# The Role of Weak Central Coherence in Explaining Social Impairments in Autism Spectrum Disorder

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## Introduction

Autism Spectrum Disorder (ASD) is characterized by impairments in three specific domains: communication, social interaction, and behavioral flexibility, with symptoms including both weaknesses and strengths among these different categories (American Psychiatric Association [APA], 1994). Often times, these symptoms are also categorized as either non-social behaviors such as restrictive interests and repetitive behaviors, or social behaviors, including difficulty orienting to people in a social environment, impaired emotional reciprocity, limitations in understanding and utilizing social norms, social withdrawal, and difficulty holding and navigating conversations (APA, 1994). As humans, our existence as a coherent society hinges on our ability to communicate and socially interact with others. For most people, navigating the social world comes with relative ease as we age and engage in and learn from social experiences throughout our lives, but this is not so in many individuals with ASD. As a result, social symptoms in individuals with ASD are often particularly visible and apparent along with posing significant challenges for individuals who wish to participate in social life, and are heavily researched. Recently, considerable research has investigated possible explanations behind these social impairments, including two major theories, the theory of mind (TOM) and weak central coherence (WCC) hypotheses.

## Theory of Mind and Weak Central Coherence

The theory of mind hypothesis argues that the social impairments that individuals with ASD experience are due to an underdeveloped theory of mind, which is generally defined as the ability to infer and attribute mental states to others, including beliefs, desires, emotions, and intentions; and reason and reflect about these mental states in both others and themselves (Baron-Cohen, 2001, p.3; Hutchins & Prelock 2008, p.340). Thus, the theory of mind hypothesis of ASD

states that individuals with ASD have difficulty inferring and understanding the minds and emotions of others, which leads to the myriad of social deficits and symptoms seen in ASD.

The weak central coherence hypothesis was first proposed by Uta Frith (1989) and attempts to account for symptoms of ASD as a difficulty or deficit in integrating disparate information in order to extract and understand the "gist" or "big picture" of a situation or object (Plaisted, 2005, p.1; Frith, 1989). A metaphor that is often applied to this hypothesis is that individuals with ASD see each individual tree in a forest (local processing) rather than see the forest as a whole (global processing),but is often expanded to other domains other than vision, including auditory and linguistic processing (Jolliffe & Baron-Cohen, 1999; Happé, 2018). In contrast to TOM that focused on only social aspects of ASD, WCC has been argued to be able to explain both the non-social and social symptoms of ASD. However, there is debate; some research argues that WCC is able to account for both social and non-social symptoms, describing WCC as accounting for decreased mentalizing abilities (resulting in social impairments) and repetitive and restricted behaviors and interests (RRBIs), while others suggest that it only serves as an explanation for non-social symptoms such as RRBIs and savant skills. RRBIs have been explained by deficits in central control processes that are responsible for bringing coherence to experience in typically inhibit these behaviors (Frith, 1989). In addition, many individuals with autism seem to be oversensitive to sensory information while also lacking the ability to selectively filter for the big picture through the noise because of their abnormal attention to detail (local processing). In this view, repetitive behaviors are thought to be an adaptive mechanism that limits environmental variance so that the world becomes more predictable. This same attention to detail could also help explain the extreme detail and skill that some individuals with ASD exhibit in activities such as art, for example Stephen Wiltshire's ability to draw the Tokyo

cityscape in incredible detail from memory after a single 20 min helicopter ride, and in music, evidenced by the high number of individuals with ASD who have perfect pitch or can hold exact pitches in their mind for weeks (Happé, 2018).

Frith and Happé, who pioneered the WCC hypothesis, have significantly revised their original hypothesis in recent years. In their early papers, they characterized WCC as being able to account for the entire symptomatology, from inability to grasp the overall meaning of a stream of speech resulting in misunderstanding the meaning behind a surface statement, to RRBIs (Plaisted, 2005, p.1; Frith, 1989). Initially, they characterized the deficit as an impairment in global processing resulting in overuse of local processing. After being challenged by several others and by Happé's research, they revised their view of WCC in several significant ways, the first being that it is not an impairment in global processing or attention, but rather a bias to the local; individuals with ASD have the capacity to processes scenarios globally if overtly directed to do so, but may not do so automatically as many typically developing individuals do (Plaisted, Swettenham, & Rees, 1999; Mottron, Burack, Iarocci, Belleville, & Enns, 2003; Frith & Happé, 2006).

Plaisted et al. (1999) administered tasks to TD and ASD children which required responding to a target that could appear at the global level, the local level, or both levels. In one condition, the child was given no instruction as to what level the target would appear. In the other condition, they were explicitly instructed to attend to either the local or the global level. In comparison to TD children, the ASD children made more mistakes when the targets appeared at the global level and less mistakes when they appeared at the local in the uninstructed condition, but in the instructed condition, no difference was seen in the performance between the two groups. Notably, the ASD group did not show lower performances when finding global targets

when explicitly instructed to attend globally, while showing stronger performance locating local targets without instruction, indicating a local bias but not a global deficit, since the ASD children demonstrated ability to correctly process globally when directed. Similarly, Mottron et al. (2003) found the same pattern enhanced local processing in unstructured tasks, but unaffected global processing in scaffolded tasks in children with ASD.

Secondly, Frith and Happé essentially abandoned the notion that WCC could serve as a unitary explanation for ASD symptoms, particularly the social deficits, and turned their attention to the hypothesis that WCC and social deficits may be explained by independent processes, including TOM (Frith & Happé, 1994). This change followed research that seemed to show no correlation between tasks that measured social impairments and tasks that measured central coherence; specifically, regardless of performance on theory of mind tasks, ASD individuals consistently showed local processing bias in central coherence tasks (Happé 1991; Happé 1997). In what follows, research and evidence for the relationship between WCC and social deficits in ASD will be presented, along with evidence of their independence, and why consideration of this research is important to the understanding of ASD.

**Evidence Supporting the Role of Weak Central Coherence in Social Impairments in ASD**

There is promising evidence that WCC can account for and help explain social deficits in ASD. The processes of inferring others' thoughts and acting in a societally expected manner is something that comes easily for many typically developing individuals through experience and age, and are often taken for granted, but are in reality extremely complex. Even simple social scenarios involve the integration of many bits of information that are perceived consciously and unconsciously in order to infer the correct interpretation of the scenario (e.g. established social

norms, expressions and emotions, contextual clues from the environment, and parts of a story or stream of speech).

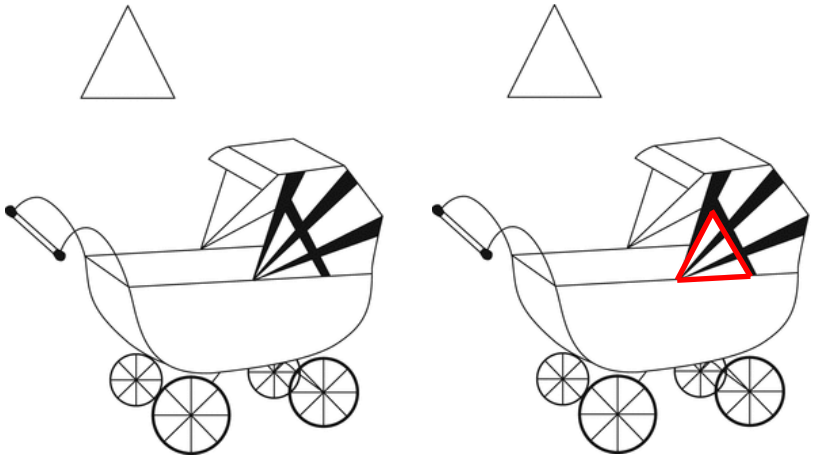
Though the mechanisms behind WCC are still unknown, most researchers who investigate the relationship between WCC and ASD agree that the symptoms of ASD are a result of either a deficit in integration processes or because individuals with ASD cannot determine the necessity in synthesizing separate pieces of information together leading to the tendency for local attention and processing, which was Frith's original line of thought (Plaistead, 2015, p.4; Frith 1989). Thus, those that attribute social and mentalizing deficits to WCC explain the relationship in terms of and lack of integration of the complex components that are necessary for mentalizing and acting accordingly in social situations. Jolliffe & Baron-Cohen (1999) investigated the ability of ASD individuals to provide mental state answers based on a series of stories. These mental state answers were context-dependent and thus could only be generated if the participant had an accurate understanding of the stories' contexts (the categories of mentalizing questions were Double Bluff, Figure of Speech, Joke, Lie, Misunderstanding, Persuade, Pretend, Sarcasm, and White Lie. Double Bluff stories attempt to deceive someone by telling them exactly what you intend to do when you know that they will assume you are lying, requiring the reader to decipher the complex intent of the bluffer from the context. Figure of Speech and Joke stories require non-literal interpretations of statements in order to extract the intended meaning which are made clear by the story context. Lie, white lie, sarcasm, and pretend stories require understanding of context in order to correctly interpret the nature of the false statements in the stories. In persuasion stories, a character is persuaded to take an action that they otherwise would have avoided, understanding of context is required to correctly conclude that the actor only performs the action because of pressure and not out of their independent willingness.

Misunderstanding stories involve an action taken because of a misunderstanding between characters, and the reasoning behind the action as a misunderstood communication requires contextual comprehension.

Compared to TD individuals (17 adults with an average age of 30 years), those with ASD (17 adults with an average age of 30.71 years) provided significantly less contextually-appropriate mental state answers and instead gave answers that tended to concentrate on the utterance in isolation. This indicates that the ASD subjects had difficulty to taking into account the context which would allow them to draw the correct conclusion about the stories in cases that involved inferring a mental state based on the information presented in the context. However, they performed just as well as TD subjects on a story task that only involved physical reasoning, and not any social or mentalizing aspect, suggesting that their failure to correctly interpret contextual information in these stories is more specific to mentalizing and social scenarios, which corresponds with the WCC hypothesis.

Jarrold, Butler, Cottington, & Jimenez (2000) examined the relationship between theory of mind and central coherence in both ASD individuals and in the general population. Through a series of three experiments, they tested whether or not there were correlations between performance on tasks that are said to probe theory of mind ability and WCC in TD adults, TD children, and children with ASD. Experiment 1 involved 30 male and female TD undergraduate students who ranged from 18-25 years old. An eye-reading task was given to probe theory of mind, in which participants saw 24 pictures of eyes separated from the rest of the face and made a forced choice between characterizing the emotion from the eyes as either concerned or unconcerned, or calm or anxious (Baron-Cohen, Jolliffe, et al., 1997).

The ability to infer the correct emotion from the eyes is said to measure theory of mind because of the need to ascribe a certain mental state to the photograph without being explicitly told. The adult version of the Embedded Figures task was given to measure central coherence, which involves finding a target object within a complex figure. In previous studies, individuals with ASD performed much better than TD individuals on this task, which is commonly explained by their preferential focus on local details, as the subject must disregard the reference image as a complete whole and rather focus in on the detailed components of the shapes and lines that comprise the full figure (Shah & Frith, 1983) (Fig. 1).



**Embedded Figures Test, Fig. 1**

The complex figure within which the target is hidden is shown on the bottom while the target figure (the single triangle) is shown on the top. On the right, the target figure embedded within the complex figure is highlighted (Happé, 2013).

Each participant was given the eye-reading task and the Embedded Figures task. They were scored on number of emotions labelled correctly on the eye-reading (accuracy) and amount of time taken to complete each Embedded Figure item.

Across the sample of 60 participants, there was significant but weak correlation between scores on the two tasks. This points toward an inverse relationship in performance; a higher score on eye task (higher performance on eye task) correlated with a longer time to locate the target on the Embedded Figures (lower performance on Embedded Figures). However, correlation between these tasks would only signify a link between theory of mind ability and WCC if these tasks were valid measures of each process. This prompted questioning of the eye-reading task as a valid measure of theory of mind, or whether other mechanisms may be involved in the task. It is possible that this task is not a pure theory of mind task; confounding central coherence effects may be present because of the necessity to visually integrate components of the eye photos in order to choose an emotion. If both the eye-reading and Embedded Figures tasks utilized central coherence processes, the inverse performance relationship could be explained by visual integration (a central coherence process) being beneficial to the eyes task but not for the embedded figures task, rather than the results coming from two related processes. Thus in the two subsequent experiments, verbal and auditory tasks were used to probe theory of mind.

The second experiment investigated these correlations in TD children. The participants were 24 5-year-olds from a single year group in school. The theory of mind task involved verbally presented stories read by the researcher which were paired with reasoning questions that fell in one of six categories: inferred belief, not-own-belief, explicit false belief, own false belief, others' false belief, second order false belief. These categories were chosen because they test theory of mind at different difficulty levels. The tasks used to probe WCC were the child version of the Embedded Figure tasks and an added Block Design task. The Embedded Figure task was similar to the adult version, but was adapted for children by using easier figures and targets. The Block Design task involves recreating a target figure using blocks with different arrangements of

designs. This task measures WCC because individuals who are more locally focused find it easier to break the figure into the components that were presented on the blocks while those who have a more globally focused processing style would have more difficulty breaking apart the figure into component parts because they would tend to see the figure as a whole object instead, posing an interference when attempting to find the embedded target.

There was only significant correlation between performance on theory of mind and central coherence tasks when verbal mental and chronological age of the subjects was accounted for, but after verbal mental and chronological were accounted for, there was a significant, moderately strong, negative correlation between the theory of mind task and the Block Design task (high theory of mind score correlated with low block score), and there was a significant, strong, positive correlation between the theory of mind task and the Embedded Figures task (high theory of mind score correlated with high embedded figure time). This indicates that TOM and WCC are inversely related, as a higher TOM performance correlates with low performance on both WCC tasks. The correlation between performances on the Embedded Figures and Block Design tasks were also calculated in order to examine if those two tasks were measuring the same construct. The correlation between these tasks was very strong and significant; higher score on the Block Design task correlated with lower time on Embedded Figures task, meaning the performance on tasks are actually positively correlated. This supports the idea that both of these tasks measure the common construct of WCC or local coherence.

In comparison to the adult sample in Experiment 1, there was a stronger link between theory of mind and WCC performance in children when developmental differences were accounted for. Verbal mental age was particularly important to note in this experiment. Verbal mental age correlated positively with theory of mind performance and block design score and

negatively with Embedded Figures time. These correlations indicate that with verbal development individuals get faster at the Embedded Figures Test and perform better on both block design and the theory of mind tasks, and thus confounding effects of verbal mental age within the sample should be accounted for by controlling for verbal mental age. By using two tasks that measure WCC instead of one and using a verbal instead of visual theory of mind task, Experiment 2 improves on Experiment 1 and shows strong correlation between theory of mind and WCC in TD children.

The final experiment investigated this correlation in children with ASD by closely replicating Experiment 2 with minor adjustments to the procedure to accommodate the ASD group. The subjects were 17 children with formal diagnoses of autism; 13 boys and 4 girls (a ratio that is consistent with the accepted sex ratio in ASD), range in age from 7 years and 4 months to 12 years and 11 months, with an average age of 9 years and 11 months. The same six theory of mind questions and two adapted WCC tasks (Embedded Figure, Block Design) were used in this experiment. As in the analyses in Experiment 2, verbal mental and chronological age were accounted for in anticipation of confounding developmental effects within the group.

The results for ASD children are similar to those seen in the TD children in Experiment 2, in which after for accounting for developmental differences, correlations are seen between theory of mind and WCC performance. After accounting for verbal mental and chronological age, there were moderately strong correlations between the theory of mind task performance and WCC task performance. There was a significant and moderate negative correlation between the theory of mind task and the Block Design task (high theory of mind score correlated with low block score), and a significant, moderate, positive correlation between the theory of mind task and the Embedded Figures task (high theory of mind score correlated with high embedded fig

time). In addition, the correlations between performance the two WCC tasks were calculated again in this experiment, and were again found to be correlated, further supporting the thought that these two tasks both tap WCC. In both groups of children there was an inverse relationship between theory of mind and WCC performance; higher theory of mind performance correlated with lower WCC performance.

The results of the three experiments presented in Jarrold et al. (2000) point toward a link between WCC and theory of mind and propose a way in which WCC may give rise to theory of mind impairments and in turn affect social impairments in individuals not only with ASD, but in the general population as well. Contrary to the hypothesis that WCC is independent and separate from social symptoms in ASD, this study suggests that strong central coherence is important in theory-of-mind development because it biases the developing individual to take a global processing style of a situation and to integrate information about both the self and the other into a coherent whole, thus speaking to the possible involvement of WCC in social symptoms seen in ASD individuals. The inclusion of both TD and ASD individuals in this study offers an important takeaway -- perhaps not only people with ASD share these characteristics and apparent links, but there might be an underlying functional link between these processes that extends to the general population as well.

In both of these studies, one element that is playing a large role in both WCC and TOM tasks is context, and thus suggests contextual processing as a link between WCC, TOM, and social impairments in ASD (Jolliffe & Baron-Cohen, 1999; Jarrold et al. 2000). The stories presented in Jolliffe & Baron-Cohen (1999) were chosen because of the necessity of correct understanding of the stories' contexts in order to answer questions. These stories represent social situations in which contextual understanding is necessary to draw the appropriate conclusions via

mental state inference. The ASD group's difficulty with answering the context-dependent questions implies they have a reduced processing of context. This contextual impairment is also suggested by performance of ASD individuals on the Embedded Figures task and Block Design task. When compared to TD individuals, ASD individuals respond in ways that indicate they have reduced interference from the complex figure on the smaller details and parts. In these cases, the context is the large figure, and the increased ability for ASD individuals to identify the small details demonstrates again a lack of contextual processing and attention. Along these lines, the processing and integrations of context may be a link between WCC and social deficits in ASD.

These results present a promising launching pad for further investigation into WCC's influence on social symptoms in ASD. By establishing the possibility of linkage between WCC and theory of mind, Jarrold et. al (2000) opened the door for further investigation into topics such as the strength of the connection between strong central coherence (global processing style) and theory of mind ability, mechanisms behind the association, whether or not these links are qualitatively comparable between ASD and TD populations, and if these links persist into adulthood.

Additionally, Jarrold et. al (2000) touches on concerns about the validity of tasks purported to be measurements of WCC and theory of mind, and by extension other methodological issues that might benefit from reexamination. This was mentioned in the discussion of the validity of the eyes task as a theory of mind task in Experiment 1. Similar sentiments about methodological concerns are echoed in Happé & Frith (2006), in which they underscore the importance of careful wording of instructions, such as instructions as similar as which line "looked the same length" versus "were the same length" produced significantly

different responses. Particularly, they highlighted the importance of open-ended tasks in capturing processing bias in WCC in individuals with ASD, since tasks that even unintentionally encourage an answer that requires global processing might mask the bias following the hypothesis that ASD individuals are able to adopt a level of global processing if provided the scaffolding guiding them to a global approach. Naturally, results and correlations drawn between processes can only be trusted if the tasks used to measure them are valid, making these important considerations in discussing past and conducting further research.

**Evidence That WCC Does Not Explain Social Impairments in ASD**

Much of the research that supports the dissociation between social impairments in ASD and WCC attributes social impairments to deficits in TOM. There is an abundance of support for TOM deficits in ASD, with most researchers employing simple first-order and second-order false belief tasks to demonstrate mentalizing difficulties in this population (Baron-Cohen, 1989; Baron-Cohen et al., 1985). Happé (1991; 1997) led to the revision of the WCC hypothesis, groups of ASD individuals who showed no ability to pass theory of mind tasks, those who passed first-order theory of mind tasks, and those who passed second order theory of mind tasks along with developmentally normal children were tested for their ability to correctly pronounce homographs embedded within sentence contexts (a test that taps WCC) (Happé 1991; Happé 1997). Homographs are words with identical spelling whose meanings and pronounciations are defined only based on their surrounding context (e.g. “It was the lead guitarist that sang at the concert” versus “It was lead in the box that made it so heavy”, with “lead” being the target homograph). Thus, the correct pronunciation of a homograph can only be extracted by understanding the word in the context of the rest of the sentence, which would involve a global processing and integration of the surrounding context.

Because the results showed that there were deficits across the ASD sample with no correlation to their ability to pass different levels of theory of mind tasks, Happé concluded that these theory of mind/mentalizing skills relied on different mechanisms than the context dependent homograph ability; in other words, WCC has appears to have no relation to mentalizing ability and social deficits in ASD. If theory of mind ability and central coherence were related, the expected results would show some type of correlation between particpants' success in passing theory of mind tasks of differing difficulty and their success in the homograph task. The lack of correlation seen between these performance levels led to the conclusion that the two processes had no influence on each other and operated independently.

Researchers have used a variety of measures and tasks in the laboratory to find evidence for connections between TOM difficulties and social situations, and with other symptoms that individuals with ASD face. These range from studies that explore interpretations of stories and speech, to interpreting emotions from eyes and voices (Happé, 1994; Kaland et al. 2002; Baron-Cohen et al., 2001; Rutherford et al., 2002). There have also been studies attempting to pit TOM and WCC directly that have resulted in conclusions that it is truly TOM that is the explanatory mechanism for social deficits, unrelated to any deficits in central coherence. For example, Beaumont & Newcombe (2006) examined the relationship between TOM and WCC by investigating responses to questions about narratives which supposedly probed central coherence and theory of mind abilities relating to social situations in ASD and typically developing (TD) adults. They reported that there were no differences in the scores between ASD and TD groups for central coherence response, but there were significant differences in regard to theory of mind responses, supporting the TOM hypothesis of social deficits. Researchers have also probed this

relationship by looking at correlations between measures of central coherence and theory of mind skills to determine if central coherence affects mentalizing skills in social situations.

Morgan, Maybery, & Durkin (2003) investigated whether WCC could account for deficits in two behaviors purported to tap capabilities fundamental to a theory of mind: joint attention and pretend play. Joint attention and pretend play were chosen as theory of mind measurements because there is evidence suggesting that they might be precursors of theory of mind and tap capabilities that are fundamental to the development of theory of mind (Baron-Cohen, 1995; Leslie, 1987; Mundy, Sigman, & Kasari, 1994; Yirmiya, Pilowsky, Solomonica-Levi, & Shulman, 1999). Additionally, difficulties in pretend play are, in part, diagnostic criteria of ASD (APA, 2013). The subjects used in this study were twenty-one 3-5-year-old children with ASD and twenty-one 3-5-year-old typically developing (TD) children, who were matched by chronological age, nonverbal ability, and gender. The authors did not specify the level of functioning of the ASD children, though from the task demands in the study, it is likely they were high-functioning.

Each of the children were asked to perform 4 different tasks in order to obtain measures for verbal and non-verbal ability, pretend play, joint attention, and central coherence. Verbal and non-verbal ability were measured using the using the Peabody Picture Vocabulary Test Form IIIA and the revised edition of the Leiter International Performance Scale, respectively (PPVT; Dunn & Dunn, 1996; Leiter–R; Roid & Miller, 1997). Pretend play was probed by providing each child with a selection of toys that could be used to depict different scenarios (a kitchen and doctor's office) by using object substitution while playing. Every 15 seconds, the child was recorded as either engaging in pretend play if they used object substitution, or other types of play: sensorimotor, ordering, functional, ambiguous, or no play. To probe joint attention, three

tasks were used, each measuring instances of eye contact with a confederate. In the first task (blocking) a researcher covered the child's hands while they were playing with a toy; a correct response was recorded if the child looked at the researcher's eyes within 5 seconds. In the second task, the researcher offered a toy and then withdrew it, and eye contact was recorded after the withdrawal. In the third task, the researcher started a mechanical toy and then stopped it, and eye contact was recorded after the toy was stopped.

Two tests of central coherence were administered, the Preschool Embedded Figures Test and the Pattern Construction subscale of the Differential Ability Scales, which is equivalent to the Block Design task (Coates, 1972; Elliot, 1990). The Embedded Figures Test and Block Design task both involve recognition of smaller target figures within a much larger image, and have been accepted as a way of tapping WCC. As noted previously, these tasks are widely accepted probes of WCC because it is thought that those with a tendency for local processing (weaker central coherence) would have an easier time locating the target object because they are better able to discern the details and parts from the whole figure, whereas those with a stronger tendency for global processing would have a more difficult time identifying the target since they are combatting interference from viewing the complex figure as a whole object rather than breaking it down into parts. While the Embedded Figures Test involves locating a target shape within a larger figure, while the Block Design/Pattern Construction subscale involves recreating a target figure using blocks with different arrangements of designs. If WCC and TOM processes are separate, there should be no correlation between performances on TOM tasks (joint attention and pretend play tasks) and WCC tasks (Embedded Figures and Pattern Construction), since independent processes should not influence or predict the performance of another.

The results of this study showed no relation between central coherence and the theory of mind measures (joint attention and pretend play) in either the ASD or control groups, even when they were controlled for chronological age and verbal mental age. In the ASD group, correlation between joint attention and WCC tasks the correlation between pretend play and WCC tasks were both weak and insignificant. Similar correlations between joint attention and WCC and pretend play and WCC were seen in the control group. These weak and insignificant correlations indicate that these tasks tap separate underlying cognitive mechanisms, supporting the hypothesis that TOM and WCC are separate, with TOM underlying social deficits because of its role in these mentalizing and social tasks that according to these results are unaffected by WCC. Each of these factors contributed significantly and independently to differentiate the TD and ASD groups, in that performance did differ significantly for each task between TD and ASD groups. Children with ASD were significantly faster at responding correctly on the embedded figures task, and also performed significantly better on the pattern construction task, highlighting that these are abilities that differ in TD and ASD individuals. However, within the two groups, the performances on tasks of central coherence and theory of mind had no correlation.

Though the results of this study do indicate a disconnect between central coherence and theory of mind, the conclusion of declaring WCC and TOM as separate processes and that WCC is not involved in social deficits might be premature. Notably, joint attention and pretend play are not widely considered to be robust theory of mind precursors or directly related to theory of mind. Other studies have found no correlation between pretend play and theory of mind performances, arguing that pretend play does not involve theory of mind (Jarrold, 1997; Jarrold, Boucher, & Smith, 1996; Lillard, 1993). This would suggest that the current study is not using a valid measurement of TOM, rendering the conclusions of its independence from WCC

inconclusive. Additionally, the connection between joint attention and theory of mind seems to be more theoretically rather than empirically supported, as there have been very few studies that directly test this association beyond conjecture (Miller, 2006). If the two tasks purported to tap theory of mind ability are not valid measurements of theory of mind, then the results of the study are rendered less reliable.

Furthermore, the current study taps into only a few behavioral facets of social interaction and does not account for other aspects of socializing that involve theory of mind skills and mentalizing, such as reading facial expression or body language in order to successfully understand and communicate with others. Similarly, while the tasks used to measure central coherence have been proven reliable as tests of local-global processing, they might not probe possible contributions of WCC to social situations because the tasks involve very non-social elements (find a shape or pattern in a picture). One peculiar aspect of the WCC hypothesis is that it is ambiguous as to what level WCC is said to operate, it could affect processing of objects in simple images, or perhaps larger situations that would be more applicable to realistic social scenarios, such as someone's face and body features or the contextual elements of a situation. The two tests used in the study might only account for one level of central coherence, while there might be other areas of weakness that directly affect social interactions and mentalizing.

**Conclusion**

As evidenced by the variety of research on both sides of the debate, at this point a consensus has not been reached regarding the ability of the WCC hypothesis to account for mentalizing deficits and social impairments that characterize ASD. There is evidence both for WCC's role in and its independence, yet at the current state of understanding of the immensely complex topics of ASD and sociality, neither is conclusive as a universal account of symptoms in

ASD. Clearly, there is much work to be done examining WCC, TOM, and other hypotheses of ASD, and the current body of work holds exciting promise for the future of research on these topics. That being said, it seems to be premature to give up on WCC as a factor contributing to social deficits. Studies that have provided evidence for independently operating processes, such as the TOM hypothesis have yet to conclusively rule out WCC as a factor entirely in light of closer scrutiny of methodological factors that may render results unreliable. In addition, there is a robust line of work that strongly suggests that WCC is involved in some capacity in these symptoms, with many avenues open for deeper examination of these relationships. Another possibility suggests that social symptoms of ASD not are unitary black and white, all-or-none, WCC or no WCC, but as an interaction or combination of WCC and TOM, and/or other hypotheses, such as executive function deficits.

Impairments in social interactions are some of the most and well-known symptoms of ASDs. As social beings that rely on interactions with others for our well-being and the well-being of our society at large, these social impairments and the pursuit of understanding their origins have been, and continue to be, a highly-pursued topic of research. The WCC theory was an exciting breakthrough because it offered the possibility of a single, unitary explanation of both non-social and social symptoms of ASD. However, the story has turned out to be much more complex, with arguments for and against its ability to explain mentalizing and social impairments otherwise attributed to TOM or other hypotheses. As a result, the future is still open to possibilities, with many promising avenues to untangle the webs of WCC and social symptoms of ASD.

References

Baron-Cohen, S. (1989). The autistic child's theory of mind: A case of specific developmental delay. *Journal of Child Psychology and Psychiatry, 30*, 285-298.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition, 21*, 37-46.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the mind in the eyes" Test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry*, 42(2), 241-251.

Beaumont, R., & Newcombe, P. (2006). Theory of mind and central coherence in adults with high-functioning autism or Asperger syndrome. *Autism, 10*(4), 365–382. https://doi.org/10.1177/1362361306064416.

Frith, U. (1989). Autism: Explaining the enigma. Oxford, UK: Blackwell.

Frith, U., & Happé, F. (1994). Autism: Beyond “theory of mind”. *Cognition, 50*(1), 115-132.

Happe, F. and Frith, U. (2006) The Weak Coherence Account: Detail-Focused Cognitive Style in Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders, 36*, 5-25. https://doi.org/10.1007/s10803-005-0039-0.

Happé, F. G. (1997). Central coherence and theory of mind in autism: Reading homographs in context. *British journal of developmental psychology, 15*(1), 1-12.

Happé, F. G. (1991). Theory of mind and communication in autism. Unpublished PhD thesis, University of London.

Happé, F. G. (2006). Why are savant skills and special talents associated with autism? *World Psychiatry, 17*(3): 280–281. 10.1002/wps.20552.

Happé F. (2013) Embedded Figures Test (EFT). In: Volkmar F.R. (eds) Encyclopedia of Autism Spectrum Disorders. Springer, New York, NY.

Hutchins, T. L., Prelock, P. A., & Chace, W. (2008). Test-Retest Reliability of a Theory of Mind Task Battery for Children with Autism Spectrum Disorders. *Focus on Autism & Other Developmental Disabilities, 23*, 195-206.

Jarrold, C., Boucher, J., & Smith, P.K. (1996). Generativity deficits in pretend play in autism. *British Journal of Developmental Psychology, 14*(3), 275-300. http://dx.doi.org/10.1111/j.2044-835X.1996.tb00706.x.

Jarrold, C., Butler, D.W., Cottington., E.M. & Jimenez, F. (2000). Linking theory of mind and central coherence bias in autism and in the general population. *Developmental Psychology. Developmental psychology. 36*. 126-38. http://dx.doi.org/10.1037/0012-1649.36.1.126.

Jarrold, C., Carruthers, P., Smith, P. K., & Boucher, J. (1994). Pretend play: Is it metarepresentational? *Mind & Language, 9*(4), 445-468.

Jolliffe, T., & Baron-Cohen, S. (1999). A test of central coherence theory: Linguistic processing in high-functioning adults with autism or Asperger syndrome: Is local coherence impaired? *Cognition, 71*(2), 149-185. http://dx.doi.org/10.1016/S0010-0277(99)00022-0.

Kaland, N., Møller-Nielsen, A., Callesen, L., Mortensen, E.L., Gottlieb, D., & Smith, L. (2002). A new 'advanced' test of theory of mind: evidence from children and adolescents with Asperger syndrome. *Journal of Child Psychology and Psychiatry, 43*(4), 517-28.

Klin, A., Jones, Warren, J., Schultz, R., Volkmar, F. & Cohen, D. (2002). Visual Fixation Patterns During Viewing of Naturalistic Social Situations As Predictors of Social Competence in Individuals With Autism. *Archives of general psychiatry, 59*. 809-16.

10.1001/archpsyc.59.9.809.

Lillard, A. S. (1993). Pretend play skills and the child's theory of mind. *Child Development, 64*(2), 348-371. http://dx.doi.org/10.2307/1131255

Miller, C.A. (2006). Developmental relationships between language and theory of mind. *American Journal of Speech-Language Pathology*, *5*(2):142-54. 10.1044/1058-0360(2006/014).

Morgan, B., Maybery, M., & Durkin, K. (2003). Weak central coherence, poor joint attention, and low verbal ability: Independent deficits in early autism. *Developmental Psychology, 39*(4), 646-656. http://dx.doi.org/10.1037/0012-1649.39.4.646.\

Plaisted, K. C. (2015). Reduced Generalization in Autism: An Alternative to Weak Central Coherence. https://www.repository.cam.ac.uk/handle/1810/248652.

Rutherford, M.D., Baron-Cohen, S. & Wheelwright, S. (2002). Reading the Mind in the Voice: A Study with Normal Adults and Adults with Asperger Syndrome and High Functioning Autism. *Journal of Autism and Developmental Disorders, 32*, 189.

Shah A, Frith U. (1983). An islet of ability in autistic children: a research note. *The Journal of Child Psychology and Psychiatry, 24*(4):613-20.