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Individual Differences in (Non-Visual) Processing Style Predict the Face Inversion Effect

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Abstract

Recent research suggests that individuals with relatively weak global precedence (i.e., a smaller propensity to view visual stimuli in a configural manner) show a reduced face inversion effect (FIE). Coupled with such findings, a number of recent studies have demonstrated links between an advantage for feature-based processing and the presentation of traits associated with autism among the general population. The present study sought to bridge these findings by investigating whether a relationship exists between the possession of autism-associated traits (i.e., as indicated by individuals' ''autism quotient'' [(AQ) and the size of the FIE. Participants completed an on-line study in which the AQ was measured prior to a standard face recognition task where half of the faces were inverted at test. The results confirmed that higher AQ levels were predictive of smaller FIEs. Implications for a common underlying factor relating to processing orientation are discussed.

Keywords: Autism-spectrum quotient; Face inversion effect; Configural versus feature-based processing

The ability to recognize other human faces is fundamental to a vast number of more complex social and cognitive functions. Consequently, it is hardly surprising that people acquire this skill very early in life (e.g., Bushnell, Sal, & Mulhn, 1989; Field, Cohen, Garcia, & Greenberg, 1984; Pascalis, de Schonen, Morton, & Deruelle, 1995). Yet, despite the apparent universality of basic face recognition skills, significant individual variation exists in the ability to accurately recognize other people's faces. Anecdotally, individuals whose cognitive functioning appears to be otherwise normal may be observed to struggle when it comes to recognizing people they have met before. Empirically, recent research demonstrates that

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individual differences in visual processing style predict differences in face recognition accuracy (Martin & Macrae, 2010).

Specifically, perceivers vary in the extent to which they process visual information in a configural manner. Configural processing entails the integration of elements within a visual image through perception of their spatial relationships. In contrast, feature-based processing involves focusing on the elements themselves, independent of their spatial arrangement. Although virtually any visual stimulus can be processed in either a configural or a feature-based manner, some stimuli are optimally processed in a particular manner. Human faces are characterized by highly distinctive configural information. The appearance of one's face is determined as much by distances and angles between features as by the features themselves (Maurer, Le Grande, & Mondloch, 2002). Thus, accurately distinguishing one face from another requires the viewer to attend to the relative configuration of facial features rather than merely to the features themselves (Kimchi & Amishav, 2010).

A substantial body of research demonstrates that encouraging feature-based processing leads to face recognition decrements (e.g., verbal overshadowing, Schooler, 2002; priming with local Navon trials, Macrae & Lewis, 2003; Perfect, 2003; Weston & Perfect, 2005). Likewise, disrupting configural processing undermines face recognition performance (e.g., composite faces; Young, Hellawell, & Hay, 1987). Of particular relevance here, numerous studies have demonstrated that inverting faces (i.e., rotating them 180°) at the time of recognition severely impairs performance, a finding known as the *face inversion effect* (FIE; Yin, 1969; see Searcy & Bartlett, 1996 for a review). It is widely believed that the FIE occurs because the configural information available when first encountering a face is disrupted when the face is inverted (Farah, Tanaka & Drain, 1995; Tanaka & Farah, 1993).

While the importance of configural information when processing faces is well documented (Kimchi & Amishav, 2010), recent research suggests that individual variation in global precedence—the tendency to process visual information in a global rather than local manner—has implications for face recognition. Martin and Macrae (2010) classified participants as showing strong or weak global precedence (i.e., a relatively stronger or weaker tendency to globally process visual information based on their response times to identify congruent vs. conflicting Navon stimuli—e.g., a large letter ''S'' formed by many smaller constituent letter ''T''s; Navon, 1977). Individuals with weak global precedence showed a significantly smaller FIE and specifically were poorer at recognizing upright faces. This study provided initial evidence that individual differences in processing style are predictive of differences in the effective use of configural information in upright face recognition.

In Martin and Macrae's (2010) study, processing style was inferred from performance on a task requiring the processing of global shapes composed of local elements. In this sense, Navon stimuli are superficially similar to faces (an observation noted by the authors themselves). However, other individual difference variables—not directly linked to processing visuospatial stimuli—may also predict differences in face processing in general, and face recognition in particular. One likely candidate emerges from the literature on autism spectrum disorders (ASD). Individuals with ASD are often found to perform worse on face recognition tasks than do mental-age matched controls (Blair, Frith, Smith, Abell, & Cipolotti, 2002; Boucher & Lewis, 1992; Lopez, Donnelly, Hadwin, & Leekam, 2004). This deficit has been widely attributed to a bias among individuals with ASD to engage in feature-based (rather than configural) processing of faces (Behrmann, Thomas, & Humphreys, 2006).

A prevailing theory of the apparent configural processing deficit among individuals with ASD is that such individuals exhibit weak central coherence (Lopez et al., 2004). Central coherence, as defined by Frith and Happé (1994, pp. 121), is ‘‘the tendency to draw together diverse information to construct higher-level meaning in context.’’ Consistent with the view that people with ASD possess weak central coherence, such individuals have been found to out-perform the general population on tasks requiring feature-based processing (e.g., the Embedded Figures Task; see Shah & Frith, 1983). Further, face inversion effects among individuals with ASD are often reduced or absent (Boucher & Lewis, 1992; Davies, Bishop, Manstead, & Tantum, 1994; but see Jemel, Mottron, & Dawson, 2006; Lahaie et al., 2006 for contradictory findings).

While individuals with ASD may represent an extreme case of weak central coherence, variation in central coherence may also exist within the general (i.e., non-ASD) population (Happé, 1999; Happé & Booth, 2008). Studies indicate that the presence of autism-associated traits in the general population extends far beyond those diagnosed with ASD (Piven & Palmer, 1999). Indeed, this view suggests a continuum of autism-associated traits, along which ASD individuals represent one extreme, as indicated by higher scores on scales measuring such traits such as the Autism-Spectrum Quotient (AQ; see Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). Individual differences in AQ have recently been found to predict differences in perceptual processing. Grinter and colleagues (Grinter, van Beek, Maybery, & Badcock, 2009b; Grinter et al., 2009a) reported that students with high AQ scores showed both more accurate and faster performance on the EFT than those with lower AQ scores (see Almeida, Dickinson, Maybery, Badcock, & Badcock, 2010 for similar findings).

Drawing on evidence that both ASD and weak global precedence are associated with an attenuated FIE (Lopez et al., 2004) and that autism-associated traits (at levels prevalent in the general population) may co-occur with an advantage for feature-based processing (Grinter et al., 2009a,b), we examined whether there is among typically developed individuals, a relationship between possession of non-perceptual ASD traits (i.e., AQ-scores) and processing of upright and inverted faces. We hypothesized that participants with higher AQ scores would show a reduced FIE, and that this would be primarily due to deficits in recognizing upright faces (Martin & Macrae, 2010).

1. Method

1.1. Participants

Participants included 270 volunteers[1] (129 women, age range 18–32, $M_{age} = 22.5$ years, $SD = 5.31$) recruited from the university community who registered for an on-line experiment in response to e-mail and intranet announcements as well as printed advertisements distributed on the university campus. Participants were entered into a £50 (approximately $80 at the time) prize draw in exchange for taking part in the study.

1.2. Procedure

The study involved three principal tasks. First, participants completed the Autism-Spectrum Quotient (AQ Scale). The AQ Scale comprises 50 items, devised to measure the degree to which an adult with normal intelligence has the traits associated with the autism spectrum (Baron-Cohen et al., 2001). The scale consists of five sub-scales (each consisting of 10 items): social skill, attention-switching, attention to detail, communication, and imagination. Participants responded using a 4-point rating scale, anchored from ''definitely agree'' to ''definitely disagree.''

After completing the AQ Scale, participants began the first part of the two-phase face recognition task. In the first phase, participants were asked to study a series of faces to remember them in a later part of the study. Participants were presented with color photographs (500×640 pixels) of 16 faces (eight men, eight women) in an upright position at the center of the screen. Faces were unframed (i.e., hair and upper neck were visible) and were uniform in age (low-mid 20s) and ethnicity (White) of the target. Faces were randomly selected from a set of 32 faces (half men, half women) drawn from a locally maintained face database. Each face was presented individually on the computer screen for 4 s.

Following an unrelated filler task (which lasted approximately 10 min), participants completed the test phase of the face recognition task. Participants were presented, in random order, with the 16 faces from the study phase, along with the 16 unstudied faces. Half of the ''old'' and ''new'' faces were presented in an upright position, while the other half were presented in an inverted (upside-down) position. Equal numbers of male and female faces from each set were presented in each position. Participants were asked to judge whether each face had been presented in the original study phase, and to indicate their response by pressing one of two keys on the keyboard.

2. Results

2.1. Upright versus inverted face recognition

Correct responses were tallied separately for upright and inverted faces, and the percent correct for each type was computed and used in the analyses. Preliminary analyses investigated whether an FIE was evident among participants in this study. A paired samples t-test confirmed that participants were more accurate in recognizing faces when they were presented in an upright position (M = 73.65%, SD = 20.23) than in an inverted position (M = 66.70%, SD = 17.31), $t(265) = 6.09$, $p < .001$, $d = 0.38$.

2.2. AQ and the face inversion effect

Among participants in this study, AQ scores ranged from 4 to 37 ($M = 16.88$, $SD = 5.97$).[2] To examine the relationship between AQ and the FIE, we examined the entire pool of participants for evidence that higher AQ scores corresponded to a weaker FIE. First, a repeated-measures analysis of covariance (ANCOVA) was carried out in which inverted versus upright faces were entered as repeated measures and AQ score was entered as a covariate. We specified a custom model allowing AQ score to interact with face orientation (see Fig. 1). As predicted, a significant interaction emerged between face orientation and AQ score, $F(1, 264) = 5.07$, $p = .03$, $\eta_p^2 = .02$). Simple linear regression analyses confirmed that this interaction was the result of a strong relationship between AQ score and accuracy in recognizing upright faces, $B = -.21$, $t(264) = 3.42$, $p = .001$, $d = 0.42$, and a much weaker one between AQ score and accuracy in recognizing inverted faces, $B = -.11$, $t(264) = 1.87$, $p = .06$, $d = 0.23$. Moreover, regression analyses confirmed that AQ scores predicted the FIE (calculated as the proportion of correct responses on upright trials minus the proportion of correct responses on inverted trials), $B = -.14$, $t(264) = 2.25$, $p < .03$, $d = 0.28$.

As noted previously, the AQ Scale consists of five sub-scales. Additional analyses tested the possibility that individual subscales may differentially predict face recognition performance. No evidence for this was found: All subscales correlated negatively but non-significantly with the FIE (r's ranging from $-.03$ to $-.09$, All p's $> .12$). This suggests that reductions in the FIE are due to a combination of AQ-related factors.

2.3. Gender differences in AQ and the FIE

In accordance with previous research on individual differences in autistic traits, we examined the effects of gender on AQ scores and on the FIE. Replicating previous findings, we

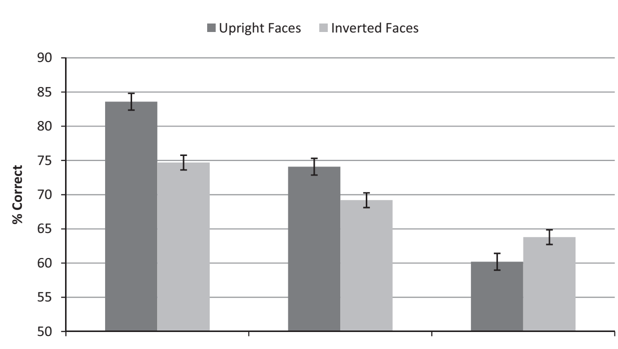

Fig. 1. Mean recognition performance (with standard errors) as a function of face orientation (upright vs. inverted) at test and AQ score based on extreme group analysis (low AQ [$N = 20$; $M = 6.70$, $SD = 1.42$]; median AQ [$N = 21$, $M = 16.00$]; high AQ [$N = 21$; $M = 29.29$, $SD = 3.41$]). Low AQ participants were significantly poorer at recognizing inverted relative to upright faces ($F[1, 63] = 6.29$, $p = .02$, $\eta_p^2 = .09$). This difference was less pronounced among median AQ participants ($F[1, 63] = 2.44$, $p = .12$, $\eta_p^2 = .04$) and reversed (though not significantly) among high AQ participants ($F[1, 63] = 1.11$, $p = .30$, $\eta_p^2 = .02$).

found that male participants had, overall, higher AQ scores (M = 18.35, SD = 5.91) than did female participants (M = 15.28, SD = 5.63), $t(264) = 4.34$, $p < .001$. To determine whether the relationship between AQ and the FIE differed between men and women, regression analyses tested for an interaction between gender and AQ in predicting the FIE. The interaction was non-significant, $B = -.08$, $t(262) = 0.42$, *ns*, as was the main effect of gender, $B = .06$, $t(262) = 0.29$, *ns*.

2.4. Summary and follow-up

This study demonstrated, for the first time, that variation in AQ scores among typically developed individuals corresponds to the magnitude of the face-inversion effect. Consistent with the view that high-AQ individuals—like those diagnosed with ASD—manifest weak central coherence (Briskman, Happé, & Frith, 2001), these individuals failed to benefit from the availability of configural information among upright faces, recognizing such faces with no greater accuracy than inverted faces.

Individuals with very high AQ scores performed worse overall at recognizing faces, whether upright or inverted. This is not entirely surprising given evidence that individuals with ASD do not modulate their attention to faces in the same ways that they do to other stimuli (Bird, Catmur, Silani, Frith, & Frith, 2006). To the extent that high AQ individuals show a similar tendency, their encoding of faces during initial encounters may be less extensive, leading to poorer overall memory later. While an interesting point for further study,[3] this possibility does not detract from our finding that high AQ individuals show no advantage when it comes to recognizing upright (compared to inverted) faces.

Notably, a recent review by McKone and Yovel (2009) suggests that inverting faces may disrupt not only configural processing but also feature-based processing. Such evidence creates some ambiguity as to whether the FIE is a direct index of configural processing. However, we note that—among studies included in the review—the majority of those using recognition memory paradigms found that inversion disrupted configural but *not* featural processing (whereas other paradigms produced evidence that both were disrupted). Nonetheless, the extent to which the relationship, observed in this study, between AQ and a reduced FIE implicates impaired configural processing warrants further consideration.

The possibility that AQ corresponds to weak central coherence (and thereby decrements in configural processing) would be further strengthened by evidence of such a relationship independent of social stimuli. As described earlier, previous work (Grinter et al., 2009a,b) provides just such evidence. However, to further establish this link, we carried out a second study that investigated the correlation between AQ (this time measured using the Empathizing Quotient and Systematizing Quotient Scales) and performance on a more direct measure of configural versus feature-based processing (the Embedded Figures Task, or EFT).

In this study, 334 undergraduates (252 women) from the University of Aberdeen were tested in a large laboratory in groups of 20–40 people. Participants completed the EQ and SQ-R Scales (Lawson, Baron-Cohen, & Wheelwright, 2004) and the Group EFT, the order of which was counter-balanced across participants. The EQ and SQ-R Scales can be combined to form a measure of AQ (Wheelwright et al., 2006). The EFT requires participants to

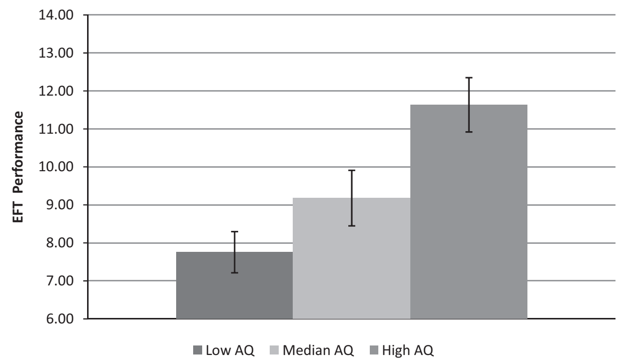

Fig. 2. Mean performance (with standard errors) on the EFT as a function of AQ Group.

identify simple geometric shapes embedded within a more complex form. The task consists of 18 items split into two equally numbered sections, with participants given a maximum of 5 min to complete each section. On any item, when a participant has identified the simple shape within the more complex form, he or she indicates its outline using a highlighter and moves on to the next item in the booklet. Performance on the EFT is determined by the number of items an individual correctly completes on both sections within the time limit.

Across the whole sample of participants, regression analyses yielded a significant positive relationship between performance on the EFT and EQSQ score, $B = .149$, $t(332) = 2.74$, $p < .01$, suggesting that people who possess a systemizing bias in cognitive style (i.e., higher scores on the SQ than the EQ Scale) tend to be more adept at feature-based processing. Fig. 2 displays performance levels for individuals classified as systematizers (SQ scores greater than EQ scores), balanced (SQ scores equal to EQ scores), and empathizers (EQ scores greater than SQ scores). As in the principal study, men scored higher on the AQ measure ($M = 17.27$, $SD = 2.76$) than did women ($M = 15.49$, $SD = 2.44$), $t(332) = 5.55$, $p < .001$, $d = 0.61$. However, there were no main or interaction effects involving gender when it came to predicting EFT performance.

The results of this follow-up study provide corroborating evidence that individual differences in autism-associated traits, present in the general population, significantly predict differences in perceptual processing. These findings provide a parallel to research demonstrating that individuals with ASD exhibit superior performance on tasks—like the EFT—that require local perceptual processing. Among our sample of non-ASD individuals, those who shared ASD-like motives to understand social and non-social agents also shared the ASD-like aptitude for local processing of visual stimuli.

3. General discussion

Individual differences in the presentation of autism-associated traits (as measured by AQ) proved to be a significant predictor of face recognition performance. Specifically, participants with higher AQ scores were impaired when it came to correctly recognizing faces that were presented in an upright (but not inverted) position. This finding bridges two recent findings in the literature.

First, it extends recent work by Grinter and colleagues (Grinter et al., 2009a,b; see also Almeida et al., 2010) by demonstrating that individual differences in AQ predict performance differences on a visual processing task that benefits from configural processing. While Grinter et al. (2009a,b) reported that AQ predicted superior performance on the EFT (a task that requires featural processing), the present research demonstrates that it also predicts a weaker FIE (which is normally magnified by preferential configural processing). Although high AQ participants did not show an absolute advantage in recognition of inverted faces, neither did their performance benefit from the configural information conveyed when seeing faces in their original upright position. This finding complements Grinter et al.'s work by demonstrating the AQ is associated not only with local processing advantages (as demonstrated by superior performance on the EFT) but also with global processing impairments (as demonstrated by poorer recognition of upright, but not inverted, faces).

Second, the current study links the above findings with recent work by Martin and Macrae (2010) which demonstrated that individual differences in the strength of global precedence predicted recognition performance for upright (but not inverted) faces. While Martin and Macrae used a measure of processing style that was explicitly visuospatial in nature, the present study demonstrates that other individual differences may be equally predictive of how perceivers process and recognize faces. Like experimental manipulations that induce a more feature-based versus global processing style, individual differences in autism-associated traits—and by extension in weak central coherence—also appear to influence perceivers' success at recognizing human faces. Notably, central coherence reflects a broad orientation toward information-processing rather than a strategy specific to processing a particular type of information (e.g., visual stimuli).

3.1. Implications for current theories of perceptual functioning in ASD

While our focus in this research was on individuals who are not diagnosed with ASD but who vary in their possession of autism-associated traits, it is worth considering the implications of our results for current theories of autism and, by extension, the broad autism phenotype. Our data may be interpreted in terms of Happé and Frith's (2006) view of autism in terms of weak central coherence. The finding that higher AQ individuals manifest an inability to benefit from available configural information when recognizing races fits well within this framework. In contrast, the fact that higher AQ individuals appeared to be worse *overall* at recognizing faces may pose a challenge to alternative theories (e.g., the Enhanced Perceptual Functioning [EPF] model of Mottron, Dawson, Soulières, Hubert, and Burack, 2006) on whose basis one might expect high AQ individuals to show superior recognition of inverted faces (compared to lower AQ individuals). At the same time, our follow-up study suggested that higher AQ individuals out-perform their lower AQ counterparts when it comes to tasks that benefit from featural processing. While this may be taken as support for Mottron et al.'s EPF model, Happé and Booth (2008) point out that tasks such as the EFT may also be influenced by the extent to which one is able to ignore the gestalt (configural) pattern to locate the feature. Thus, individuals with weak central coherence might also be expected to perform well on such tasks.

It is also worth considering our results in the context of suggestions that autism (and by extension AQ) represents a ''fractionable'' collection of characteristics. Happé, Ronald, and Plomin (2006) suggest that, based on both genetic and neurological evidence, a single explanation of autism (e.g., autism as caused by an ''extreme male brain;'' see Baron-Cohen, 2002) is untenable. Rather, they suggest that the social and non-social impairments common among individuals with ASD should be assessed separately. Our data imply that, at least among our samples of normally functioning individuals, the social and non-social dimensions of the autism phenotype are not easily separated. No single sub-component of the AQ Scale proved to be a uniquely strong predictor of the FIE (and notably, the social skills component fell somewhere in the middle of the subscales in terms of its predictiveness). Further, the EQ-SQ Scale, designed to assess the extent to which empathizing is sacrificed in favor of systematizing, effectively predicted performance on a purely perceptual measure of configural versus feature-based processing. Further research will be required to establish how the ''fractionable triad'' of social and non-social deficits among individuals with ASD are represented among normally functioning individuals with autism-associated traits.

3.2. *Processing style: one dimension or many?*

Indeed, it is somewhat remarkable that such a broad processing orientation—measured in these studies by scales on which most items do not relate to visual information—reliably predicts performance on a specific form of visual processing. Face recognition, as a processing task, is highly practiced even among individuals characterized by autism-associated traits. Yet such individuals performed no better (indeed, slightly worse) in the current study when faces were presented in their natural, upright position than when they were presented in an inverted orientation. This finding suggests that the manner in which visual stimuli (whether they be complex patterns as in the Embedded Figures Test, or faces as in the present research) are processed is closely tied to individual differences in a broad orientation toward information integration and meaning-seeking.

The present research highlights another way in which apparently discrete indices of processing style may reflect a common underlying factor. Growing evidence from distinct research literatures appears to point toward such a commonality. As noted above, research into individual differences in AQ suggests that distinctions between global and local visual processing correspond to strong versus weak central coherence (e.g., Shah & Frith, 1983). At the same time, social cognitive research stemming from construal level theory (see Trope & Liberman, 2010) suggests that several distinct forms of psychological distance (including spatial, temporal, and social distance) give rise to differences in relatively global versus detailed processing across a wide variety of measures, including both visual processing measures (performance on the EFT and Gestalt Completion Tests, see Smith & Trope, 2006; Liberman & Förster, 2009; and on face recognition tasks, see Wyer, Perfect, & Pahl, 2010) and semantic processing measures (e.g., category breadth, see Liberman, Sagristano, &

Trope, 2002; use of abstract versus concrete language, see Liberman & Trope, 1998). Taken together, these findings appear to reflect a common underlying difference in how individuals approach information processing. Both visual and verbal processing may be approached in a relatively global or detail-oriented manner. To the extent that individuals adopt a particular mode of processing (due to a dispositional tendency or to situational constraints that impose that form of processing), subsequent verbal and/or visual information may be dealt with in that manner.

Thus, the present study provides new evidence of a link between individual differences in broad processing orientation (in this case, AQ) and tools used in recognizing faces. Faces are optimally recognized by using the configural information they provide. While extensive research has shown that conditions that allow configural processing (e.g., by presenting faces in an upright rather than inverted orientation) optimize face recognition, evidence of individual differences in this relationship has only begun to accumulate. The findings reported here open the door for further investigations into how a wide range of factors that influence processing orientation may impact upon the basic task of determining whether one has seen a face before.

Acknowledgment

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Notes

1. Due to a technical error, incomplete data were obtained for four participants. Analyses are thus based on the remaining set of 266 participants.
2. It should be noted that participants were not screened to rule out an ASD diagnosis. AQ scores above 32 are indicative of clinically significant levels of autism-associated traits (Baron-Cohen et al., 2001). Four individuals in the present sample achieved scores between 33 and 37. Analyses excluding these participants produced equivalent results.
3. As noted by a reviewer, our use of an on-line procedure prevented a direct investigation of the role of attention, which under laboratory conditions might be best assessed by using eye-tracking methods.

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