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Differences in Visual Field Bias in Emotional Attribution Tasks Between Children with Autism Spectrum Disorders and Typical Development

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ABSTRACT

Autism spectrum disorders (ASD) are characterized by social deficits in emotional comprehension. Since typical emotional attribution improves when using the left visual field, effects of lateralization on facial affect assessment were compared between children with ASD, pervasive developmental disorder not otherwise specified (PDD-NOS) and typical development (TD). The ASD group showed significantly lower percent accuracy, longer response time and slower pulse rate than the TD group. Within the ASD group, there was a significant right visual field bias in emotional attribution tasks, which contrasted with the left visual field bias seen within the TD group. The PDD-NOS group demonstrated no visual field advantage. Emotional attribution tasks could be an assessment tool to differentially diagnose disorders within the autism spectrum.

Keywords: autism, visual field bias, emotional comprehension

INTRODUCTION

Autism spectrum disorders (ASD) are characterized by social deficits in emotional comprehension with evidence that individuals with ASD use an atypical approach to processing emotions (Celani, Battacchi, & Arcidiacono, 1999; Hay & Cox, 2000). Typically, the right hemisphere together with subcortical limbic structures synthesize elements of emotion into a “perceptual Gestalt” facilitating a visceral understanding of the overall meaning of the expressed emotion (Brosnan, Scott, Fox, & Pye, 2004; Plaisted, Dobler, Bell, & Davis, 2006). Research indicates that individuals with ASD instead rely on the left cerebral hemisphere, which analyzes information and considers specific features of facial expressions using a “piecemeal encoding” approach (Pierce, Muller, Ambrose, Allen, & Courchesne, 2001; Rutherford & Towns, 2008).

In addition to cerebral activity, physiological reactivity (e.g., heart rate, blood pressure, electrodermal activity, temperature, etc.) has been measured to examine responses to emotional stimuli (Bernat, Patrick, Benning, & Tellegen, 2006). There is evidence that the transition from one affective state to another is accompanied by a 2 to 15 beats-per-minute shift in pulse rate (Bradley, Miccoli, Escrig, & Lang, 2008). Children with ASD tend to not

show this distinctive departure from baseline heart rate in response to emotional stimuli (Corona, Dissanayake, Arbelle, Wellington, & Sigman, 1998). Instead, they show a muted, more controlled autonomic reaction (Willemsen-Swinkels, Buitelaar, Dekker, & Van Engeland, 1998). Therefore, without a strong psychophysiological feedback response to condition the right hemispheric neural pathways, people with ASD may need contrived left visual field practice in viewing faces to overcome their emotional processing deficits.

To test the role lateralization has on emotional perceptions, the current study compared the effects of isolating visual fields on performance in tasks of facial affect assessment between children with ASD and those with typical development (TD). Participants with ASD were expected to have lower accuracy, longer reaction times and slower finger pulse rates than TD participants when viewing emotional pictures. Emotional face stimuli viewed in the left visual field were predicted to evoke the highest accuracy, the shortest reaction time and the fastest finger pulse rate. Both participants with ASD and the matched TD control participants were expected to show a similar visual field bias pattern favoring the left visual field (i.e., the right brain hemisphere)

METHODS

Participants

Eighteen school-aged participants between the ages of 5 and 13 years ($M = 9.11$, $SD = 2.03$) participated in this study. Nine participants ($M = 9.00$ years of age, $SD = 2.18$) had pervasive developmental disorders on the autism spectrum. Six of these participants met the State of South Dakota Department of Education criteria for autism. The PDD-NOS group consisted of three participants who had pervasive social and cognitive deficits identified by the school diagnostics team as subthreshold autistic symptoms. Nine typically developing participants ($M = 9.22$ years of age, $SD = 1.99$) served as matched controls to the ASD and PDD-NOS participants by chronological age and gender. Participants were treated in accordance to the “Ethical Principles of Psychologists and Code of Conduct” (American Psychological Association, 2002) in addition to the guidelines established by the Human Subjects Committee of South Dakota State University. The SDSU Institutional Review Board approved the project.

Materials

SuperLab, version 4.0, software (Cedrus Corporation, 2008) was employed to present emotional face stimuli showing happy, sad or angry expressions. Participants were required to match the facial emotion displayed on screen for 3.5 seconds to one of three corresponding labeled emoticons on the subsequent response-choice screen, as seen in Figure 1. SuperLab recorded accuracy and reaction time of each response. Visual stimuli were sourced from an educational photo bank and Microsoft Office public domain clip-art. These images were modified using Adobe Photoshop Elements, version 4.0 (Adobe Systems Inc., 2005), to include only shoulder-to-face shots with softened white backgrounds. A panel of six college-aged judges categorized the pictures into three emotions (happy, sad, angry). Only pictures with an inter-rater correlation of at least 0.80 were presented as stimuli.

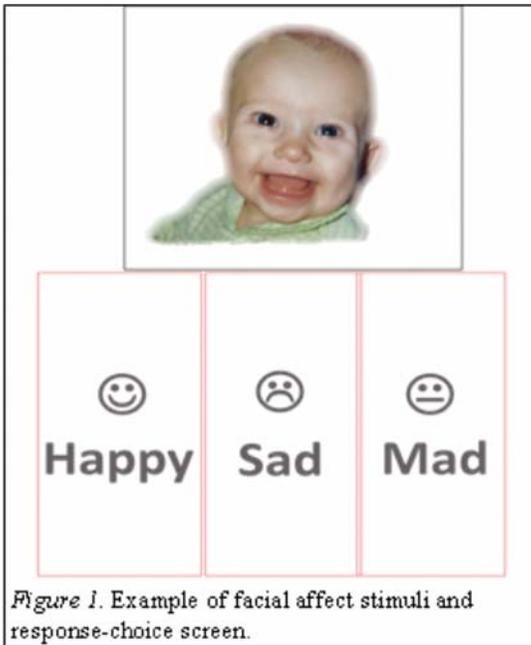


Figure 1. Example of facial affect stimuli and response-choice screen.

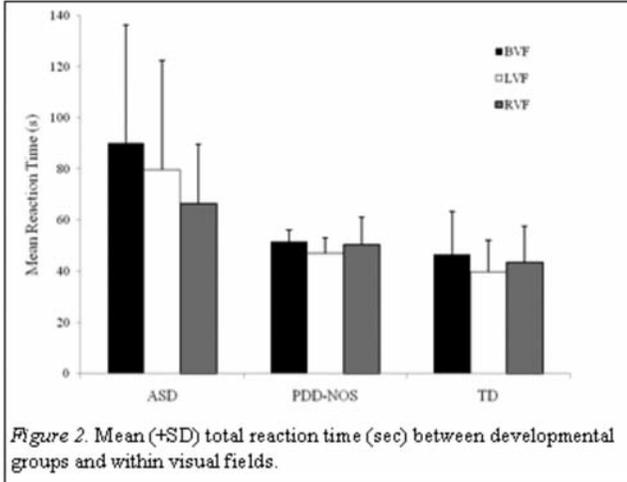
Biopac Student Lab Pro Software (Biopac Systems, Inc., 2007) was used to record and analyze finger pulse measurements using a reflection photoplethysmograph wrapped around the participant's index finger of the non-dominant hand. Data was converted into beats-per-minute (BPM) pulse rates by averaging the total number of beats over the total visual field block time interval. At 3.5 seconds per stimulus presentation, each visual field block was designed to last approximately 3 minutes. Liu, Conn, Sarkar and Stone (2008) reported 2 to 4 minutes to be adequate for detecting physiological reactivity in similar Biopac and computer-based tasks.

Design and Procedure

Participants completed three blocks, each consisting of thirty-eight presentations of different emotional faces. Each block presented the same set of facial affect stimuli, but participants used a discrete visual field for each block: both visual fields (BVF), left visual field (LVF) or right visual field (RVF). With both eyes uncovered, participants started with a practice block to allow for adjustment to the headband, plethysmograph and procedures. After the practice block, participants again used both eyes to view the stimuli. For the remaining two blocks, the participant's left or right eye was covered with a patch attached to a headband to contrive visual field lateralization. The order of the lateralized visual field was counterbalanced.

The project was designed to be a mixed 3 (development: ASD, PDD-NOS, TD) x 3 (visual field: BVF, LVF, RVF) factorial experiment. An alpha level of .05 was adopted for

significance in all analyses. Three measures were collected: SuperLab recorded accuracy and reaction time for emotional attribution of each facial affect stimuli, and Biopac measured finger pulse rates over each visual field block.



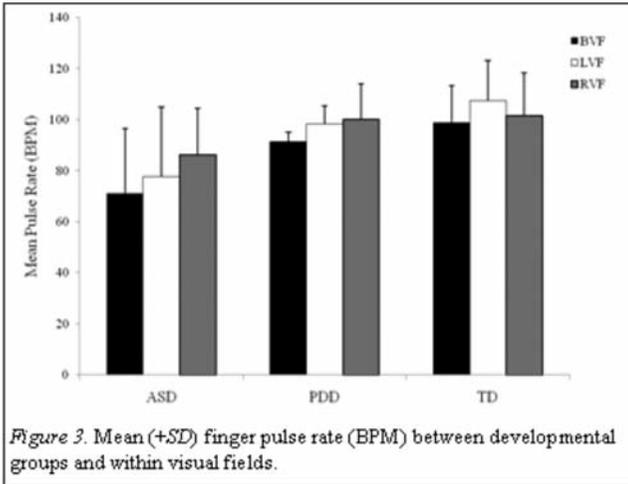
Results

Total mean accuracy scores reflected that ASD participants were less accurate ($M = 72.08\%$, $SD = 21.48$) than PDD-NOS participants ($M = 79.53\%$, $SD = 7.87$) and TD participants ($M = 87.82\%$, $SD = 6.03$). The ASD group had a significantly higher mean accuracy when using the right visual field ($M = 75.44\%$, $SD = 22.68$) than when using both visual fields ($M = 69.74\%$, $SD = 24.73$), $t(5) = -2.60$, $p = .05$ (two-tailed).

A 3 (development) \times 3 (visual field) mixed-model ANOVA revealed a significant main effect of development on reaction time, $F(2, 15) = 4.24$, $p = .04$. A post-hoc Tukey HSD test showed that the mean total reaction time of the ASD group was significantly greater than that of the TD group, $p = .03$. A significant main effect for visual field was not found. However, exploratory paired-samples t tests revealed significant differences in reaction time between the LVF and BVF within the ASD group, $t(5) = 4.67$, $p = .01$ (two-tailed), and within the TD group, $t(8) = 2.29$, $p = .05$ (two-tailed). The PDD-NOS participants showed no significant differences in reaction time among visual fields. Mean total reaction times are summarized in Figure 2, in which visual field bias patterns are evident between the developmental groups and within visual fields. Note that only the ASD group showed a significantly reduced reaction time when using the right visual field.

Finger pulse rates (BPM) were compared using a 3 (development) \times 3 (visual field) mixed-model ANOVA and revealed significant effects of development, $F(2, 15) = 3.66$, $p = .05$, and visual field, $F(2, 30) = 5.64$, $p = .01$. A post-hoc Tukey HSD test validated that the means for the ASD group and the TD group significantly differed ($p = .04$), but the mean BPM for the PDD-NOS group did not significantly differ from the ASD group ($p = .30$) or

the TD group ($p = .86$). Paired-samples t tests comparing mean pulse rates were conducted to examine the developmental groups' visual field patterns depicted in Figure 3. For the ASD and PDD-NOS groups, mean pulse rates were slowest when using BVF, faster using the LVF and fastest using the RVF. However, for the TD group, the fastest mean pulse rate occurred when using the LVF. Within the ASD group, there were significant differences in mean BPM between the LVF and BVF, $t(5) = -3.94, p = .01$ (two-tailed), and between the RVF and BVF, $t(5) = -2.87, p = .04$ (two-tailed). The TD group had significant differences in mean BPM between the LVF and BVF, $t(8) = -4.06, p < .01$ (two-tailed). The PDD-NOS group showed no significant differences in BPM among visual fields.



DISCUSSION

As expected, ASD participants had the lowest percent accuracy, longest reaction times and slowest finger pulse rates in carrying out emotional attribution tasks when compared to the other participants. Significant differences were also obtained in reaction time and pulse rate when participants used distinct visual fields. However, the hypothesized left visual field advantage was only found within the TD group; the TD group produced their highest mean percent accuracy, shortest mean reaction time and fastest mean pulse rate when emotional face stimuli were viewed with the left eye. Conversely, the ASD group demonstrated an advantage when viewing the facial affect stimuli in the right visual field. Interestingly, the PDD-NOS group did not significantly differ from the TD group or the ASD group in percent accuracy, reaction time or pulse rate. Furthermore, unlike the other groups, the PDD-NOS group did not show significant discrepancies in performance when using different visual fields. Consequently, the findings that ASD participants had a consistent right visual field bias in all three measures further supports a left-brain approach for emotional processing at perhaps even a basic physiological level.

The present findings corroborate other results in similar research. For example, Ashwin, Chapman, Colle and Baron-Cohen (2006) found that ASD participants were significantly less accurate than matched TD participants in recognizing photographs of basic emotions. The BPM findings were consistent with the expected normal range for pulse rates in children (60 – 100 BPM) and with similar studies of physiological reactivity in ASD populations (Bölte, Feineis-Matthew, & Poustka, 2008; Liu et al., 2008). Additionally, changes in pulse between visual fields concurred with the published change in heart rate in response to altering affect stimuli (2 – 15 BPM) (McManis et al., 2001). Furthermore, the left visual field advantage found in the TD group replicated previous findings of TD individuals responding faster to stimuli in the left visual field (Bourne, 2008; Piggot et al., 2004). The current findings of a right visual field bias for ASD participants are supported by the “piecemeal” emotional processing theory proposed by others (Grelotti, Gauthier, & Schultz, 2002; Rosset et al., 2008).

Due to limited access to pediatric populations with developmental disorders, the present study had a small sample size, particularly in the PDD-NOS group. The PDD-NOS participants in the current study were classified as PDD-NOS based on education criteria set by the school diagnostic team. It may be that the PDD-NOS group had learning disabilities that affected social interactions, thus creating shared ASD symptoms. Despite these shortcomings, the PDD-NOS participants, as expected, did not perform as well as the TD participants in accuracy or reaction time when assessing facial emotions. Consequently, future studies will not only include separate and equal groups for both the ASD and PDD-NOS participants, but will also validate both diagnoses using reliable assessment tools (e.g., Autism Diagnostic Interview – Revised) (Lord, Koenig, Klin, & Volkmar, 2008).

In the present study, total percent accuracy seemed the least affected by factors of development or visual field. The exposure time (3.5 s) may have allowed for ASD participants to correctly deduce the emotion by assessing specific features (e.g. a turned up mouth, a furrowed brow, etc.) instead of holistically understanding the emotion. Clark, Winkielman and McIntosh (2008) reported that typical, young adults extract emotional information from faces in as little as 10 ms. In future studies, a shorter presentation of emotional facial stimuli should be used to reduce the piecemeal tendencies of the ASD group and therefore acquire a better understanding of the deficits in accuracy and response time.

Last, the study’s method for isolating visual fields was a limitation. Most studies (Ashwin, Wheelwright, & Baron-Cohen, 2005; Bourne, 2008) measuring lateralization in face processing use the chimeric face test in which one half of the facial stimuli expresses an emotion and the other half expresses a neutral expression. Visual field bias is quantified by the accuracy in identifying the emotion when it is presented in the left or right visual field (i.e., the left or right half of the chimera). A left visual field bias in typical populations has been extensively reported for emotion perception using chimeric faces (for review, see Adolphs, 2002). However, some reports (Butler et al., 2005) indicated problems with the chimeric face test and eye movement patterns that disrupt the heuristics used to determine which cerebral hemisphere is being engaged. This was of particular concern for the current study enlisting children with ASD. In an effort to limit erratic or overly biased eye movement patterns, a patch was designed to occlude one eye while the participant sat directly centered at the computer screen. Whether occluding an eye with a patch is isolating the left or right

visual field as reliably and accurately as the chimeric picture test has yet to be determined. However, the current findings not only confirmed the widely reported left-visual field/right-hemisphere dominance in typical emotional processing using chimeric tests, but also verified the accuracy and reaction time deficits seen with ASD participants using chimeric tests.

The results of the present study have exciting implications. First, reaction time and pulse rate measurements on emotional recognition tasks could be used as a tool to differentiate children with developmental disorders. The unexpected difference found between the ASD group and the PDD-NOS group in trends for visual field advantage may offer a subtle but important marker for differentiating disorders within the autism spectrum. Testing visual field bias may be a helpful addition to the battery of ASD diagnostic tests by including the phenotype of a right visual field bias. Further studies are underway to investigate if more severe autistic symptoms correlate with stronger right visual field performance patterns. Other implications of the present study include potential for interventions with children who have an ASD diagnosis. It is also possible that an early preference for the right visual field does not maximize the emotion-favored right brain hemisphere when viewing facial expressions and thus contributes to the atypical social development in autism spectrum disorders. Future studies are planned to test if left visual field practice could improve affect comprehension in children with ASD. Children with ASD may be able to train their brains to become more expert at noticing and even understanding the subtle and complex emotional cues others perceive by using a more effective Gestalt processing strategy.

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