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Research report

Impaired perception of facial emotion in developmental prosopagnosia

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ABSTRACT

Developmental prosopagnosia (DP) is a neurodevelopmental condition characterised by difficulties recognising faces. Despite severe difficulties recognising facial identity, expression recognition is typically thought to be intact in DP; case studies have described individuals who are able to correctly label photographic displays of facial emotion, and no group differences have been reported. This pattern of deficits suggests a locus of impairment relatively late in the face processing stream, after the divergence of expression and identity analysis pathways. To date, however, there has been little attempt to investigate emotion recognition systematically in a large sample of developmental prosopagnosics using sensitive tests. In the present study, we describe three complementary experiments that examine emotion recognition in a sample of 17 developmental prosopagnosics. In Experiment 1, we investigated observers' ability to make binary classifications of whole-face expression stimuli drawn from morph continua. In Experiment 2, observers judged facial emotion using only the eye-region (the rest of the face was occluded). Analyses of both experiments revealed diminished ability to classify facial expressions in our sample of developmental prosopagnosics, relative to typical observers. Imprecise expression categorisation was particularly evident in those individuals exhibiting apperceptive profiles, associated with problems encoding facial shape accurately. Having split the sample of prosopagnosics into apperceptive and non-apperceptive subgroups, only the apperceptive prosopagnosics were impaired relative to typical observers. In our third experiment, we examined the ability of observers' to classify the emotion present within segments of vocal affect. Despite difficulties judging facial emotion, the prosopagnosics exhibited excellent recognition of vocal affect. Contrary to the prevailing view, our results suggest that many prosopagnosics do experience difficulties classifying expressions, particularly those with apperceptive profiles. These individuals may have difficulties forming view-invariant structural descriptions at an early stage in the face processing stream, before identity and expression pathways diverge.

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1. Introduction

Developmental prosopagnosia[1] (DP) is a lifelong neurodevelopmental disorder associated with impaired face recognition, thought to affect as many as one in every 50 people (Kennerknecht, Ho, & Wong, 2008; Kennerknecht et al., 2006). Individuals with DP exhibit deficits recognising personally familiar faces as well as problems discriminating unfamiliar faces, despite normal intelligence, typical low-level vision, and an absence of manifest brain injury (Behrmann & Avidan, 2005; Duchaine & Nakayama, 2006a,b; Susilo & Duchaine, 2013). Due to characteristic problems with face recognition, individuals with DP often utilise cues derived from hairstyle, voice, and gait, for person recognition. Nevertheless, recognising familiar people encountered out of context or following changes in external appearance, can prove challenging (Shah, Gaule, Sowden, Bird, & Cook, 2015).

The precise origin of the face recognition deficits seen in DP remains unclear. Cognitive accounts have argued that, relative to typically developing (TD) individuals, DPs exhibit reduced holistic processing of faces – whereby individual features (eyes, nose, mouth) are integrated into a coherent unified whole – compromising the accuracy and efficiency of their face recognition (Avidan, Tanzer, & Behrmann, 2011; Liu & Behrmann, 2014; Palermo et al., 2011). At the neurological level, differences in cortical structure (Behrmann, Avidan, Gao, & Black, 2007; Garrido, Eisner, et al., 2009; Garrido, Furl, et al., 2009), structural (Gomez et al., 2015; Thomas et al., 2009) and functional connectivity (Avidan & Behrmann, 2009; Avidan et al., 2013) have been observed in inferotemporal regions including the fusiform gyrus, a region thought to be crucial for face processing (Kanwisher, 2000). Strikingly, DP often runs in families (Duchaine, Germine, & Nakayama, 2007; Johnen et al., 2014; Lee, Duchaine, Wilson, & Nakayama, 2010; Schmalzl, Palermo, & Coltheart, 2008), suggestive of a genetic component.

The characteristic deficits of facial identity recognition seen in DP have attracted substantial research attention (Susilo & Duchaine, 2013). However, there has also been considerable interest in the expression recognition abilities of individuals with DP. The facial expressions of others are a rich source of social information, conveying cues to affective and mental states (Adolphs, 2002; Frith, 2009; Parkinson, 2005). The ability to interpret facial expressions correctly is therefore important for fluent social interaction and wider socio-cognitive development. Moreover, the question of emotion recognition in DP also has important implications for neuro-cognitive accounts of the condition (Bate & Bennetts, 2015; Kress & Daum, 2003a). Where observed together, difficulties recognising facial identity and facial emotion are suggestive of apperceptive prosopagnosia (De Renzi, Faglioni, Grossi, & Nichelli, 1991); difficulties may arise early on in the face processing stream, leaving observers unable to form an accurate, view-invariant description of face shape (Bruce & Young, 1986; Haxby, Hoffman, & Gobbini, 2000). Alternatively, intact expression recognition despite impaired recognition of facial identity suggests a locus of impairment relatively late in the face processing stream, after the divergence of expression and identity analysis pathways (Bruce & Young, 1986; Duchaine, Parker, & Nakayama, 2003; Haxby et al., 2000).

Presently, difficulties recognising facial expressions are thought to be relatively uncommon in DP. Palermo et al. (2011) examined the performance of twelve DPs on three emotion recognition tests: *The Ekman 60 Faces Test*, in which participants label 60 greyscale images of prototypical basic emotions (Young, Perrett, Calder, Sprengelmeyer, & Ekman, 2002); *The Emotion Hexagon Test*, in which participants label expressions drawn from morph continua constructed from the six basic emotions[2] (Young et al., 2002); and *The Reading the Mind in the Eyes Test*, in which participants identify subtle social emotions from cues present around the eye region (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). Strikingly, the twelve DPs were unimpaired at both the group and single-case level, relative to aged-matched controls, on all three tasks (Palermo et al., 2011). Dobel, Bölte, Aicher, and Schweinberger (2007) described intact emotion recognition in six DPs, having administered the Tübingen Affect Battery – a 4 alternative-forced-choice (AFC) emotion labelling task. Similar findings were reported by Humphreys, Avidan, and Behrmann (2007), having administered *The Emotion Hexagon Test* to three DPs,[2] and Lee, et al. (2010), having tested three DPs using *The Reading the Mind in the Eyes Test* and a 3AFC match-to-sample task. Several further studies of single cases have described intact emotion recognition in DP (Bentin, Degutis, D'Esposito, & Robertson, 2007; Duchaine et al., 2003; Kress & Daum, 2003b; Nunn, Postma, & Pearson, 2001). Moreover, a study of four DPs indicated that they made typical judgements of facial trustworthiness (Todorov & Duchaine, 2008), an inference thought to be mediated by subtle emotion cues.

Nevertheless, many DPs report problems recognising facial expressions in their daily lives (e.g., Lee et al., 2010), and case studies have described individuals with DP, who *do* exhibit deficits of expression recognition (Ariel & Sadeh, 1996; De Haan & Campbell, 1991; Duchaine, Murray, Turner, White, & Garrido, 2009; Duchaine, Yovel, Butterworth, & Nakayama, 2006; Minnebusch, Suchan, Ramon, & Daum, 2007; Schmalzl et al., 2008). For example, Duchaine et al. (2006) described a 53-year-old male DP, Edward, who exhibited clear expression recognition impairments on *The Reading the Mind in the Eyes Test* and on a 3-AFC match-to-sample task. Similarly, De Haan and Campbell (1991) tested AB, the original case of DP first described by McConachie (1976), and found that as an adult she exhibited problems labelling prototypical basic emotions. Importantly, however, these reports are relatively infrequent (regarded as 'the exception' rather than 'the norm'), and no systematic investigation has found evidence for a group difference.

[1] We use the term Developmental Prosopagnosia in preference to Congenital Prosopagnosia to reflect the possibility that the condition emerges during development, and may not necessarily be present from birth.

[2] While expression stimuli were drawn from morph continua, psychophysical analyses were not employed (e.g., psychometric functions were not estimated). The authors' analysis was restricted to proportions of correct responses, defined through reference to the dominant emotion signal present in each stimulus.