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Evaluating information processing in Autism Spectrum Disorder: The case for Fuzzy Trace Theory

Haylie L. Miller [a,*], Timothy N. Odegard [b], Greg Allen [c]

[a] Department of Physical Therapy, University of North Texas Health Science Center, United States
[b] Department of Psychology, University of Texas at Dallas, United States
[c] Department of Educational Psychology, University of Texas at Austin, United States

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ABSTRACT

Literature on the developmental trajectory of cognition in Autism Spectrum Disorders (ASD) presents several inconsistent findings. In this review, we focus on information processing, and specifically, the use of gist and verbatim representations to guide memory, reasoning, and concept formation. The added perspective of Fuzzy Trace Theory may help to resolve mixed results regarding the frequency, nature, and effectiveness of gist processing in ASD by providing established process models and tasks suitable for use in individuals at all levels of functioning. In order to demonstrate the utility of FTT to the field of ASD research, we present evidence from three complementary theories–Weak Central Coherence (WCC), Executive Function (EF), and Theory of Mind (ToM)–which have dominated the landscape to date. We discuss the potential utility of FTT tasks and process models, proposing testable hypotheses that address ambiguous or conflicting results in the current literature. Applying a theory of typical development to the study of ASD may add value to past and future research.

Introduction

For over 20 years, three dominant theories provided the foundation for studies of cognitive development in Autism Spectrum Disorder (ASD). Weak Central Coherence (WCC; Frith, 1989; Frith &

* Corresponding author. Address: Department of Physical Therapy, 3500 Camp Bowie Blvd., Fort Worth, TX 76107, United States.
E-mail address: haylie.miller@unthsc.edu (H.L. Miller).

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Happé, 1994; Happé & Frith, 2006), Executive Function (EF; Hill, 2004), and Theory of Mind (ToM; Baron-Cohen, Leslie, & Frith, 1985) each provide a useful basis for understanding the unique cognitive profile of ASD. However, studies of these theories have produced inconsistent results. As this area of developmental research grows, it is necessary to look beyond prevailing perspectives to resolve conflicting findings in the current literature.

Fuzzy Trace Theory (FTT; Reyna & Brainerd, 1995) offers a wide range of complementary process models and tasks that may help to place our understanding of ASD in a broader context (Bauer, Larkina, & Deocampo, 2011; Howe, 2011; Raj & Bell, 2010; Schneider, 2011; Shing & Lindenberger, 2011). FTT describes the developmental shift from reliance on *verbatim representations*, or detailed encoding of information as it was presented, to *gist representations*, or broader encoding of the pattern of associated concepts related to the original input (Brainerd & Reyna, 1992; Reyna & Brainerd, 1991a, 1991b).

Viewing ASD through the lens of a well-characterized theory of cognitive development such as FTT may prove useful, as the trajectory of cognitive skill acquisition and refinement in this developmental disorder remains unclear. Despite neuroanatomical and neurophysiological differences in ASD, the deficits experienced by this population are not indicative of overall delay or dysfunction across all cognitive skills. In fact, individuals with ASD consistently score within normal range on tests of cognitive function, although mean scores often differ from those of typically-developing controls (Bennetto, Pennington, & Rogers, 1996; Griebling et al., 2010; Minshew & Goldstein, 2001; Mottron, Morasse, & Belleville, 2001; Siegel, Minshew, & Goldstein, 1996; Williams, Goldstein, & Minshew, 2006). Notably, standard IQ tests rely heavily on verbal presentation of items and verbal responding. Given the frequent occurrence of language delay or impairment in this population (American Psychiatric Association, 2000; CDC, 2008), these tests likely underestimate cognitive ability in ASD.

Individuals with ASD also exhibit inconsistent performance on tests of cognitive ability that rely less on verbal prompting or response, such as those measuring nonverbal IQ (NVIQ). For example, individuals with ASD typically have lower NVIQ scores on Wechsler intelligence tests (i.e., WASI, WISC, WAIS) than on Raven's Progressive Matrices (RPM; Bölte, Dziobek, & Poustka, 2009; Dawson, Soulières, Gernsbacher, & Mottron, 2007; Soulières, Dawson, Gernsbacher, & Mottron, 2011). While Wechsler NVIQ scores may underestimate cognitive ability in ASD, studies of performance on the RPM clearly demonstrate that individuals with ASD have the ability to process complex information sets and abstractions (Dawson et al., 2007). This discrepancy underscores the importance of understanding nuanced differences between the information processing styles of ASD and typical development, including strategies used for encoding, retrieval, and use of information.

Koldewyn, Jiang, Weigelt, and Kanwisher (2013) demonstrated that individuals with ASD could encode both independent pieces of information and associative, higher-order relationships as effectively as typically-developing controls under optimal conditions. However, they do not appear to call upon global-level representations of information in the same way or with the same degree of automaticity observed in typical development. A recent neuroimaging study also found differences in network activation during local versus global information processing, suggesting a neural underpinning to these differences in cognitive style (Gadgil et al., 2013). Further study is needed to identify specifically which processes or neural networks in ASD produce difficulty in spontaneously using complex sets of associated information to guide responding under certain conditions (Bennetto et al., 1996; Bigham, Boucher, Mayes, & Anns, 2010; Minshew & Goldstein, 2001; Williams et al., 2006).

Cognitive features of ASD

The Diagnostic and Statistical Manual of Mental Disorders (5th edition) describes two core features of ASD: (1) persistent deficits in social communication and social interaction across contexts, and (2) restricted, repetitive patterns of behavior, interests, or activities (DSM-5; American Psychiatric Association, 2013). Both core features relate to the ability to effectively use gist representations to guide behavior. With regard to social communication and interaction, gist-based information processing enables individuals to transfer skills to multiple contexts, strategize based on prior experiences, and make associative connections between related concepts. Similarly, while restricted, repetitive patterns