al., 2008; Busigny et al., 2010; Rossion et al., 2009). Also, one can ask whether this effect is limited to an eye/mouth contrast or is part of a more general upper/lower face contrast, by examining the perception of external facial contour. In healthy subjects the perception of external contours is just as vulnerable to the inversion effect as is the perception of facial features (Malcolm, Leung, & Barton, 2004). Figure 4 of the Bubbles study (Caldara et al., 2005) suggests that subject PS uses the external contour of the lower but not the upper face.

A third question relates to the perceptual conditions under which this eye vulnerability emerges. Two reports found that some prosopagnosic subjects perform better or even normally when given blocks in which only one type of facial change is to be detected, than with blocks containing trials with many different changes (Barton et al., 2002; Ramon & Rossion, 2010). This suggests that the impairment is more evident when attention needs to be divided across the whole face. If so, this defect may be related to or interact with holistic mechanisms (Rossion et al., 2009; de Xivry, Ramon, Lefèvre, & Rossion, 2008).

Finally, there is the question of whether these perceptual deficits are accompanied by changes in the way faces are explored with eye movements. One potentially trivial explanation is that subjects do not attend to the eyes, which may be