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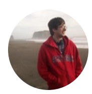

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Original Article

Emotional Faces Capture Spatial Attention in 5-Year-Old Children

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Abstract: Emotional facial expressions are important social cues that convey salient affective information. Infants, younger children, and adults all appear to orient spatial attention to emotional faces with a particularly strong bias to fearful faces. Yet in young children it is unclear whether or not both happy and fearful faces extract attention. Given that the processing of emotional faces is believed by some to serve an evolutionarily adaptive purpose, attentional biases to both fearful and happy expressions would be expected in younger children. However, the extent to which this ability is present in young children and whether or not this ability is genetically mediated is untested. Therefore, the aims of the current study were to assess the spatial-attentional properties of emotional faces in young children, with a preliminary test of whether this effect was influenced by genetics. Five-year-old twin pairs performed a dot-probe task. The results suggest that children preferentially direct spatial attention to emotional faces, particularly right visual field faces. The results provide support for the notion that the direction of spatial attention to emotional faces serves an evolutionarily adaptive function and may be mediated by genetic mechanisms.

Keywords: child, facial expressions, spatial attention, emotion, behavior genetics

Introduction

Facial expressions are important nonverbal signals that relay affect-related information to other individuals. These basic emotional expressions appear to be consistent across cultures and even other mammalian species (Darwin, 1872). Infants are able to detect emotional faces very early in life, followed closely by the ability to categorize mere months after birth (Montague and Walker-Andrews, 2001; Nelson, 2001). It has been proposed that the early ability to detect emotional faces may serve as an evolutionarily adaptive function to facilitate social interaction and threat avoidance and thus enhance an individual's likelihood of survival (Vaish, Grossmann, and Woodward, 2008). In particular, the tendency to automatically direct internal visual processing resources (i.e., enhancement of visual signal relative to background noise) to the location in visual space of others' emotional cues provides an individual with nonverbal insight into others' affective states.

This unintentional modulation of internal visual processing resources is referred to as covert spatial attention. Spatial attention to emotional faces is predicated on basic visual attention abilities such as visual alertness, spatial orienting, and attention to object features which develop during the first six months of life (Colombo, 2001). Sustained visual attention emerges later, from six months to three years of age, as greater cognitive resources develop (Colombo, 2001). These abilities develop in the context of emotional stimuli, particularly human faces. Infants display a partiality for faces that appears very early in life, as infants preferentially orient to faces within several hours of birth (Nelson, 2001). After only a few months, four-month-old infants reveal preferential biases in gaze to emotional facial expressions (Montague and Walker-Andrews, 2001) and infants less than a year old are able to discriminate emotional facial expressions including happiness (Bornstein and Arterberry, 2003) and anger (Serrano, Iglesias, and Loeches, 1995). Interestingly, young infants tend to allocate greater attention to happy expressions very early in life, which transitions to negative faces later in the first year of life (Vaish et al., 2008). For example, recent research by LoBue and DeLoache (2010) indicates that 8- to 14-month-old infants preferentially look more quickly at angry (but not fearful) faces compared to happy expressions. This transition likely serves an important evolutionary attachment purpose where it is critical for younger (immobile and completely dependent) infants to attend to positive cues for acquiring resources, whereas for older (more mobile) infants the need and ability to avoid potential harm becomes more important.

Across early childhood, visual attention and facial cues become increasingly integrated as visual-emotional stimuli in the environment are used for social referencing (Bruce et al., 2000; Repacholi and Gopnik, 1997; Vaish et al., 2008). As evidence, infants and children have been shown to preferentially direct their gaze toward emotional faces (Bornstein and Arterberry, 2003; Montague and Walker-Andrews, 2001; Serrano et al., 1995; Vaish et al., 2008). Relatedly, recent research suggests that more peripheral and effortful behavioral measures such as hand-initiated responses to task-relevant stimuli are facilitated by enhanced attention to threatening (i.e., fearful and angry faces) compared to happy faces in five-year-old children (LoBue, 2009) as well as other threatening stimuli such as snakes, as young as three years old (LoBue and DeLoache, 2008). In contrast to this, by nine years of age, spatial attention is preferentially directed to both positive and negative emotional stimuli when compared to a neutral baseline (Waters, Lipp, and Spence, 2004), with anxious children attending more to threat-related stimuli (Puliafico and Kendall, 2006). Research in adults (Carlson and Reinke, 2008; Mogg and Bradley, 1999; Pourtois, Grandjean, Sander, and Vuilleumier, 2004) and children (Puliafico and Kendall, 2006; Waters et al., 2004) has indicated that emotional facial expressions (especially those expressing fear) capture spatial attention. In adults, it has been proposed that regardless of valence, both rewarding and threatening stimuli, such as infant faces vs. snakes, capture spatial attention due to their high biological significance (Brosch, Sander, and Scherer, 2007). Yet, there is little research (i.e., LoBue, 2009) on emotional face-elicited spatial attention in younger children, with many unanswered questions remaining. For example, although fearful faces have been shown to preferentially capture attention relative to happy faces (LoBue, 2009), it is unclear whether or not other emotional expressions such as happy faces capture attention relative to neutral faces. Additionally, prior affective attention research in younger children has primarily utilized the visual search task where participants are explicitly instructed to find a target face (e.g., happy or fearful) amongst distracter faces with expressions incongruent to the target face. Therefore, in the visual search task emotional facial expressions are task relevant and it remains unclear to what extent emotional faces may facilitate attention in task-irrelevant contexts (e.g., the dot-probe task).

In a recent review (Iarocci, Yager, and Elfers, 2007) it was suggested that behavioral genetic research can help address questions of social development using facial and emotional recognition. At present, it remains unclear to what extent genes influence shifts in attention to emotional faces in young children. However, some twin research has examined the genetic influence on facial and emotional processing. Previous twin studies have found heritability estimates on general reaction time and speed of information processing that ranged from .11 to .61 in both adults (Neubauer, Spinath, Riemann, Angleitner, and Borkenau, 2000) and infants (DiLalla, Fulker, and Thompson, 1989). A recent ERP study on adolescent twins found significant heritability in the neural response of processing facial affect, ranging from .36 to .64 (Anokhin, Golosheykin, and Heath, 2010). A recent review of emerging twin literature has also concluded there to be a 'strong role for nature in face (identity) recognition' wherein a unique genetic influence was found for face-specific processes over and above simple visual (non-face) and verbal recognition (McKone and Palermo, 2010, p. 1). In addition, recent neuroimaging twin studies have reported genetic influences for adult face processing in the ventral visual cortex (Polk, Park, Smith, and Park, 2007) and amygdala (Wolfensberger, Veltman, Hoogendijk, Boomsma, and de Geus, 2008). Also, genetic influences in adult twin attention and emotional processing have been associated with anterior cingulate activity and genetic influence on incongruent trials over congruent trials (h^2 = .37; Matthews et al., 2007). Finally, selective attention has been found to be genetically influenced in children across the ages of 5 to 12 years old (h^2 =.56; Polderman et al., 2007). Although these studies suggest that genetics influence aspects of emotion, face, and attention processing, it remains unclear what role genes might play in mediating an integrated attentional response to spatially distinct emotional faces and at what point in development this behavior first manifests.

The primary aim of the current study was to test the spatial attention eliciting properties of fearful and happy facial expressions in five-year-old children. A secondary aim was to assess a potential genetic influence on fearful and happy face-elicited spatial attention using twins. Five-year-old twins performed a dot-probe task (e.g., Mogg and Bradley, 1999) with happy and fearful face cues. It was hypothesized that emotional facial expressions would capture spatial attention in five-year-old children. Five-year-old children were included for two reasons. (1) There is a relative dearth of research on spatial attention in early childhood, and (2) this age represents the earliest point at which children can competently perform a complex dot-probe computer task, not possible at younger ages. If fearful and happy facial expressions draw spatial attention to their location (relative to the location of competing neutral faces), then one would expect faster reaction times to targets that follow emotional (rather than neutral) faces. Additionally, we conducted preliminary behavior genetic analyses on our small sample to begin to examine whether this behavior would be mediated by a genetic component, which would be revealed by more similar emotional face-elicited attentional biases in monozygotic (MZ), compared to dizygotic (DZ), twins.

Materials and Methods

Participants

Twins were recruited as part of the Southern Illinois Twins and Siblings Study (SITSS; DiLalla, 2002). Families initially were located through a variety of methods, including newspaper birth announcements, references from other twin families, the Mothers of Twins Club, and through invitations to twins found in the community.

Ten twin pairs and one set of triplets were brought to the lab for testing at age 5 years. All children were tested within one month of their 5th birthday to increase similarity in developmental age. One twin child was dropped from overall analyses due to fussing and unwillingness to perform the dot-probe task, and thus this twin pair was dropped from genetic analyses. This resulted in 22 individuals, 11 male and 11 female, for the primary, non-twin analyses. For exploratory genetic analyses 12 pairings of twins were used (triplets yielded one MZ pair and two DZ pairs) composed of five MZ pairs, who share 100% of their genetic profile, and seven DZ pairs, who share on average 50% of their genetic profile. Parents' consent was obtained prior to testing and buccal cell collection. Buccal cells were used to confirm twin zygosity. Handedness was assessed by asking children which hand they used most often to color with (14 right handed, 8 left handed). Children were treated in accordance with the guidelines of the Institutional Review Board. Families were paid $50 for participation and each child was given approximately $10 in toys to thank them for participating.

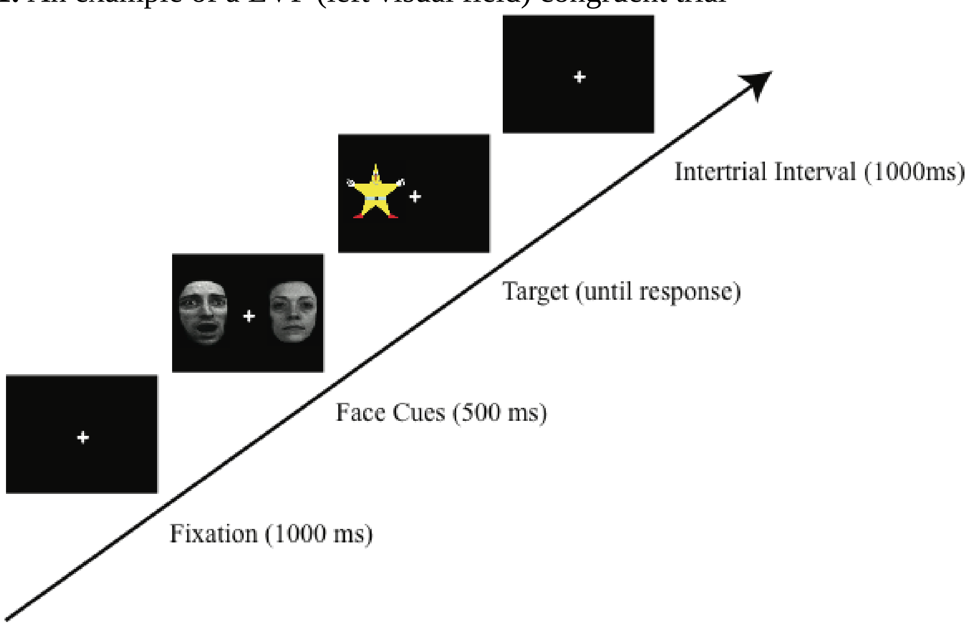
Stimuli and procedure

Families initially were contacted by letter with information regarding the present study. Appointments were scheduled at the family's convenience to facilitate testing and to accommodate children's daily routines. On the day of the visit, the family was escorted to the testing room where the twins were first introduced to the testing area. After becoming familiar with the lab, one twin was brought to a separate testing room containing a computer where the spatial attention task was administered. After completion of the task the first twin was escorted back to the main lab and the second twin was brought to the testing room to complete the spatial attention task. Both twins were always tested on the same day.

Four (two male and two female) gray scale facial identities of fearful, happy, and neutral 3D faces (Gur et al., 2002) were used in the dot-probe task. A cartoon character, "Star Man," was created and used as the target stimulus. Stimuli were presented on a 60 Hz 16" computer monitor. Children were initially seated 40 cm from the screen. As displayed in Figure 1, each trial started with a white fixation cue (+) that children were told to focus on throughout the experiment, centered on a black background for 1000 ms. Two face stimuli (each 7.13 × 9.93° and separated by 19.30° of visual angle) were simultaneously presented (500 ms) to the left and right of fixation. After presentation of these faces, the target Star Man (4.29 × 5.71° of visual angle) was presented in the location of either the left or the right face. If children shifted very much in their sitting position, attempts were made to return them to their initial position.

The children's task was to indicate the location of Star Man as quickly as possible by using a computer keyboard. Participants used their right index finger on the bottom right enter button to indicate that the target occurred on the right side of the screen and left index finger on the spacebar to indicate that the target occurred on the left side of the screen. Star Man remained on the screen until the participant responded. The fixation cue remained in the center of the screen throughout each trial. In an attempt to measure emotional face-elicited covert shifts in spatial attention, children were instructed to always fixate on this cue (see Figure 1). The study consisted of two blocks of 64 trials. Trials consisted of one emotional (fearful or happy) and one neutral face, which were half congruent (Star Man presented on the same side of the screen as the emotional face) and half incongruent (Star Man presented on the same side as the neutral face with the emotional face on the opposite side).

Figure 1. An example of a LVF (left visual field) congruent trial



Note: Each trial started with a fixation cue, which was followed by two bilateral face cues. Face cues contained one emotional (fearful or happy) and one neutral face, with the emotional face occurring in the LVF or RVF (right visual field). These faces were immediately followed by the target star man, which randomly occurred in either the LVF or RVF. Children responded to the location of the Star Man as quickly as possible.

Variations of the dot-probe task have been used in numerous studies of spatial attention (see Yiend, 2010). The dot-probe task is thought to measure an individual's attentional bias to a certain stimulus, in this case emotional faces, which should facilitate faster responses on congruent relative to incongruent trials. That is, if emotional facial expressions automatically or exogenously draw spatial attention to their location, then children should respond faster to congruent rather than incongruent trials. Given that all trials contained one emotional and one neutral facial expression and these faces were task irrelevant, differences between congruent and incongruent trials should reflect exogenous emotion-elicited spatial attention rather than endogenous (or any other type) of attention. Additionally, given that the target Star Man occurred with equal probability (i.e., 50%) at either spatially congruent or incongruent locations, attentional shifts cannot be attributed to learned associations between facial cues and targets. Given that attentional capture in this task is defined as the difference in reaction times between two conditions (i.e., congruent and incongruent) and that the facial cues are task irrelevant, differences in attentional capture cannot be attributed to general measures such as speed of information processing. Differences in congruent and incongruent reaction times are thought to represent an overall measure of attentional capture that includes both the initial orienting of attention to the emotional face and the disengagement of attention from the emotional face (i.e., on incongruent trials; see Carlson and Reinke, 2008, and Koster, Crombez, Verschuere, and De Houwer, 2004 for methods on disentangling these different effects).

Results

Overall dot-probe analyses

For reaction time (RT) analyses, only correct responses between 150 ms and 2000 ms were used (82% of the original data). Trials with reaction times less than 150 ms or more than 2000 ms were discarded to eliminate premature and delayed responses not associated with the participant's initial allocation of attention. Incorrect responses accounted for 12% and premature and delayed responses accounted for 7% of trials. A 2 (visual field: left vs. right) × 2 (congruency: congruent vs. incongruent) × 2 (valence: fearful vs. happy) repeated measures Analysis of Variance (ANOVA) was conducted on participants' RTs to the target Star Man. Sex and handedness were included as between-subjects factors. The interaction between visual field and congruency was significant, $F(1,18) = 10.55$, $p < .05$, $\eta_p^2 = .37$. Within the right visual field (RVF), congruent trials (M = 910.51 ms) were faster than incongruent trials (M = 998.54 ms, $p < .001$), whereas in the left visual field (LVF), congruent trials (M = 967.68 ms) did not significantly differ from incongruent trials (M = 948.98 ms). The main effect for congruency approached significance, with faster reaction times for congruent (M = 939.09 ms) relative to incongruent trials (M = 973.78 ms), $F(1,18) = 3.22$, $p = .09$, $\eta_p^2 = .15$. The main effects of visual field, valence, sex, and handedness were not significant (F's < 1). No other interaction effects were found to be significant (F's < 1).

Exploratory genetic analyses on spatial attention and general information processing

The potential for genetic influences was tested by comparing reaction times for MZ versus DZ twins. To test for a genetic influence on spatial attention to emotional faces, difference scores were calculated for each twin pair's attention index. First, the attention index was calculated for each child as the difference between congruent and incongruent RTs. Whereas RTs for congruent trials represent the facilitated processing of targets at the site of attentional capture, RTs for incongruent targets represent the cost of processing targets outside the site of attentional capture. The difference between these trials (i.e., the attention index) is an established measure of overall attentional capture (Koster et al., 2004).

To assess how similarly both twins' attention was captured by emotional faces, attention-related twin differences (ARTD) were calculated as the absolute difference between the twins' attention indices. Smaller ARTDs indicate more similarity between twins. An independent samples t-test ($t(10) = 2.72$, $p < .05$) revealed that MZ (ARTD = 20.57 ms, *SD* = 27.20) twin pairs had significantly more similar patterns of attentional capture by emotional faces than DZ twins (ARTD = 123.11 ms, *SD* = 80.25), which suggests that directing spatial attention to emotional faces is mediated by genetic influences. In addition, MZ twins demonstrated greater similarity on the attention index with an intraclass correlation of .22 (*p* = ns) whereas a DZ twin correlation of .02 (*p* = ns) was found. Based on Falconer and MacKay's (1966) formula, a rough estimate of heritability can be calculated of twice the difference between MZ and DZ twin correlations ($h^2 = 2(r\text{MZ} - r\text{DZ})$), yielding an estimate of .40. It should be noted that this estimate is preliminary given the non-significance of the correlations and small sample size. Because it is larger than the MZ correlation, it is appropriate to consider the MZ correlation of .22 as a closer estimate. However, these results do indicate the presence of a genetic influence on allocation of attention in spatial responding to emotional events. Importantly, our preliminary finding of a genetic contribution on emotion-elicited spatial attention cannot be attributed to the already established genetic contribution to speed of information processing as these more general effects should be present across (but not between) conditions in the dot-probe task. The genetic effect reported here is measured by a condition-specific difference between congruent and incongruent trials (i.e., the attention index). Next we explored the genetic influence on general information processing.

Within-pair differences were compared for MZ versus DZ twins in a one-way MANOVA for each trial type (mean response, overall attentional index, LVF attention index, RVF attention index, LVF emotion, RVF emotion, congruent, incongruent, happy, fearful) to determine if there were differences between trial types and twin type on RTs (see Table 1). In all trial types we found that MZ twins' reaction times were more similar than DZ twins'. These differences were significantly different in all trials except RVF emotion and RVF attention index. Thus, across a variety of trial types RTs were more similar for MZ than DZ twins, which indicates that information processing in general was influenced by genetics. Additionally, consistent with the ARTD results reported above, a significant mean difference was found for the overall attentional index, as well as the LVF attention index, but not RVF attention index. In summary, these differences support the possible presence of genetic influences on general information and spatial attention processing. However, these genetic influences bear replication as this aspect of the study is preliminary and used a small sample for twin analyses.

Table 1. Within pair differences for MZ and DZ subjects mean reaction times by trial type in milliseconds

	Mean Difference (*SD*)		
Trial Type	MZ (*n* = 10)	DZ (*n* = 14)	*F*(1,10)
Mean Response	46.05 (34.65)	244.35 (162.58)	7.02*
Attention Index	20.57 (27.20)	123.11 (80.25)	7.37*
Congruent	49.52 (33.74)	248.41 (194.09)	5.00*
Incongruent	51.39 (41.07)	240.29 (164.98)	6.12*
Happy	67.58 (47.05)	232.09 (154.34)	5.20*
Fearful	41.18 (24.59)	256.61 (182.07)	6.72*
LVF Emotion	54.17 (27.25)	238.39 (174.17)	5.35*
RVF Emotion	78.63 (98.92)	250.31 (159.70)	4.47†
LVF Attention	36.52 (16.87)	175.09 (120.41)	6.36*
RVF Attention	76.09 (65.25)	117.05 (60.93)	1.25

Note: * $p < .05$; † $p = .06$

Discussion

Our results provide the first evidence that 5-year-old children preferentially allocate spatial attention to happy and fearful faces, especially those in the right visual field (RVF). The results demonstrate that, relative to neutral non-salient faces, both positive and negative emotional expressions enhance attention in young children. As discussed below, this general emotion/saliency bias may have served several important evolutionary functions. We provide additional new preliminary evidence that genes may play an important role in determining the extent to which emotional facial expressions capture spatial attention across individuals, especially those in the left visual field (LVF). This effect was demonstrated in a small sample of young twins, suggesting an early genetic influence on emotion-elicited spatial attention, which lends support to the notion that the allocation of attentional resources to emotional expressions serves an important evolutionary function. Preliminary genetic influences also were observed for general information processing.

General spatial attention-related effects

Our results indicate that in 5-year-old children, RVF fearful and happy facial expressions elicit enhancements in spatial attention relative to neutral faces. This result augments previous findings in this age group that have demonstrated that threatening stimuli are more attention-grabbing than positive or neutral stimuli (LoBue, 2009; LoBue and DeLoache, 2008). Here, we demonstrated that in younger children, happy facial expressions are attended to more than neutral expressions in environments containing only happy and neutral expressions. Given that our study did not contain trials in which fearful and happy faces were presented at the same time, it is somewhat difficult to make direct comparisons to prior work at this age, which to the best of our knowledge has only assessed attentional biases to threatening stimuli compared to neutral or happy stimuli (LoBue, 2009; LoBue and DeLoache, 2008). Yet, based on our findings and this earlier work, it is reasonable to speculate that when confronted with an environment containing fearful and happy faces, 5-year-olds attend to the threat-related stimulus; however, in environments containing either fearful or happy vs. neutral faces, both types of emotional faces appear to equally elicit 5-year-olds' attentional resources. This may indicate that 5-year-olds' attentional responses are "all or none" and that the most salient visual stimulus is preferentially attended to.

From an evolutionary perspective it is obviously advantageous to direct one's attention to the location of potential threat so that this threat can be avoided or at least minimized and thus reduce the chances of bodily harm. However, in the absence of threat, attending to positive cues also appears to have several adaptive functions. It may be that an evolutionary advantage is conveyed by attending to both threatening and positive stimuli when they are highly biologically significant, such as faces (Brosch et al., 2007). For example, in a social context children would be more likely to develop relationships with peers and form strong bonds that may last beyond childhood into adulthood and promote prosocial group behavior important for survival. Additionally, at age five, attending to happy faces may promote play behavior, which appears to be important in the development of one's motor skills as well as social skills. Finally, smiling or happy expressions may signal the obtainment of a valuable resource such as food in the expresser and attentive viewers may be more likely to obtain this resource for themselves as well. Thus, we provide evidence that young children allocate spatial attention to fearful and happy faces, which is a behavior that would seem to be adaptive in 5-year-old children.

It should be noted that our results also extend previous work in this age group by demonstrating that emotional facial expressions can enhance attention and facilitate behavior even in circumstances where these facial expressions are task-irrelevant and children are not actively searching for a particular affective facial expression. This indicates that the processing of stimuli (e.g., the non-face Star Man) subsequently occurring within the emotional-face elicited "spotlight of attention" is enhanced rather than just an enhancement in the processing of the affect face itself. Recent research in adults indicates that this type of emotion-enhanced stimulus/target processing is represented by enhanced activation in location specific areas of visual cortex (Carlson, Reinke, LaMontagne, and Habib, 2010).

We found a visual field × congruency interaction, which upon further investigation revealed that attention was directed to RVF, but not LVF, emotional faces in 5-year-old children. Visual field effects in adult studies with participants not evaluated for anxiety levels have been inconsistent and have reported bilateral (Carlson and Reinke, 2008), RVF (Pourtois et al., 2004), and LVF (Carlson, Reinke, and Habib, 2009) congruency effects for fearful faces. On the other hand, highly anxious adult participants tend to display LVF congruency effects for threatening faces (Mogg and Bradley, 1999). Therefore, individual differences may mediate visual field effects in adult populations and explain inconsistencies in studies with unselected populations. Studies of emotion-elicited attentional bias in older children have not reported visual field effects (Puliafico and Kendall, 2006; Waters et al., 2004). The distinct findings in this age group may reflect a reliance on left hemisphere featural, rather than right hemisphere configural, processing. Evidence suggests that the development of featural face processing precedes that of configural processing, and thus children typically process faces based on their featural components rather than configurally as adults do (Freire and Lee, 2003). An additional explanation of the visual field interaction may be that the enhanced RVF response may be due to the predominance of right handed (n = 14) vs. left (n = 7) handed children. The RVF corresponding to the left visual cortex and subsequently right motor control may have inadvertently speeded responses to stimuli in that visual field. To attempt to examine this possibility, handedness was included in analyses, but no significant interaction effects were observed. Nevertheless, at age 5, RVF fearful and happy faces appear to preferentially capture spatial attention.

Exploratory genetic-related effects

Differences were found between MZ and DZ twins on the spatial attention index, with MZ twin scores being more similar than DZ twin scores. This indicates that in addition to a possible genetic influence on emotional facial processing, the extent to which emotional faces capture spatial attention across individuals may be influenced by an underlying genetic component as well. This was found for both happy and fearful faces, suggesting that it is the featural properties of emotional faces that are genetically influenced and not properties for a specific emotion. These results are consistent with previous neuroimaging and behavioral research that has found genetic influences on attention (Matthews et al., 2007; Polderman et al., 2007), general face (Polk et al., 2007), and emotional face (Wolfensberger et al., 2008) processing. Whereas previous research has demonstrated that emotion- and cognition-related neural processing are independently influenced by genetics, we provide new preliminary evidence suggesting the interplay between emotion and spatial attention also may be influenced by genetics. This genetic influence appears at a relatively young age, reinforcing the hypothesis that there may be an innate component to face-elicited spatial attention (Darwin, 1872). The presence of such an influence would indicate a possible benefit in attending to spatially diverse facial signals. Thus, both happy and fearful faces would be important, each conveying distinct biologically relevant information (Brosch et al., 2007). Such an innate response to fearful and happy faces in early childhood would likely confer an advantage in promoting group socialization, social cognition, and in extreme cases survival (Brosch et al., 2007).

It should be noted that even though there were very similar orienting preferences within MZ twin pairs, there were variable preferences across MZ (and DZ) twin pairs. That is, while one MZ pair may similarly orient towards emotional faces, another MZ pair may orient away from emotional faces. These differences across MZ pairs are likely attributable to differences in personality traits and/or specific genetic composition. Given this variability, future research that targets specific genotypes is needed to more precisely determine the nature and mechanism(s) of this underlying genetic effect. One candidate gene is the serotonin transporter (5HTT), which is associated with emotion and stress-related phenomena including amygdala reactivity to fearful faces (Hariri and Holmes, 2006). Importantly, the amygdala has also been found to mediate the orienting of spatial attention to threatening faces in both adults (Carlson et al., 2009) and children with generalized anxiety disorder (Monk et al., 2008). Furthermore, in adult samples, 5HTT genotype has been associated with attentional biases to positive and negative emotional stimuli (Beevers, Gibb, McGeary, and Miller, 2007; Fox, Ridgewell, and Ashwin, 2009; Perez-Edgar et al., 2010). Yet, it is unclear if 5HTT genotype plays a role in younger children's affective attentional biases or the observed genetic effects of this study. Our finding of a genetic influence on the capture of spatial attention by emotional facial expression provides a basis for further exploration into the genetic makeup of this complex behavior in younger samples.

In addition to the genetic influence of emotional expression on spatial attention, significant differences were found between MZ and DZ twins for overall RT and across a number of trial types (see Table 1). These results are consistent with previous research showing general genetic influences on RTs (Neubauer et al., 2000), which may be attributed to speed of information processing. Speed of processing represents a lower mental ability which has been linked to higher cognitive processes such as memory and IQ (Neubauer et al., 2000). In the present study it is likely that individual differences in speed of information processing partially influenced performance on the spatial attention task. However, studies have shown that genetic influences on facial recognition are independent of memory (McKone and Palermo, 2010) and that a distinct genetic influence likely exists for visual attention independent of speed of information processing (Luciano et al., 2001). The design of the present study allowed for a test of differences in visual spatial attention, outside of general influences on speed of information processing.

This study was the first to investigate genetic influences on reaction time to emotional faces in 5-year-old twins. It must be noted that the sample size was small for genetic analyses, and these results must be considered preliminary. Future research replicating this effect in larger samples is needed before any strong conclusions can be made. Additionally, based on our results, it is unclear to what extent our attention-related genetic effect is specific to fearful and happy emotional facial expression. Thus, future investigations should include other emotional (e.g., sadness, disgust, anger, and surprise) and non-emotional (e.g., tongue sticking out) facial expressions in addition to other types of salient attention grabbing stimuli (e.g., flashing objects). Nonetheless, the presence of a preliminary genetic influence suggests that even at a young age genes may influence general emotional processing in addition to the more complex influence they may have on emotional face-related spatial attention.

In summary, we found that RVF emotional faces in general captured spatial attention in a sample of 5-year-old children, which may be associated with left hemisphere dominant featural processing. The use of twins in the present study allowed rough estimation of genetic influence on a number of trial types. Critically, we provide the first evidence that the preferential orienting of spatial attention to emotional facial expressions is mediated by a genetic component in children as young as 5 years, which supports the notion that directing spatial attention to emotional faces is hereditary. Additionally, there were general genetic influences on reaction time to emotional stimuli. Although these twin findings must be viewed cautiously, the presence of a genetic influence on emotional face-elicited spatial attention on 5-year-old twins adds important and novel knowledge to the current understanding of early emotional and social development.

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References

Anokhin, A. P., Golosheykin, S., and Heath, A. C. (2010). Heritability of individual differences in cortical processing of facial affect. *Behavior Genetics, 40*, 178–185.

Beevers, C. G., Gibb, B. E., McGeary, J. E., and Miller, I. W. (2007). Serotonin transporter genetic variation and biased attention for emotional word stimuli among psychiatric inpatients. *Journal of Abnormal Psychology, 116*, 208–212.

Bornstein, M. H., and Arterberry, M. E. (2003). Recognition, discrimination and categorization of smiling by 5–month–old infants. *Developmental Science, 6*, 585–599.

Brosch, T., Sander, D., and Scherer, K. R. (2007). That baby caught my eye…Attention capture by infant faces. *Emotion, 7*, 685–689.

Bruce, V., Campbell, R. N., Doherty–Sneddon, G., Import, A., Langton, S., McAuley, S., and Wright, R. (2000). Testing face processing skills in children. *British Journal of Developmental Psychology, 18*, 319–333.

Carlson, J. M., and Reinke, K. S. (2008). Masked fearful faces modulate the orienting of covert spatial attention. *Emotion, 8*, 522–529.

Carlson, J. M., Reinke, K. S., and Habib, R. (2009). A left amygdala mediated network for rapid orienting to masked fearful faces. *Neuropsychologia, 47*, 1386–1389.

Carlson, J. M., Reinke, K. S., LaMontagne, P. J., and Habib, R. (2010). Backward masked fearful faces enhance contralateral occipital cortical activity for visual targets within the spotlight of attention. *Social Cognitive and Affective Neuroscience*, DOI: 10.1093/scan/nsq076.

Colombo, J. (2001). The development of visual attention in infancy. *Annual Reviews of Psychology, 52*, 337–367.

Darwin, C. (1872). *The expression of the emotions in man and animals*. London: John Murray.

DiLalla, L. F. (2002). Social development in twins. *Twin Research and Human Genetics, 9*, 95–102.

DiLalla, L. F., Fulker, D. W., and Thompson, L. A. (1989). An anticipation paradigm as a measure of infant intelligence. Poster presented to the Society for Research in Child Development, Kansas City, Missouri.

Falconer, D. S., and MacKay, T. F. C. (1996). *Introduction to quantitative genetics* (4th ed.). Harlow, Essex, UK: Longmans Green,

Fox, E., Ridgewell, A., and Ashwin, C. (2009). Looking on the bright side: Biased attention and the human serotonin transporter gene. *Proceedings of the Royal Society, 276*, 1747–1751.

Freire, A., and Lee, K. (2003). Person recognition by young children: Configural, featural, and paraphernalia processing. In O. Pascalis and A. Slater (Eds.), *The development of face processing in infancy and early childhood: Current perspectives* (pp. 191–205). Hauppauge, NY: Nova Science.

Gur, R. C., Sara, R., Hagendoorn, M., Marom, O., Hughett, P., Macy, L., Turner, T., Bajcsy, R., Posner, A., and Gur, R. E. (2002). A method for obtaining 3–dimensional facial expressions and its standardization for use in neurocognitive studies. *Journal of Neuroscience Methods, 115*, 137–143.

Hariri, A. R., and Holmes, A. (2006). Genetics of emotional regulation: The role of the serotonin transporter in neural function. *Trends in Cognitive Science*, *10*, 182–191.

Iarocci, G., Yager, J., and Elfers, T. (2007). What gene–environment interactions can tell us about social competence in typical and atypical populations. *Brain and Cognition*, *65*, 112–127.

Koster, E. H., Crombez, G., Verschuere, B., and De Houwer, J. (2004). Selective attention to threat in the dot probe paradigm: differentiating vigilance and difficulty to disengage. *Behavior Research Therapy, 42*, 1183–1192.

LoBue, V. (2009). More than just another face in the crowd: superior detection of threatening facial expressions in children and adults. *Developmental Science, 12*, 305–313.

Lobue, V., and DeLoache, J. S. (2008). Detecting the snake in the grass: attention to fear–relevant stimuli by adults and young children. *Psychological Science, 19*, 284–289.

LoBue, V., and DeLoache, J. S. (2010). Superior detection of threat–relevant stimuli in infancy. *Developmental Science, 13*, 221–228.

Luciano, M., Wright, M. J., Smith, G. A., Geffen, G. M., Geffen, L. B., and Martin, N. G. (2001). Genetic covariance among measures of information processing speed, working memory, and IQ. *Behavior Genetics, 31*, 581–592.

Matthews, S. C., Simmons, A. N., Strigo, I., Jang, K., Stein, M. B., and Paulus, M. P. (2007). Heritability of anterior cingulate response to conflict: An fMRI study in female twins. *NeuroImage, 38*, 223–227.

McKone, E., and Palermo, R. (2010). A strong role for nature in face recognition. *Proceedings of the National Academy of Sciences, 107*, 4795–4796.

Mogg, K., and Bradley, B. P. (1999). Orienting of attention to threatening facial expressions presented under conditions of restricted awareness. *Cognition and Emotion, 13*, 713–740.

Monk, C. S., Telzer, E. H., Mogg, K., Bradley, B. P., Mai, X., Louro, H. M. C., Chen, G., McClure–Tone, E. B., Ernst, M., and Pine, D. S. (2008). Amygdala and ventrolateral prefrontal cortex activation to masked angry faces in children with generalized anxiety disorder. *Achieves of General Psychiatry*, *65*, 568–576.

Montague, D. P. F., and Walker–Andrews, A. S. (2001). Peekaboo: A new look at infants' perception of emotion expressions. *Developmental Psychology, 37*, 826–838.

Nelson, C.A. (2001). The development and neural bases of face recognition. *Infant and Child Development, 10*, 3–18.

Neubauer, A. C., Spinath, F. M., Riemann, R., Angleitner, A., and Borkenau, P. (2000). Genetic and environmental influences on two measures of speed of information processing and their relation to psychometric intelligence: Evidence from the German observational study of adult twins. *Intelligence, 28*, 267–289.

Perez–Edgar, K., Bar–Haim, Y., McDermott, J. M., Gorodetsky, E., Hodgkinson, C. A., Goldman, D., Ernst, M., Pine, D. S., and Fox, N. A. (2010). Variations in the serotonin–transporter gene are associated with attention bias patterns to positive and negative emotion faces. *Biological Psychology, 83*, 269–271.

Polderman, T. J., Posthuma, D., De Sonneville, L. M., Stins, J. F., Verhulst, F. C., and Boomsma, D. I. (2007). Genetic analyses of the stability of executive functioning during childhood. *Biological Psychology, 76*, 11–20.

Polk, T. A., Park, J., Smith, M. R., and Park, D. C. (2007). Nature versus nurture in ventral visual cortex: A functional magnetic resonance imaging study of twins. *The Journal of Neuroscience, 27*, 13921–13925.

Pourtois, G., Grandjean, D., Sander, D., and Vuilleumier, P. (2004). Electrophysiological correlates of rapid spatial orienting towards fearful faces. *Cerebral Cortex, 14*, 619–633.

Puliafico, A. C., and Kendall, P. C. (2006). Threat–related attentional bias in anxious youth: A review. *Clinical Child and Family Psychology Review, 9*, 162–180.

Repacholi, B. M., and Gopnik, A. (1997). Early reasoning about desires: Evidence from 14– and 18–month–olds. *Developmental Psychology, 33*, 12–21.

Serrano, J. M., Iglesias, J., and Loeches, A. (1995). Infants' responses to adult static facial expressions. *Infant Behavior and Development, 18*, 477–482.

Vaish, A., Grossmann, T., and Woodward, A. (2008). Not all emotions are created equal: The negativity bias in social–emotional development. *Psychological Bulletin, 134*, 338–403.

Waters, A. M., Lipp, O. V., and Spence, S. H. (2004). Attentional bias toward fear–related stimuli: An investigation with nonselected children and adults and children with anxiety disorders. *Journal of Experimental Child Psychology, 89*, 320–337.

Wolfensberger, S. P., Veltman, D. J., Hoogendijk, W. J., Boomsma, D. I., and de Geus, E. J. (2008). Amygdala responses to emotional faces in twins discordant or concordant for the risk for anxiety and depression. *Neuroimage, 41*, 544–552.

Yiend, J. (2010). The effects of emotion on attention: A review of attentional processing of emotional information. *Cognition and Emotion, 24,* 3–47.