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Factors contributing to individual differences in facial expression categorisation

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ABSTRACT
Individuals vary in perceptual accuracy when categorising facial expressions, yet it is unclear how these individual differences in non-clinical population are related to cognitive processing stages at facial information acquisition and interpretation. We tested 104 healthy adults in a facial expression categorisation task, and correlated their categorisation accuracy with face-viewing gaze allocation and personal traits assessed with Autism Quotient, anxiety inventory and Self-Monitoring Scale. The gaze allocation had limited but emotion-specific impact on categorising expressions. Specifically, longer gaze at the eyes and nose regions were coupled with more accurate categorisation of disgust and sad expressions, respectively. Regarding trait measurements, higher autistic score was coupled with better recognition of sad but worse recognition of anger expressions, and contributed to categorisation bias towards sad expressions; whereas higher anxiety level was associated with greater categorisation accuracy across all expressions and with increased tendency of gazing at the nose region. It seems that both anxiety and autistic-like traits were associated with individual variation in expression categorisation, but this association is not necessarily mediated by variation in gaze allocation at expression-specific local facial regions. The results suggest that both facial information acquisition and interpretation capabilities contribute to individual differences in expression categorisation within non-clinical populations.

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Facial expressions of emotion transmit a wealth of visual information that is indicative of an individual's emotional state and intention. The ability to recognise other people's expression accurately and quickly plays a crucial role in our social communication. Even though common facial expressions, such as happy, sad, fear, anger, disgust and surprise, represent our typical emotional states, are associated with distinctive patterns of facial muscle movements, and are culturally similar (universal) among humans (Ekman & Friesen, 1976; Ekman & Rosenberg, 2005), psychological studies often observe significant individual differences in perceptual accuracy for categorising these common expressions (e.g. Arrais et al., 2010; Hall & Matsumoto, 2004). However, it is still unclear what personal factors are contributing to the observed individual differences in expression recognition, especially among non-clinical populations. Considering that facial expression categorisation would involve (at least) two main stages of cognitive processing, selectively extracting diagnostic facial information from local facial features and then integrating and interpreting these facial cues appropriately, it is plausible that individual variability in cognitive strategy and/or performance in these two processing stages could contribute to individual differences in expression categorisation.

At the processing stage of facial information selection and extraction, by presenting parts of an expressive face in isolation (e.g. through masking or "bubbles" protocol in which participants viewed a face through a set of simultaneously presented, randomly allocated small Gaussian windows across the face), previous studies have suggested that the key internal facial features (i.e. eyes, nose and mouth) and their surrounding regions contain diagnostic

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information for recognising some facial expressions (Blais, Roy, Fiset, Arguin, & Gosselin, 2012; Calvo & Nummenmaa, 2008; Smith, Cottrell, Gosselin, & Schyns, 2005). For instance, the eyes and mouth often transmit crucial cues for detecting angry and happy expressions, respectively. This suggestion has been confirmed by recent eye-tracking studies with an expression categorisation task. Although participants tended to scan all key facial features (Guo, 2012, 2013; Guo & Shaw, 2015), they looked more often at the local facial regions that are most characteristic for each facial expression, such as the mouth in happy faces (Eisenbarth & Alpers, 2011; Guo, 2012, 2013).

The importance of extracting appropriate featural cues for expression recognition has been highlighted by studying neurological patients such as SM. With bilateral amygdala damage, SM showed a selective impairment in recognising fearful expression and was unable to spontaneously look at a person's eyes when viewing expressive face images. However, if she was explicitly instructed to fixate the eye region she was able to recognise fearful faces at a level similar to that of healthy controls (Adolphs et al., 2005). Taking these behavioural, eye-tracking and neuropsychological observations together, it seems that the tendency to attend to local facial features could be associated with expression recognition accuracy, and individual variation in gaze allocation in face-viewing might contribute to individual differences in expression perception.

An individual's capability of integrating and interpreting the selected and extracted expressive facial information could be another contributing factor. For instance, although men and women attend to the same facial parts in face-viewing (Smith et al., 2005; see also Vassallo, Cooper, & Douglas, 2009), women often outperform men by demonstrating higher accuracy and/or faster responses in recognising facial expressions (Hall & Matsumoto, 2004; Hampton, van Anders, & Mullin, 2006), especially for disgust, fearful and sadness expressions (Mandal & Palchoudhury, 1985; Rotter & Rotter, 1988). Recent studies have also observed that some personal traits could be linked to our ability to decode facial affects. For instance, aggressive people tend to classify ambiguous facial expression as anger (Penton-Voak et al., 2013); sensitivity to detect fearful expression is positively correlated with an individual's trait anxiety and personality traits such as neuroticism and harm avoidance (Doty, Japee, Ingvar, & Ungerleider, 2013); and anxious girls are less accurate at recognising disgusted faces and often mistake this emotion for anger (Lee, Herbert, & Manassis, 2014). It appears that different groups of individuals may have different ways of interpreting the perceived facial affect information.

Given that our gaze allocation in natural vision can be modulated or even determined by top-down cognitive processes such as expectation, memory, semantic and task-related knowledge (Tatler, Hayhoe, Land, & Ballard, 2011), it is plausible that a dynamic interaction between stages of information selection/extraction and interpretation could exist in the processing of expressive faces. Studies on neuropsychiatric disorder with deficits in emotion perception have implied this might be the case. For instance, individuals with high social anxiety or social phobia have exaggerated perceptual sensitivity to threatening faces (Staugaard, 2010). They tend to avoid looking at the eye region (Horley, Williams, Gonsalvez, & Gordon, 2003), and are more likely to misinterpret vague or neutral facial expressions as negative (Rapee & Heimberg, 1997) and show higher accuracy in identifying negative facial expressions such as anger (Hunter, Buckner, & Schmidt, 2009). Autism spectrum disorder (ASD) is also a commonly studied neurodevelopmental disorder in emotion perception. The patients have a tendency to avoid looking at other people's eyes, with a preference instead towards the mouth (Klin, Jones, Schultz, Volkmar, & Cohen, 2002), and show deficit in detecting emotions often signalled by the eyes such as anger and fear (Bal et al., 2010; Pelphrey et al., 2002).

Taken together, it is not unreasonable to hypothesise those individual differences in facial expression recognition could be (at least partly) accounted for by individual variability in face-viewing gaze allocation and/or facial information interpretation. Although some previous studies have contrasted processing differences at one particular stage of expression categorisation between "normal" and "special"/clinical populations, it is unclear to what extent these two stages are correlated with an individual's ability for expression recognition in the non-clinical population. Furthermore, the expressive faces in early studies often represented peak or exaggerated intensity for each emotional category, whereas we see less intense expressions more frequently in daily life. As the interpretation of subtle expressions heavily relies on fixation allocation (Vaidya, Jin, & Fellows, 2014) and is increasingly difficult with low-intensity facial affects (Guo, 2012), using face images with a range of expression intensities could enhance both ecological validity and manifestation of individual differences in expression perception.

In this eye-tracking study, we presented face images displaying six basic facial expressions of emotion (happy, sad, fearful, angry, disgusted and surprised) with low, medium and high intensities, and measured expression categorisation performance and associated gaze behaviour from healthy adults. The behavioural data were later correlated with their anxiety levels and autistic scores, as these two personal traits are well associated with emotion processing capability in the clinical population, but often generate inconsistent findings across laboratories, such as to what extent variance in expression recognition performance associated with anxiety or ASD is emotion-specific (fear: Surcinelli, Codispoti, Montebarocci, Rossi, & Baldaro, 2006; sad and ager: Kessler, Roth, von Wietersheim, Deighton, & Traue, 2007; happy, sad and disgust: Simonian, Beidel, Turner, Berkes, & Long, 2001), valence-specific (negative valence: Jarros et al., 2012) or across all basic emotion categories (Evers, Steyaert, Noens, & Wagemans, 2015).

We also included participants' self-monitoring (SM) scores in the correlation analysis. SM measures an individual's capability to understand other peoples' emotion and behaviour, appreciate the environmental context surrounding a situation, and modify one's own presentation accordingly (Lennox & Wolfe, 1984). As this measurement, comprising key elements of charisma, performance and social sensitivity (Riggio & Friedman, 1982), is correlated with emotional intelligence (Schutte et al., 2001), individuals with high level SM behaviour might be skilled at reading and understanding the others' emotion. Based on previous observations, we hypothesised the existence of correlation between participant's facial expression categorisation accuracy, face-viewing gaze distribution and personal trait measurements (indicated by anxiety level, autistic trait and SM score) in the non-clinical population.

Materials and methods

Participants

One hundred and four participants (29 males and 75 females), aged between 18 and 48 years (mean age 20.3), volunteered to participate in this study. All participants reported no history of neuropsychiatric disorders (e.g. ASD, depression, anxiety disorder and social phobia) and had normal or corrected-to-normal visual acuity. The Ethical Committee in School of Psychology, University of Lincoln approved this study. Written informed consent was obtained from each participant prior to the study, and all procedures complied with the British Psychological Society Code of Ethics and Conduct.

Visual stimuli

Grey-scale western Caucasian face images, consisting of five female and five male models, were selected from the Karolinska Directed Emotional Faces CD ROM (Lundqvist, Flykt, & Öhman, 1998). Each of these models posed one neutral and six high-intensity facial expressions (happy, sad, fearful, angry, disgusted and surprised) in full frontal view. Although they may have real-world limitations, and categorisation performance for some expressions could be subject to culture influence, these well-controlled face images were chosen for their comparability and universality in transmitting facial expression signals, at least for our observer group. The faces were processed in Adobe Photoshop to remove external facial features (e.g. hair) and to ensure a homogenous grey background, face size and brightness. Our previous research has shown that the participants' expression categorisation accuracy is monotonically increased when the expression intensity is increased from low (20%) to medium (40%) and then to high (100%) level (Guo, 2012). To enhance ecological validity of this study, for each of the six expressions of each model, Morpheus Photo Morpher was used to create 3 levels of intensity (20%, 40% and 100%) by morphing the emotional face with the neutral face. As a result, 180 expressive face images were generated for the testing session (6 expressions × 3 intensities × 10 models, see Figure 1 for examples).

The face images were presented through a ViSaGe graphics system (Cambridge Research Systems, UK) and displayed on a non-interlaced gamma-corrected colour monitor (30 cd/m^2 background luminance, 100 Hz frame rate, Mitsubishi Diamond Pro2070SB) with the resolution of 1024 × 768 pixels. At a viewing distance of 57 cm, the monitor subtended a visual angle of 40° × 30°. The faces were presented in random order in the centre of the screen with a resolution of 420 × 600 pixels (15° × 22°).

Figure 1. Examples of a female face image presented with varying facial expressions (from left to right: happiness, sadness, fear, anger, surprise and disgust) at three different expression intensities (from top to bottom: 20%, 40% and 100%).

Procedure

All of our participants were aware of universal facial expressions. Before the testing, they were shown a PowerPoint presentation containing one male and one female model posing happiness, sadness, fear, anger, disgust and surprise (sampled from Pictures of Facial Affect), and were asked to label each facial expression as carefully as possible without time constraint. All of them could recognise these facial expressions or agree with the classification proposed by Ekman and Friesen (1976).

A self-paced task was then used to mimic natural viewing condition. During the eye-tracking experiment, the participants sat in a chair with their head restrained by a chin-rest, and viewed the display binocularly. Horizontal and vertical eye positions from the dominant eye (determined through the Hole-in-Card test) were measured using a Video Eyetracker Toolbox with 250 Hz sampling frequency and up to 0.25° accuracy (Cambridge Research Systems, UK). Eye movement signals were first calibrated by instructing the participant to follow a fixation point (FP, 0.3° diameter, 15 cd/m^2 luminance) displayed randomly at one of 9 positions (3 × 3 matrix) across the monitor (distance between adjacent FP positions was 10°). After the calibration procedure, the participant pressed the response box to initiate a trial. The trial was started with an FP displayed 10° left or right to the screen centre to minimise central fixation bias (Tatler et al., 2011). If the participant maintained fixation for 1 s, the FP disappeared and a face image was presented at the centre of the screen. The participant was instructed to "categorize this facial expression as accurately and as quickly as possible", and to respond by pressing a button on the response box (for collecting reaction time data) with the dominant hand followed by a verbal report of the perceived facial expression (six alternative identification task: happiness, sadness, fear, anger, disgust and surprise). The face image disappeared immediately after manual response and the gaze tracking was stopped. No reinforcement was given during this procedure.

Either before or after the eye-tracking task, the participants were required to complete three questionnaires: (1) the Adult Autism Spectrum Quotient, chosen for its good internal consistency, high sensitivity and specificity in autism research (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). (2) the Beck Anxiety Inventory which includes 21 anxiety symptoms and allows the participant to rate to what level each symptom has bothered them during the past month (Beck, Epstein, Brown, & Steer, 1988). This questionnaire was chosen for its minimised overlap between anxiety and depression measurement (e.g. state–trait anxiety inventory tends to be highly correlated with depression), established high level of internal consistency and high discriminant validity when used in a non-clinical sample of anxiety research (Ayala, Vonderharr-Carlson, & Kim, 2005; Creamer, Foran, & Bell, 1995). (3) the Self-Monitoring Scale which includes 25 statements to measure participant's charisma, social performance and social sensitivity (Riggio & Friedman, 1982). This scale was chosen due to its established internal consistency and temporal stability in SM research (Snyder, 1974). Among the tested participants, 69 (20 males, 49 females; age range 18–39) completed all three questionnaires, and the remaining 35 (9 males, 26 females; age range 18–48) only completed the Autism Spectrum Quotient.

Data analysis

All the collected data was analysed off-line. For eye movement data, the software developed in Matlab computed horizontal and vertical eye displacement signals as a function of time to determine eye velocity and position. Fixation locations were then extracted from the raw eye-tracking data using velocity (less than 0.2° eye displacement at a velocity of less than 20°/s) and duration (greater than 50 ms) criteria (Guo, Mahmoodi, Robertson, & Young, 2006). While determining fixation allocation within key facial features (i.e. eyes, nose and mouth), a consistent criterion was adopted to define boundaries between local facial features for different faces (for details see Guo, Tunnicliffe, & Roebuck, 2010). Specifically, the "eye" region included the eyes, eyelids and eyebrows; the "nose" or "mouth" region consisted of the main body of the nose or mouth and immediate surrounding area (up to 1°). The division line between the mouth and nose regions was the midline between the upper lip and the bottom of the nose. Each fixation was then characterised by its location among feature regions and its time of onset relative to the start of the trial. The number of fixations directed at each feature was normalised to the total number of fixations sampled in that trial.

Results

Expression categorisation performance and face-viewing gaze distribution

Using similar stimuli, our previous research has shown that increasing expression intensity would improve expression categorisation accuracy and shorten reaction time (Guo, 2012). Similar trend was also observed in this study for all the tested facial expressions. For instance, the participants' categorisation accuracy for happy expression was gradually enhanced from 47% ± 21 (mean ± SD) to 85% ± 13 and then to 99% ± 3 when expression intensity was increased from 20% to 40% and then to 100%. As the varying levels of expression intensity has similar impact on the participants' behavioural performance of recognising individual facial expressions, but has little impact on their face-viewing gaze distribution, such as proportion of fixations and viewing time directed at internal facial features (Guo, 2012), the experimental data from three intensity levels were pooled together for the below correlational analyses. This approach would also reduce the number of conditions or measures for each correlational analysis, and hence family-wise error rate.

In agreement with our early observations (Guo, 2012, 2013; Guo & Shaw, 2015), the participants demonstrated different perceptual sensitivities in categorising different facial expressions ($F(5,515) = 178.77$, $p < .001$, $\eta_p^2 = 0.64$) with higher recognition accuracy for happy and sad expressions, and lower accuracy for surprise and fear expressions (Bonferroni correction for multiple comparisons, $p < .01$ for all comparisons). As shown in Table 1, there was evident performance variance between individual participants in categorising different facial expressions. For instance, for happy expressions the lowest performing participant scored 43% accuracy and the highest performing scored 100%.

When viewing expressive faces, the participants on average made 6.02 ± 2.86 fixations and needed reaction time of 1.91s ± 0.74 to categorise facial expressions. Although the participants' reaction time was positively correlated with the number of fixations made per trial (two-tailed Pearson correlation, $r = 0.51$,

Table 1. Expression categorisation accuracy across participants.

All expressions	Happy	Sad	Anger	Fear	Disgust	Surprise
55–74% (65% ± 5)	43–100% (77% ± 10)	55–100% (84% ± 10)	30–93% (67% ± 12)	7–67% (43% ± 14)	37–83% (63% ± 12)	27–77% (56% ± 10)

Note: Data in each cell were expressed as minimum–maximum (mean ± SD).

Table 2. Proportion of fixation allocated at the eyes, nose and mouth regions across all participants.

	All expressions	Happy	Sad	Anger	Fear	Disgust	Surprise
Eyes	2–87% (35% ± 19)	0–83% (31% ± 18)	1–88% (36% ± 20)	2–90% (38% ± 20)	2–82% (36% ± 19)	3–90% (38% ± 20)	0–88% (33% ± 19)
Nose	4–95% (42% ± 19)	4–93% (42% ± 18)	5–97% (44% ± 19)	5–98% (41 ± 19)	2–95% 43% ± 19)	2–96% (40% ± 19)	8–89% (44 ± 19)
Mouth	0–64% (20% ± 13)	0–67% (25% ± 14)	0–57% (17% ± 14)	0–69% (19% ± 13)	0–62% (19% ± 13)	0–60% (19% ± 13)	0–70% (21% ± 14)

Note: Data in each cell were expressed as minimum–maximum (mean ± SD).

Table 3. Correlation analysis between gaze allocation and expression categorisation accuracy.

	Eyes	Nose	Mouth
All expressions	0.07 (0.49)	−0.06 (0.58)	0.01 (0.96)
Happy	−0.12 (0.21)	0.03 (0.73)	0.12 (0.23)
Sad	−0.13 (0.19)	0.20 (0.04)*	−0.04 (0.72)
Anger	0.03 (0.97)	0.02 (0.85)	−0.03 (0.75)
Fear	0.06 (0.54)	−0.03 (0.79)	−0.05 (0.59)
Disgust	0.22 (0.02)*	−0.28 (0.004)**	0.10 (0.30)
Surprise	0.14 (0.16)	−0.10 (0.31)	−0.07 (0.51)

Note: Values in the table represent *r* value (*p* value). *$p < .05$, **$p < .01$.

Table 4. Correlation analysis between personal trait measurements and expression categorisation accuracy.

	Autism Spectrum Quotient	Beck Anxiety Inventory	Self-Monitoring Scale
All expressions	−0.11 (0.24)	0.26 (0.03)*	0.12 (0.34)
Happy	0.14 (0.17)	0.12 (0.32)	0.11 (0.36)
Sad	0.20 (0.04)*	−0.04 (0.77)	0.07 (0.60)
Anger	−0.20 (0.04)*	0.14 (0.25)	0.18 (0.15)
Fear	−0.18 (0.06)	0.21 (0.08)	−0.14 (0.25)
Disgust	−0.17 (0.08)	0.11 (0.35)	0.01 (0.96)
Surprise	0.01 (0.91)	0.05 (0.67)	0.14 (0.24)

Note: Values in the table represent *r* value (*p* value). *$p < .05$, **$p < .01$.

$p < .001$), neither of them was correlated with expression categorisation accuracy ($p > .62$ for all comparisons). Regarding gaze distribution, majority of these fixations (97% ± 3) were allocated at the key internal facial features, such as eyes (35% ± 19), nose (42% ± 19) and mouth (20% ± 13). However, the proportion of fixations directed at a given facial feature significantly varied across participants with 2–87% fixations at the eyes, 4–95% fixations at the nose and 0–64% fixations at the mouth region (Table 2).

To examine to what extent gaze allocation in face-viewing was related to facial expression recognition, we conducted a series of two-tailed Pearson correlation analysis between participants' expression categorisation accuracy and proportion of fixations at the eyes, nose and mouth regions (Table 3). Although the overall expression categorisation accuracy was not correlated with participant's gaze distribution in face-viewing, the recognition of a few specific expressions tended to be linked with gaze allocation. Specifically, proportion of fixations directed at the eyes was positively correlated with the recognition of disgust faces ($r = 0.22$, $p = .02$). On the other hand, fixation at the nose region was positively correlated with the recognition of sad faces ($r = 0.2$, $p = .04$), but negatively correlated with the recognition of disgust faces ($r = -0.28$, $p = .004$).

Categorisation performance and trait measurements

Participants' personal traits were assessed using the Adult Autism Spectrum Quotient, the Beck Anxiety Inventory and the Self-Monitoring Scale. Across the participants, the Autism Quotient (AQ) score varied between 0 and 46 (14.93 ± 8.36), the anxiety inventory (AI) level varied between 1 and 47 (15.52 ± 10.16) and the SM score varied between 5 and 21 (12.97 ± 3.69). To examine to what extent these personal traits were correlated with an individual's facial expression recognition performance, we conducted two-tailed Pearson correlation analysis between AQ, AI or SM scores and expression categorisation accuracy

(Table 4). Participants' AQ scores were positively correlated with the recognition of sad expressions ($r = 0.2$, $p = .04$), but negatively correlated with the recognition of anger expressions ($r = -0.2$, $p = .04$). Although not reaching the significant level, AQ scores also showed tendency to be negatively correlated with the recognition of fear ($r = -0.18$, $p = .06$) and disgust expressions ($r = -0.17$, $p = .08$). On the other hand, AI scores were positively correlated with overall facial expression categorisation accuracy ($r = 0.26$, $p = .03$), but were not correlated with the recognition of individual expressions. SM scales, however, had no evident correlation with expression categorisation performance.

Face-viewing gaze distribution and trait measurements

To examine whether participants' personal trait measurements were related to their gaze distribution in face exploration, we performed a series of two-tailed Pearson correlation analysis between AQ, AI or SM scores and proportion of fixations directed at the eyes, nose or mouth region (Table 5). The analysis demonstrated no apparent correlation between AQ or SM score and face-viewing gaze distribution regardless of expression types. Although not reaching the significant level, AI scores showed tendency to be positively correlated with proportion of fixations directed at the nose region across all facial expressions. However, there was no clear correlation between AI score and proportion of fixations directed at the eyes or mouth region. Furthermore, no significant correlation was found between trait measurements and reaction time or number of fixations per trial ($p > .15$ for all comparisons).

Expression categorisation bias and trait measurements

Full confusion matrices were computed to illustrate which expressions were mistaken for others. For each displayed expression, we calculated the percentage of the trials in which the participant categorised the expression using each of the six expression labels (Table 6). Across all the participants, the percentages of labelled expression for each displayed expression were then analysed by ANOVA combined with a posteriori analysis. Similar as in previous observations (Guo, 2012, 2013), happy, anger, fear, disgust and surprise expressions were often mislabelled as sad expression ($p < .001$ for all comparisons). Furthermore, fear expression was frequently mislabelled as surprise; and disgust and surprise were confused with anger and fear, respectively ($p < .001$ for all comparisons).

Table 5. Correlation analysis between personal trait measurements (Autism spectrum quotient, beck anxiety inventory, Self-Monitoring Scale) and proportion of fixations allocated at local facial regions.

		Autism Spectrum Quotient	Beck Anxiety Inventory	Self-Monitoring Scale
Eyes	All expressions	−0.003 (0.97)	−0.11 (0.37)	0.01 (0.95)
	Happy	−0.02 (0.86)	−0.10 (0.42)	0.03 (0.78)
	Sad	0.02 (0.85)	−0.09 (0.44)	0.01 (0.95)
	Anger	0.004 (0.97)	−0.10 (0.39)	−0.01 (0.91)
	Fear	0.01 (0.96)	−0.10 (0.40)	0.01 (0.91)
	Disgust	−0.02 (0.81)	−0.09 (0.44)	−0.01 (0.94)
	Surprise	−0.01 (0.93)	−0.15 (0.23)	0.02 (0.89)
Nose	All expressions	−0.04 (0.73)	0.22 (0.07)	−0.02 (0.89)
	Happy	0.001 (0.99)	0.19 (0.11)	−0.05 (0.71)
	Sad	−0.05 (0.61)	0.21 (0.09)	0.01 (0.96)
	Anger	−0.05 (0.63)	0.20 (0.10)	−0.01 (0.97)
	Fear	−0.04 (0.69)	0.22 (0.07)	−0.04 (0.73)
	Disgust	−0.01 (0.90)	0.23 (0.06)	−0.02 (0.89)
	Surprise	−0.05 (0.60)	0.22 (0.07)	−0.003 (0.98)
Mouth	All expressions	0.02 (0.82)	−0.15 (0.23)	0.04 (0.77)
	Happy	−0.01 (0.95)	−0.14 (0.24)	0.43 (0.73)
	Sad	0.01 (0.92)	−0.15 (0.22)	0.01 (0.96)
	Anger	0.06 (0.54)	−0.12 (0.32)	0.05 (0.67)
	Fear	0.01 (0.96)	−0.16 (0.20)	0.05 (0.68)
	Disgust	0.03 (0.77)	−0.18 (0.14)	0.06 (0.62)
	Surprise	0.04 (0.68)	−0.11 (0.39)	−0.01 (0.96)

Note: Values in the table represent r value (p value).

Table 6. Confusion matrices of expression categorisation (in bold): percentage of participants selecting the expression labels, averaged across the stimuli and participants.

	Categorised expression (%)					
Displayed expression	Happy	Sad	Anger	Fear	Disgust	Surprise
Happy	**77.26**	10.26	3.75	3.37	3.75	1.57
Sad	2.69	**82.69**	4.74	4.39	5.45	0.10
Anger	4.29	18.24	**67.34**	3.59	5.38	0.93
Fear	4.90	19.87	4.55	**43.17**	4.68	22.72
Disgust	3.33	14.62	16.47	2.31	**62.56**	0.54
Surprise	6.12	17.85	3.20	14.76	1.47	**56.63**

Table 7. Correlation analysis between personal trait measurements and expression categorisation bias.

	Categorised expression					
Displayed expression	Happy	Sad	Anger	Fear	Disgust	Surprise
Autism Spectrum Quotient						
Happy		0.19 (0.05)*	−0.01 (0.32)	−0.09 (0.39)	−0.21 (0.03)*	−0.21 (0.03)*
Sad	0.11 (0.25)		−0.24 (0.02)*	−0.06 (0.53)	−0.09 (0.38)	0.03 (0.77)
Anger	0.25 (0.01)*	0.23 (0.02)*		−0.01 (0.90)	−0.14 (0.15)	−0.15 (0.13)
Fear	0.13 (0.19)	0.18 (0.07)	−0.17 (0.09)		−0.02 (0.87)	0.06 (0.53)
Disgust	0.12 (0.21)	0.29 (0.003)**	−0.04 (0.71)	−0.10 (0.32)		−0.18 (0.08)
Surprise	0.18 (0.07)	0.17 (0.09)	−0.17 (0.08)	−0.18 (0.08)	−0.09 (0.35)	
Beck Anxiety Inventory						
Happy		−0.20 (0.11)	0.03 (0.80)	0.02 (0.88)	−0.01 (0.91)	−0.04 (0.73)
Sad	0.08 (0.50)		−0.14 (0.24)	−0.02 (0.89)	0.11 (0.38)	0.01 (0.95)
Anger	0.01 (0.92)	−0.13 (0.29)		0.11 (0.39)	−0.07 (0.57)	−0.09 (0.47)
Fear	0.08 (0.50)	−0.29 (0.02)*	−0.05 (0.70)		−0.04 (0.72)	−0.06 (0.64)
Disgust	−0.06 (0.65)	−0.01 (0.96)	−0.13 (0.30)	0.17 (0.15)		−0.21 (0.08)
Surprise	0.10 (0.08)	−0.28 (0.02)*	0.15 (0.21)	0.09 (0.45)	0.09 (0.48)	
Self-Monitoring Scale						
Happy		−0.08 (0.49)	−0.001 (0.99)	−0.18 (0.15)	0.05 (0.68)	0.01 (0.92)
Sad	−0.001 (0.99)		−0.09 (0.47)	−0.07 (0.56)	0.12 (0.32)	0.12 (0.33)
Anger	0.02 (0.90)	−0.16 (0.12)		−0.14 (0.25)	0.04 (0.78)	−0.09 (0.47)
Fear	−0.02 (0.90)	0.04 (0.75)	0.06 (0.63)		−0.24 (0.04)*	−0.26 (0.03)*
Disgust	0.07 (0.59)	−0.17 (0.16)	0.15 (0.22)	−0.13 (0.29)		0.05 (0.66)
Surprise	0.01 (0.94)	−0.01 (0.97)	−0.09 (0.46)	−0.12 (0.34)	−0.04 (0.73)	

Note: Values in the table represent *r* value (*p* value). **p* < .05, ***p* < .01.

To examine to what extent participants' categorisation bias could be associated with their personal traits, we conducted two-tailed Pearson correlation analysis between AQ, AI or SM scores and categorisation bias for each displayed expression. As shown in Table 7, the participants scoring higher on AQ had a consistent tendency to label other expression as sad. They also tended to mistake anger with happy ($r = 0.25$, $p = .01$), but were less likely to mistake happy with disgust ($r = -0.21$, $p = .03$) and surprise ($r = -0.21$, $p = .03$). It should be noted that given their relatively low confusion rate in Table 6 (e.g. 4.29% for anger being mistaken as happy), these correlation findings should be interpreted cautiously. On the other hand, participants scoring higher on AI were less likely to mistake fear or surprise with sad ($p < .02$ for all comparisons); and those scoring higher on SM were less likely to mistake fear with disgust or surprise ($p < .04$ for all comparisons).

Discussion

In this study we investigated the contributing factors to individual differences in facial expression categorisation performance using four different comparisons: face-viewing gaze distribution and expression recognition accuracy; personal traits and expression recognition accuracy; personal traits and face-viewing gaze distribution; and personal traits and expression categorisation bias. The results revealed that gaze allocation had limited emotion-specific impact on categorising expressions. Autistic traits tended to affect the recognition of sad and anger expressions, and contributed to categorisation bias towards sad expressions; whereas higher anxiety level was associated with greater categorisation accuracy across all expressions and a tendency of gazing at the nose or mid-face region. Interestingly, although personal traits, such as AQ, could affect expression categorisation accuracy and bias, there is no consistent expression-specific relation between personal trait and gaze allocation. It seems that both facial information selection and interpretation capabilities would contribute to individual differences in expression categorisation within the non-clinical populations.

It has been established that the internal facial features (i.e. eyes, nose and mouth) and their surrounding regions transmit diagnostic cues for expression recognition (Calvo & Nummenmaa, 2008; Smith et al., 2005), and people often look more at local facial regions that are most characteristic for each expression, such as mouth in happy faces, and eyes in sad and fearful faces (Eisenbarth & Alpers, 2011; Guo, 2012; Vaidya et al., 2014). Here we demonstrated when viewing faces of varying levels of expression intensity, the observers' tendency to gaze at local facial features was directly linked with their categorisation performance for some expressions. Specifically, longer gaze at the eyes tended to improve disgust recognition, and longer gaze at the nose would enhance sad recognition but impair disgust recognition (Table 3). Interestingly, previous studies have indicated that nose is diagnostic for recognising disgust expression and eyes for sad when the expression is displayed at peak intensity (Eisenbarth & Alpers, 2011; Smith et al., 2005). The differences in expression intensity used in different studies may contribute to the observed discrepancies. It is plausible when the expressive facial signals are subtle or ambiguous, we tend to use cues from other facial regions to validate those cues from the "diagnostic" region in order to reliably decode low-intensity facial expressions.

We did not observe significant correlation between gaze allocation and categorisation accuracy for happy, anger, fear and surprise expressions. This might be partly caused by a "holistic" viewing strategy we frequently adopt when exploring facial expressions with varying intensities (Guo, 2012, 2013). Considering that the emotional cues from a single facial feature of (especially low- and mid-intensity) expressive faces are often ambiguous, people tend to scan all key internal facial features (i.e. eyes, nose and mouth) to extract and integrate expressive featural cues in order to reliably decode facial affects (Guo, 2012). This "holistic" gaze behaviour consequently reduces reliance of gazing at a particular facial region for recognising a specific expression. It is also plausible that after initial fixation selection to extract expressive facial cues from the diagnostic facial region, such as mouth in happy faces and eyes in angry faces, the frequent re-fixations at the same region is not necessarily needed to improve recognition performance for these facial expressions (at least) in the non-clinical population. This possibility could be explicitly examined in the future research.

In addition to face-viewing gaze allocation, some of the measured personal traits were also closely correlated with individuals' expression categorisation performance. Specifically, autistic traits led to enhanced recognition for sad expressions but impaired recognition for anger expressions (Table 4), which is consistent with clinical observation of more errors in detecting anger expression in autistic children (Bal et al., 2010; Tanaka et al., 2012). Interestingly, unlike clinically diagnosed ASD patients who often show "eye avoidance" face-viewing gaze behaviour (Falck-Ytter & von Hofsten, 2011; Klin et al., 2002), in our study autistic traits were not correlated with gaze allocation at the eyes, nose or mouth regions in face-viewing (Table 5). It is plausible that in the non-clinical population autistic traits mainly affect the interpretation of more ambiguous expressive cues, rather than the selection/fixation of local facial information. Furthermore, as autistic traits were associated with the increased categorisation bias of labelling other expressions as sad (Table 7), this cognitive bias could (at least) partly account for the enhanced sad expression recognition accuracy.

The impact of anxiety on emotion perception (particularly on threatening facial cues such as fearful and angry expressions) has been widely reported in both clinical and non-clinical population. Clinical studies have revealed that women with social anxiety disorder required less emotional intensity for categorising fearful, sad and happy faces (Arrais et al., 2010). In non-clinical population, individuals with higher levels of trait anxiety were more accurate at recognising fearful faces (Surcinelli et al., 2006), and were more sensitive to detect fearful cues in the emotionally ambiguous faces (Richards et al., 2002) or in a masked face paradigm (Doty et al., 2013). Trait anxiety was also positively associated with attention bias towards angry faces in the visual-probe task (Telzer et al., 2008). In our study on non-preclassified healthy individuals, we noticed that participants' anxiety level was indicative for their general expression categorisation performance rather than just for specific expressions. More anxious individuals tended to show higher recognition accuracy regardless of expression types (Table 4), they were also less likely to confuse fear or surprise with sad expressions (Table 7). In addition to other factors (such as variance in face stimuli, clinical and non-clinical participant population) that could lead to inconsistent findings between laboratories, different measurements of anxiety might be a contributing factor. In this study we used Beck Anxiety Inventory to measure participants' recent (i.e. for the past month) general anxiety or prolonged state anxiety rather than more specific type of anxiety, such as social, state or trait anxiety, and panic disorder. While this measurement could better represent the complex construct of our day-to-day anxious level as a whole, it is unclear to what extent different components of anxiety (e.g. cognitive, somatic, affective and behavioural components) affect the participants' enhanced sensitivity to expression categorisation. It would be interesting to address this issue in the future research. Self-Monitoring Scale, on the other hand, was not correlated with expression recognition performance, suggesting that individuals with high level SM traits might use other non-face cues to aid their emotional intelligence (Friedman & Miller-Herringer, 1991).

It seems that at the cognitive stages of processing facial expressions, performance variance in both information selection/extraction (manifested in face-viewing gaze allocation) and information interpretation (manifested in individual's autistic traits and anxiety level) were correlated with individual differences in judging expressions. Unlike in the clinical population, we did not observe significant interaction between two cognitive stages in the healthy participants. Only individuals with higher anxiety level showed a tendency to gaze more often at the mid-face nose region, but this tendency has not reached significant level (Table 5). When using high-intensity expressive faces, previous studies have demonstrated that anxious individuals oriented towards diagnostic facial features (i.e. eyes and mouth) in angry and fearful faces (Bradley, Mogg, White, Groom, & De Bono, 1999; Fox, 2002). It might be that anxious individuals tend to perform featural analysis by gazing at an informative facial region when viewing high-intensity expressive faces, but use more holistic analysis with a tendency of gazing at the central face region when exploring facial expressions with varying intensities. Taken together, although both anxiety and autistic-like traits were associated with individual variation in expression categorisation, this association is not necessarily mediated by variation in gaze allocation at expression-specific local facial regions.

In addition to facial expression categorisation, face identity recognition performance also varies significantly across individuals in the non-clinical population. Interestingly, individual's face recognition ability seems to be strongly dissociated from general intelligence or cognitive ability, but is highly heritable (Wilmer, Germine, & Nakayama, 2014). Recent eye-tracking research further revealed some individual differences in gaze distribution during face identification which persisted over time (Peterson & Eckstein, 2013). However, it is argued that individual's face recognition performance is associated with the transition differences among fixation locations, rather than the spatial distribution differences alone (Chuk, Chan, & Hsiao, 2014). For instance, frequent gaze shifting between the left and right eyes in the viewed faces is linked with better face encoding and recognition performance (Sekiguchi, 2011).

Just like their impact on facial expression perception, personal traits also affect face identity recognition ability. Recent studies have indicated that an individual's poorer face recognition skill and performance is associated with higher social anxiety (Davis et al., 2011), higher autistic trait (Weigelt, Koldewyn, & Kanwisher, 2012), lower empathy level (Bate, Parris, Haslam, & Kay, 2010) and higher introversion personality trait (Cheung, Rutherford, Mayes, & Partland, 2010). Taken together, it seems that although facial expression and face identity are different types of facial cues (e.g. changeable vs. invariant information) and involve different neural circuits for information processing (Calder & Young, 2005), the recognition performance of these facial cues are subject to the influence from similar gaze behaviour and personal traits, and are possibly correlated with each other (Franklin & Adams, 2010). Future research could systematically examine the extent to which an individual's ability to recognise facial expressions is associated with their ability to recognise face identity.

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References

Adolphs, R., Gosselin, F., Buchanan, T. W., Tranel, D., Schyns, P., & Damasio, A. R. (2005). A mechanism for impaired fear recognition after amygdala damage. *Nature*, *433*, 68–72.

Arrais, K. C., Machado-de-Sousa, J. P., Trzesniaka, C., Filhoa, A. S., Ferrari, M. C. F., Osorio, F. L., … Crippa, J. A. S. (2010). Social anxiety disorder women easily recognize fearful, sad and happy faces: The influence of gender. *Journal of Psychiatric Research*, *44*, 535–540.

Ayala, R. J., Vonderharr-Carlson, D. J., & Kim, D. (2005). Assessing the reliability of the Beck Anxiety Inventory scores. *Educational and Psychological Measurement*, *65*, 742–756.

Bal, E., Harden, E., Lamb, D., Van Hecke, A. V., Denver, J. W., & Porges, S. W. (2010). Emotion recognition in children with autism spectrum disorders: Relations to eye gaze and autonomic state. *Journal of Autism and Developmental Disorders*, *40*, 358–370.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism spectrum quotient (AQ): evidence from asperger syndrome/high functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders*, *31*, 5–17.

Bate, S., Parris, B., Haslam, C., & Kay, J. (2010). Socio-emotional functioning and face recognition ability in the normal population. *Personality and Individual Differences*, *48*, 239–242.

Beck, A. T., Epstein, N., Brown, G., & Steer, R. A. (1988). An inventory for measuring clinical anxiety: Psychometric properties. *Journal of Consulting and Clinical Psychology*, *56*, 893–897.

Blais, C., Roy, C., Fiset, D., Arguin, M., & Gosselin, F. (2012). The eyes are not the window to basic emotions. *Neuropsychologia*, *50*, 2830–2838.

Bradley, B. P., Mogg, K., White, J., Groom, C., & De Bono, J. (1999). Attentional bias for emotional faces in generalized anxiety disorder. *British Journal of Clinical Psychology*, *38*, 267–278.

Calder, A. J., & Young, A. W. (2005). Understanding the recognition of facial identity and facial expression. *Nature Review Neuroscience*, *6*, 641–651.

Calvo, M. G., & Nummenmaa, L. (2008). Detection of emotional faces: Salient physical features guide effective visual search. *Journal of Experimental Psychology: General*, *137*, 471–494.

Chuk, T., Chan, A. B., & Hsiao, J. H. (2014). Understanding eye movements in face recognition using hidden Markov models. *Journal of Vision*, *14*(11): 8.

Cheung, C. H. M., Rutherford, H. J. V., Mayes, L. C., & Partland, J. C. (2010). Neural responses to faces reflect social personality traits. *Social Neuroscience*, *5*, 351–359.

Creamer, M., Foran, J., & Bell, R. (1995). The Beck Anxiety Inventory in a non-clinical sample. *Behaviour Research and Therapy*, *33*, 477–485.

Davis, J. M., McKone, E., Dennett, H., O'Connor, K. B., O'Kearney, R., & Palermo, R. (2011). Individual differences in the ability to recognise facial identity are associated with social anxiety. *PLoS ONE*, *6*(12), e28800.

Doty, T. J., Japee, S., Ingvar, M., & Ungerleider, L. G. (2013). Fearful face detection sensitivity in healthy adults correlates with anxiety-related traits. *Emotion*, *13*, 183–188.

Ekman, P., & Friesen, W. (1976). *Pictures of facial affect*. Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., & Rosenberg, E. L. (2005). *What the face reveals: Basic and applied studies of spontaneous expression using the facial action coding system (FACS)*. New York, NY: Oxford University Press.

Eisenbarth, H., & Alpers, G. W. (2011). Happy mouth and sad eyes: Scanning emotional facial expressions. *Emotion*, *11*, 860–865.

Evers, K., Steyaert, J., Noens, I., & Wagemans, J. (2015). Reduced recognition of dynamic facial emotional expressions and emotion-specific response bias in children with an autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *45*, 1774–1784.

Falck-Ytter, T., & von Hofsten, C. (2011). How special is social looking in ASD: A review. *Progress in Brain Research*, *189*, 209–222.

Franklin, Jr. R. G., & Adams, Jr. R. B. (2010). What makes a face memorable? The relationship between face memory and emotional state reasoning. *Personality and Individual Differences*, *49*, 8–12.

Friedman, H. S., & Miller-Herringer, T. (1991). Nonverbal display of emotion in public and private: Self-monitoring, personality, and expressive cues. *Journal of Personality and Social Psychology*, *61*, 766–775.

Fox, E. (2002). Processing emotional facial expressions: The role of anxiety and awareness. *Cognitive, Affective, & Behavioural Neuroscience*, *2*, 52–63.

Guo, K. (2012). Holistic gaze strategy to categorize facial expression of varying intensities. *PLoS One*, *7*(8), e42585.

Guo, K. (2013). Size-invariant facial expression categorization and associated gaze allocation within social interaction space. *Perception*, *42*, 1027–1042.

Guo, K., Mahmoodi, S., Robertson, R. G., & Young, M. P. (2006). Longer fixation duration while viewing face images. *Experimental Brain Research*, *171*, 91–98.

Guo, K., & Shaw, H. (2015). Face in profile view reduces perceived facial expression intensity: An eye-tracking study. *Acta Psychologica*, *155*, 19–28.

Guo, K., Tunnicliffe, D., & Roebuck, H. (2010). Human spontaneous gaze patterns in viewing of faces of different species. *Perception*, *39*, 533–542.

Hall, J. A., & Matsumoto, D. (2004). Gender differences in judgements of multiple emotions from facial expressions. *Emotion*, *4*, 201–206.

Hampton, E., van Anders, S. M., & Mullin, L. I. (2006). A female advantage in the recognition of emotional facial expressions: Test of an evolutionary hypothesis. *Evolution and Human Behaviour*, *27*, 401–416.

Horley, K., Williams, L. M., Gonsalvez, C., & Gordon, E. (2003). Social phobics do not see eye to eye: A visual scanpath study of emotional expression processing. *Journal of Anxiety Disorders*, *17*, 33–44.

Hunter, L. R., Buckner, J. D., & Schmidt, N. B. (2009). Interpreting facial expressions: The influence of social anxiety, emotional valence, and race. *Journal of Anxiety Disorders*, *23*, 482–488.

Jarros, R. B., Salum, G. A., da Silva, C. T. B., Toazza, R., de Abreu Costa, M., de Salles, J. F., & Manfro, G. G. (2012). Anxiety disorders in adolescence are associated with impaired facial expression recognition to negative valence. *Journal of Psychiatric Research*, *46*, 147–151.

Kessler, H., Roth, J., von Wietersheim, J., Deighton, R. M., & Traue, H. C. (2007). Emotion recognition patterns in patients with panic disorder. *Depression and Anxiety*, *24*, 223–226.

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry*, *59*, 809–816.

Lee, T. C., Herbert, M., & Manassis, K. (2014). Do anxious boys and girls differ in emotion recognition accuracy? *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, *23*, 61–64.

Lennox, R. D., & Wolfe, R. N. (1984). Revision of the self-monitoring scale. *Journal of Personality and Social Psychology*, *46*, 1349–1364.

Lundqvist, D., Flykt, A., & Öhman, A. (1998). *The Karolinska directed faces – KDEF*. CD ROM from Department of Clinical Neuroscience, Psychology section, Karolinska Institute, ISBN 91-630-7164-9.

Mandal, M. K., & Palchoudhury, S. (1985). Perceptual skill in decoding facial affect. *Perceptual and Motor Skills*, *60*, 96–98.

Pelphrey, K. A., Sasson, N. J., Reznick, J. S., Paul, G., Goldman, B. D., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders*, *32*, 249–261.

Penton-Voak, I. S., Thomas, J., Gage, S. H., McMurran, M., McDonald, S., & Munafò, M. R. (2013). Increasing recognition of happiness in ambiguous facial expressions reduces anger and aggressive behaviour. *Psychological Science*, *24*, 688–697.

Peterson, M. F., & Eckstein, M. P. (2013). Individual differences in eye movements during face identification reflect observer specific optimal points of fixation. *Psychological Science*, *24*, 1216–1225.

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy*, *35*, 741–756.

Richards, A., French, C. C., Calder, A. J., Webb, B., Fox, R., & Young, A. W. (2002). Anxiety-related bias in the classification of emotionally ambiguous facial expressions. *Emotion*, *2*, 273–287.

Riggio, R. E., & Friedman, H. S. (1982). The interrelationships of self-monitoring factors, personality traits, and nonverbal social skills. *Journal of Nonverbal Behaviour*, *7*, 33–45.

Rotter, N. G., & Rotter, G. S. (1988). Sex differences in encoding and decoding of negative facial emotion. *Journal of Nonverbal Behavior*, *12*, 139–148.

Schutte, N. S., Malouff, J. M., Bobik, C., Coston, T. D., Greeson, C., Jedlicka, C., … Wendorf, G. (2001). Emotional intelligence and interpersonal relations. *Journal of Social Psychology*, *141*, 523–536.

Sekiguchi, T. (2011). Individual differences in face memory and eye fixation patterns during face learning. *Acta Psychologica*, *137*, 1–9.

Simonian, S. J., Beidel, D. C., Turner, S. M., Berkes, J. L., & Long, J. H. (2001). Recognition of facial affect by children and adolescents diagnosed with social phobia. *Child Psychiatry and Human Development*, *32*, 137–145.

Smith, M. L., Cottrell, G. W., Gosselin, F., & Schyns, P. G. (2005). Transmitting and decoding facial expressions. *Psychological Science*, *16*, 184–189.

Snyder, M. (1974). Self-monitoring of expressive behaviour. *Journal of Personality and Social Psychology*, *30*, 526–537.

Staugaard, S. R. (2010) Threatening faces and social anxiety: A literature review. *Clinical Psychology Review*, *30*, 669–690.

Surcinelli, P., Codispoti, M., Montebarocci, O., Rossi, N., & Baldaro, B. (2006). Facial emotion recognition in trait anxiety. *Journal of Anxiety Disorders*, *20*, 110–117.

Tanaka, J. W., Wolf, J. M., Klaiman, C., Koenig, K., Cockburn, J., Herlihy, L., … Schultz, R. T. (2012). The perception and identification of facial emotions in individuals with autism spectrum disorders using the let's face it! Emotion skills battery. *Journal of Child Psychology and Psychiatry*, *53*, 1259–1267.

Tatler, B. W., Hayhoe, M. M., Land, M. F., & Ballard, D. H. (2011). Eye guidance in natural vision: Reinterpreting salience. *Journal of Vision*, *11*(5): 5.

Telzer, E. H., Mogg, K., Bradley, B. P., Mai, X., Ernst, M., Pine, D. S., & Monk, C. S. (2008). Relationship between trait anxiety, prefrontal cortex, and attention bias to angry faces in children and adolescents. *Biological Psychology*, *79*, 216–222.

Vaidya, A. R., Jin, C., & Fellows, L. K. (2014). Eye spy: The predictive value of fixation patterns in detecting subtle and extreme emotions from faces. *Cognition*, *133*, 443–456.

Vassallo, S., Cooper, S. L., & Douglas, J. M. (2009). Visual scanning in the recognition of facial affect: Is there an observer sex difference? *Journal of Vision*, *9*(3), 11.

Wilmer, J. B., Germine, L. T., & Nakayama, K. (2014). Face recognition: A model specific ability. *Frontiers in Human Neuroscience*, *8*, 769.

Weigelt, S., Koldewyn, K., & Kanwisher, N. (2012). Face identity recognition in autism spectrum disorders: A review of behavioral studies. *Neuroscience and Biobehavioral Reviews*, *36*, 1060–1084.