Accessing Meaning of Ambiguous Homographs Embedded within Sentences

in Children with ASD

Ryan Beabout

Marietta College

A Thesis Submitted to the Faculty of

Marietta College

In Partial Fulfillment of the Requirement for the Degree of

Masters of Arts in Psychology

August 2015
Accessing Meaning of Ambiguous Homographs Embedded within Sentences
in Children with ASD

Ryan Beabout
Marietta College

This thesis has been approved for the Department of Psychology
of Marietta College by

Dr. Christopher L. Klein, Ph.D.
Thesis Committee Chair

Dr. Mary V. Barnas, Ph.D.
Thesis Committee Member
Abstract

Comprehension deficiencies are problematic in individuals with autism, yet the cognitive atypicalities of these impairments are still not well understood. To date, evidence pertaining to the ability of children with Autism Spectrum Disorder (ASD) to process verbal information in context remains mixed, and has mainly focused on pronunciation tasks. This study investigates how children with autism can use meaning activation of word primes to disambiguate target homographs inserted in the context of sentences at automated (300ms) and controlled (1000ms) stimulus onset asynchronies (SOAs). Individuals with ASD and controls were presented with semantically related or unrelated primes for homograph targets. The current study compared reaction times and accuracy pertaining to the relatedness of the primes, while also exploring meaning activation at involuntary and voluntary stages of processing.
Table of Contents

Abstract .................................................................................................................. 3
Acknowledgements ............................................................................................... 5
Introduction ............................................................................................................ 6
Theory of Mind ....................................................................................................... 6
Weak Central Coherence in ASD ......................................................................... 7
Executive Function in ASD .................................................................................... 9
Verbal Processing in ASD ..................................................................................... 11
Purpose of the study .............................................................................................. 17
Hypotheses ........................................................................................................... 18
Method .................................................................................................................. 19
Participants .......................................................................................................... 19
Materials .............................................................................................................. 20
Procedure ............................................................................................................. 23
Results ................................................................................................................. 25
Discussion ............................................................................................................. 27
References ........................................................................................................... 37
Tables .................................................................................................................... 41
Figures ................................................................................................................. 45
Acknowledgements

Firstly, I would like to express my sincere gratitude to my advisor Dr. Chris Klein for the continuous support of my thesis study for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing for this thesis. I could not have imagined a better mentor and advisor for my thesis study. This is the first study I have done on my own and all the feedback concerning insight to my project was extremely useful. He has made me a better critical thinker as well as a better researcher.

Besides my advisor, I would also like to thank Dr. Barnas for being apart of my thesis committee. She has provided me insightful comments and encouragement, while also asking the hard questions. This incentivized me to widen my research from various perspectives and think about it in different ways.

I thank every member of my fellow cohort for the late nights we spent in the lab, the time we spent together outside of class, and for all the fun we had in the last two years. We built great friendships together over the course of two years at Marietta College and these friendships will last a lifetime.

Last but not least, I would like to thank my parents for supporting me during my two years at Marietta, throughout the writing of my thesis, and my life in general.
Accessing Meaning of Ambiguous Homographs Embedded within Sentences in Children with Autism

Autism Spectrum Disorder (ASD) is a developmental disorder that is best represented by a two domain model concerning deficits in social communication and restricted and repetitive behavior/interests. (American Psychiatric Association, 2013). Considerable research focus has been directed towards the cognitive atypicalities that may account for impairments associated with ASD. The Theory of Mind (ToM) model (Baren-Cohen, Leslie, & Frith, 1985) proposes that autism is caused predominantly by an inability to represent mental states to one’s self and to others. Alternatively, others have proposed that deficits in autism are due to a weak central coherence (WCC) (Frith, 1989, 2003; Frith & Happe, 1994), or lack of executive functioning (EF) (Hughes & Russel, 1993; Oznoff, Pennington, & Rodgers, 1991). The commonality between these two accounts is the assumption that there is a core deficit in verbal processing in ASD. Individuals with ASD show a wide range of communication deficiencies often involving language comprehension. Currently, the cause of language comprehension deficiencies in individuals with ASD is still not fully understood. Comprehension depends on many cognitive processes, and can fail due to many reasons. The aim of this study was to examine the cognitive processes that underlie verbal comprehension abilities in persons with ASD. More specifically, the current study utilized semantic priming to assess the ability of individuals with ASD to use word meaning to disambiguate homograph word targets.

Theory of Mind

The Theory of Mind account proposes that individuals with ASD lack the tendency to be able to attribute mental representations to self and others in order to make predictions and explanations about behavior (Baren-Cohen, Leslie, & Frith, 1985). This theory is extremely useful in the study of child development because it provides a causal account that specifically
focuses on the impairments associated with ASD and tries to make links between the behavioral symptoms of ASD. It makes predictions concerning the deficits in areas such as communication, socialization, and imagination in individuals with ASD (Leslie, 1987). The main idea is that individuals with ASD lack the ability to “mentalize”, which called upon a mentalizing-deficit account to address the impaired and unimpaired communicative and social behaviors of individuals with ASD due to this “mind blindness.” Impairments concerning the ToM can have profound impacts on the social relationships of children with ASD, as emotional and behavioral responses depend on understanding another person’s mental state. This model is powerful because it was the first to make fine predictions regarding the continuum of behaviors in individuals with ASD, and also explains the social and communicative behavior in these individuals compared to typically developing children. The main limitation of the ToM account is that it does not give a full explanation of ASD; more specifically, it lacks a complete framework for explaining basic cognitive differences in persons with ASD. The mentalizing account has provided a strong understanding concerning deficits in social interaction, and communication. However, this account cannot provide a clear explanation concerning non-social task and non-triad impairments based on the older DSM diagnostic criteria for autism such as restricted repertoire of interests, obsessive desire for sameness, and savant abilities. Additionally, research has also shown that some individuals with ASD can pass ToM measures consistently such as the Sally-Ann task and ordering pictures or stories involving mental states (Ozonoff, Rodgers, & Pennington, 1991). For these reasons, two other models that account for cognitive impairments in individuals with ASD have been postulated.

**Weak Central Coherence in ASD**
The WCC model (Frith 1989, 2003; Frith & Happe, 1994) makes an argument that people with ASD lack the natural propensity to process information in context at a global level. Rather, individuals with ASD integrate information on a more local level of processing. This claim provides a theoretical framework for the empirical findings of the increased ability shown by individuals with ASD on visuo-spatial measures that require detailed rather than global information processing as compared to typically developing individuals (Frith, 1989; Happe, 1994, 1996; Snowling & Frith, 1986). Many studies have contributed convergent evidence for children with ASD showing superior performance compared to typically developing children on tasks that require the ability to ignore global information, such as the Embedded Figures Test (Shar & Frith, 1983) and the Wechsler Block Design (Shar & Frith, 1983). Conversely, evidence from other studies show inconsistencies with the WCC model of autism, where no superiority of performance was found in children with autism in relation to typically developing children (Ozonoff, Pennington, & Rodgers, 1991).

These inconsistent findings can best be understood by comparing evidence in which deficits do and do not occur. The studies that support evidence for failure of global processing often involve patterns of semantic deficiencies such as sentence processing (Happe, 1997) and semantic memory (Tager-Flusberg, 1991). Alternatively, the studies that fail to show differences between ASD and typically developing samples use visuo-spatial measures such as illusions (Ozonoff, Strayer, McMahon, & Filloux, 1994) or exposure to semantic information presented visually (Lopez & Leekam, 2003). These mixed results can be best explained by examining the conceptualization of global processing across these cognitive tasks.

The WCC theory has interpreted deficiencies in global processing both in terms of a semantic deficit related to reading and memory measures and in terms of a failure to extract
perceptual information from studies utilizing visuo-spatial measures (Happe, 1996). The difficulty with global processing in individuals with ASD can be explained as a difficulty with context. The evidence that exclusively relates to this impairment in using contextual information is found utilizing tasks that involve verbal processing, such as in studies in which individuals with ASD show failure in the recall of semantically related words (Tager-Flusberg, 1991) and the utilization of contextual information when reading homographs in measures that involve sentence processing (Frith & Snowling, 1983). The results of both of these studies explain that impairments in global processing are due to a lack of the capacity to integrate information in context due to forming meaningful connections between verbal items (Happe, 2000).

Studies demonstrating superior performance from individuals with ASD as compared to typically developing children on visuo-spatial task such as the Embedded Figures Test (Shah & Frith, 1983), Block Design Task (Shah, & Frith, 1983), and visual illusions (Ozonoff, Strayer, McMahon, & Filloux, 1994) utilize advantageous measures that require the ability to ignore global features of information and focus on more local features. These tasks require individuals to focus on featural levels of information, and do not require individuals to integrate these local details into global entities. This fits with the idea of the WCC theory in that individuals with ASD tend to process information in a piecemeal like fashion. Thus, the exact essence of WCC in explaining difficulties with global processing has yet to be established. However, the data that corresponds exclusively to this failure stem from the studies that examine verbal processing and complications with processing context. One explanation of these mixed findings is that individuals with ASD may have more of a specific executive functioning (EF) deficit that compromises comprehension.

**Executive Functioning in ASD**
Welsh (1991) defined the term executive function as goal directed behavior, planning, and impulse control that are moderated by the pre-frontal cortex (Welsh, Pennington, & Grossier, 1991). Considerable amounts of research (Ozonoff et al, 1991; Hughes & Russel, 1993; Hughes, et al 1994; & Oznoff et al, 1994) have all found evidence that individuals with ASD often have trouble on executive measures, specifically on measures that require the use of working memory resources associated with the ability to inhibit appropriate actions (Roberts & Pennington, 1996). Ozonoff (1997) confirms that this impairment of executive dysfunction is specifically related to measures that combine working memory and inhibitory control in individuals with autism. This evidence suggest that individuals with ASD may have a more distinct EF deficit preventing the suppression of distracting information which has a direct affect on their ability to comprehend contextual information. This is important because EF determines the extent to which individuals can exert top-down control over cognitive processing. Top-down control is especially crucial in later stages of semantic processing, when the meaning of verbal information needs to be retrieved and used for further contextual processing. When comparing the two accounts of WCC and EF in individuals with ASD, the measures of WCC can overlap as EF measures in some instances. The argument here is that at least some of the measures of WCC can be recast as executive tasks. Of particular interest in the current study are the measures of WCC that evaluate the comprehension of ambiguous words embedded in the context of sentences. These studies all use pronunciation tasks to assess whether individuals with ASD make use of sentence context in pronouncing a homograph (Frith &Snowling, 1983, Happe, 1997, Lopez & Leekam, 2003). However, these sentence-processing tasks pose significant executive challenges because children with ASD must inhibit any response to use the most frequent pronunciation of the ambiguous word, while at the same time keeping the sentence context in working memory.
Verbal Processing in ASD

Some studies have evaluated verbal processing in individuals with ASD using tasks that require the ability to enunciate homographs that are embedded in a sentence comprehension task (Frith & Snowling, 1983; Happe, 1997; Lopez & Leekam, 2003). A homograph is a linguistic term that is defined as a group of words that are spelled the same way, but differ in origin, meaning, and often times, pronunciation. For example, the word *close* could refer to the action to shut, or could refer to something nearby.

Frith (1983) tested 8 children with autism who had reading levels who had approximate reading levels of 8-10 year-olds, and compared them to two control groups of dyslexic and typically developing children on a context appropriate task (Frith & Snowling, 1983). The rationale behind this task is that in order for individuals to choose the correct context appropriate pronunciation, the individual must be able to process the final word as part of the whole meaning of the sentence. For example, take the following two sentences *He had a pink bow; He made a deep bow*. For an individual to be able to process the previous sentences he or she must be able to process the final word as a whole part of the sentence, thus evaluating global processing. In a comparison of accuracy, children with autism tended to give a more common enunciation, without regard to context. These results suggest that while individuals with autism may be superior at decoding single words, impairments were visible when context had to be used, implying a use of piecemeal processing.

Happe (1997) expanded the evidence pertaining to the WCC theory in relation to extracting meaning in context. Happe assessed 16 high functioning individuals with ASD, and compared them to a control group of typically developing children on a homograph-reading task in which pronunciation of a target word was determined by integration of whole sentence
context. For example, *There was a large tear in her dress* versus *Johnny had a big tear in his eye*. The key difference between Happe’s (1997) and Frith’s (1983) study is the interest in whether individuals with autism would differ in accuracy of the homograph based on positioning of sentence context. The results of Frith’s (1983) study found that typically developing children were more responsive to the position of target homographs and disambiguous context. The typically developing children showed greater benefit when sentence context occurred before (rare pronunciation) target words. Conversely, the children with ASD tended to ignore position of context, and gave the more frequent enunciation regardless if the homograph was rare and preceded context.

While these two previous studies are consistent with an imbalance in integration at global levels of processing, an alternative explanation concerning executive challenges can also be interpreted from the results. The participants in these studies were given ambiguous words to pronounce, while also having to store the context of the sentences in memory. The memory demand required of the individual with autism in these studies may have been set too high. Specifically, the tasks required individuals with ASD to use a combination of working memory and inhibitory control, exactly the dual demands Pennington (1996) claimed to be most problematic for children with ASD. More recent research efforts sought to reduce the executive load in sentence a processing task to gain a better understanding of the propensity of children with autism to use context to separate the ambiguous meanings of homographs (Lopez & Leekam, 2003; Hala, Pexman, Glenwright, 2007). These studies have utilized a semantic priming paradigm to investigate the same type of processing that is involved in sentence comprehension task, while simultaneously minimizing the executive demands of the task.
The semantic priming paradigm is a commonly used tool for investigating cognitive processes related to language, attention, and memory (e.g., Ochsner, Chiu, & Shacter, 1994). A typical semantic priming task consists of participants making responses (naming, lexical, etc) to a stimulus target. The stimulus target is normally preceded by a semantically related or unrelated word prime. Priming effects occur when responses toward semantically consistent targets (CAT-DOG) are faster/or more accurate than unrelated (FISH-HOUSE) prime-target pairs. Semantic priming effects occur when participants respond faster to semantically consistent information. Semantic priming can test automatic processing, which consists of facilitating the processing of prime-target pairs without awareness or minimal effort, or it can test more controlled operation of processing, in which participants rely on voluntary effort and strategic based mechanisms. (See Neely, 1991, for a full review of this literature).

Additionally, semantic priming tasks involving both automatic and controlled processing typically incorporate an automatic and controlled stimulus onset asynchronies (SOAs) to compare implicit and explicit meaning activation in children with autism. A good reason for incorporating an automatic SOA condition in this realm of research comes from research studies that demonstrate semantic processing difficulties in children with autism (Hermelin & O’Connor, 1967; & Toichi & Kamio, 2002). These studies found that individuals with autism have issues in semantic and syntactic attributes that assist recall for organized sentences. The premise of these studies suggest that individuals with autism do not encode stimuli meaningfully, consistent with evidence from Tager-Flusberg’s (1991) study which depicts encoding shortages in children with autism. More recent evidence found by Toichi (2002) suggests that deep levels of encoding rely on processing of the semantic aspects of material, which leads to an intensified memory recall. On the other hand, simplistic encoding processes depend on non-semantic features. Interestingly,
studies that have employed the semantic processing paradigms also have found consistent evidence demonstrating the preeminence of individuals with autism on simplistic levels of encoding (Toichi & Kamio, 2002), implying that children with autism may be superior at processing information that is provided quickly and involves little mental effort. Including a short SOA allows for comparisons between rapid and involuntary activation towards concepts and ideas with little mental effort, while long SOAs are used for voluntary activation that require full mental effort to process concepts and ideas.

Lopez & Leekam (2003) utilized a semantic priming measure with individuals with autism. In a series of studies, the researchers examined semantic processing in context using an integration of nonambiguous visual-spatial and verbal priming tasks in individuals with autism. Two experiments examined if proper context would facilitate word recognition in individuals with autism, compared with typically developing children in the visual domain. In a third experiment the researchers used a measure to test the recall of semantic category information in the both the visual and verbal domains. The results of the first three experiments showed that when individuals with autism and typically developing children were primed with pictorial and verbal nonambiguous stimuli, a reduction in reaction times occurred when the primes were semantically consistent with the targets in both the verbal and visual domains. This suggests that individuals with ASD took into account contextual information when connecting single items on the basis of meaning. This fails to support a case for a deficit concerning WCC, because performance of individuals with ASD did not differ significantly in performance when compared to that of typically developing individuals. In general, participants with ASD took into account context and were also sensitive to semantic category information, regardless of whether the information was either presented verbally or in the form of a picture. These studies only required
the individuals make meaningful connections between single items. This left the question as to whether or not persons with ASD are able to integrate multiple items of information in sentence context.

In a fourth experiment, Lopez & Leekam (2003) replicated the same homograph task utilized by Frith and Snowling (1983) to determine if the same individuals used in the first three experiments would have difficulty processing contextual information used in a sentence. The results of this final experiment were consistent with previous findings found by Frith (1983) and Happe (1997) in which individuals with ASD displayed a deficit in the use of contextual verbal information. Overall, the first three experiments in this study show evidence that individuals with ASD can make meaningful connections between single items of information. Additionally, when individuals with ASD are primed in their identification of nonambiguous stimuli, they are faster at responding when the primes were semantically related to the targets in the visual and verbal domains. However, results of the final study show that individuals with ASD failed to give the most context-appropriate pronunciation; rather, they gave the most frequently used enunciation of the homograph. Overall, these results pinpoint the specific deficiency in using context as a distinct deficit in using sentence context to make meaningful connections between multiple pieces of information, but not between single items.

Although Lopez and Leekam (2003) found discrepancies between children with autism and typically developing children in meaning activation concerning multiple pieces of information, they failed to test if these difficulties in integrating multiple pieces of information are due to processing ambiguous stimuli. Hala (2007) addressed this gap by assessing the semantic processing capability of individuals with autism on a single word semantic priming task using the five stimuli from Frith’s (1983) and Happe’s (1997) studies to disambiguate
homographs (dove, wind, row, bow, & lead) word targets. In this priming task, the researchers presented target homographs that were introduced either by a rare pronunciation or frequent pronunciation depending on the trial. The study examined whether children with ASD would be able to use the semantically related primes to disambiguate the homograph target. Additionally, they added non-homographs that were either semantically related (CAT-DOG) or unrelated (FISH-HOUSE), in order to validate that the ambiguously related target primes used would activate word meaning in the participants. The observation of semantic priming effects in the non-homograph target condition would provide evidence that the related primes could activate meaning in the homograph word targets.

The pattern of responses predicted in this study differs according to whether the explanatory model is one of the WCC or EF. If context deficits are explained by WCC, children with autism should not use the primes and make errors based on the most frequent pronunciation, as Happe (1997) found. Alternatively, if the problem is due to executive functioning, individuals with autism should correctly pronounce the homograph on the first presentation, but on the second presentation may have difficulties repeating that pronunciation because of difficulties in set shifting and inhibiting the first response towards that enunciation. The results of this study found that individuals with autism were as accurate as typically developing children in enunciating a target homograph that was related to the meaning of its prime during the first time it was displayed. This would imply that individuals with autism are using contextual information to disambiguate homographs, a conclusion that contradicts previous evidence (Snowling & Frith, 1986; Happe, 1997; & Lopez & Leekam, 2003) in which individuals with autism failed to use context, but relied on the most frequent pronunciation to disambiguate target words.
The second conclusion found in the Hala (2007) study supports the findings by Lopez & Leekham (2003) that children with autism were faster in pronouncing nonambiguous words that were semantically consistent with the target prime than those that were preceded by an unrelated prime. However, the conclusions drawn from this study are limited by the task provided to evaluate meaning activation of the response towards the target homograph, and the simple word association of single word primes to disambiguate the meaning of the single target homographs. The measure used was a pronunciation task, which made deductions about which meaning was activated through pronunciation responses. This suggests that individuals with autism may have just been able to pronounce the word correctly, rather than comprehend the actual meaning of the word in context, which sets up the foundation for the present study.

The current study utilized a semantic priming task to assess the ability of children with autism to disambiguate ambiguous homographs in actual sentence context compared with typically developing children. The priming task in this experiment consisted of homograph targets embedded in sentences that were preceded by a related or unrelated prime depending on the trial. Additionally, this experiment included automatic (300ms) and controlled (1000ms) SOAs to compare implicit and explicit meaning activation in children with autism. Integrating a 300ms SOA in this study allows for comparisons between rapid, involuntary activation towards homograph meaning, and voluntary responses (1000ms) toward homograph meaning that occur during a later time in semantic processing.

The purpose of the current study is to examine meaning activation when ambiguous homographs are presented in the context of a sentence. This differs from previous studies (Frith & Snowling, 1983; Happe, 1997; Lopez & Leekam, 2003; Hala, Pexman, Glenwright, 2007) which emphasized pronunciation of related/or unrelated primes and the target homographs at
voluntary levels of processing. The key additions to this study are the utilization of a semantic priming task that measures reaction time and errors through keystrokes, rather than the enunciation of the prime and homograph target. The incorporation of the automatic condition is also an added component that allows examination of observed priming effects at an involuntary response stage of processing.

The first experimental prediction of this study follows from the WCC account, which predicts individuals with autism show reduced priming for related conditions at both SOAs. This was predicted because of the deficiencies integrating sentence context in individuals with ASD, which requires excessive processing demands (Lopez & Leekham, 2003). The WCC postulates a general deficiency of integration of information in context, which suggests that individuals with ASD fail to process information in a global fashion. If individuals with autism are not using the prime to disambiguate the homograph embedded in the sentence, reaction times would elicit slower responses towards connecting the target word to the prime in unrelated conditions because of this failure of not being able to connect information to form contextual meaning.

The second prediction stems from the EF model, which predicts children with autism would show related and unrelated priming effects at short and long SOAs. If processing ambiguous homographs is a problem of an executive processing nature, individuals with autism should have difficulties inhibiting information from the context-related trials (WIND-BREEZE), but maintain the same meaning of the homograph on later trials in the experiment that uses a different prime (TURN-WIND). This implies that there is a failure in inhibiting previously (but now irrelevant) information.

The third hypothesis stems from the research concerning the semantic priming literature utilizing ambiguous words. Semantic priming studies using ambiguous words (Duffy, Kambe, &
Rayner, 2001; Simpson & Foster, 1986) posit that multiple meanings of homographs are activated instantaneously after a word is presented from the prime to target in a short duration. Conversely, later processing activates meaning based on lexical and contextual information factors, with lexical factors interacting with context (Duffy et al., 2001; Tabossi & Sbisa, 2001). Based on this evidence, a difference between reaction times would occur between automatic (300ms) and controlled (1000ms) SOA’s. It is possible that individuals with autism access semantic information early on in processing, but fail to sustain the representations of meaning due to distractions or interferences.

Method

Participants

Ten high-functioning children with ASD (9 males, 1 female) aged 11 to 15 years took part in the study. Four children were recruited from Youngstown State University’s Rich Center for Autism. The remaining six children were recruited from Potential Development High School in Youngstown, Ohio. All participants with ASD had previously received a clinical diagnosis of autism. Parents of the children enrolled at the Rich Center completed the Adolescent Autism Quotient (AQ), because Autism Diagnostic Interviews-Revised (ADI-R) scores were not obtained. Vineland II assessment scores were collected from Evaluation Team Reports (ETRs) of each child enrolled at Potential Development Middle School to also confirm diagnosis of ASD. All participants who took the AQ scored above a 32 ($M = 42.3$), which is a strong indicator for ASD. Additionally, the mean average ($M = 71.3$) of the six children who took the Vineland II is almost two standard deviations below the normal average, which is also a strong indicator of ASD. All kids who took the Vineland scored at least 1.5 standard deviations below normal which indicates all participants had forms of ASD. The participants with ASD were matched with ten
typically developing controls (6 Males, 4 females) aged 12 to 15 (recruited from local Marietta City (OH), schools) according to chronological age and mental age. Participants’ mental age was assessed with the Kaufman Brief Intelligence Test – Second Edition (K-BIT 2; Kaufman & Kaufman, 2004). Participant characteristics are summarized in Table 1. Neither chronological age \( t(18) = -.23, p = .82 \), Verbal IQ \( t(14.37) = -1.30, p = .21 \), Nonverbal IQ \( t(11.52) = -.651, p = .53 \), nor Composite IQ \( t(11.69) = -.97, p = .35 \) were significantly different in the two groups. Participants were given $5 gift cards to Wal-Mart in exchange for their time and effort. Informed consent documents were given to the parents of all participants in the study, to allow individuals to participate. Individuals participating also gave affirmative assent that they specifically agreed to participate. This gave them an understanding that they had the option to withdraw from the study at any time, as they are unable to legally provide consent.

**Materials**

**The Adolescent Autism Quotient (AQ).** The Autism Adolescent Quotient quantifies autistic traits in adolescents. The AQ was developed because of a lack of quick and quantitative self-report instrument for assessing how many autistic traits and adolescent has. The minimum score of the AQ is 0 and the maximum is 50. If an adolescent has equal to or more than 32 out of 50 such traits, this is highly predicted of ASD. Five different areas comprise the AQ: social skill, attention switching, attention to detail, communication, and imagination. Ten questions for each specific area are presented and are scored one point if the respondent records the abnormal or autistic-behavior either mildly or strongly (Baron-Cohen, Wheelright, Skinnier, Martin, & Clubley, 2001).

**The Vineland Adaptive Behavior Scale, Second Edition.** The Vineland Adaptive Behavior Scale (Vineland-II) measures the personal and social skills of individuals. It is typically
used as an aid by clinicians in diagnosing and classifying intellectual and developmental
disabilities. The content and scales of the Vineland II are organized within a three domain
structure: communication, daily living, and socialization. The focus of this particular instrument
is the measure of adaptive behaviors such as the ability to cope with environmental changes,
learn everyday new skills, and also demonstrate independence. A composite score is given to
summarize the individual’s performance across the three domains. Raw scores are converted to
standardized scores with a mean of 100 and a standard deviation of 15 (Sparrow, Chicchetti, &
Balla, 2004). Sub scores and composite scores were reported so that correlational analyses could
be conducted to examine relationships between ASD symptomatology and performance on the
semantic priming task.

Kaufman Brief Intelligence Test, Second Edition. The Kaufman Brief Intelligence Test
(KBIT-2) is a brief, individually administered measure of verbal (vocabulary subtest) and non
verbal (Matrices Subtest) intelligence for individuals from 4 to 90 years of age. It is designed for
traditional brief assessment purposes such as screening, conducting periodic cognitive
reevaluations, and cognitive functioning. The verbal portion is composed of two subtests that
assess receptive vocabulary and general information (Verbal Knowledge), as well as
comprehension, reasoning, and vocabulary knowledge (Riddles). The non-verbal section is made
up of a Matrices Subtest that assesses the ability to solve new problems using visual analogies.
All responses involve either pointing or one-word answers with binary scoring. The test takes
approximately 25 minutes to complete Scores from the verbal and non-verbal scales are tallied,
standardized for age, and are transformed into an IQ score on a standardized scale with a mean of
100 and standard deviation of 15 (Kaufman & Kafuman, 2004).
**Semantic Priming Task.** Five homographs targets such as those presented in the studies conducted by Frith (1986) and Happé (1997) were used along with an additional 25 homographs to increase the overall number of trials. 15 related (BREEZE-WIND) and 15 unrelated primes (TURN-WIND) were created for the short SOA condition (300ms) along with 15 related/unrelated primes for the long SOA (1000ms) conditions. This created a total of 60 primes-target pairs. Additionally, 60 trials containing primes and sentences that did not make sense were created for the control condition. Some of the sentences used in the experiment included a related prime (BREEZE) with a sentence that corresponded to the relatedness of the prime “The wind blew down the house.” A second half of sentences included unrelated primes (TURN) that correspond to infrequent meanings of the homograph “I always forget to wind my watch.” Additionally, control sentences were used that consisted of a prime (BREEZE) followed by a sentence that did not make any sense “I appeared to have dropped my elephant.” The reason for these control sentences is that observations of priming effects under prime-non sentence targets allowed for expectations that related primes could activate meaning of the homographs embedded within a sentence.

Each trial of the semantic priming task consisted of the word prime (related-unrelated), a 300ms or 1000ms delay, followed by the target homograph embedded in the context of a 6-8 word sentence. No homograph appeared in the control sentences because these were supposed to not make any sense. The task was given on a computer using Inquisit software (Inquisit, 2006). A fixation point (+) representing the trial signal was implemented in the middle of the screen (500ms) to indicate the start of the trial. A prime flashed on the screen (eg. BREEZE) for (100ms) followed by a blank interval (200ms or 900ms). A target sentence then appeared “The wind blew down the house,” which participants had to judge if the sentence makes sense. The
target cue stayed on the screen until a response has been given. Once a response had been given, the fixation point (+) reappeared for (2000ms) indicating the next trial is about to begin. Reaction times and errors were recorded in the process based on how long participants take to press a key and if the key pressed was the correct response. The order of SOAs, target pairs, and control sentences were divided into blocks and counterbalanced in order.

Additionally, a pilot study was conducted using students from the Marietta College psychology subject pool to test the appropriateness and effectiveness of the related/unrelated primes used in the actual experiment to make sure they were appropriate. Thirty homographs were presented to participants (on computers running Inquisit presentation software), followed by the related/unrelated words in relation to the homographs that will be used in the current study. At the bottom of each screen below each related/unrelated prime a built in likert-type scale was provided, so that a response can be made to the appropriateness of each related/unrelated word associated with each homograph. Primes were chosen if the average response by participants was above a score of sixty based on the likert scale provided (0-100). If the average response towards a prime was below an average of sixty, a better word was chosen by the researcher for the actual experiment.

The experiment was run on a Lenovo Thinkpad T-410 series laptop computer. Both the pilot study and current study utilized this laptop for observation and data collection. The monitor for these laptops is a 14.1” WXGA (1440x900) with a refresh rate of 60hz. In addition, it came with antiglare and LED black light features. All participants used the standard keyboard that comes with the laptop. Additionally, a USB mouse was provided, as it was more convenient and easier to use than the track pad or touch pad that comes built into the laptop. All participants
were seated 2 feet away from the computer screen during the task to ensure that the task was not too strenuous on their eyes.

**Procedure**

Recruitment letters were mailed to the parents of each child participating in the experiment. Parents completed an informed consent documents for their child before their child arrived at the lab, and all participants in the study were asked to give verbal assent prior to starting the experiment. The researcher administered the IQ measure before the task began. Participants were tested individually in a quiet lab room at Youngstown State University and Potential Development Middle School. Participants were told that they would see a series of different words that appear on the laptop computer screen, followed by a sentence. Their task was to determine if the sentence following the word is real or made up. During the experimental task, participants were given a number of practice trials to make sure they understood the procedure asked of them. There were 2 practice blocks, each containing ten-practice trials before the experimental task began. The researcher viewed each participant during the practice phase, and answered any questions the participant had about the task they were doing. If the participant failed to understand or complete the practice trials, the experimenter showed the participant how to do the task step by step. The experimental task did not begin until participants had a full understanding of the task being asked of them. Each participant was then given all 120 primes-target pairs, which were split into four conditions. The trials were presented in a randomized order. The total time of completion for each participant took approximately 10-15 minutes. Reaction times (RTs) and accuracy on each trial were the items recorded by the experimental task program during the course of the study. Debriefing forms were handed out at the conclusion
of the experiment to individuals and parents to give them some information about the study and what was being investigated.

**Results**

Responses were recorded as correct if the participant correctly determined if the sentence made sense or not; responses were incorrect if the participant failed to correctly determine if the sentence made sense or not. Participant accuracy was then compiled and aggregated. Examined first was the percentage of correct and incorrect responses for each trial. These values are presented in Table 2 and Table 3. The data were analyzed by means of a 2 x 3 x 2 mixed designs ANOVA with participant group as the between-subjects factor (ASD vs Control) and prime condition (Related vs Unrelated vs Control) and SOA (Short vs Long) as the within-subjects factors. The analysis of accuracy data (using a Greenhouse-Geisser correction for sphericity) revealed that there was not a significant main effect of prime condition, \( F(1.12, 20.13) = .86, p = .38, \eta^2 = .03 \) The interaction between participant group and prime condition was also not significant, \( F(.09, 20.13) = .87, p = .38, \eta^2 = .03 \) Additionally, there was not a significant main effect of SOA, \( F(1, 18) = .17, p = .68, \eta^2 = 0.001 \) There was also not a significant interaction between participant group and SOA, \( F(1, 18) = .03, p = .87, \eta^2 = .00 \) A significant main effect of group was also not found, \( F(1,18) = 2.01, p = .17, \eta^2 = .01 \). However, there was a moderate interaction between prime condition and SOA, \( F(2,36) = 2.89, p = .07, \eta^2 = .002 \).

Reaction time was also recorded for participant trials. The data were analyzed once again by means of a mixed designs 2 x 3 x 3 ANOVA with participant group as the between-subjects factor (ASD vs Control) and prime condition (Related vs Unrelated vs Unrelated) and SOA (Short vs Long) as the within-subject factors. All data was transformed using a logarithmic transformation to meet the assumptions of normality. These values are also presented in Table 2
and Table 3. The analysis of reaction time (using a Greenhouse-Geisser correction for sphericity) revealed that there was not a significant main effect of reaction time on prime condition, $F(1.27, 23.02) = 2.30, p = .14, \eta^2 = .002$. There was also not a significant interaction between reaction time on prime condition and participant group, $F(1.27, 23.07) = .16, p = .75, \eta^2 = .001$. However, there was a moderate main effect of SOA, $F(1, 18) = 4.34, p = .051, \eta^2 = .008$, but there was no significant interaction between SOA and participant group, $F(1, 18) = .32, p = .58, \eta^2 = .006$. No main effect was found for group, $F(1,18) = 2.50, p = .13$. Lastly, there was no significant interaction between reaction time and SOA, $F(1.31, 23.68) = .08, p = .85, \eta^2 = .00$.

Additional correlation analyses were also run to examine the relationships between ASD symptomatology and performance on the semantic priming task. There was no significant relationship between the scores on the Vineland II of six children assessed with ASD and accuracy on the semantic priming task in either related, $r(4) = .14, p = .80$ or unrelated, $r(4) = -.25, p = .63$, prime conditions with short SOAs. No significant relationships were also present in related, $r(4) = -.17, p = .74$, and unrelated $r(4) = .002, p = .9$, prime conditions with long SOAs. There was also no significant relationship between scores of 4 children assessed with the AQ and accuracy on the semantic priming task in either related $r(2) = .88, p = .12$, and unrelated $r(2) = .94, p = .10$ prime conditions with short SOAs as well as related $r(2) = .86, p = .14$ and unrelated $r(2) = .92, p = .13$ prime conditions with long SOAs. Correlational analyses were also run to examine the relationship between ASD symptomatology and reaction time on related and unrelated prime conditions with short and long SOAs. There was no significant relationship between the six scores on the Vineland II and reaction time on the semantic priming task in either related $r(4) = .46, p = .35$ and unrelated $r(4) = -.05, p = .93$ prime conditions with short SOAs as well as related $r(4) = .34, p = .50$ and unrelated $r(4) = .67, p = .15$ with long SOAs. No
significant relationships also found between the four scores on the AQ and reaction time on the priming task in related $r(2) = -.24, p = .76$ and unrelated $r(2) = -.05, p = .95$ prime conditions with short SOAs as well related $r(2) = -.03, p = .97$ and unrelated $r(2) = -.12, p = .88$ prime conditions with long SOAs.

**Discussion**

The goal of the current study was to investigate whether children with ASD were able to disambiguate target homographs in actual sentence context compared to typically developing children by utilizing a semantic priming keystroke task. The first major finding of this study was that children with ASD were as accurate as typically developing children in disambiguating the target homograph in each sentence. Incorrect responses between frequent and infrequent meaning trials of each target homograph did not differ between the two groups. This finding suggests that individuals with ASD are using the context of the sentence to disambiguate the meaning of the homograph, a finding which runs contrary to results found in other studies covered in the review. These studies showed that individuals with ASD failed to use context and only used the most frequent pronunciation of each homograph word target (Snowling & Frith, 1986; Happe, 1997; & Lopez & Leekam, 2003). However, these results are consistent with Hala’s (2007) study, which showed that children with ASD were as accurate as typically developing children in pronouncing a target homograph that was related to the meaning of its prime.

The contribution of the current study to the existing body of research was the use of a novel task that required actual reading comprehension rather just pronunciation of the target homograph, in order to judge whether the results regarding verbal deficits in children with ASD can be accommodated by the WCC or the EF account of ASD. Given that this study used a much
larger number of trials than previous studies, included more homograph word targets, and presented the individuals with actual sentences containing these word targets instead of a pronunciation task, the results provide strong evidence that children with ASD are using the contextual information provided by the related and unrelated primes in this study to disambiguate the target homograph that was located in the subsequent sentences. The results were unexpected in the light of the evidence that children with ASD have deficits in the use of contextual verbal information (Snowling & Frith, 1986; Happe, 1997; & Lopez & Leekam, 2003). A feature common to the methodology from previous studies that this study utilized was the meaning of ambiguous words was always derived from a context embedded within the presented sentence. However, the major difference in this study is that children with ASD did not have to read the sentence aloud. The present findings cannot be clearly explained by the WCC account alone because children with ASD were able to process information in a global like fashion for this study. Based on the WCC hypothesis, individuals with ASD have difficulties processing multiple items of information. In other words, children with ASD are thought to have a deficit in integrating pieces of information into a larger whole, but are able to process single items of information. The results of this study suggest children with ASD are making connections between primes and targets even though they are not explicitly told to do so. This suggests that the priming task utilized in this study somehow directed participants with ASD to a relationship between primes and homograph word targets. As such, children with ASD in this study appear to not show a deficit in processing and integrating multiple pieces of information.

The results pertaining to accuracy are also surprising in light of the EF account. The main idea of a deficit concerning executive functioning is that children with ASD are often impaired on executive tasks. Specifically, executive tasks that combine the dual demands of working
memory and inhibitory control (Oznoff, 1997). This has a direct effect on verbal comprehension because it prevents the inhibition of previously learned or irrelevant information, which affects their ability to comprehend and understand language. In this study, a cognitive deficit pertaining specifically to EF was also not found. Children in this study were just as accurate in their responses on unrelated trials. This suggests that when children with ASD were presented context related primes and homographs (WIND-BREEZE), they were able to suppress this information on trials that presented unrelated primes and infrequent meanings of homographs (WIND-TURN). This would suggest that children with ASD do not have difficulty with the inhibition of recently encountered but now irrelevant information, as they were able to suppress this information and give accurate responses on unrelated trials. It may be possible that deficits in inhibition are more pronounced when there is more information to be processed or when information to be inhibited comes from the spoken domain of language. This would also relate back to the ToM, which shows evidence concerning communication and socialization deficits in individuals with ASD. It could be that individuals with ASD have trouble expressing themselves and socializing with others because spoken language is harder for them due to the demands placed on EF. However, for simply reading single word primes and basic sentences, it appears that children with ASD have no problems concerning working memory and inhibitory control.

In addition to the findings related to accuracy, this study also examined participant reaction time. The second major finding of this study is that children with ASD were as fast as typically developing children in making the determination as to whether a sentence made sense or not in all three prime conditions. Again these results run contrary to the findings found in previous studies (Lopez & Leekam, 2003; Hala, 2007). These studies both found that children with ASD were significantly faster in pronouncing words preceded by semantically related
primes than for those preceded by an unrelated prime. In the current study children with ASD were just as fast as typically developing children in disambiguating target homographs in both prime conditions consisting of related and unrelated primes. A feature added to this study that was not found in previous research was the inclusion of short and long stimulus onset asynchronies (SOAs) to compare implicit and explicit meaning activation. The purpose of these SOAs was to compare rapid activation of homograph meaning that occurs early on in semantic processing and voluntary response towards homograph meaning that occurs later on in semantic processing. This study found that all participants performed faster in conditions that involved short SOAs. This finding was expected because short SOAs involve rapid activation of homograph meaning early on in processing, which means all participants should be quicker in determining if a sentence makes sense or not. However, it was predicted that children with ASD would be slower on trials involving voluntary levels of processing because holding the representation of a homograph meaning contains a much greater mental effort and involves the inhibition of distractions and interferences to sustain that meaning in working memory in order to make a correct decision as to whether a sentence made sense or not. So it was an unexpected finding that children with ASD were just as fast as typically developing children in disambiguating target homographs in prime conditions that involved voluntary SOAs.

Again, this finding runs contrary to the EF hypothesis regarding deficits in the processing of verbal information in children with ASD. Including short and long SOAs allow for the observation of top-down (voluntary/goal driven processing) and bottom-up (involuntary) semantic processing. Literature regarding semantic processing in individuals with ASD has found that children with ASD are typically superior in processing information that requires little mental effort and is provided quickly, but have trouble holding mental representations of this
information due to distraction or interferences which leads to slower reaction times and possibly failure to fully comprehend the information (Tochi & Kamio, 2002). The results of the current study show that children with ASD were just as fast as typically developing children on both related and unrelated trials consisting of long SOAs. This suggests that children with ASD are able to process multiple meanings of a prime, once activated, and then retrieve the correct meaning of a homograph just as fast and accurately as typically developing children. It appears individuals with ASD were exhibiting top-down processing, as they were able to use strategic processing and meaning selection as they made their response on trials involving long SOAs.

Taken as a whole, the results of this study do not support evidence derived from the theories of WCC and EF in individuals with ASD concerning ambiguity resolution. The WCC account of autism posits that individuals with ASD are impaired in processing information in context (Happe, 1997). In the priming task used in the present study children with ASD were able to use the information provided by the word primes that preceded sentences containing homograph word targets to produce accurate and just as fast responses as typically developing children. This suggests that children with ASD are able to make connections using the primes and targets in order to disambiguate the meaning of the homograph. Given these results, it appears that children with ASD do not show an absolute deficit in the ability to use contextual information.

The results of this study also do not support evidence concerning a deficit in Executive Functioning. The EF account of ASD proposes that children with ASD have trouble on executive measures that combine the use of working memory and inhibitory control (Oznoff, 1997). The main idea behind this theory is that children with ASD have a deficit in being able to suppress interferences or distracting information, which may have a direct effect on their ability to
comprehend contextual information. In this study children with ASD were able to inhibit information from context related trials, as they were just as accurate in providing the correct response in unrelated trials. Additionally, the incorporation of rapid and voluntary SOAs was another way to look at EF in children with ASD in a different way from previous studies. Children with ASD in this study were just as fast in typically developing children in trials involving voluntary SOAs in both related and unrelated prime conditions. Again, this is inconsistent with the theory of EF, because children with ASD should be slower on trials involving voluntary processing because of a deficit in being able to store the representation multiple meanings of a homograph due to the failed suppression of distraction and interferences. The results of this study show that children with ASD are indeed able to suppress outside interference and make correct decisions at higher levels of processing.

The most fitting explanation concerning the results of this study is that children with ASD may have a specific language-processing deficit that prevents them from using semantic knowledge in spoken language. The pattern of results found in this study show no deficit in verbal comprehension on a priming task that did not require pronunciation. Children with ASD in this study may have benefited from the task because it did not require pronunciation. It is possible that children with ASD may have difficulties in regulating and controlling incoming information in spoken domains because it is more demanding on executive functioning. For instance, making children with ASD read multiple sentences aloud requires a much greater deal of cognitive functioning than simply having them read a short sentence to themselves. This leads to more possibilities of distractions and interference because they are reading sentences, holding multiple meanings of a word at once in working memory, and try to inhibit the irrelevant information. The theories of WCC and EF may put too much emphasis on pronunciation of a
word rather than actual comprehension of the meaning of a word. This does not mean these theories are wrong, but they are limited in the claims they provide because the evidence is largely restricted to the spoken domain of language. More studies focusing on verbal comprehension of language in the written domain need to be conducted under the premise of these two theories in order to examine if ambiguity resolution in individuals with ASD is solely a deficit in the realm of spoken language.

Admittedly, there are some limitations to the current study. One of the major limitations in this study was the sizeable qualitative difference between sentences that made sense and sentences that did not. Sentences that did not make sense in this study included random words and often did not obey grammatical rules. It may have been too easy to make a determination that these sentences did not make sense. For example, in constructing these sentences to not make grammatical sense, it is possible that the researcher created stimuli where children with ASD were just able to look at the sentences that did make sense, and, because they looked grammatically correct make a decision based off that. “Green mice afraid ghost jump out car height balloon,” is easily viewed as grammatically incorrect. A real sentence containing the infrequent meaning of the homograph used in context such as the “The man forgot to wind his watch” is grammatically correct and at the same time looks grammatically correct compared to the control sentence. However, it is unlikely that this was a fatal problem, because in order to determine if the sentence made sense, the children with ASD still had to read each sentence in their head. If they were using only the most frequent pronunciation of a homograph while reading the sentence it would clearly not make sense to them on unrelated trials because they would be reading the sentence wrong on those particular trials. The length of the computer task was also another limitation that possibly had an impact on results. Many participants felt the task
became boring because it was doing the same thing over and over again for one hundred and twenty trials. The purpose of using more homographs in this study was to build strong enough evidence concerning cognitive deficits, as other studies only used approximately five of six. Figure 1 shows the distribution of reaction times. Looking at the results across time, fatigue or boredom did not seem to have a large impact on reaction time and accuracy as there was no differential effect of fatigue across time.

The current study also used a different methodology, which creates a limitation on its own. This study utilized a computer task involving keystrokes to make responses. The purpose of developing a methodology in this type of way was to give a more direct measure of meaning activation, as it involved children actually having to read the sentences and make a determination as to whether it made sense or not without actually having to pronounce the homograph. Language tasks often create a limitation because conclusions drawn from those types of tasks are restricted to the domain of language processing and really only determines if the participant could pronounce the correct enunciation of the homograph, rather than comprehend the actual meaning of the word. The current study made sure that children could actually read the sentence, disambiguate the homograph, and make a response towards that sentence. Given that this was the first time a procedure like this was utilized, a replication using the same type of methodology is certainly needed to reinforce the support regarding the findings of this paper.

Future research should also look to utilize tasks that do not require the pronunciation of sentences. As mentioned earlier, previous studies have only used pronunciation measures to examine if individuals with ASD are able to use contextual information. More focus needs to be placed on reading comprehension tasks to examine if this deficit in using context found in previous research is specific to the domain of spoken language. It may be the case that some
individuals with ASD can read and understand written language perfectly well, but have trouble expressing and pronouncing ambiguous words in spoken language. More research on studies involving the comprehension of written language should clear-up this potential grey area. Additionally, a replication of this study utilizing a pronunciation task, instead of a keystroke task may also prove to be beneficial. For example, children with ASD could read the sentences provided aloud and then be asked if the sentence makes sense or not. This would be a good measure as to whether children with ASD can actually can pronounce the homograph and understand the sentence at the same time. Lastly, I think incorporating a response window to force participants to respond within a narrower time frame would also prove to be fruitful. Response windows would force participants to give extremely fast reactions, thus typically too short for high amounts of accuracy. This is beneficial in controlling a speed-accuracy tradeoff by reducing even more variance in response latencies, thereby avoiding the dilution of priming effects amongst response latency and accuracy. These are all potential studies that would add more concrete evidence concerning verbal comprehensions in individuals with ASD under the theories of WCC and EF.

In conclusion, this study demonstrates that children with ASD are able to use contextual information provided by word primes in order to disambiguate target homographs embedded within the context of a sentence. The unique contribution of this study is that it utilized a different methodology than previous studies with more homograph word targets. The reading task programmed on the computer made sure the participants had to read and completely understand the sentence in order to make a correct determination as to whether the sentence made sense or not. The results of this study are not consistent with either the WCC or EF accounts concerning cognitive deficits in children with ASD on verbal task involving the
disambiguation of homograph word targets. Children with ASD in this study were just as fast and accurate as typically developing controls in both related and unrelated prime conditions as well at both short and long SOAs. Given the results presented in this paper, it appears that there is not a cognitive deficit accommodated by the WCC and EF accounts concerning the processing of contextual information for children with ASD. Although these results need replicating, I argue that neither the theory of WCC or EF can fully explain verbal comprehension deficits in children with ASD concerning accessing the meaning of ambiguous words.
References


List of Tables

Table 1. Participant Characteristics .............................................................. 42

Table 2. Mean proportion of accurate responses and mean reaction times for related, unrelated, and control conditions with short SOAs.........................................................43

Table 3. Mean proportion of accurate responses and mean reaction times for related, unrelated, and control conditions with long SOAs............................................................44
Table 1

<table>
<thead>
<tr>
<th>n*</th>
<th>Group</th>
<th>CA*</th>
<th>VIQ*</th>
<th>NVIQ*</th>
<th>CIQ*</th>
<th>VII*</th>
<th>AQ*</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>ASD</td>
<td>13.8(1.7)</td>
<td>90.0(16.0)</td>
<td>91.6(22.7)</td>
<td>89.6(20.6)</td>
<td>71.3(5.9)</td>
<td>42.3(1.7)</td>
</tr>
<tr>
<td>(9m, 1f)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Control</td>
<td>13.9(1.9)</td>
<td>97.60(9.2)</td>
<td>96.6(8.5)</td>
<td>96.4(8.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6m, 4f)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Verbal, nonverbal, and composite IQ were measured with the Kauffman Brief Intelligence Test-KBIT-2 (Kauffman & Kauffman, 2004). Mean values are shown with standard deviation in parentheses.

*Six participants with ASD were measured with the Vineland II and the remaining four were measured with the AQ.
Table 2
*Mean proportion of accurate responses and mean reaction times for related*(R)*, unrelated*(U)*, *and control (C)*conditions with Short SOAs*

<table>
<thead>
<tr>
<th>n</th>
<th>Group</th>
<th>Accuracy</th>
<th>Reaction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>R</td>
<td>U</td>
</tr>
<tr>
<td>10</td>
<td>ASD</td>
<td>Mean .94</td>
<td>.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD .07</td>
<td>.14</td>
</tr>
<tr>
<td>10</td>
<td>Control</td>
<td>Mean .94</td>
<td>.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD .07</td>
<td>.12</td>
</tr>
</tbody>
</table>
Table 3
Mean proportion of accurate responses and mean reaction times for related (R), unrelated (U), and control (C) conditions with Long SOAs

<table>
<thead>
<tr>
<th>n</th>
<th>Group</th>
<th>Accuracy</th>
<th>Reaction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>R</td>
<td>U</td>
</tr>
<tr>
<td>10</td>
<td>ASD</td>
<td>Mean .91</td>
<td>.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD .09</td>
<td>.16</td>
</tr>
<tr>
<td>10</td>
<td>Control</td>
<td>Mean .90</td>
<td>.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD .08</td>
<td>.10</td>
</tr>
</tbody>
</table>
List of Figures

Figure 1. Graph showing the characteristic shape of Reaction Time Distributions across the 120 trials……………………………………………………………………………….46

Figure 2. Graph showing the characteristic shape of Accuracy Distribution across the 120 trials……………………………………………………………………………47

Figure 3. Graph showing mean accuracy on related, unrelated, and controlled trials between participant groups………………………………………………………………………...48

Figure 4. Graph showing mean accuracy for short and long SOA conditions between participant groups………………………………………………………………………………49

Figure 5. Graph showing mean reaction time for related, unrelated, and controlled trials between participant groups……………………………………………………………………...50

Figure 6. Graph showing mean reaction time for short and long SOA conditions between participant groups……………………………………………………………………...51
Figure 1. Graph showing the characteristic shape of reaction time distribution across the 120 trials.
Figure 2. Graph showing the characteristic shape of accuracy distribution across the 120 trials.
Figure 3. Graph showing mean accuracy on related, unrelated, and controlled trials between participant groups
Figure 4. Graph showing mean accuracy for short and long SOA conditions between participant groups
Figure 5. Graph showing mean reaction time for related, unrelated, and controlled trials between participant groups.
Figure 6. Graph showing mean reaction time for short and long SOA conditions between participant groups