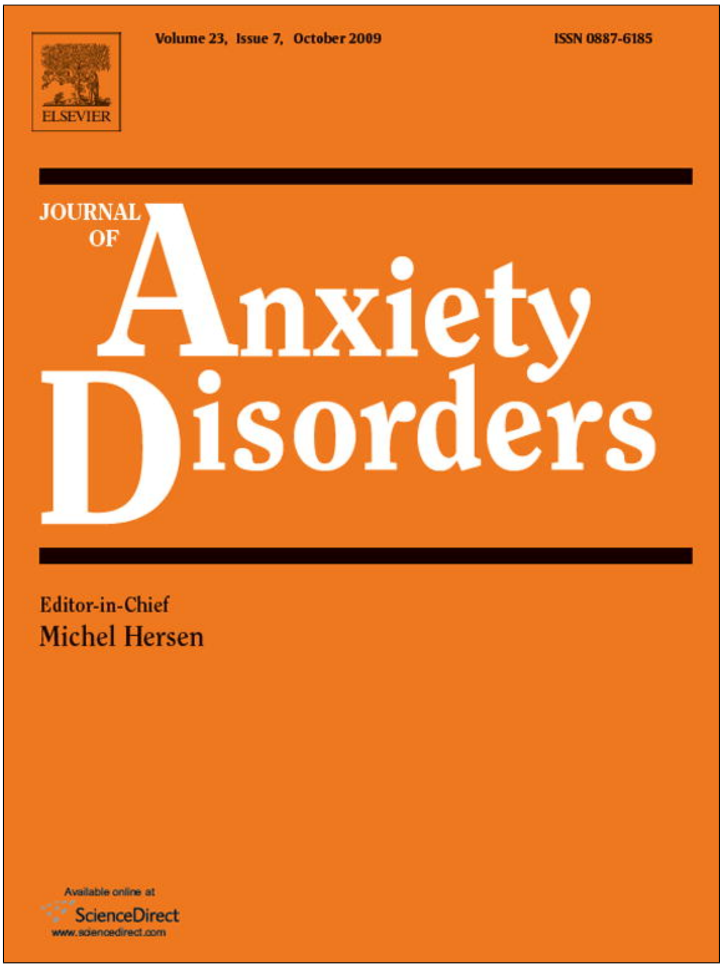
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Shyness and face scanning in children

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ABSTRACT

Contrary to popular beliefs, a recent empirical study using eye tracking has shown that a non-clinical sample of socially anxious adults did not avoid the eyes during face scanning. Using eye-tracking measures, we sought to extend these findings by examining the relation between stable shyness and face scanning patterns in a non-clinical sample of 11-year-old children. We found that shyness was associated with longer dwell time to the eye region than the mouth, suggesting that some shy children were not avoiding the eyes. Shyness was also correlated with fewer first fixations to the nose, which is thought to reflect the typical global strategy of face processing. Present results replicate and extend recent work on social anxiety and face scanning in adults to shyness in children. These preliminary findings also provide support for the notion that some shy children may be hypersensitive to detecting social cues and intentions in others conveyed by the eyes. Theoretical and practical implications for understanding the social cognitive correlates and treatment of shyness are discussed.

The eyes convey important information for facial identification (Gold, Sekuler, & Bennett, 2004; Heisz & Shore, 2008) and intention detection (Baron-Cohen, Wheelwright, & Jolliffe, 1997). Clinically impaired populations characterized by extreme social deficits are known to avoid the eyes during face scanning. For example, children with autism tend to dwell on the mouth rather than the eyes when processing faces (Klin, Jones, Schultz, Volkmar, & Cohen, 2002) and show impaired face recognition performance (Dawson et al., 2002). Evidence on the extent to which these findings generalize to non-clinical populations characterized by social deficits is relatively limited.

Individuals who are socially anxious are characterized by social deficits (see Crozier & Alden, 2005, for a review). Non-clinical socially anxious individuals are known to make less eye contact with an interviewer than their non-socially anxious counterparts (Daly, 1978). People who are socially anxious look less at their audience than non-anxious individuals (Eves & Marks, 1991), and their looking-time is related to their level of anxiety (Jurich & Jurich, 1974). Still others have noted that increased social anxiety was related to decreased eye contact in social interactions (Farabee, Holcom, Ramsey, & Cole, 1993). However, a relation between level of anxiety and eye gaze behavior is not always observed (Hofman, Gerlach, Wender, & Roth, 1997). Taken together, these studies are potentially limited by the behavioral coding method of monitoring eye movements, which can only provide a crude measure of gaze position in contrast to the more reliable methods presently available.

Using eye tracking, one study found that adults with social phobia avoided the eye region of the face more than normal controls (Horley, Williams, Gonsalvez, & Gordon, 2003). However, a more recent study, using eye tracking with a non-clinical adult sample reported that women high in social anxiety tended to fixate longer at the eye region than medium or low socially anxious women (Wieser, Pauli, Alpers, & Mulhberger, 2009). Even though direct gaze generated more anxiety (as measured by increased heart rate), fixations to the eye regions by high socially anxious women were observed regardless of whether the gaze direction of the stimuli was direct or averted. These results suggest that social anxiety may not be associated with gaze aversion—at least in a laboratory setting.

The primary goal of the present study was to extend recent findings of Wieser et al. (2009) by examining the relation between temperamental shyness and face scanning behavior in a non-clinical sample of 11 year-old children. Shyness and social anxiety are known to be conceptually and empirically related and have often been used interchangeably in the extant literature even though they have, in part, different meanings (Rubin & Asendorpf, 1993; Schmidt & Buss, 2009). Although social anxiety and shyness reflect the process of affective (e.g., nervousness), cognitive (e.g., fear of evaluation) and behavioral (e.g., awkward social responses) uneasiness in social situations, temperamental shyness is presumed to be an enduring trait-like characteristic of one's personality (Biedel & Turner, 1998; Kagan, 1994).

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Shyness is known to be associated with avoidant behavior, especially during social interactions, and such behaviors are prevalent throughout development. As early as the second year of post-natal life, 10–15% of typically developing toddlers consistently turn away and hide from novel people, objects, and situations (Fox, Henderson, Rubin, Calkins, & Schmidt, 2001; Kagan, 1994, 1999). Of these toddlers, some will maintain their avoidant tendencies and develop into temperamentally shy children and adults (Biedel & Turner, 1998; Schmidt & Schulkin, 1999). Interestingly, although the avoidance of eye contact is an observable behavior presumed to maintain non-clinical shyness (Cheek & Buss, 1981; Garcia, Stinson, Ickes, Bissonnette, & Briggs, 1991; Pilkonis, 1977), no studies have used eye tracking to reliably capture precise face scanning patterns in relation to shyness among non-clinical samples and apparently none with children.

To do so, we used the *Jane test* of face identity (Mondloch, Le Grand, & Maurer, 2002). Twelve new versions of a single Caucasian female face ('Jane') were created. Four differed in the shape of the eyes and mouth (feature set), four differed in the shape of the external contour (contour set), and four differed in the spacing among facial features (spacing set). During the task, participants made same/different judgments for pairs of faces from each of the three face sets. This task has been used previously to measure developmental changes in sensitivity to each of these cues to facial identity (Mondloch et al., 2002), the effects of early deprivation on later face processing (Le Grand, Mondloch, Maurer, & Brent, 2001; Le Grand, Mondloch, Maurer, & Brent, 2003), face processing in individuals with Williams syndrome (Karmiloff-Smith et al., 2004), and to compare the sensitivity of shy versus non-shy children to each of these cues to facial identity (Brunet et al., in press).

We elected to use the Jane task in the current study for two reasons. First, it allowed us to determine whether scanning patterns differed across the three face sets. Each face set isolates a different aspect of the face that can be used for identification: the shape of facial features (feature set), the shape of the face (contour set), and configural face information represented by the distance among features (spacing set). We anticipated greater fixation on the eye region during the feature block than during the spacing and contour blocks; attending to a single internal feature (eye or mouth) would result in high accuracy on the feature set, whereas high accuracy on the spacing requires integration across the internal features and high accuracy on the contour set would require attending to either a local external feature (e.g., chin shape) or global face shape. Second, in a previous study, we tested 40 typically developing 10-year-old children on this task and, based on their scores on maternal report of shyness using the Colorado Child Temperament Inventory (CCTI; Buss & Plomin, 1984; Rowe & Plomin, 1977), we assigned them to one of three groups: low, medium, and high shy (Brunet et al., in press). The high-shy children made more errors than their non-shy peers on the spacing set, but not on either of the feature or contour sets. These results suggest that the relation between shyness and face processing may vary with the type of information that is critical for discrimination.

In the present study, we re-tested a subset of our original sample (28 of the original 40 children) one year later. For each face set, we examined whether scanning patterns differed as a function of shyness. The present investigation appears to be the first study to explore the relation between shyness and face scanning using eye-tracking technology in a non-clinical sample of children, and thus it provides a test of two contrasting hypotheses.

According to an *avoidance* hypothesis, a positive relation between shyness and eye avoidance during face scanning is expected. Shyness is characterized by avoidance behaviors (Pilkonis, 1977), and one very salient avoidant behavior is not looking at the eyes and eye region because these areas convey possible social threat (Farabee et al., 1993).

Alternatively, shy individuals may exhibit hyper-vigilance looking to the eyes for important social cues, albeit brief, as a result of their heightened self-consciousness during social interactions (Crozier, 1979). Shy people are overly concerned that other people will evaluate them negatively during social interactions. Fatis (1983) found that shy individuals report greater negative cognitions during social interactions, including self-consciousness about their social skills during the interaction, worry about how the other person is evaluating them, and general unpleasantness of the situation. This latter hypothesis is in line with the recent report that socially anxious adults fixate longer at the eyes during face scanning (Wieser et al., 2009), leading to the *hyper-vigilance* hypothesis: a positive relation between shyness and dwell time to the eyes.

1. Method

1.1. Participants

Twenty-eight (14 males) 11-year-old children (*M* age = 11.14 years, S.D. = 6.49 months) and their parents were recruited from a Child Database maintained by the Department of Psychology, Neuroscience & Behaviour at McMaster University. The database contains contact information of children born at hospitals in the Hamilton, Ontario region whose mothers volunteered to be contacted about research at the time of the child's birth. All children were Caucasian, born healthy and full-term, were typically developing, and had normal or corrected to normal vision at the time of testing. Participants were first recruited one year prior for another research study. At that time, participants were selected based on their age. They were not selected based on their temperament scores. Parents and children were not assessed for anxiety or psychological disorders at either time points.

1.2. Face identity task

The face stimuli have been used in previous studies (e.g., Mondloch et al., 2002). A single Caucasian female face (Jane) was modified to create 12 new versions ('Jane's sisters'). Four sisters (the spacing set) differed only in the spacing of features (e.g., spacing between the eyes), four (e.g., the featural set) differed only in the appearance of the eyes and mouth, and four (e.g., the contour set) differed only in the shape of the external contour. Jane and three completely novel faces ('Jane's cousins') comprised the control stimuli; these faces differed on all three dimensions. All stimuli were 10.2 cm wide and 15.2 cm high ($5.7^\circ \times 9.1^\circ$ from the testing distance of 100 cm).

1.3. Temperament measure

The CCTI is a widely used instrument to index children's temperament and has excellent psychometric properties (Buss & Plomin, 1984; Rowe & Plomin, 1977). The CCTI comprises 30 items and six subscales: shyness, sociability, activity, attention span, emotionality, and soothability. Of particular interest were the shyness (e.g., "Child takes a long time to warm up to strangers") and sociability (e.g., "Child likes to be with people") subscales. In the present study, the alpha coefficients were .77 and .67 for the shyness and sociability subscales, respectively. We examined sociability to determine specificity, given that sociability is conceptually and empirically orthogonal to shyness but related to social behavior (Cheek & Buss, 1981; Schmidt, 1999). Items were answered on a 5-point scale, with 1 representing "not at all like my child" and 5 for "a lot like my child." There are 5 items per subscale, thereby giving a possible range of 5–25.

1.4. Procedure

Upon arrival, the parent and child were briefed about the procedures and written consent was obtained. The McMaster University Research Ethics Board approved all procedures.

The experiment began with a practice task requiring same/different judgments of two identical faces or two radically different versions of the same face (e.g., a face with eyes rotated 45° clockwise; Mondloch et al., 2002). To participate in the main experiment, participants were required to be correct on at least 10 of the 12 practice trials; every child met this criterion.

On each trial of the main task, one of five possible faces appeared for 200 ms, followed by a 390 ms inter-stimulus interval and then by a second face that appeared until the participant responded "same" or "different" by pressing one of two buttons on a joystick. There were three blocks of trials (n = 40 trials per block); within each block, all of the faces were from the same set (e.g., featural), and the correct response was "same" for half of the trials. The order of the blocks varied across participants. After completing the experimental blocks, the child completed a control block in which they made same/different judgments about 'Jane' and her cousins. To ensure that each participant was "playing the game" at the end of the task, they were each required to achieve 70% accuracy in this block (Mondloch et al., 2002). All children met this criterion.

While the child was completing the face identity task, the parent completed the CCTI at age 11. The parent also completed the CCTI approximately one year prior at age 10 as part of another study (Brunet et al., in press). Upon completion of the procedures, the child was given the opportunity to choose from among several age appropriate children's books as a prize for his/her participation.

1.5. Eye-tracking apparatus, procedures and measures

A Power Mac G4 computer was connected to a ViewSonic Professional Series P220f monitor for presentation of the stimuli using the Psychophysics toolbox (Version 2.55; Pelli, 1997) running within the MatLab interpreter (Version 5.2.1; Mathworks Inc.). An additional Dell computer was used to collect eye movement data using the EyeLink II system (Version 1.1, 2002).

Before beginning the experiment, participants were introduced to the eye-tracking apparatus and familiarized with the head-mounted eye tracker. Prior to each block, the eye tracker was calibrated: a target circle was randomly presented at one of nine locations (3 × 3 matrix) on the monitor and the participant was instructed to fixate the target for 1 s and to track the target as it moved randomly to each of the nine locations. This procedure was repeated to validate calibration accuracy; calibration was accepted if the average error between fixation location and target location was less than 1° RMS. Otherwise breaks were not given, and participants were not told how the faces differed. Drift was corrected at the start of each trial. Only 0.9% of trials were excluded because of calibration issues, and excluded trials were not systematically related to the shyness or sociability measure ($P > .05$).

Eye movement analyses were time-locked to the second face presentation and limited to the first second to equate trial duration across tasks.[1] Eye movements, with information regarding velocity, position, and pupil size, were sampled at 500 Hz. Fixations were defined by EyeLink II online parsing system as eye movements with pupil diameter greater than 0 and velocity less that 30°/s. The online parsing system also tagged the start and end of each fixation, and this information was used to compute dwell time. Fixation count (W = .968, P = .53) and dwell time (W = .968, P = .53) were normally distributed, as determined by Shapiro-Wilk normality test. Moreover, mean fixation count and mean dwell time for each participant were within 2 S.D. of the mean.

A single template of non-overlapping rectangular sections defined each area of interest [left eye (right visual field: RVF), right eye (left visual field: LVF), nose, and mouth]. We computed proportions of fixations and dwell time for each area of interest. Eye movement analyses were based on trials with a correct response. Reaction time and accuracy scores were not correlated with temperament in any of the blocks (r's < .34; P's > .05).

[1] Overall mean RTs were 1.26 ± 0.27.

2. Results

2.1. Stability of temperament

To provide a more reliable assessment of shyness, stability of temperament was first established by comparing CCTI shyness and sociability scores at time of testing (i.e., age 11) and approximately 1 year prior (i.e., age 10). Because scores were highly stable across time (shyness: r = .72, $P < .005$; sociability: r = .72, $P < .005$), we computed separate composite measures of stable shyness (CCTI Shyness at Time 1 + Time 2) and stable sociability (CCTI Sociability at Time 1 + Time 2) to provide our best estimate of these trait-like characteristics. The original CCTI subscales have a range of 5–25; consequently, the combined score for Time 1 and Time 2 have a possible range from 10 to 50. In our sample, the participants ranged from 12 to 38.

2.2. Relation between shyness and face scanning

Is shyness associated with decreased fixations (avoidance hypothesis) or with increased fixations (hyper-vigilance hypothesis) in the eye region? In order to determine whether temperament influenced scanning patterns across global and local face processing during the face identity task, we computed a series of Pearson zero-order correlations between the stable shyness measure and both proportion dwell time and fixation count. In order to see whether the relations were specific to shyness, we conducted the same analyses using the CCTI sociability measure as well.

We found that the relation between shyness and face scanning patterns differed across face sets. For the *feature* block, shyness was associated with looking longer at the left eye [r = .41, $P < .05$; see Fig. 1A and B]. However, during the *contour* block, shyness was associated with more first fixations to the left eye [r = .38, $P < .05$] and fewer first fixations to the nose [r = −.44, $P < .05$]. During both the *spacing* and the *cousins* blocks, neither dwell time nor fixation count correlated with shyness, P's > .05). Sociability did not correlate with any of these face scanning measures (P's > .05).

Is shyness related to increased fixation to the mouth? To address this question, we computed Pearson zero-order correlations between shyness, sociability and proportion dwell time and fixation count in the mouth region. We found decreased fixation count [r = −.45, $P < .05$] and shorter fixation duration [r = −.45, $P < .05$] to the mouth during the *cousins* block, and fewer second fixations to the mouth across all conditions [r = −.39, $P < .05$], with increased levels of shyness. Sociability did not correlate with any of these measures (P's > .05).

2.3. Scanning patterns across the 3 face sets

We next examined patterns of face scanning during the face identity task in order to examine whether scanning patterns differed across the three face sets. Fig. 2 depicts the mean proportion of (A) dwell time and (B) fixation count to the right eye (LVF), left eye (RVF), nose and mouth across cousin, contour,

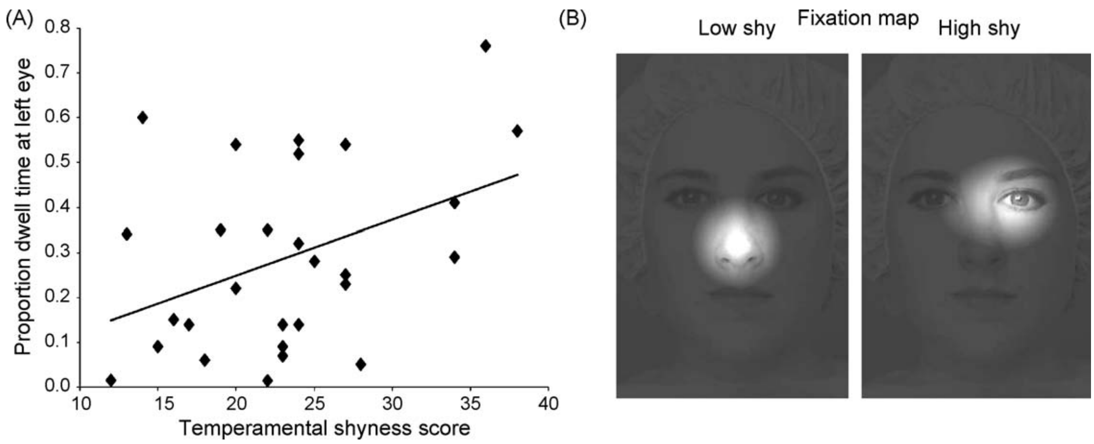

Fig. 1. Scatter plot (A) illustrates the relation between shyness and looking-time, with higher shyness associated with looking longer at the left eye (RVF) during the feature block. Fixation maps (B) depict overall fixation pattern during feature trials of the lowest and the highest shy children. The light areas represent fixation locations during the first second of the trial. The fixation map was created with EyeLink2 software using default values corresponding to a standard deviation of the Gaussian distribution for each fixation point set to 1°. Each fixation point extended 3 standard deviations and the contrast between fixation hotspot and background was set at 0.01.

feature, and spacing blocks for all children. Overall, scan patterns for the feature task differed from those for other tasks in that fixations were shorter durations [$F(3, 81) = 7.87$, $P < .01$] and more equally distributed to the right eye, left eye, and nose [$F(3, 81) = 4.67$, $P < .05$] indicative of local processing; during the other tasks, fixations were longer, focusing mostly to the nose area indicative of integrating information across larger regions of the face [% dwell time: $F(9, 243) = 4.50$, $P < .01$; % fixation count: $F(9, 243) = 3.27$, $P < .05$].

3. Discussion

Contrary to folk psychology, we found that shyness was not related to avoidance of others' eyes in children. Increased shyness was related to increased dwell time to the eye region and decreased in dwell time and fixation counts to the mouth. These relations were not found for sociability but were specific to the shyness temperament. Overall, these results are consistent with those of Wieser et al. (2009) who recently reported that a group of non-clinical socially anxious women tended to fixate longer to the eye region than their non-socially anxious counterparts. Our findings extend their recent results to shyness and face scanning in a non-clinical sample of children. The present findings also support a hyper-vigilance hypothesis that may be involved in the characterizing of shyness. That is, individuals who are shy may be hypersensitive to seeking out evaluative cues and intentions in others that are conveyed by the eyes and as a result may be more likely to fixate initially, albeit brief, to the eye region during face scanning. At least, this seems to be true for static face images presented in the laboratory.

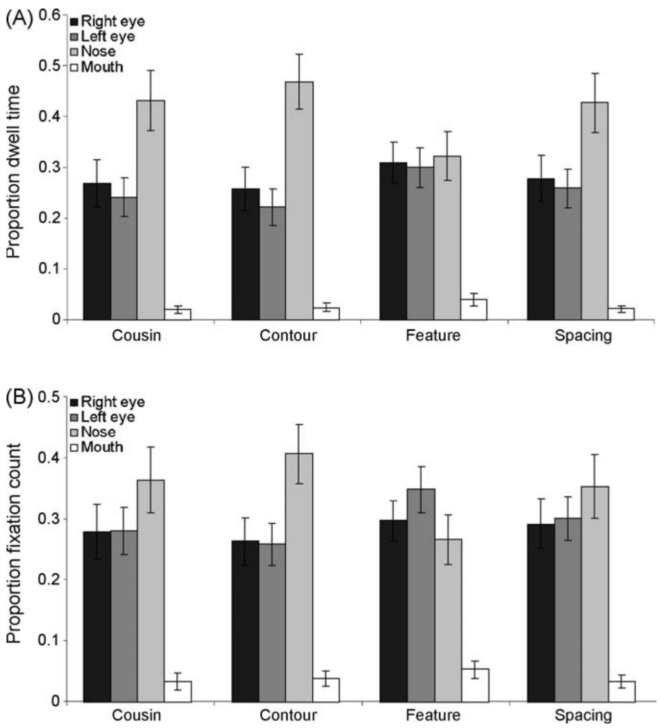

Fig. 2. Mean proportion (A) dwell time and (B) fixation count to the right eye (LVF), left eye (RVF), nose, and mouth across cousins, contour, feature, and spacing blocks for all participants. Error bars represent standard error of the mean.

It is also interesting that shyness was associated with fixations to the left eye (RVF). Typically, face processing is associated with greater right hemisphere activation (Kanwisher, McDermott, & Chun, 1997; McCarthy, Puce, Gore, & Allison, 1997). It is possible that shy children rely more on the left hemisphere for face processing, but this requires verification from neuroimaging studies.

It is also important to note, however, that we focused on only the first few fixations, which may differ from scanning patterns across an entire social interaction. Within the first few fixations, shy individuals may look at the eyes to collect necessary information and have no need to revisit the eye region. Alternatively, shy individuals may be subtly looking at the eyes throughout an interaction, but may not be making or sustaining eye contact, and therefore are perceived as avoiding the eyes in general.

Our results may also clarify misconceptions regarding the relation between social deficits and face processing. For example, individuals with autism are known to look at the mouth instead of the eyes, especially during dynamic social situations (Klin et al., 2002; Speer, Cook, McMahon, & Clark, 2007). Although the pattern of social deficits in autism may be more extreme than in shyness, the pattern of face scanning observed in individuals with autism may not be the same for non-clinical samples with lesser forms of social deficits such as those who are shy. The static nature of images in our task may be critical to the observed findings. With these images some shy children spent longer on the eye region for the feature set. During social interactions, they may not dwell on the eye region at all. By this logic, they perform well on discriminating facial identity (a static characteristic) but would miss dynamic cues such as changing emotional expressions (Wieser et al., 2009). Shy children are known to show deficits in classification of emotional facial expression (Battaglia et al., 2004; Melfsen & Florin, 2002; Stirling, Eley, & Clark, 2006; Strand, Cerna, & Downs, 2008) and in accurately identifying emotional facial expressions (Simonian, Beidel, Turner, Berkes, & Long, 2001).

It is also important to point out that scanning patterns differed depending on the nature of the task—spacing, features or external contour. When faces differed in the spacing of features or the shape of the external contour, participants made fewer, longer fixations to the center of the face image; when faces differed in the shape of the eyes and mouth, participants made more and shorter fixations to the prominent features. These differential scanning patterns were observed across all individuals, suggesting a general scanning strategy for extraction of cues to facial identity regardless of temperament.

3.1. Limitations and future research

The present study provided a logical first step in the investigation of individual differences in the face scanning behavior and shyness. Future research should extend these findings to address if these scanning patterns continue beyond the first few fixations. The current study also addressed scanning patterns used for facial identification but did not directly measure eye contact in a dynamic situation. To do so, eye-tracking technology would need to be used during a real social interaction instead of during the viewing of static images. However, under those conditions a head-mounted eye-tracking system would be too intrusive. Consequently, a desk mounted eye-tracking system would be an appropriate choice, as it would not compromise the ecological validity of the social interaction.

3.2. Conclusions and implications

Present results have theoretical and practical implications. The present study extends earlier work on social anxiety and face scanning in clinical and non-clinical samples of adults to shyness and face scanning in a non-clinical sample of children apparently for the first time in the extant literature. Our preliminary findings also have implications in terms of how we characterize shyness. People who are shy appear to be hypersensitive to their environment and to detecting threat. Within a social interaction, the eyes of others convey intention and are thus a key environmental stimulus. We believe that people who are shy go rapidly to the eyes, albeit brief, for social information and intention detection and then move off of the eyes as a means of coping with social threat (see also, Beaton, Schmidt, Schulkin, Antony, Swinson, & Hall, 2009).

Our findings also have practical implications to intervention protocols involving how to improve eye contact and gaze aversion for extremely shy individuals. Human shyness is a phenomenon characterized by social deficits and avoidance behavior (Crozier & Alden, 2005). People who are shy are characterized as averting eye contact during social interactions as a means of coping with their social anxiety (Pilkonis, 1977). Perhaps such avoidance of eye contact explains why shy children show deficits in classification of emotional facial expression (Battaglia et al., 2004; Melfsen & Florin, 2002; Stirling et al., 2006; Strand et al., 2008), in accurately identifying emotional facial expressions (Simonian et al., 2001), and in sensitivity to one cue to face recognition—detecting differences among faces in the spacing among facial features (Brunet et al., in press) as noted above. Given that people who are shy apparently can, and do, look at the eyes, this ability to make eye contact could then be perhaps further trained so that people who are shy can learn to maintain eye contact perhaps preventing the manifestation of a cascade of secondary negative events associated with social deficits and the phenomenon of shyness.

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