Impaired perception of facial emotion in developmental prosopagnosia:
A reply to Van den Stock's commentary

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1. Interactions between identity and emotion processing

In his commentary, Van den Stock (2017) first raises the possibility that the processing of facial identity and facial expression interact to a greater degree than has been acknowledged in the past. Classic models of face perception posit a bifurcation of identity and expression processing after an initial structural encoding stage (Bruce & Young, 1986; Haxby, Hoffman, & Gobbini, 2000). While these models do allow for some interaction between the identity and expression streams, they also emphasise dissociation. We agree with Van den Stock (2017) that widespread interaction between the visual processing of facial expression and identity is likely. In addition to the lines of evidence cited in the commentary, we would also highlight reports that characteristic patterns of expression and facial motion aid the recognition of familiar others (Knight & Johnston, 1997), and recently reported detrimental effects of expression when sorting unfamiliar faces by identity (Redfern & Benton, 2017). Expression variation may also aid the learning of facial identities (Murphy, Ipser, Gaigg, & Cook, 2015).

The findings described by Biotti and Cook (2016) are broadly consistent with putative interactions between identity and expression processing. The aim of this study was to determine whether 17 observers with Developmental Prosopagnosia (DP) – a condition characterised by problems recognising and discriminating facial identity – exhibited co-occurring deficits of expression recognition. While difficulties recognising facial emotion had been reported in isolated cases (e.g., Duchaine, Yovel, Butterworth, & Nakayama, 2006), this profile was thought to be relatively uncommon in the DP population (Humphreys, Avidan, & Behrmann, 2007). In our experiments, however, we found that sensitive psychophysical paradigms revealed significant expression recognition impairments at the group level (see also Burns, Martin, Chan, & Xu, 2017). Rather than *dissociation* between identity and expression processing, these results imply a degree of *association*.

In our paper, we speculated that co-occurring deficits of identity and expression recognition may be caused by problems forming a structural description, early in the face processing network, before the bifurcation of the identity and expression streams. This view was suggested by the fact that our DPs' performance on the Cambridge Face Perception Test (CFPT) was closely related to their expression recognition ability. In his

commentary, Van den Stock (2017) suggests an alternative possibility; that expression deficits arise from aberrant interactions between the identity and expression stream after the bifurcation (see Figure 1, Van den Stock, 2017). While we regard this as an interesting possibility, we would query any suggestion that emotion recognition difficulties are simply a by-product of identity recognition problems. Despite lifelong problems recognising facial identity, several of our DPs exhibited normal expression recognition (see also Duchaine, Parker, & Nakayama, 2003). These findings indicate that expression recognition problems are not an inevitable consequence of identity recognition deficits.

2. Do expression perception deficits reflect domain-general impairment?

In the second strand of his commentary, Van den Stock (2017) suggests that, where observed, expression recognition difficulties in DP may not be caused by a face-specific problem; rather difficulties may reflect a domain-general deficit affecting visual object recognition. Contrary to this possibility, we found no relationship between the Cambridge Car Memory Test (CCMT) or the Cambridge Bike Memory Test (CBMT) and any measure of expression recognition ability described in Experiments 1 or 2, either in the combined sample, or in the DP and control groups independently (all r's < .30; p's > .20). Moreover, all of the DPs in our sample performed within the normal range (within 2 SDs) on both the CBMT and the CCMT. These results accord with previous findings reporting that, in many cases, DP is associated with a face-specific perceptual deficit (Duchaine et al., 2006; Shah, Gaule, Gaigg, Bird, & Cook, 2015).

It is beyond doubt, however, that some DPs *do* exhibit problems recognising non-face objects including cars and bodies (e.g., Biotti, Gray, & Cook, 2017; Cook & Biotti, 2016; Duchaine, Germine, & Nakayama, 2007). The presence of non-face deficits is often taken as evidence that an individual has a domain-general perceptual deficit that affects the processing of all object categories, including faces (Avidan, Tanzer, & Behrmann, 2011; Behrmann, Avidan, Marotta, & Kimchi, 2005). Interestingly, this view predicts that perceptual ability for one non-face category ought to predict perceptual ability for others. Contrary, to this suggestion, we recently observed little or no correlation between DPs' ability to match bodies and cars (Biotti et al., 2017). In this paper, we suggest that forms of developmental agnosia affecting the perception of faces, bodies, and cars may be best thought of as independent neurodevelopmental conditions. Importantly, genetic and

environmental risk factors that predispose an individual to one neurodevelopmental condition often increase their risk of developing others (e.g., Bishop & Rutter, 2008; Gilger & Kaplan, 2001). Individuals at risk of developing face recognition problems may therefore be at risk of developing other specific types of developmental agnosia.

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