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Crowd perception in prosopagnosia

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ABSTRACT

Prosopagnosics, individuals who are impaired at recognizing single faces, often report increased difficulty when confronted with crowds. However, the discrimination of crowds has never been fully tested in the prosopagnosic population. Here we investigate whether developmental prosopagnosics can extract ensemble characteristics from groups of faces. DP and control participants viewed sets of faces varying in either identity or emotion, and were asked to estimate the average identity or emotion of each set. Face sets were displayed in two orientations (upright and inverted) to control for low-level visual features during ensemble encoding. Control participants made more accurate estimates of the mean identity and emotion when faces were upright than inverted. In all conditions, DPs performed equivalently to controls. This finding demonstrates that integration across different faces in a crowd is possible in the prosopagnosic population and appears to be intact despite their face recognition deficits. Results also demonstrate that ensemble representations are derived differently for upright and inverted faces, and the effects are not due to low-level visual information.

1. Introduction

Every day we interact with crowds of people. Whether it is on a city bus, in a classroom, or in a business meeting, we routinely view and extract important information from groups of faces, and do so rather rapidly. Indeed, recent studies have shown that people are adept at recognizing crowd characteristics, such as average gender, identity or emotion, even when crowds are viewed so briefly that information about any specific individual is not extracted (De Fockert & Wolfenstein, 2009; Haberman & Whitney, 2007, 2009). For example, as a passenger on a bus, we form a general impression of important characteristics of a crowd standing on the street corner, even if we are only able to view the crowd for a split-second as we ride by.

Given the frequency with which we interact with crowds, a deficit in perceiving crowd characteristics would likely pose a hindrance in a host of social situations. Anecdotal evidence suggests that individuals with prosopagnosia, a deficit in discriminating individual faces, feel overwhelmed in crowded situations, perhaps in part due to their inability recognize familiar faces in a crowd. For example, one prosopagnosic describes his experience walking into a reception hall, "*There are a lot of people there, perhaps as many as a hundred or so people. These are all people I am supposed to know, each with a supposedly unique face. My goal is to find just one specific individual. I can scan the room for hours in frustration*. . . (Asprin, 2011)." Another prosopagnosic expresses frustration saying, "*Faces in public are just all faces to me, I don't see them individually. This is especially [true] in crowded public areas. When I look into a crowd, most look very much alike to me* (BP, 2011)." Can prosopagnosics' discomfort with crowds be explained entirely by their deficits in perceiving single faces? Or could it reflect a more general impairment in integrating and extracting face-related information from a crowd? On the other hand, might prosopagnosics actually be better at ensemble coding because they do not perceive crowd members as distinct individuals?

The perceptual characteristics of developmental prosopagnosics[2] (DPs), individuals who have never fully developed the ability to recognize faces, have been increasingly studied during the last decade. However, almost all of the previous research used single faces to investigate processing in DPs. Although the study of individual face processing in DP added essential information aiding the understanding of problems related to individual face recognition, we know virtually nothing about how DPs extract information from groups of faces and whether it is normal or not.

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[2] Developmental prosopagnosia is also referred to as congenital prosopagnosia.

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When processing crowds, typical viewers initially discount individual faces in a group and instead formulate unitized percepts that accurately describe crowd characteristics (De Fockert & Wolfenstein, 2009; Haberman & Whitney, 2007, 2009). The ability to generate a gestalt percept of the crowd, independent of information derived from individual faces, can be viewed as a mechanism that compensates for the limited capacity of the visual system to process multiple items simultaneously. Redundant information across items in a scene is compressed into an average representation of the entire set, referred to as the "ensemble code" (Alvarez, 2011; Ariely, 2001; Chong & Treisman, 2003). This average representation provides a more precise description in comparison to individual evaluations of each member of the set because noise from one individual evaluation cancels out uncorrelated noise from another individual evaluation (Alvarez, 2011). As such, it has been shown that typical viewers can accurately extract both the mean emotional expression and mean identity of the crowd, although performance is at chance when they are asked to discriminate, identify, or localize individual members of a previously seen set (De Fockert & Wolfenstein, 2009; Haberman & Whitney, 2007, 2009).

Previous research suggests that DPs have trouble integrating individual face features into a gestalt (Behrmann, Avidan, Marotta, & Kimchi, 2005; de Gelder & Rouw, 2000; Lobmaier, Bölte, Mast, & Dobel, 2010), and may be generally impaired at identifying the global shape of a stimulus, showing such deficits for objects as well as faces (Avidan, Tanzer, & Behrmann, 2011; Behrmann & Avidan, 2005; Behrmann et al., 2005; Bentin, DeGutis, D'Esposito, & Robertson, 2007; Palermo et al., 2011). For alternative findings see: Le Grand et al. (2006), Duchaine, Yovel, & Nakayama (2007), Schmalzl, Palermo, Green, Brunsdon, and Coltheart (2008) and Lee, Duchaine, Wilson, and Nakayama (2010). Ensemble coding, like other holistic processing tasks, requires the integration of features across space (Alvarez, 2011) or time (Haberman, Harp, & Whitney, 2009). If DPs have difficulty with this type of integration in general, we may expect that they will have trouble forming a unitary percept of any attribute of a crowd, not just average identity. Alternatively, it is possible that the deficits DPs experience during individual face recognition tasks will be minimized via the process of ensemble coding. As mentioned previously, ensemble coding involves canceling out "noisy" individual evaluations, thereby achieving a more precise representation of the group as a whole. Although individual face evaluations are suboptimal in DP, the averaging process inherently reduces such imprecision. This leaves open the intriguing possibility that DPs, who are impaired at individual face identification, may be able to extract the mean identity of the crowd just as well as controls. If DPs do not experience interference by individual faces in the crowd, they could potentially be better than normal perceivers at extracting ensemble information.

The aim of this study was to explore whether DPs can successfully perceive ensemble characteristics of face sets, or "crowds." In order to distinguish between deficits specific to the perception of face identity and impairment in ensemble coding in general, we measured the ability to estimate not only the average identity of upright faces, but also the average emotional expression, an attribute for which DPs typically exhibit little impairment when performing judgments on individual faces (Bentin, Deouell & Soroker, 1999; Dobel, Bölte, Aicher, & Schweinberger, 2007; Duchaine, Parker, & Nakayama, 2003; Humphreys, Avidan, & Behrmann, 2007; Jones & Tranel, 2001; for an different view see Palermo et al., 2011). Accordingly, we limited our group of participants to those who reported no or very little impairment in emotional processing of faces. Furthermore, we included conditions in which the face sets were inverted to control for low-level visual effects during ensemble coding.

2. Methods

2.1. Participants

Four DP individuals (DP1, DP2, DP3, and DP4) participated in the experiment. Three of the 4 DPs were recruited from a volunteer pool of previously diagnosed prosopagnosics (results from original tests are reported in Section 2.3). One had not participated in previous studies and was newly screened. We asked the DP participants to describe their experiences with faces and whether they found it difficult to recognize individuals and/or the emotion of individual faces by vision alone. All of them reported experiencing severe difficulty in face recognition and reported that these deficits substantially interfered with daily functioning. For instance, DP1 (female, 43 years) noted she had difficulty watching movies because the characters appeared similar to her; DP2 (female, 30 years) mentioned having trouble finding her parents in an airport; and DP3 (female, 54 years) reported experiencing difficulty recognizing close friends out of context; DP4 (female, 59 years) noted that she was unable to distinguish between students in her classroom. By contrast, none of them reported problems recognizing emotions from faces, albeit DP1 described mild impairment in emotional processing. These questions were asked before any tests were administered.

We recruited twenty participants to serve as controls for this experiment. Five control participants were matched on age and gender to each of the prosopagnosics. Control group mean ages and standard deviations are as follows: DP1 control group: $M = 38.8$ $SD = 3.03$; DP2 control group: $M = 30$ $SD = 3.32$; DP3: control group $M = 53.4$ $SD = 4.98$; DP4 control group: $M = 59.8$ $SD = 4.92$. All control participants were recruited from the general population, first by a short telephone interview. All reported that they had no difficulty recognizing or identifying faces. Qualified participants were then asked to come into the lab for testing and underwent the same standardized and experimental tests as the DPs.

2.2. Standard face recognition tests

Before experimental testing, we administered two standardized face processing tests. In the Benton Face Recognition Test (BFRT, Benton & Van Allen, 1968) a greyscale target face is presented at the top in each display, and the participant is asked to select the face that is the same person from among 6 faces in different rotated orientations below it. In the Warrington Recognition Memory Test (WRMT, Warrington, 1984) 50 study faces (greyscale) with hair and clothing intact are presented sequentially. At test, two faces are presented. One is the same as a study face, and the participant is asked to choose which of the two faces was previously viewed. All faces are presented in the same orientation and with the same lighting conditions at both study and test. To control for general memory ability, 50 words are also presented sequentially for study. At test, a single sheet of paper is presented containing half study words and half new words. The participant verbally reports the words that were previously viewed. In addition, we presented the Berkeley Famous Faces Test, a locally developed test, in which participants were asked to identify 25 celebrity faces (e.g., Bill Clinton, Elvis Presley, etc.). The aim of this test was to assess face identification in DP relative to typically developed individuals with the same cultural background. Importantly, participants were not required to recall the name of the celebrity (although giving the correct name was clear evidence of recognition). For instance, if they said an American president for Bill Clinton, that was considered correct. After the test was concluded, we also controlled for participants' familiarity with celebrities by asking participants to confirm their exposure to each celebrity presented in the test. If the participant was unfamiliar with a particular celebrity, their response to this celebrity was excluded from the analysis. Table 1 shows participants' exposure levels. Despite these allowances, all DPs had great difficulty recognizing celebrity faces (all 60% or less accuracy) and all DPs were statistically worse than controls on at least one of the face measures (see below).

2.3. Results for standardized face recognition tests

Fig. 1a shows performance on the Berkeley Famous Faces Test. Each DP is shown as a single triangle in a given color with their controls shown in the same color as the DP to which they were matched. All DP's performed worse than their respective control participants on a t-test designed for single case studies with small n (all $p < .05$ Crawford, Garthwaite, & Howell, 2009). Fig. 1b shows performance on the BFRT. Two DPs (DP1 and DP2) scored significantly below the mean of their matched controls ($p < .05$ and the remaining two were trending in the same direction).[3]

Table 1 presents the scores on the Warrington Recognition Memory Test. Again, two of the DP participants (DP2 and DP4) performed significantly below controls and one was trending toward significance. Traditionally, Warrington scores are presented as the difference in performance between word and face recognition. Participants who score better on word recognition compared to face recognition are categorized as having a "face discrepancy" (Warrington, 1984). While a face

[3] Norms defined by Benton are as follows: *Normal* = 75–100%; *Borderline* = 72–74%; *Moderately Impaired* = 69–70%; *Severely Impaired* = <69%.