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Research report

Intranasal inhalation of oxytocin improves face processing in developmental prosopagnosia

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ABSTRACT

Developmental prosopagnosia (DP) is characterised by a severe lifelong impairment in face recognition. In recent years it has become clear that DP affects a substantial number of people, yet little work has attempted to improve face processing in these individuals. Intriguingly, recent evidence suggests that intranasal inhalation of the hormone oxytocin can improve face processing in unimpaired participants, and we investigated whether similar findings might be noted in DP. Ten adults with DP and 10 matched controls were tested using a randomized placebo-controlled double-blind within-subject experimental design (AB-BA). Each participant took part in two testing sessions separated by a 14–25 day interval. In each session, participants inhaled 24 IU of oxytocin or placebo spray, followed by a 45 min resting period to allow central oxytocin levels to plateau. Participants then completed two face processing tests: one assessing memory for a set of newly encoded faces, and one measuring the ability to match simultaneously presented faces according to identity. Participants completed the Multidimensional Mood Questionnaire (MMQ) at three points in each testing session to assess the possible mood-altering effects of oxytocin and to control for attention and wakefulness. Statistical comparisons revealed an improvement for DP but not control participants on both tests in the oxytocin condition, and analysis of scores on the MMQ indicated that the effect cannot be attributed to changes in mood, attention or wakefulness. This investigation provides the first evidence that oxytocin can improve face processing in DP, and the potential neural underpinnings of the findings are discussed alongside their implications for the treatment of face processing disorders.

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1. Introduction

Face recognition is an important cognitive skill that most people take for granted, yet it depends on a complex set of cognitive and neural processes (Bruce & Young, 1986; Haxby, Hoffman, & Gobbini, 2000). In some individuals this process can be selectively disrupted, resulting in a condition termed "prosopagnosia" or "face-blindness". While prosopagnosia can be acquired following brain injury (e.g., Damasio, Damasio, & Van Hoesen, 1982), many more individuals simply fail to develop normal face recognition abilities (e.g., Bate, Haslam, Jansari, & Hodgson, 2009; Bate, Haslam, Tree, & Hodgson, 2008; Behrmann & Avidan, 2005; Bentin, Deouell, & Soroker, 1999; Duchaine, Germine, & Nakayama, 2007; Duchaine & Nakayama, 2006; Jones & Tranel, 2001; Schmalzl, Palermo, Green, Brunsdon, & Coltheart, 2008). The latter form of the disorder has been termed 'developmental prosopagnosia' (DP; but for a discussion of terminology see Susilo & Duchaine, 2013), and has been attributed to a failure to develop the visual recognition mechanisms necessary for successful face recognition, despite intact low-level visual and intellectual functions. Interestingly, there also appears to be a genetic component to the disorder in at least some individuals (Duchaine et al., 2007; Grueter et al., 2007). In the last decade it has become increasingly clear that DP represents a significant clinical disorder, with recent reports suggesting that two percent of the population have the condition (Bowles et al., 2009; Kennerknecht et al., 2006).

Although many studies have investigated the cognitive, neural and genetic basis of DP, little attention has been directed towards improving face recognition in these individuals. While some researchers have attempted to remedy face processing deficits using extensive visual training programmes (e.g., DeGutis, Bentin, Robertson, & D'Esposito, 2007; Schmalzl et al., 2008), recent evidence suggests that an alternative methodology warrants investigation. Specifically, in some circumstances, intranasal inhalation of the hormone oxytocin has been found to improve face processing in both healthy participants (e.g., Rimmele, Hediger, Heinrichs, & Klaver, 2009; Savaskan, Ehrhardt, Schulz, Walter, & Schachinger, 2008) and individuals with autism (Andari et al., 2010).

Oxytocin is a nonapeptide centrally involved in the regulation of basic social and reproductive behaviours, such as cohabitation, gestation, and breastfeeding. It has been found to be crucial for social recognition, grooming, approach behaviour, sexual activity and stress regulation in non-human mammals (e.g., Carter, 1998; Ferguson, Aldag, Insel, & Young, 2001; Lim & Young, 2006). Recent evidence demonstrates that oxytocin also facilitates social cognition and pro-social behaviour in humans (Baumgartner, Heinrichs, Vonlanthen, Fischbacher, & Fehr, 2008; Heinrichs, von Dawans, & Domes, 2009; Mikolajczak et al., 2010; Zak, Stanton, & Ahmadi, 2007). Indeed, studies using healthy participants have shown that intranasal inhalation of oxytocin can strengthen memory for social but not non-social stimuli (Guastella, Mitchell, & Dadds, 2008), including faces (Rimmele et al., 2009; Savaskan et al., 2008). However, the precise influence of oxytocin on face memory remains unclear, as the hormone seems to only improve the recognition of faces displaying particular emotional expressions, and existing studies have reported conflicting findings. For instance, while Rimmele et al. (2009) found oxytocin improved memory for faces displaying both positive and negative expressions, Guastella et al. (2008) observed improved memory for happy but not angry or neutral faces, and Savaskan et al. (2008) reported improved recognition of neutral and angry but not happy faces.

While the precise influence of oxytocin on face memory remains to be unravelled, it is pertinent that the hormone has also been found to influence processing strategy. Indeed, oxytocin has been reported to increase the time spent looking at the eye region of the face (Guastella et al., 2008), an area thought to provide critical information for identification (Ellis, Shepherd, & Davies, 1979; Young, McWeeny, Hay, & Ellis, 1986). It is of note that this shift in processing strategy has also been reported in individuals with autistic spectrum disorder (Andari et al., 2010), who commonly experience face recognition deficits (Schultz, 2005).

The findings discussed above suggest that intranasal inhalation of oxytocin may also facilitate face recognition in DP. The current investigation set out to address this issue, investigating whether oxytocin can improve performance in 10 DPs and 10 matched control participants on a task that assesses the encoding and recognition of new faces. In addition, we also assessed performance on a face matching task that assesses the ability to *perceive* facial identity (thereby placing minimal demands on long-term memory for faces). This issue is particularly relevant to the current study given that some prosopagnosics also have face perception deficits, and sequential models of face processing predict that such impairments inevitably bring about recognition deficits (e.g., Bruce & Young, 1986). This latter task also represents a novel contribution to the literature, given that no studies have examined the influence of oxytocin on face perception skills.

2. Methods

2.1. Design

The study used a randomized, placebo-controlled, double-blind within-subject experimental design (AB-BA) to examine the effects of a one-time 24 IU intranasal dose of oxytocin on face processing performance in 10 individuals with DP and 10 matched control participants. Two face processing tests were used to assess changes in performance: one that measured memory for newly encoded faces, and one that measured the perceptual ability to match faces of the same identity.

2.2. Participants

A group of 10 adults with DP took part in this study [seven male, mean age = 49.2 years, standard deviation (SD) = 14.2]. All participants had contacted our laboratory because they experience severe difficulties with face recognition in everyday life. Prior to the investigation, each participant attended an initial diagnostic testing session where they were interviewed about their neuropsychological history and