AN STUDY OF WEAK CENTRAL COHERENCE IN CHILDREN HAVING AUTISM SPECTRUM DISORDER

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Abstract- Perceptual abnormalities have long been observed in individuals with Autism Spectrum Disorder (ASD). Research suggests that superior visual processing on a variety of tasks evidenced in individuals with ASD may be related to enhanced local processing. Two theories have been proposed to account for this superior local processing. Visual illusions are one measure that has been used to test these theories, producing mixed results. The purpose of the present study was to address the discrepancy in results across studies by conducting a direct replication of the initial study investigating susceptibility to visual illusions in ASD. The current study also extended the scope of previous research by including eye-tracking data. 36 children completed a visual illusion task and an existing measure of central coherence. Results indicated no group differences in illusion susceptibility; however, individual differences in illusion susceptibility were related to increased local processing at the start of viewing the illusions. Implications of these findings, limitations, and future directions arediscussed.

Keywords: Perceptual abnormalities, Autism Spectrum Disorder, Visual illusions

INTRODUCTION

Autism Spectrum Disorder (ASD), as defined by the most recent iteration of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013), includes impairment in two primary domains: social-communicative functioning and restricted and repetitive behaviors. These criteria reflect several changes from DSM-IV. First, the term Autism Spectrum Disorder replaced the three distinct disorders (Autistic disorder, Asperger's disorder, and Pervasive Developmental Disorder- Not Otherwise Specified) that comprised three of the five Pervasive Developmental Disorders (PDD). This change reflects research demonstrating the lack of a clear distinction between the PDD's. Specifically, these disorders reflect differences in the severity of one underlying condition (Young & Rodi, 2014). The second major change involved combining social and communicative behaviors into one category, creating a dyad of symptoms to replace the previous triad. A smaller, yet significant, change to the diagnostic criteria for the DSM-5 is the inclusion of atypical sensory behaviors within the restricted and repetitive behavior category (Young & Rodi, 2014). This includes hypo and hyper-reactivity to sensory input as well as an unusual interest in sensory aspects of the environment. Sensory and perceptual abnormalities were not typically included as primary symptoms of ASD and did not appear in earlier versions of the DSM. However, differences in sensory and perceptual functioning were evident from the first descriptions of Autism (Kanner, 1943), autobiographical accounts (Grandin, 1984), and the early experimental literature (Hermelin & O'Connor, 1964; Wing,1969).

Although sensory-perceptual abnormalities have been described to occur in all of the main modalities (vision, auditory, tactile, and oral), visual processing has been studied extensively, with individuals with ASD displaying both superior

visuospatial skills as well as deficits in visual processing (Kern et al., 2007). Individuals with ASD have demonstrated superior performance in their ability to find hidden figures (Shah & Frith, 1983), visual search tasks that involve scanning a visual array for a target stimulus (O'Riordan, Plaisted, Driver, & Baron-Cohen, 2001), completing pattern construction tasks (Shah & Frith, 1993) as well as copying impossible figures (Mottron, Belleville, & Menard, 1999a). While research has demonstrated superior visuospatial skills, most of the research addressing deficits in visual processing is mixed. For example, facial processing deficits are not clearly demonstrated in individuals with ASD. Deficits in visual processing that have been more clearly demonstrated include motion perception and difficulty processing gaze (i.e., determining where someone is looking) (Dakin & Frith, 2005; Simmons, Robertson, McKay, Toal, McAleer, & Pollick, 2009).

One phenomenon commonly described in the literature that is evidenced by the unique visual processing profile of individuals with ASD, is the tendency to process information on a local level versus on a global level (Wang, Mottron, Peng, Berthiaume, & Dawson, 2007). Local processing refers to the focus on elements or details of a visual scene. Conversely, global processing consists of processing information within its context, which involves combining information to create higher-level meaning (Chouinard, Noultym, Sperandio & Landry, 2013). This local processing bias evident in individuals with ASD differs from typically developing individuals who tend to automatically perceive elements of a visual scene as meaningful wholes, that is, toprocess visual information globally before it is processed locally (Bolte, Poustka, Scheurich & Schmidt, 2007; Navon, 1977). Individuals with ASD have been shown to be less prone to combining the elements of a visual scene using Gestalt principles to create a whole as compared to control groups (Bolte et al., 2007; Brosnan, Scott, Fox & Pye, 2004).

The mixed findings evidenced above may be ascribed to the use of different methods of responding (verbal judgment versus manual adjustment), varying ages of participants, and different illusions tested. Notably, global processing has been demonstrated to develop with age, with children under 8 years of age displaying lower levels of global processing (Nayar,

Franchak, Adolph, & Kiorpes, 2015). In addition, visual illusions are not homogeneous. Some appear to tap holistic processing and the ability to integrate contextual information more than others. Many of the illusions that have been commonly tested (i.e., Titchener circles, Ponzo) require participants to ignore contextual information in order to judge the size of the figure appropriately. It is possible that the effect is only demonstrated with a subset of illusions that are more easily partitioned into their component elements and contextual cues. The Muller-Lyer illusion, for example, appears to be one that individuals with ASD may be more susceptible since it is not as easily partitioned into its component parts (Chouinard et al., 2013). Similarly, there is little research to suggest that the Hering and Poggendorf illusions are tapping local-global processing.

The current study attempted to address the discrepancy in results across studies investigating visual illusion susceptibility in ASD. First, this study attempted to replicate the results of Happe (1996) through the use of the same method and illusions. This study also extended previous work by including eye-tracking data in order to assess how individuals with ASD make judgments about the illusions and whether they demonstrate increased focus on elements of the illusions as opposed to the contextual information that gives rise to them. The purpose of this was to test the assertion that visual illusions are measures of local-global processing, which may account for the decreased susceptibility in individuals with ASD.

Method

To assess the presence and severity of ASD symptoms, the Childhood Autism Rating Scale-Second Edition (CARS-2; Schopler, Van Bourgondien, Wellman, & Love, 2010), the Social Communication Questionnaire (SCQ; Rutter, Bailey, & Lord, 2003), and the DSM-IV-TR Checklist for Autism Spectrum Disorders were administered. The CARS-2 is an observational rating scale that was developed to assist in identifying individuals with ASD and distinguishing the severity of the disorder. The measure consists of 15 items that are rated on a scale from 1 (behavior is within normal limits compared to typically developing individuals of the same age) to 4 (behavior is severely abnormal compared to same age

peers). The CARS-2 has been demonstrated to have moderate to excellent psychometric properties.

Participation consisted of completing an assessment session and an experimental session. During the assessment session, parents completed the SCQ and a short demographic questionnaire. Parents of typically developing children did not complete the SCQ as this measure is related to Autism severity. During this time, children were administered either the WPPSI-IV or WISC-IV. Child observations and parent-completed measures were used to complete the CARS-2 and the DSM-IV-TR checklist. The assessment session lasted approximately 1.5 hours. Children returned approximately one week later to complete session two of the study (the experimental session). For participants who chose to complete the study as one long session, a short break was provided between the assessment and experimental sessions. During the experimental session, participants were presented with the visual illusions and a series of experimentaltasks that are part of a larger study (see Sevlever, 2014). The experimental session took approximately 45 minutes.

The first 25 participants were conducted as part of a larger study in collaboration with Lahore medical college. The procedure and materials used were replicated and data collection continued at Jinnah medical college. The Jinnah site was a duplicate of the lahore site with respect to computer equipment, instrumentation, and the child chair and desk. The remainder of participants were conducted at Jinnah medical college. Participants completed IQ testing in one of the assessment rooms at the Institute for Child Development (ICD) at Jinnah medical college. The room was equipped with one table and two chairs. There was a small bin of toys in the room for children to play with during a short break between assessments.

Responses to the visual illusions were recorded by hand and entered into an electronic database. The total number of illusions that participants were susceptible was added up for a total score of 6, with higher scores indicating a greater number of illusions that a participant was susceptible to. AOI's for each

illusion were selected and grouped based on whether they were considered elements of the illusion or contextual information. Total fixation duration was calculated for each AOI for each illusion from Tobii Studio 2.2.8. Total fixation duration is defined as the duration in seconds for all fixations within an AOI group. These durations were calculated as a proportion of total viewing time to account for varying lengths that the illusions were viewed for. This data was then transferred to SPSS for analysis.

Results

Dependent variables (verbal IQ, block design, and illusion susceptibility scores) were analyzed for normality and outliers. One significant outlier was identified for verbal IQ ($z = -2.83$). Upon review, this participant's score on this measure is not considered representative of a typical population and was thus removed from the analysis. Another significant outlier was identified for block design ($z = 2.75$). Upon review of this participant's performance, this score is considered a valid score and was kept in the analysis. No other significant outliers were identified for these variables. Normality was assessed separately for each group using measures of skew and kurtosis. The skewness of block design scores for the ASD group was in the appropriate range (skew = -.039), but was positively skewed for the TD group (skew = 1.127). This variable underwent a square root transformation to correct for the observed skewness. Upon re-running the analysis, skewness was found to be in the appropriate range (skew = .787).

The dependent eye tracking variables (proportion of fixation duration on context, elements, and other, and fixation duration at start) were also analyzed for outliers and normality. Two significant outliers were identified for proportion of fixation duration on the elements ($z = 2.40$ and $z = 2.15$). Additionally, three significant outliers were identified for fixation duration on elements at start ($z = 2.02, 2.47,$ and 2.27) and fixation duration on context at start ($z = 2.29$). Upon review of the data these outliers are considered part of the population and were not removed from the analyses. For the ASD group, both dependent eye tracking variables for fixation on elements were skewed(skew = 1.085 and 1.682) and fixation on elements at start for this group was also kurtodid (kurtosis = 2.510). These

variables underwent a square root transformation and were corrected. Skew and kurtosis were in the appropriate range for the remainder of the eye tracking variables.

To assess for group differences on block design scores, an independent samples t- test was conducted on the transformed variable. Means and standards deviations are reported based on the untransformed data. Although TD children scored higher on block design ($M = 10.36$, $SD = 2.77$) compared to the ASD group ($M = 8.29$, $SD = 4.26$) this was not in the statistically significant range ($t(34) = 1.747$, $p = .066$). Given the small sample size of ASD participants that could be included in the analysis of visual illusion susceptibility (n = 9), the Mann-Whitney U was selected to test for differences between groups on illusion susceptibility. No differences between groups were found ($Z = .158$, ns.). In order to assess for differences in fixation on the contextual parts versus elements of the illusion, a repeated measures ANOVA (Group x Proportion of Fixation Duration) was conducted. Mauchly's Test of Sphericity was significant indicating a lack of sphericity. To account for this the Greenhouse-Geisser correction was applied. Since a main effect was expected (i.e., an increased proportion of time spent looking at the context is expected due to increased area of the contextual versus elemental parts of the illusion), the analysis focused on the interaction between proportion of time spent fixating on various parts of the illusion (context, elements, and other) and group membership (ASD versus TD). No significant interaction effects were found ($F(1,34) = 2.99$, $p = .09$). While group differences were not observed, individual differences in susceptibility to visual illusions were examined with relation to scores on block design and proportion of time spent fixated on elements versus context of the illusions. Since block design scores and susceptibility to illusions may both be impacted by age, a partial correlation between block design and illusion susceptibility was calculated that controlled for age. A significant negative correlation was found between block design and visual illusion susceptibility while controlling for age ($r(25) = -.541$, $p < .01$). No significant correlations were observed between visual illusion susceptibility and fixation on elements or context of the illusion.

In order to determine whether early fixation on elements of the illusions is associated with susceptibility, the first three seconds of fixation on each illusion was included in a separate analysis. Correlations were first calculated between fixation on context at start, fixation on elements at start, and illusion susceptibility. While there was no significant correlation between illusion susceptibility and fixation on context at start, there was a significant correlation between fixation on elements at start and illusion susceptibility ($r(24) = -.413$, $p = .045$). A regression analysis was then conducted to determine whether this early fixation on elements predicts lowered susceptibility to illusions. Fixation on elements at start significantly predicted illusion susceptibility ($b = -3.275$, $t(23) = -2.124$, $p = .045$) and explained 13% of the variance in illusion susceptibility scores (adjusted $R^2 = .13$, $F(1,23) = 4.512$, $p = .045$). Group differences on early fixation patterns were assessed using a repeated measures ANOVA (Group x Total Fixation Duration at Start). Again, since a main effect was expected, the analysis focused on the interaction effect for which no significant differences were found ($p > .05$).

In order to examine susceptibility patterns to each illusion separately, the percentage of participants that were susceptible to each illusion was calculated for each group. These results are displayed in Table 4, indicating a similar pattern of susceptibility to illusions across groups. The ASD group demonstrated similar or increased susceptibility to all illusions with the exception of the Poggendorf illusion, wherein the ASD group was overall less susceptible to this illusion compared to the TD group.

Finally, correlations were calculated between potential moderator variables (age, VIQ, *SCQ*, and *CARS-2*) to examine the relationship between these variables and fixation patterns on the illusions. No significant correlations were found for age or the *CARS-2*.

VIQ was significantly correlated with mean fixation on both elements ($r(35) = .462$, $p = .005$) and context ($r(35) = .558$, $p = .001$) of the illusions. Additionally, *SCQ* was correlated with mean fixations on elements in the first three seconds of viewing the illusions ($r(15) = .760$, $p = .001$).

To account for the notion that the Hering and Poggendorf illusions may not be as clear measures of local-global processing, the analyses described above were repeated with the exclusion of these two illusions. Overall, no differences were found with regards to the pattern of findings related to group differences and relationship with age, verbal ability, and level of functioning. The only difference observed was fixation on elements at start was no longer significantly correlated with illusion susceptibility when the Hering and Poggendorf illusions wereremoved.

Discussion

The current study examined differences in visual illusion susceptibility across children with ASD and typically developing controls in an attempt to replicate the results of Happe (1996) and to investigate two major theories underlying local-global processing in ASD using visual illusions as a measure. Six visual illusions were presented and participants were asked to make a verbal judgment about a feature of the illusion (consistent with Happe, 1996). Eye tracking data was also incorporated in the present study to extend the work of Happe and assess whether the main tenant of WCC and EPF (i.e., enhanced local processing in ASD) is supported when using visual illusions as a measure. Based on the results of Happe and relevant theory, it was predicted that children with ASD would be less susceptible to the illusions. This study also included a previously established measure of central coherence (block design) to assess differences in central coherence across groups and how these differences related to observed differences in illusion susceptibility. Based on previous work, it was predicted that children with ASD would score higher on block design and this would be associated with lowered susceptibility to the illusions. Consistent with WCC theory, it was also expected that individuals in the control group scoring higher on block design would exhibit decreased susceptibility to the illusions. Finally, each illusion was partitioned into its component elements and the contextual parts giving rise to the illusion to determine whether decreased susceptibility to the illusions is associated with increased fixation on elements and whether group differences exist in terms of attending to elements versus contextual information of visual illusions.

Analyses of group differences revealed no significant differences between groups on visual illusion susceptibility, block design, or the proportion of time spent looking at the elements versus contextual parts of the illusions. While these results are inconsistent with some research (Happe, 1996; Shah & Frith, 1993), they are consistent with more recent research suggesting that individuals with ASD have the ability to process information globally (i.e., do not display an overall deficit), but may be more inclined to focus on elements under certain conditions (Van der Hallen, Evers, Brewaeys, Van den Noortgate, & Wagemans, 2014). Further, recent research suggests that when using accuracy as a measure there are no group differences on global processing; however, individuals with ASD are slower at processing global information (Van der Hallen et al., 2014). In the present study, children were given unlimited time to make a judgmentabout the illusions and children with ASD were found to be just as susceptible to the illusions as typically children. This is in line with research suggesting that when given enough time children with ASD are just as able to see the global form of afigure.

Consistent with the notion that individuals with ASD are slower at processing global information, there is also a tendency for individuals with ASD to process local information first (Van der Hallen et al., 2014). The observed local precedence in ASD differs from global precedence observed in typically developing populations. Research suggests that typical processing involves focusing on the whole of a form first before dividing it into its component elements (Kimchi, 1992; Navon, 1977). In ASD, evidence suggests that grouping elements in wholes occurs with more explicit effort and time, suggesting that early perception in ASD is more detailed focused and information is processed locally and then globally rather than globally to locally (Van der Hallen, 2014). In the present study, illusion susceptibility was related to early local fixation, which suggests that where participants fixate first is important in the perception of visual illusions. However, contrary to the notion of local precedence in ASD, no group differences were observed in terms of focusing first on local versus global information.

The comparison regarding percentage of participants susceptible to each illusion produced results consistent with the lack of observed group differences. A similar pattern of findings was evidenced across both groups that are inconsistent with the pattern reported by Happe (1996). Interestingly, participants with ASD were slightly more susceptible to the majority of illusions. One consistent finding between the present study and Happe is the percentage of participants susceptible to the Muller-Lyer illusion.

Happe found a high susceptibility rate for the Muller-Lyer for both the ASD and TD group that is consistent with the results found for that illusion in this study. This result supports the notion that for the Muller-Lyer illusion it may be more difficult to separate the parts of the illusion from the contextual information. Surprisingly, and inconsistent with Happe, the Kanizsa triangle was observed to fool 100% of the participants in both the ASD and TD groups in the present study. This result was unexpected given Happe found only 8% of the ASD group to be susceptible to the Kanizsa illusion. Since this result was evidenced across both groups in the present study it may have been related to how the question is posed to participants (i.e., "how many triangles can you see here?"). The language implies that there are triangles within the image to find and may bias participants to respond based on how many triangles they see versus how many triangles actually exist. While this is a plausible explanation, the same question was posed to participants in the Happe study so the difference in results warrants further investigation.

Correlations between fixation patterns and potential moderator variables suggested that verbal abilities were related to fixation on elements and context of the illusions. This suggests that individuals with higher verbal abilities may have been better able to understand what they were being asked leading them to spend more time comparing elements to context to derive an answer. Conversely, individuals with lower verbal abilities may not have spent as much time comparing the parts of the illusion to the whole and thus have lower mean fixations. This may have impacted the results for the ASD group since overall this group displayed lower VIQ. The relationship between early fixation on elements and *SCQ* suggests that there

may be some relationship between symptoms of ASD and tendency to fixate on elements first before viewing the illusion in its global form. This is consistent with the literature suggesting a tendency towards early fixation on details for individuals with ASD. Although group differences were not observed, this relationship suggests that heterogeneity of the ASD population may have suppressed the ability to find an effect and that individuals displaying more symptoms of ASD display greater tendency to process information locallyfirst.

Limitations and Future Directions

There are several limitations to the present study that must be addressed. First, consistent with much research conducted with an ASD population, this study consisted of a sample of ASD participants that were heterogeneous in nature. The ASD group differed in terms of severity as well as verbal and cognitive ability. Although this variability is consistent with that observed in the population, it creates a challenge when trying toassess group differences. Additionally, higher VIQ was observed in typically developing participants, which may have impacted the results of the verbally administered visual illusion task.

Additionally, whether visual illusions are accurate measures to assess local-global processing is up for debate. While several of the illusions used in this study (e.g., Titchener circles, Kanizsa triangle, Muller-Lyer, and Ponzo) could be easily partitioned into elements and contextual information that was supported by previous research(Chouinard et al., 2013; Happe, 1996; Nayar et al., 2015), there is little research to support that the Hering and Poggendorf illusions are indeed measures of local-global processing. While these illusions can be partitioned into their component elements and the contextual information that is involved in making a judgment about the elements, this partitioning was done in the present study based on conceptual rather than empirical information. Research on these two illusions has focused on the ability to make accurate judgments about line orientations, angles, and direction rather than local-global processing (Morgan, 1999; Smeets & Brenner, 2004). How local-global processing may operate in these two illusions requires further investigation and empirical support.

Finally, the current study permits conclusions to be drawn regarding the relationship between local-global processing and ASD. However, the design of the study did not permit conclusions about the specificity of this relationship to ASD. To do so, inclusion of a third group would be necessary. Several other clinical populations (e.g., individuals with schizophrenia, depression, anxiety, and eating disorders) have demonstrated differences with regards to typical local-global processing (Basso, Schefft, Ris, Dember, 1996; Johnson, Lowery, Kohler, & Turetsky, 2005; Lopez, Tchanturia, Stahl, & Treasure, 2009;). Thus, it will be important for future studies to investigate what aspects are unique to ASD, what aspects are shared with other disorders, and how this informs our understanding of perception in ASD.

Conclusion

In summary, no group differences were observed on visual illusion susceptibility or local-global fixation patterns, which is consistent with some of the previous literature assessing illusion susceptibility in a similar manner (Hoy, Hattan, & Hare, 2004; Ropar & Mitchell, 1999) but is inconsistent with other studies (Happe, 1996). Individual differences in illusion susceptibility were related to a previously established measure of central coherence (block design) and were associated with where participants allocated their attention to first, supporting previous research suggesting local-global processing is a factor in the perception of visual illusions. The results of the current study are also in line with EPF theory and the more recent account of WCC theory, which suggests that individuals with ASD demonstrate a *tendency* towards local processing rather than an overall bias in perceiving figures in their global form.

References

American Psychiatric Association (2013). Diagnostic and Statistical Manual of Mental Disorders (5th Edition). Washington, DC: American Psychiatric Association.

Basso, M.R., Schefft, B.K., Ris, M.D., Dember, W.N. (1996). Mood and global-local visual processing. *Journal of the International Neuropsychological Society, 2(3),* 249- 255. doi: 10.1017/S1355617700001193.

Berument, S.K., Rutter, M., Lord, C., Pickles, A., & Bailey, A. (1999). Autism screening questionnaire: diagnostic validity. *The British Journal of Psychiatry, 175,* 444-451. doi: 10.1192/bjp.175.5.444.

Bolte, S., Holtmann, M., Poustka, F., Scheurich, A., & Schmidt, L. (2007). Gestalt perception and local-global processing in high-functioning autism. *Journal of Autism and Developmental Disorders, 37,* 1493-1504. doi: 10.1007/s10803-006-0231-x.

Brosnan, M.J., Scott, F.J., Fox, S., & Pye, J. (2004). Gestalt processing in autism: Failure to process perceptual relationships and the implications for contextual understanding. *Journal of Child Psychology and Psychiatry, 45(3),* 459-469. doi: 10.1111/j.1469 7610.2004.00237.x.

Chouinard, P.A., Noultym W.A., Sperandio, I., & Landry, O. (2013). Global processing during the Muller-Lyer illusion is distinctively affected by the degree of autistic traits in the typical population. *Experimental Brain Research, 230,* 219-231. doi: 10.1007/s00221-013-3646-6.

Dakin, S., & Frith, U. (2005). Vagaries of visual perception in autism. *Neuron, 48,* 497- 507. doi: 10.1016/j.neuron.2005.10.018. Frith, U. (1989). *Autism: Explaining the enigma*. Malden, MA: Blackwell.

Grandin, T. (1984). My experiences as an autistic child and review of selected literature. *Journal of Orthomolecular Psychiatry, 13(3),* 144-174.

Happe, F.G.E. (1996). Studying weak central coherence at low levels: Children with autism do not succumb to visual illusions. A research note. *Journal of Child Psychology and Psychiatry, 37(7),* 873-877.

Happe, F., Briskman, J., & Frith, U. (2001). Exploring the cognitive phenotype of autism: Weak "Central Coherence" in parents and siblings of children with autism: I. Experimental tests. *Journal of Child Psychology and Psychiatry, 42(3),* 299-307. doi: 10.1111/1469-7610.00723.

Happe, F., & Frith, U. (2006). The weak central coherence account: Detail-focused cognitive style in autism spectrum

disorders. *Journal of Autism and Developmental Disorders, 36(1),* 5-25. doi: 10.1007/s10803-005-0039-0.

Hermelin, B., & O'Connor, N. (1964). Effects of sensory input and sensory dominance on severely disturbed, autistic children and on subnormal controls. *The British Journal of Psychiatry, 55(2),* 201-206.

Hoy, J.A., Hatton, C., & Hare, D. (2004). Weak central coherence: A cross-domain phenomenon specific to autism? *Autism, 8(3),* 267-281. doi: 10.1177/1362361304045218.

Ishida, R., Kamio, Y., & Nakamizo, S. (2009). Perceptual distortions of visual illusions in children with high-functioning autism spectrum disorder. *Psychologia, 52,* 175-187. doi: 10.2117/psysoc.2009.175.

Johnson, S.C., Lowery, N., Kohler, C., Turetsky, B.I. (2005). Global-local visual processing in schizophrenia: Evidence for an early visual processing deficit. *Biological Psychiatry, 58(12),* 937-946. doi: 10.1016/j.biopsych.2005.04.053.

Koldewyn, K., Jiang, Y.V., Weigelt, S., & Kanwisher, N. (2013). Global/local processing in Autism: Not a disability but a disinclination. *Journal of Autism and Developmental Disorders, 43,* 2329-2340. doi: 10.1007/s10803-013-1777-z.

Mottron, L., Dawson, M., Soulieres, I., Hubert, B., & Burack, J. (2006). Enhanced perceptual functioning in autism: An update, and eight principles of autistic perception. *Journal of Autism and Developmental Disorders,* 36(1), 27-43. doi: 10.1007/s10803-005-0040-7.

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology, 9,* 353-383.

Nayar, K., Franchak, J., Adolph, K., & Kiorpes, L. (2015). From local to global processing: The development of illusory contour perception. *Journal of Experimental Child Psychology,* 131, 38-55. doi: 10.1016/j.jecp.2014.11.001.

Shah, A., & Frith, U. (1983). An islet of ability in autistic children: A research note. *Journal of Child Psychology and Psychiatry. 24(4),* 613-620. doi: 10.1111/j.1469-7610.1983.tb00137.x.

Shah, A., & Frith, U. (1993). Why do autistic individuals show superior performance on the Block design Task? *Journal of Child Psychology and Psychiatry, 34(8),* 1351- 1364. doi: 10.1111/j.1469-7610.1993.tb02095.x.

Simmons, D.R., Robertson, A.E., McKay, L.S., Toal, E., McAleer, P., & Pollick, F.E. (2009). Vision in autism spectrum disorders. *Vision Research, 49,* 2705-2739. doi: 10.1016/j.visres.2009.08.005.

Smeets, J.B.J., & Brenner, E. (2004). Curved movement paths and the heringillusion: Positions or directions? *Visual Cognition, 11(2/3),* 255-274. doi: 10.1080/13506280344000356.

Van der Hallen, R., Evers, K., Brewaeys, K., Van den Noortgate, W., & Wagemans, J. (2014). Global processing takes time: A meta-analysis on local-global visual processing in ASD. *Psychological Bulletin.* http://dx.doi.org/10.1037/bul0000004

Walter, E., Dassonville, P., & Bochsler, T.M. (2009). A specific autistic trait that modulates visuospatial illusion susceptibility. *Journal of Autism and Developmental Disorders, 39,* 339-349. doi: 10.1007/s10803-008-0630-2.

Young, R.L., & Rodi, M.L. (2014). Redefining autism spectrum disorder using DSM-5: The implications for the proposed DSM-5 criteria for autism spectrum disorders. *Journal of Autism and Developmental Disorders, 44,* 758-765. doi: 10.1007/s10803- 013-1927-3