

Autism Spectrum Disorder:
A Review of Four Contemporary Theories

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Abstract

Autism Spectrum Disorder (ASD) is a developmental disorder characterized by impairments in social interaction and communication, and by restricted and repetitive behaviour. While, there is some debate among researchers regarding the underlying deficit causing ASD, determining such a deficit is critical to guiding early identification and fostering effective instruction for individuals with ASD. The purpose of this paper is to evaluate four contemporary theories of ASD - theory of mind, central coherence, executive functioning, and hyper-systemizing - in terms of their explanatory power, specificity, and universality. The evaluation reveals that the concomitant deficits in/of theory of mind, central coherence, or executive functioning do not meet the criteria of primary deficit in individuals with ASD. While more research is necessary, the superior explanatory power of Baron-Cohen's (2006) proposed hyper-systemizing theory of autism, suggests that this is a promising new account of the core deficit in ASD. In order to encourage the integration of theory, research, and practice, this paper discusses the implications of hyper-systemizing theory to future research and to the development of educational interventions.

Introduction

Autism Spectrum Disorder (ASD) is a developmental disorder estimated to affect 1 in every 165 Canadians (Fombonne, 2003). Genetic research over the last 10 years has led to a common understanding that ASD is most accurately represented as a syndrome, reflecting a variety of underlying features, each perhaps with a different neuropathological mechanism (Coleman & Betancur, 2005). A triad of impairments is required for a diagnosis of ASD and it is thought that each could, potentially, be the result of a different neurological mechanism. In light of this research, the utility of identifying a single explanation of ASD has been questioned (Happé & Plomin, 2006). However, a theoretical framework, which could account for all aspects of the common phenotype, would provide critical information as to how so many different diseases could lead to the same group of symptoms.

According to the American Psychiatric Association's (2000) *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR), the phenotype of ASD is currently represented by the diagnostic criteria for autistic disorder and includes a triad of impairments, originally proposed by Wing (1988) and Rutter (1978). The diagnostic criteria include qualitative impairments in social interaction and communication, as well as restricted and repetitive behaviours. Frith and Happé (1994) discussed the importance of considering, as part of the phenotype, non-triad characteristics consistently documented to be associated with ASD. These included a restricted repertoire of interests, obsessive desire for sameness, preoccupation with parts of objects, and exceptional proficiency in very specific skills (e.g., excellent rote memory in some individuals with ASD). In order to fully understand the underlying processes that result in this consistent and common phenotype, any theoretical framework attempting to explain ASD must account for this full pattern of symptoms.

The purpose of the current review is to elucidate and evaluate contemporary theories of ASD, which direct research and the treatment of individuals with ASD. Each of the current theories implicates one deficit as the primary deficit in ASD (i.e., deficit that causes all others and accounts for the full pattern of symptoms evidenced in individuals with ASD). To date, literature has not compared the utility of each of the four contemporary theories in understanding the profile of individuals with ASD. Identifying which of the theories provides the most substantive evidence will be critical in guiding the early identification and effective intervention for individuals with ASD, such as determining ways that students with ASD can be most effectively taught in the classroom.

Within the literature, current theories explaining the primary deficit in ASD have implicated either (a) lack of theory of mind, (b) weak central coherence, (c) weak executive functioning, or (d) hyper-systemizing. Lack of theory of mind refers to the inability to attribute independent mental states to oneself or to others in order to explain or predict behaviour (Frith & Happe, 1994). Central coherence theory asserts that ASD is characterized by an imbalance in the integration of information at different levels; individuals with ASD see the parts rather than a whole and lack the cognitive capacity to integrate the parts into a whole (Frith & Happe, 1994). Executive function refers to the ability to maintain an appropriate problem-solving strategy to attain future goals; it encompasses behaviours such as planning, impulse control, inhibition of irrelevant responses, organized search, and flexibility of thought and action (Ozonoff, Pennington, & Rogers, 1991). The theory of executive dysfunction asserts that the difficulties facing individuals with autism are best explained by an inability to engage executive functioning. Finally, as Baron-Cohen (2002) postulated in the hyper-systemizing theory of autism, individuals differ in the degree to which they systemize (i.e., analyze the rules underlying a system in order to predict behaviour). The hyper-systemizing theory holds that individuals with ASD are only able to process information highly systemizable and law-governed information.

An evaluation of these contemporary theories will reveal that deficits related to theory of mind, executive functioning, and/or central coherence do not meet the criteria necessary to be considered the core deficit in ASD. Baron-Cohen (2006) has proposed the theory of hyper-systemizing, and while more research is necessary to explore the specificity and universality of this theory, its superior explanatory power suggests it is a promising new account of the core deficit in ASD. Thus, I will discuss the implications of hyper-systemizing theory in order to encourage the integration of theory, research, and practice.

Evaluation of Theories of ASD

Evaluation Criteria

Each theory will be examined according to the following three criteria: (a) explanatory power; (b) universality; and (c) specificity. In order to determine explanatory power, each theory will be examined to ascertain whether it is able to account for both the triad of impairments and the characteristics consistently associated with ASD. Ozonoff et al. (1991) argued that a primary deficit must be specific only to individuals with ASD and be universal across all individuals with ASD. The universality and specificity of a deficit are critical, as without them the deficit can only be considered a single feature of ASD rather than the underlying cause of the full pattern of features associated with ASD. For example, a deficit could not be considered primary if it was also found in another disorder; a primary deficit causes the full pattern of features associated with ASD and no other disorders share the full pattern of features associated with ASD. Consistent with Ozonoff et al.'s recommendations, I will review evidence of the specificity of each deficit limited to individuals with ASD and evidence of the universality of each deficit across all individuals with ASD.

The studies cited in the present article were located through the PSYC Info Database. I selected articles that provided information on the universality and/or specificity of the four theories being

reviewed, as well as articles that discussed the explanatory power of any of these theories. The selected articles were both theoretical and experimental.

Theory of Mind

Lack of theory of mind refers to the inability to attribute independent mental states to oneself or to others in order to explain or predict behaviour (Frith & Happe, 1994). Baron-Cohen, Leslie, and Frith (1985) conducted the research that underlies the theory of mind explanation of ASD. In their research, participants (20 children with ASD, 14 with Down syndrome, and 27 who were typically developing) watched a puppet play during which a marble was moved from a box to a basket while a character was absent. The researchers found that typically developing children of 3.4 years of age and children with Down syndrome could predict that the character held an incorrect belief (i.e., the marble is in the box) and use this incorrect belief to predict the character's behaviour (i.e., she will look in the box), whereas 80% of 11-year old children with ASD, whose intelligence was in the average range, showed no evidence of such an ability. Baron-Cohen et al. concluded that children with ASD did not appreciate the difference between their own and the puppet's knowledge, and asserted that this study strongly supported the hypothesis that individuals with ASD fail to employ a theory of mind, and that they are unable to represent mental states. Based on this research, the authors developed a theoretical framework implicating lack of theory of mind as the primary deficit of ASD. However, in the original experiment, 20% of participants with ASD were able to attribute a false belief to the character, thus demonstrating theory of mind and, consequently, making the universality of theory of mind questionable.

Recognizing this as a weakness in his theory, Baron-Cohen (1989) conducted another study to attempt to resolve this dilemma. In the subsequent study, participants (10 with ASD, 10 with Down syndrome, and 10 typically developing) who had successfully passed the first-order theory of mind tests were tested on second-order theory of mind tests. The mean age of the individuals with ASD was 15.3 years. The first-order tests measured the ability of the participants to think about another person's thoughts of an objective event, while second-order tests measured their ability to think about another person's thoughts about a third person's thoughts (e.g., "What did Jenny think John thought?"). Baron-Cohen found that none of the participants with ASD were able to successfully answer the second-order theory of mind tests which appeared to resolve the problem of universality. However, Ozonoff et al. (1991) have demonstrated that some individuals with ASD, between the ages of 8 and 20, are able to pass the second-order theory of mind tests. Their research suggests that deficits in theory of mind are not universal across individuals with ASD.

Furthermore, the specificity of theory of mind deficits to individuals with ASD has been challenged. Brune and Brune-Cohrs (2006) have reviewed recent studies and found that individuals with schizophrenia, bipolar affective disorder, some forms of dementia, "psychopathy", and other psychiatric disorders are noted to have deficits in theory of mind. In addition, Baron-Cohen (1989) determined that 10% percent of the participants who were typically developing and 40% of the Down syndrome participants were unable to successfully answer the second-order theory of mind tests.

Concerns have also been raised with respect to the ability of theory of mind to fully account for the pattern of symptoms in individuals with ASD. Frith (1989) asserted that lack of theory of mind accounts for social impairments, such that both are consequences of failing to understand other people in terms of what they think, feel, or want. She argued that communication failure is also an inevitable consequence of this deficiency. Frith and Happe (1994) claimed that deficits in theory of mind have most successfully addressed the triad of impairments; however, Joseph and Tager-Flusberg (2004) examined the degree to which individual differences in theory of mind could account for variation in the triad of symptoms evidenced in individuals with ASD. Thirty-one children with ASD, aged 5 to 14, were behaviourally evaluated with respect to their severity in the triad of impairments and were administered tests to assess their theory of mind. The three measures were parallel to the first- and second-order tests used in the research by Baron-Cohen et al. (1989). Results revealed that theory of mind accounted for variation in communication but did not account for variation in social impairment, or repetitive and stereotyped behaviour. The ability of theory of mind deficits to account for the nontriad features of ASD has not been

addressed. Frith and Happe (1994) asserted that theory of mind does not attempt to explain nontriad symptoms of ASD because it cannot do so. They suggested that weak central coherence together with lack of theory of mind could account most comprehensively for the full pattern of symptoms in individuals with ASD.

Central Coherence

The theory of weak central coherence asserts that ASD is characterized by an imbalance in the integration of information at different levels; individuals with ASD see the parts rather than a whole and lack the cognitive capacity to integrate the parts into a whole (Frith & Happe, 1994). Frith (1989) reviewed research on the cognitive profiles of individuals with ASD. The findings from this research demonstrated a pattern in the cognitive profile of individuals with ASD. Frith demonstrated that individuals with ASD have small islets of ability, and they often performed well when context was unimportant and demonstrated skill at rote learning. Further, she argued that these factors are most successfully accounted for by the theory of central coherence. Frith and Happe found that the strengths and weaknesses of cognition in individuals with ASD all had a common denominator. Such individuals performed much better on tasks requiring attention to one piece of information than on tasks where they were required to pull together information. The theory that central coherence is weak in individuals with ASD can explain this pattern of abilities.

Subsequent researchers have challenged the assertions of weak central coherence theory. Norbury (2004) conducted two experiments to explore the ability of 9- to 17-year olds with ASD to use contextual information to identify the meaning of ambiguous words. Participants included 20 individuals with language impairment, 20 individuals with ASD, 28 individuals with both ASD and language impairment, and 28 individuals who were typically developing. The first experiment was designed to investigate participants' knowledge of multiple meanings of ambiguous words; the findings suggested that participants were aware of both the dominant and the subordinate meanings of such words. In the second experiment, the same words were presented in a sentence and participants were asked to identify which meaning was more syntactically appropriate. It was found that children with ASD who did not have language impairments took advantage of context as much as their typically developing peers. This finding was inconsistent with the predictions made by the weak central coherence account of ASD.

The results of research by Hoy, Hatton, and Hare (2004) were also inconsistent with predictions made by the theory of weak central coherence. In this experiment, 17 children with ASD, and 17 typically developing participants, all between 4 and 9 years of age, were asked to complete two tasks. The first involved identifying the meaning of a homophone when a context was given, while the second was a visual illusion task. In the illusion task, individuals who process the whole picture as opposed to the details are less likely to be able to identify the illusion. Results for the homophone task were consistent with research conducted by Norbury (2004). This research indicated that, when differences in receptive verbal ability were controlled, the individuals with ASD did not differ from their typically developing peers. Similarly, Hoy et al. did not find any difference between the two groups' performances on the illusion task. These two research projects demonstrated that individuals with ASD are able to attend to the gestalt, suggesting that weak central coherence is not a universal feature of ASD.

Furthermore, a recent review reveals that central coherence does not meet the criteria of specificity. Happe and Frith (2006) documented the finding that individuals with schizophrenia, Williams syndrome, depression, and right-hemisphere damage share the feature of weak central coherence. In response to empirical findings, Happe and Frith have recently reconfigured their conceptualization of the theory of central coherence. As opposed to Frith's (1989) original conception of a core deficit, they suggested that weak central coherence is a secondary outcome to some other core deficit, and is only one aspect of cognition alongside deficits in social cognition.

Executive Functioning

A lack of executive function refers to the inability, on the part of individuals with ASD, to maintain an

appropriate problem-solving set for attainment of a future goal. Executive functioning includes behaviours such as planning, impulse control, inhibition of irrelevant responses, organized search, and flexibility of thought and action (Ozonoff et al., 1991). Ozonoff et al. conducted a study to help identify the nature of the primary deficit(s) underlying ASD. They presented the results of a battery of tests on a group of 8- to 20-year-olds with ASD. The participants (23 children with and 20 without ASD) were tested in four different domains: emotions perception, theory of mind, executive function, and discriminant domains. Executive function tasks involved the Tower of Hanoi task, which measured planning and inhibitory behaviour, and the Wisconsin Card Sorting Test, which measured the ability to flexibly modify incorrect strategies and to inhibit incorrect responses. The researchers sought to address two questions: First, do deficits in these domains exist both in individuals with high-functioning and low-functioning ASD? Second, do one or more of the deficits appear primary to ASD; for example, were deficits related to theory of mind or executive functioning universal across individuals with ASD and specific to individuals with ASD? The study found that individuals with high-functioning ASD had selective deficits in executive function, theory of mind, emotion perception, and verbal memory. Ozonoff et al.'s original hypothesis was that impairments in theory of mind were primary to ASD, while executive function impairments were a correlated deficit. However, they found that while executive function and theory of mind deficits were significantly more widespread among the participants with ASD than the other deficits, impairment on theory of mind tasks was present in only a subset of the group, whereas impairments in executive functioning were present in the entire group. The researchers argued that the universality of the executive function deficits found in the sample of individuals with ASD suggests that it might be the primary deficit of ASD.

Other researchers have failed to replicate the finding that executive function deficits are universal across all participants with ASD. Hughes, Russell, and Robbins (1994) conducted a study where individuals between 7- and 18-years of age were presented with two tests that measured different aspects of executive functioning: set-shifting and measured planning. Set shifting was measured using the Intradimensional-Extradimensional set shifting task. This task required participants to learn a rule to discriminate between two objects, and then learn a new rule that was incompatible with the first to discriminate between the same two objects. The Tower of London planning task measured planning by asking participants to mentally pre-plan a sequence of moves to ensure that their set of discs ended up matching the stimulus pattern. In this study, 6 of 35 children with ASD, compared to 10 of 38 children without ASD, demonstrated set-shifting abilities. As well, 2 of 35 children with ASD, compared with 5 of 38 children without ASD, demonstrated planning abilities. These results challenged both the universality and the specificity of the executive dysfunction account of ASD.

Happe, Booth, and Charlton (2006) compared IQ- and age-matched participants with either ASD ($n = 32$), attention deficit hyperactivity disorder ($n = 30$), or who were developing typically ($n = 32$) on a range of executive functioning tests. Participants were between 8 and 16 years of age. The results revealed that individuals with attention deficit hyperactivity disorder (ADHD) showed greater inhibitory problems when playing a computer game set in the context of war. They were instructed to respond to all airplanes in a computer game but not to respond to bombs. The researchers found that individuals with ADHD had difficulty inhibiting their responses to bombs. Individuals with ASD showed greater problems in response selection and monitoring when asked to estimate the length, area, density, or duration of everyday objects or events for which no exact answer is likely to exist in their memory. Notably, they found that the participants with ASD who were between 11 and 16 years of age outperformed the ADHD group. Furthermore, they performed as well as their typically developing peers on many executive functioning measures. This research highlighted three important concerns with respect to executive functioning. First, within the broad umbrella of executive functioning, there are areas that are difficult for individuals with ASD and areas that are not. This suggests that executive functioning, in general, is not impaired in individuals with ASD, but that some components of executive functioning tasks might be difficult. Second, as the older participants with ASD did not demonstrate executive functioning impairments, these impairments are evidently not universal across individuals with

ASD. This finding is consistent with research by Hughes et al. (1994). Finally, the presence of greater executive functioning impairments evidenced in participants with ADHD on some measures challenges the specificity of this deficit. This is consistent with findings by Zelazo, Carter, Reznick, and Frye (1997), who noted that executive function accounts have now been offered for several disorders with a childhood onset. These include ADHD, obsessive-compulsive disorder, and Gilles de la Tourette syndrome. Hill (2004) has also noted the utility of this theory as a primary deficit account of ASD is limited, given that executive dysfunction is found in conditions other than ASD. The explanatory power of this theory has also been questioned.

Hughes et al. (1994) investigated the ability of executive dysfunction to account for pattern of symptoms evidenced in individuals with ASD. They argued that rigid routines or a strong resistance to change could be explained by lack of flexibility, which is a feature of executive dysfunction. They also proposed that conversation requires the ability to integrate diverse knowledge bases and that an executive dysfunction would impair this ability. Joseph and Tager-Flusberg (2004) investigated whether differences in executive functioning could account for variation in the triad of symptoms evidenced in individuals with ASD. Thirty-one children with ASD, ranging 5 to 14 years of age, were behaviourally evaluated with respect to their level of severity in the triad of impairments and were administered a battery of tests to measure their levels of executive functioning. Participants were administered measures assessing working memory, asked to respond according to an arbitrary rule while inhibiting a natural response, and asked to mentally pre-plan a sequence of moves to arrive at a final goal. Results revealed that while executive dysfunction accounted for variation in communication, it did not account for variation in social impairment, or repetitive and stereotyped behaviour. These findings supported earlier claims by Joseph (1999) that for executive dysfunction to provide a convincing alternative to the theory of mind view, it will need to account for the social impairments that are central to the disorder.

Hyper-Systemizing

The hyper-systemizing theory holds that individuals with ASD are only able to process information that is highly systemizable (i.e., information that follows predictable laws and rules). Some information is highly lawful, or systemizable, such as a mathematical formula, and other information is not highly lawful, such as interpreting others' emotions. Recently, Baron-Cohen (2006) has proposed a new theory of ASD. According to this theory, all individuals are situated along a continuum in their ability to process and structure information. Individuals on the high end of the continuum can only process information that is highly systemizable, while individuals on the low end of the continuum can process information even if it does not have an evident and predictable structure. On the systemizing continuum (levels 1 to 8), Baron-Cohen argued that individuals with ASD are on the extreme high end of the continuum, from levels 5 to 8. Furthermore, he posited that the higher the individual's placement on the continuum, the lower his/her functioning will be. For example, an individual with extremely low functioning autism would be rated a level 8 on the continuum, and an individual with Asperger's syndrome would be rated a level 5 on the continuum.

Furthermore, Baron-Cohen (2006) argued that hyper-systemizing theory has the power to account for the pattern of symptoms evidenced in individuals with ASD. An individual who is a hyper-systemizer would attempt to systemize everything and would only process information that he/she was able to systemize. Given that many aspects of an environment are too complex and unpredictable to be systemized, such individuals would focus on systems that are predictable and law-governed, providing an explanation for the triad of impairments. Social withdrawal would result from an inability to systemize the social world, severe language delays would result from the variability in the structure of language, and repetitive and stereotyped behaviour would provide comfort, as this behaviour, by definition, is highly law-governed and predictable (Baron-Cohen). Nontriad symptoms of ASD can also be explained by this paradigm. Islets of ability would be the natural consequence of immersion into a system that is lawful. The need for sameness is the individual's attempt to create a world that is systemizable. Finally, the reduced ability to generalize would result from a reluctance to formulate a law until there has been sufficient data collected. Therefore, each new concept would need to be formulated independently. In addition to being able to account for the full pattern of symptoms associated with ASD, this theory can account for weak central

coherence and executive functioning. Baron-Cohen (2006) argued that tasks which draw on central coherence and executive functioning require the ability to process information that is not highly systemized. As such, performance indicating weak central coherence and executive dysfunction could be reinterpreted as the performance of a hyper-systemizer who is unable to process information that is not highly systemized.

While Baron Cohen's (2006) theory has demonstrably superior explanatory power than other proposed theories of ASD, research is necessary before an evaluation of its specificity and universality is possible. The empirical support for this theory came from research that assessed the systemizing quotient in the general population, in individuals with high-functioning ASD, and in individuals with Asperger syndrome. No research to date has compared the systemizing quotient of individuals in the general population with that of individuals with ASD. Nevertheless, the ability of this theory to account for both the triad and nontriad impairments in ASD, in a parsimonious way, suggests that this is a fertile new direction for future research.

Future Research

Continued research is required in order to fully investigate the validity of the hyper-systemizing account of ASD. Specifically, it is not known whether this theory would provide universality across individuals with ASD, in addition specificity to only individuals with ASD. Baron-Cohen's (2006) prediction that there is an association between functioning of individuals with ASD and their placement on the systemizing quotient requires further examination. Further research investigating the effectiveness of interventions designed on the basis of hyper-systemizing theory is also essential. Another promising avenue for future research is to integrate findings from neurological research to discover what is known about the common phenotype evidenced in individuals with ASD. While Baron-Cohen has asserted that genes and other biological factors are responsible for levels of systemizing, he has yet to propose the mechanism that maps the relationship between the biological factors and the behavioural features. The types of neurological activity that might account for hyper-systemizing will require further investigation.

Coleman (2005) reviewed research aimed at identifying a neurological basis for ASD and concluded that the available evidence suggested that the deficits resulting in the ASD phenotype are likely due to abnormally varied neural circuits or to abnormality in network components of more standard neural pathways. Persico and Bourgeron (2006) conducted an extensive review of neurological research and concluded that ASD is the result of altered neuronal migration, abnormalities in the formation of synapses, and abnormalities of neuron structure, including abnormal dendritic structure. This combination of abnormalities paints a general picture of aberrant cortical connectivity. More recently, Courchesne et al. (2007) conducted the first review of research exploring the neurological correlates of ASD in young children. They demonstrated that children with ASD tend to have early brain overgrowth at the beginning of life and an arrest or slowing of brain growth in later life. They proposed that this overgrowth is the result of an excess of neurons. They argued that this excess of neurons generates excessive local excitation that impedes signals from distant brain regions.

If a coherent picture of the deficits underlying ASD is to be developed, neurological researchers should explore the ways in which their findings are manifest in behaviour. Hyper-systemizing theory might provide a useful framework for conceptualizing this relationship. Future researchers could explore the prediction that individuals higher on the systemizing quotient display more aberrant cortical connectivity and a greater early excess of neurons. The development of a coherent picture to improve our understanding of the cognitive profile of individuals with ASD is critical to empowering practitioners to ensure that the environment and education is accessible to this population.

Educational Implications

The utility of a theory lies in its ability to aid in the development of more effective practice. Although

deficits in theory of mind, executive function, and central coherence are widespread in individuals with ASD, they are not primary deficits. This finding implies that intervention directed towards individuals with ASD should be aimed towards improving their abilities in these three areas, but should not be focused exclusively on any one.

Early intensive behavioural intervention (EIBI) is currently a widely advocated and employed intervention for children with ASD. McEachin, Smith, and Lovaas (1993) followed-up an earlier study by Lovaas (1987) and found that, after an intensive behavioral intervention (IBI), an experimental group of 19 preschool-aged children with ASD achieved less restrictive school placements and higher IQs than did the control group. McEachin et al. (1993) subsequently assessed participants at a mean age of 11.5 years. Results demonstrated that the experimental group preserved its gains over the control group. Of the nine experimental participants who had achieved the best outcomes at seven years of age, eight of them were indistinguishable from their peers on tests of intelligence and adaptive behaviour. The researchers suggested that intensive early intervention, a behavioural intervention using discrete trial training, could compensate for neurological anomalies in children with ASD.

Discrete trial training involves categorizing teaching into steps and, systematically and repetitively, teaching each step. The hyper-systemizing account of ASD would predict that an effective intervention be implemented systematically and would present relevant information in a rule-oriented format. It is, therefore, possible that the success of the EIBI lies not in its systematic control of consequence but in the congruence between the systematic teaching style, characteristic of a behavioural approach, and the learning style of individuals with ASD. This implies that there is more room for flexibility in the design of such intervention than McEachin et al. (1993) contended. The hyper-systemizing account of ASD, then, would shift the focus of the intervention away from considerations of reinforcing desirable behaviours or punishing undesirable behaviours to presenting information in a systematic rule-governed manner. This shift would allow for many adaptations to the current EIBI model. For example, EIBI is traditionally conducted individually, with one therapist for every child (McEachin et al.). This model ensures that the children receive reinforcement whenever they obtain a correct response. Once children are school-aged, however, this treatment usually ceases (Hess, Morrier, Heflin, & Ivey, 2008), possibly because schools are largely not equipped to provide one-on-one instruction to all their students with ASD and are, therefore, at a loss in how best to approximate EIBI in the schools. A treatment based on hyper-systemizing theory would provide a framework for instruction for children with ASD in the schools.

Information presented in classrooms could be presented in a systematic, rule-governed manner, and children with ASD could still benefit from the principles underlying the success of EIBI. In order for children to benefit, teachers need to be cognizant of using language that could be easily systematized. For lower functioning children this process includes using pictures to help them understand exactly what each word means in the most concrete and systemizable way possible. For more high-functioning children this process might simply involve using language that has one predictable meaning. Rules need to be explicitly provided. Reading programs and math programs have to be designed to teach skills in a law-governed manner. For reading, it is critical to highlight that much of reading is law-governed and provide explicit instructions on those predictable rules as well as the exceptions to the rules. Once children with ASD are able to read, their reading ability could be a useful tool for further teaching. Explicit rules to help them complete assignments could be written out and made accessible for them to refer to. When a task requires knowledge of activities that are not law-governed, such as reading comprehension where an understanding of a characters feelings are involved, the instructor needs to be aware that this task will be difficult and provide his/her students with some written suggestions for rules to follow in helping them understand the emotions of others. Teachers would need also to be aware that students with ASD might need more support to prepare for a class in which more abstract, less systemizable information is being presented.

The hyper-systemizing theory opens up many avenues to explore in the creation of more effective interventions. While this is a promising new theory, it has not yet been fully established. It is essential that practitioners and teachers constantly observe and question the effectiveness of interventions and

instruction that are designed in accordance with hyper-systemizing theory. Future research regarding the effectiveness of interventions designed in accordance with hyper-systemizing theory would provide critical information with respect to its utility.

Conclusion

The current review contributes to the existing literature by offering an examination and evaluation of four contemporary theories in understanding the phenotype of individuals with ASD. Identifying which of these theories most accurately portrays the deficit underlying ASD is critical to guiding early identification of ASD and effective instruction for individuals with ASD. This paper has demonstrated that, although deficits in theory of mind, central coherence, and executive functioning have provided researchers and educators with a more thorough understanding of the symptoms underlying ASD, they have failed to satisfy the necessary criteria to be a comprehensive theory of ASD. Hyper-systemizing theory has superior explanatory power, such that it is able to account for both triad and nontriad symptoms evidenced in individuals with ASD. However, additional research is essential before an assessment of its utility is possible. Future research directions include exploring the universality and specificity of hyper-systemizing to individuals with ASD, assessment of the utility of hyper-systemizing as a framework for aberrant cortical connectivity, and assessment of the utility of hyper-systemizing in the design of effective intervention for individuals with ASD. Hyper-systemizing theory predicts that if educators presented material to their students with ASD in a law-governed format, these students would be able to process and engage in their education. This theory provides several promising implications for improving the education of students with ASD.

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