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Semantic Processing in Adults with High Functioning Autism

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SEMANTIC PROCESSING OF ADULTS WITH

HIGH-FUNCTIONING AUTISM

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By

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ABSTRACT

SEMANTIC PROCESSING OF ADULTS WITH

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Thesis supervised by Diane L. Williams, Ph.D.

This study examined the semantic processing of 19 adults with high-functioning autism (HFA) and 18 age and verbal-IQ matched controls using language tasks that varied in the demand for simple or integrative processing. On standardized measures, the individuals with autism had relatively intact vocabulary skills compared to controls, whereas the comprehension and use of figurative language was relatively weaker. The adults with HFA were relatively insensitive to context and incorrectly completed sentences with a commonly associated word pair rather than a semantically appropriate response. On a 3-letter word stem completion task, the autism group provided a similar mean number of words for each word stem as the controls. The individuals with autism had a significantly longer reaction time when choosing a real word versus nonword

compared to the control group. Semantic processing skills are relatively intact in individuals with HFA but are affected by demands for integration and time constraints.

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Chapter 1

Autism

Autism is a neurodevelopmental disorder that presents as behavioral difficulty with social communication, reciprocal behavior, and imagination and reasoning with the presence of stereotyped and repetitive behaviors (APA, 2000). Current models of autism view it as a disorder of complex information processing; this means that tasks that require integration of multiple processes, management of large amounts of information without an explicit structure, and information that must be processed under a time constraint are difficult for individuals with autism (Minshew, Goldstein, & Siegel, 1997; Williams, Goldstein, & Minshew, 2006). The difficulty with information processing appears to affect individuals with autism across the cognitive domains, meaning that language tasks that require complex processing would be disrupted in autism.

Language Problems in Autism

Language development and functioning in individuals with autism varies widely based on the severity of the disorder. Autism is a spectrum disorder which presents with a range of severities. Language skills have been studied most extensively in individuals classified as having high-functioning autism (HFA), those with overall intelligence quotient (IQ) scores greater than 80. The convention in the field of autism research is to alternate the use of *HFA* with the more general term *autism* to express the point that the characteristics identified through research tasks are thought to apply more broadly to the entire spectrum, not only the high-functioning individuals on the spectrum who were able to perform the tasks. Most individuals with HFA speak in fluent, complete sentences; however, this does not mean that their language system is comparable to individuals without developmental challenges. Individuals with autism typically have intact abilities for basic procedural and mechanical language skills, such as phonology and simple syntax, but have difficulty with more complex language skills that may require interpretation or integration of information (Frith, 1989; Minshew, Goldstein, & Siegel, 1995; Tager-Flusberg, 1996). The functional use of language, or pragmatics, is a primary area of language difficulty for individuals with autism (Walenski, Tager-Flusberg, & Ullman, 2006). However, other areas of language such as semantics may also be impaired even in verbal, high-functioning individuals with autism, depending on the demands of the semantic processing task (Frith & Snowling, 1983; Tager-Flusberg, 1991).

Minshew, Goldstein, & Siegel (1995) conducted a study of the language functioning of individuals with autism to construct a profile of their language abilities. The participants were 62 individuals with HFA (mean age of 17.79 years and a mean Verbal IQ of 94.06) and 50 age- and Verbal IQ-matched controls. Based on a battery of standardized tests, procedural and mechanical language skills such as simple syntax, phonology, word retrieval and word recognition were intact when compared to the controls, indicating that basic language skills were relatively unimpaired in individuals with autism. However, these relatively able individuals with autism had significant impairments in more demanding language tasks such as those with a significant verbal working memory load and those that required comprehension or interpretation of language forms such as syntactically complex sentences or paragraph-length material (Minshew et al., 1995). .

In terms of basic language, individuals with autism appear to have a relatively intact phonological system similar to individuals with typical phonological development (Bartak, Rutter & Cox, 1975; Bartolucci & Pierce, 1977). With respect to grammatical development, the growth of mean length of utterance (MLU) of children with autism has been found to mirror that of typically developing children albeit at a somewhat slower pace (Tager-Flusberg et al., 1990). Verbally fluent individuals with HFA are not generally impaired with respect to development of phonology or early syntactical forms.

While fundamental procedural and mechanical language skills have been shown to be intact in individuals with autism, reasearchers agree that there are consistent deficiencies in pragmatics, or the functional use of language (Walenski et al., 2006; Charman, Drew, Baird & Baird, 2003; Mundy, Sigman & Kasari, 1994; Wetherby & Prutting, 1984; Ghaziuddin & Gerstein, 1996; Ramberg, Eglers, Nyden, Johansson & Gillberg, 1996; Adams, Green, Gilchrist & Coz, 2002; Fine, Bartolucci, Szatmari & Ginsberg, 1994; Surian, Baron-Cohen & Van der Lely, 1996; Shriberg, et al., 2001; Ozonoff & Miller, 1996). The difficulty with pragmatics in individuals with HFA extends beyond difficulty with conversational reciprocity. Related to their difficulty with pragmatics, children with autism do not have the speech acts associated with social functioning (e.g., making comments, engaging with the listener, requesting information) (Wetherby & Prutting, 1984). Older adolescents with autism have been shown to speak in a monologue style and speak too much in conversation (Ghaziuddin et al., 1996; Ramberg et al., 1996). They also consistently demonstrate difficulty responding to questions, specifically while discussing a personal narrative or event (Adams et al., 2002) and referencing people or places in conversation (Fine et al., 1994). They have also been found to have difficulty judging how much information is necessary to communicate effectively (Surian et al., 1996). Additionally, deficits in the pragmatic use of prosody have been found in individuals with autism, such as speaking with a monostress pattern or at the other extreme, speaking with an exaggerated use of prosody (Shriberg et al., 2001).

In addition to conversational forms and the social use of language, pragmatics also includes the use of higher order forms of language such as making inferences based on context, interpreting humor, and understanding indirect requests. These aspects of pragmatic language have all been reported to be affected in verbally fluent individuals with autism (Rumsey & Hanahan, 1990; Ozonoff & Miller, 1996).

The difficulty individuals with autism have with these pragmatic aspects of comprehension are thought to be related to an inflexibility of language (Ozonoff & Miller, 1996), in which adults with autism were asked to choose appropriate endings to jokes or stories. For the joke measure, the subjects were asked to identify the funny and correct endings to the jokes. For the story measure, the humorous correct ending was removed, and the participants were instructed to choose the appropriate, ordinary, nonhumorous ending to the story. Results indicated the individuals with autism had significantly more difficulty with the joke condition than the story condition when compared to the controls who showed no difference across the conditions. The participants with autism had more errors of across all tasks than the control group and used significantly more humorous non-coherent endings during the joke condition and significantly more straightforward endings in the story condition. This suggests that the individuals with autism had learned the structure of story and could choose an appropriate ending, but had greater difficulty with the joke measure. Further analysis suggested that the individuals with autism understood the difference between a story and a joke, therefore the deficits in joke comprehension were not due to a basic misunderstanding of the concept of a joke. Understanding the concept of a joke is different than understanding the meaning of a joke. Understanding the meaning requires an understanding of the intention of the speaker and an integration of the meaning of the context, which are both cognitive skills that are deficient in autism (Ozonoff & Miller, 1996).

In another task in the same study (Ozonoff & Miller, 1996), the same individuals with HFA, even though they could select reasonable endings to stories, had difficulty answering inferential and factual true or false questions when presented with a short 2-sentence story that contained a sentence with misleading information followed by a sentence with clarifying information (Ozonoff & Miller, 1996; Brownell, Potter, Bihrle & Gardner, 1986). Once the ambiguous information was presented, the individuals with autism had difficulty using the clarifying sentence to determine the appropriate answer, suggesting an underlying impairment in flexibility or integration of the new information.

The narrative development of individuals with autism has been examined previously through narration of picture stories and using puppets to retell stories (Baron-Cohen, Leslie & Frith, 1986; Tager-Flusberg, 1995; Loveland, McEvoy & Tunali, 1990). Findings from these studies consistently demonstrate violations of pragmatics in narratives of individuals with autism such as unrelated or inappropriate utterances, failure to use causal and mentalistic explanations, and deficits in using mental state language. Research has also demonstrated individuals with autism have difficulty with knowing the needs of their listener and determining the amount of information needed for effective communication (Loveland, Tunali, Kelley & McEvoy, 1989; Paul & Cohen, 1984b; Grice, 1975).

This range of deficits in the understanding and use of discourse in individuals with autism are generally interpreted as consistent with the significant impairment in the social use of language that is accepted as characteristic of autism (Wetherby, 1986). However, it has been suggested that some of the difficulty with social use of language in autism may be indicative of weaknesses in semantic processing (Prizant, 1983).

Semantics in Autism

The semantic system of individuals with HFA has conventionally been looked at as an area of strength (Frith & Snowling, 1983; Tager-Flusberg, 1985; Klinger & Dawson, 2001); however, increasing evidence of deficits in this aspect of language is emerging (Tager-Flusberg, 1991; Harris et al., 2006; Just, Cherkassky, Keller & Minshew, 2004; Dunn, Vaughan, Kreuzer & Kurtzberg, 1999; Dunn and Bates, 2005). Individuals with HFA have been considered to be generally unimpaired with respect to semantics because of their relatively strong vocabulary and categorization skills (Tager-Flusberg, 1985; Klinger & Dawson, 2001). Some behavioral studies, however, demonstrate weaknesses in reading comprehension and language interpretation and integration that could be related to weaknesses in the semantic system (Frith & Snowling, 1983; Ozonoff & Miller, 1996). Supporting these behavioral findings are recent reports of semantic system abnormalities in studies using neurofunctional measures, such as functional magnetic resonance imaging and event-related potentials (Harris et al., 2006; Just et al., 2004; Dunn et al., 1999; Dunn and Bates, 2005). Children with autism have been reported to have intact categorization skills when compared to children with mental retardation and children with normal development (Tager-Flusberg, 1985; Klinger & Dawson, 2001). A study that assessed verbal and non-verbal categorization abilities at the level of basic object classification and the superordinate level of concept classification as well as the lexical organization for superordinate level concepts found the children with autism had the ability to categorize objects at the basic level and concepts at the abstract superordinate level. The results also suggested that the lexical organization of these children was similar to those of adults and older children with normal development, with words having similar meanings and categorization.

Similarly when children with autism were given a rule to follow for a categorization task, they did not vary in their ability to correctly categorize stimuli and did so as well as their normally developing peers (Klinger & Dawson, 2001). The children with autism also inferred a rule at some level to create a category when a rule was not explicitly provided. However, these same children with autism were unable to form the prototypes, a more complex and integrative process, necessary to categorize effectively (Klinger & Dawson).

In summary individuals with autism have a relative strength in category recognition at the basic and superordinate levels. However, individuals with autism appear to have more difficulty with forming categories, indicating some difficulty with this higher order semantic task. Therefore, although individuals with autism often have intact vocabulary and categorization abilities, weaknesses are still evident in their semantic systems. Difficulty with semantic processing in autism is further supported by additional studies of written and spoken language with this population.

Studies of reading skills have generally supported intact lexical skills in children with autism. For example, children with autism, ages 9 to 17 years with Verbal IQs ranging from 54-103, were reported to have age-appropriate lexical strategy use during reading and to have normal access to lexical semantics in terms of speech and differentiation between abstract and concrete words (Frith & Snowling, 1983). However, despite these strengths, impairments in reading comprehension were noted that may in fact, be related to weaknesses in semantic processing. The children with autism, when compared to their typically developing peers, had more difficulty with tasks that involved using semantic and syntactic cues to determine correct pronunciation of homographs and using semantic cues to choose semantically appropriate words in sentences. Individuals with autism were aware of and capable of utilizing syntactic constraints in sentences; however they had difficulty with comprehension that required complex semantic processing to accomplish lexical access (Frith & Snowling, 1983).

A semantic processing deficit in children with autism was also noted in a study conducted to determine the free recall of semantically related and unrelated word lists (Tager-Flusberg, 1991). The children with autism recalled the unrelated and related words with no significant difference in retrieval, whereas the children with normal development were better able to recall semantically related words. This difference in performance suggests that the children with normal development stored the semantically related words together, but that the children with autism did not use this same cognitive strategy, suggesting an underlying difference in semantic processing (Tager-Flusberg, 1991). Further testing indicated that when the children with autism were given a semantic cue, their performance in using the cues to retrieve words they otherwise could not recall was comparable to matched controls, suggesting that the children with autism had successfully encoded the information but had difficulty accessing the information (Tager-Flusberg, 1991).

Recent neurofunctional research indicates that semantic organization in the brain of typically developing individuals is not only complex, but highly specific to different aspects of language which require “a high degree of interactivity and interdependence” (Bookheimer, 2002). Specifically, the inferior frontal gyrus (IFG), an area previously associated with syntactic processing, has been shown through functional magnetic resonance imaging (fMRI) to play a role in semantic information processing (Petersen, Fox, Posner, Mintum & Raichle, 1989; Petersen, Fox, Snyder & Raichle, 1990; Fiez, 1997; Fiez and Petersen, 1998; Gabrieli, Poldrack & Desmond, 1998; Michael, Keller, Carpenter & Just, 2001). Bookheimer (2002) suggested the IFG may be the region involved in “executive control of semantic information processing” which may include integration, retrieval, comparison and selection of information in the brain. It has also been suggested that the IFG is an interaction of “small compact zones with relatively narrow functions” that are active in semantic processing (Bookheimer, 2002). These zones must interact and communicate in order to process information appropriately. Therefore, semantic processing is an integrative task that may be affected in autism related to the complex information processing deficits associated with the disorder (Minshew et al., 1997; Williams et al., 2006).

Neurofunctional measures provide evidence of semantic impairments in individuals with autism. For example, in a study that compared brain activation patterns of adults with HFA and well-matched controls, Harris et al. (2006) identified abnormal language-related activation in the individuals with autism. Specifically, the individuals with autism had less activiation in the regions of the cortex related to language processing such as the left IFG, during semantic decision tasks as compared to the controls, even though their performance on the tasks was similar. The individuals with autism also had more activation of the the left middle temporal gyrus during the processing task wheras the controls did not have significant activation in this area. Subjects with autism also showed less differential activation between concrete and abstract words during a task, along with diminished processing for semantic processing relative to perceptual processing tasks. These findings suggest, that even when behavioral performance on semantic tasks is similar, individuals with autism have underlying differences in the way they are processing at the cortical level. Other fMRI research suggests that the brains of individuals with HFA do not engage in integrative processing during sentence reading (Just et al., 2004). In this study, the individuals with autism had relatively more activation in Wernicke's area (a semantic processing area) than in Broca's area (an integrative language area) which was different from the controls, who demonstrated more activation in Broca's area during sentence comprehension. Functional connectivity, a correlational measure of the time series of activation in two related brain areas, was found to be lower between frontal and parietal areas in the autism group relative to the control group which suggests differences in anatomical connectivity between the specific cortical areas involved in language processing. The theory of underconnectivity in autism, which was proposed based on the results of this study, predicts that when a cognitive function, including language processing, is dependent on the integration of cortical centers, specifically when "computational demand of the coordination is too large,” there is a possibility of disruption (Just et al., 2004). Although the Just et al. (2004) study was not specifically investigating semantic processing, the model of language processing in autism suggested by the findings from that study, such as the relatively increased activation in Wernicke’s area, would be consistent with intact processing for simple semantic processing tasks with relative difficulty in semantic processing which requires interaction and integration of frontal and posterior regions.

Another neurofunctional measure, event-related potentials (ERP), has also been used to examine language processing in individuals with autism. In an initial study (Dunn et al, 1999), individuals with autism failed to show a task specific response pattern; they used the same brain response pattern for categorizing words that were both in and out of context, unlike the controls, who demonstrated a differential brain response pattern when they performed the different tasks (Dunn et al., 1999). In a second ERP study, the neural processing development in children with autism was investigated by measuring the N4 component in response to auditorily presented words either in a semantic category or outside the category (Dunn & Bates, 2005). Children from two age groups, 8 to 9 years of age and 11 to 12 years of age, participated in the study. In typically developing children, N4 is evoked when words in a task are unrelated to the context (Kutas & Hillyard, 1980). N1b and N1c components reflect the speed of transmission of the physical aspect of the stimulus to the auditory cortex. In children with autism, delayed N1c but normal N1b in response to language suggests impairment in the auditory association cortex. Based on the result from the N4 measures, the children with autism appeared to process words apart from their categorical context (Dunn & Bates, 2005). N1b and N1c results indicated that as the children with autism got older, their response times for processing words got faster, suggesting that the early cortical processing speed of auditory verbal stimuli improved with age and that abnormal processing of the information may not be an immediate consequence of the delayed processing (Dunn & Bates, 2005). These results provide further evidence that individuals with autism have difficulty integrating words with higher order conceptual information . Individuals with autism demonstrate deficits in their semantic systems, particularly as the demands for integration with contextual or previously learned information increase.

Model of Autism as a Disorder of Complex Information Processing

Problems associated with semantic processing of individuals with HFA can be understood based on the model of autism as a disorder of complex information processing and the associated underconnectivity model of autism (Minshew & Williams, 2007) . These models suggest that, in autism, skills that require smaller information processing networks and more localized processing will be more intact than skills that require the use of larger, more complex information processing networks and more integrative processing. Additionally, they suggest that at the brain level in individuals with HFA, there is an underdevelopment in the connectivity between the frontal and posterior cortical systems as well as overconnection in local areas of the cortex (Minshew, Williams & McFadden, 2008).

Evidence for autism as a disorder of complex information processing is detailed in an investigation by Minshew, Goldstein, & Siegel (1997) where 33 adults with HFA and 33 indiviudally-matched controls were given a large neurpsychological battery that included measures across the cognitive domains that were selected to vary in information processing demands. Findings indicated attention, sensory perception, elementary motor, simple memory, simple language, rule learning, and visuospatial areas were intact in individuals with autism. Deficits in the cognitive functioning of individuals with HFA included complex motor, complex memory, complex language, and concept formation. This profile of the cognitive functioning of individuals with autism demonstrated an underlying pattern; that is, the impairments in autism affected cognitive abilities requiring higher and more complex processing demands across the cognitive domains (Minshew et al., 1997). A replication of the adult study conducted with 56 children with HFA and 56 age- and IQ-matched controls yielded similar findings (Williams et al., 2006) .

The complex information processing model of autism suggests that it is not a single deficit that results in the impairments associated with autism; instead there is an underlying shared characteristic or principle for all the deficits (Minshew et al., 2008). According to this model, the deficits are not found in the acquistion of certain aspects of information or a domain-specific problem; in fact, most impairments appear in the same domain as intact skills. Therefore, there is not a single underlying cognitive deficit in autism. Rather, deficits occur across the cognitive domains when cognitive demands are high. As a result, one would expect to find relative impairments in all types of cognitive processing in autism when the demands are challenging. Specifically related to language, individuals with autism have intact procedural and mechanical language skills with impairments in complex language comprehension and interpretation; simple language skills are intact but deficits are found in langauge skills that have higher information processing demands (Minshew et al., 1995).

One cannot assume that semantic processing is unaffected in autism based on the results of simple information processing tasks because this level of processing is not expected to be impaired. However, one would expect to observe difficulty in semantic processing when the processing demands are more challenging, such as when tasks require more interpretative and integrative processing. Therefore, when studying the semantic processing in individuals with autism, it is necessary to measure both simple and complex levels of processing in the same individuals before conclusions about the status of their semantic processing can be drawn.

Purpose of the Study

The purpose of this study was to further investigate the semantic processing of adults with HFA using tasks that differ in demands for simple versus integrative processing. The study used three standardized measures that were compared to standardized norms to establish the basic level of language functioning of the participants. The standardized language measures were chosen to represent tasks in which individuals with HFA had been reported to be relatively unimpaired, such as tests of receptive and expressive vocabulary, and tasks in which indiviudals with HFA had been reported to have relatively more difficulty, that is, higher order measures of comprehension and production. Three experimental tasks drawn from previous research on semantic processing were used to further investigate the abilities of individuals with HFA in terms of semantic processing. These experimental tasks were specifically chosen to assess previously reported strengths and weaknesses in individuals with HFA. All of the above-mentioned measures were conducted with a single group of adults with autism to measure skills in tasks that require simple and complex information processing in the semantic system of the same individuals.

Hypotheses

The hypotheses for this study were as follows:

1. Individuals with HFA would perform similarly to age and Verbal IQ-matched controls on standardized measures of receptive and expressive vocabulary.

2. Individuals with HFA would perform more poorly than age and Verbal IQ-matched controls on each subtest of the Test of Language Competence—Expanded related to the complexity of language assessed by this measure.

3. Individuals with HFA would have a shorter reaction time than age and Verbal IQ-matched controls when judging words versus nonwords, reflecting their whole word process of reading and consistent with processing of words at a simple level.

4. Individuals with HFA would complete binomials with a commonly associated word rather than a word that is appropriate to the meaning of the sentence at a greater rate than age and Verbal IQ-matched controls, reflecting a tendency to retrieve words based on associations rather than semantic context and failure to integrate word meaning with context.

5. Individuals with HFA would have fewer responses for the items in a word stem completion task as compared to age and Verbal IQ-matched controls, reflecting a whole word process of storage and difficulty with integration of verbal working memory and word search processes.

Chapter 2

Methods

Participants

Two participant groups were used for this study, a group of 19 adolescents and young adults with HFA and a group of 18 adolescents and young adults with typical development. The participants were recruited from a larger pool of participants who had been recruited for the National Institutes of Health funded Autism Center of Excellence (ACE) research program at the University of Pittsburgh. The participants were from a variety of racial backgrounds including 35 Caucasians, one Asian-American, and one African-American, and one unknown. The participants all spoke English as their primary language. All participants had Full Scale and Verbal IQ scores greater than 80 based on the Wechsler Abbreviated Scales of Intelligence (WASI; Wechsler, 1999). The participants were individually matched on age and Verbal IQ scores. Demographic data for the two groups are provided in Table 1.

Table 1. Demographic Information for Autism and Control Groups.

	Autism n=19		Control n=18				
	M	SD	M	SD	t	df	*p*
Age	19.68	6.25	23.22	5.14	-1.876	35	.069
Gender	1.16	.375	1.06	.236	.993	35	.330
Full Scale IQ	103.37	9.75	110.83	6.62	-2.710	35	.010
Verbal IQ		11.23	109.00	7.52	-1.915	35	.064
Performance IQ	103.37	15.04	109.89	7.06	-1.672	35	.103

The group of individuals with HFA was comprised of 16 males and 3 females with diagnosis of autism (not autism spectrum disorder), 15 to 38 years of age. This group was made up of one Asian-American, 17 Caucasian-Americans, and one individual whose race was unknown. The individuals with HFA were diagnosed by highly qualified clinicians, using the *DSM*-IV criteria (American Psychiatric Association , 2000) operationalized as meeting cut-offs for autism on the *Autism Diagnostic Interview-Revised* (ADI-R; Rutter, LeCouteur & Lord, 2003) and the *Autism Diagnostic Observation Schedule* (ADOS; Lord, Rutter, DiLavore, & Risi., 2002). The HFA group had positive evidence of problems with development as defined by the ADI-R, before three years of age and the diagnosis of autism were verified by expert clinical opinion. If potential participants were found to have evidence of an associated genetic, infectious, neurological or metabolic disorder such as fragile X syndrome, cytomegalovirus, or tuberous sclerosis based on neurologic history and examination, physical examination, genetic testing, and if necessary, metabolic testing, they were excluded from the study.

The control group consisted of 17 males and 1 female ranging in age from 15-32 years, who were medically healthy and typically developing. This group was comprised of one African-American, 15 Caucasian-Americans, and one individual whose race was unknown. These participants were drawn from a larger group of community volunteers who were part of the participant pool of the ACE. At the time of the initial recruitment for the ACE, they were screened by telephone, questionnaires, face-to-face interview, and observation during psychometric screening tests. Exclusionary criteria included a history or evidence of birth or developmental abnormalities; brain injury; poor school attendance; evidence of a learning or language disorder; and past or current history of psychiatric or neurological disorder. Also excluded were individuals with a medical disorder implicating the central nervous system or requiring regular usage of medications; a family history of first-degree relatives with autism, learning disability, mood disorder, developmental cognitive disorder, anxiety disorder, alcoholism, or other neuropsychiatric disorders that may have a genetic component.

Procedures

All participants were seen individually for a two to three hour assessment. Each participant was assessed using standardized measures of language as well as experimental tasks to assess semantic processing. All measures were administered individually to the participant by the investigator or the research coordinator. Testing was performed at the offices of the Autism Center of Excellence at the University of Pittsburgh in a distraction-free environment. The examiner used the same instructions, either the standardized instructions provided in the manuals of the standardized tests, or a specific set of instructions for the experimental tasks. Each session was recorded using an audio tape recorder.

Standardized tests.

Based on previous research, individuals with HFA are reported to generally have intact vocabulary; therefore, the vocabulary skills of the participants were measured using the *Peabody Picture Vocabulary Test-Third Edition* (PPVT-III; Dunn & Dunn, 1997) and the *Expressive Vocabulary Test* (EVT; Williams, 1997), both standardized tests of language skills. The tests were administered using the standard procedures as described in the manual for each test. The PPVT is designed to assess receptive vocabulary and as a screening tool of verbal ability for individuals ages 2 years, 6 months through 90+

years. The participants were presented auditorally with a word for which they chose the corresponding picture from a display of four pictures. Raw scores were converted to a standard score following standard psychometric procedures from the test manual (Dunn & Dunn, 1997). The EVT assesses expressive vocabulary and word retrieval in individuals ages 2 years, 6 months through adulthood; the participants labeled or gave synonyms of pictorial stimuli. Raw scores of the EVT were converted to standard scores following the instructions in the manual (Williams, 1997).

Previous research has demonstrated individuals with HFA have increased difficulty in inferencing and interpreting figurative language (Lewis et al., 2007). The *Test of Language Competence-Expanded Edition* (TLC-E; Wiig & Secord, 1989) was used to measure these types of language skills. The TLC-E is designed to evaluate emerging linguistic competence and the use of semantic, syntactic, and pragmatic language. Level 2 of the TLC-E is used for ages 9 to 18+ years and consists of the following subtests: Ambiguous Sentences; Listening Comprehension: Making Inferences; Oral Expression: Recreating Sentences; and Figurative Language. In Ambiguous Sentences, the participants selected two different meanings for an ambiguous sentence from four printed choices. For Making Inferences, the examiner read two statements that provided incomplete information about a single event and the participant chose two of four possible explanations. For Recreating Sentences, the participant was orally and visually given three single words that were supposedly spoken by people in a scene and was asked to use the words to construct a sentence that could have been used in the pictured situation. For Figurative Language, the participant was asked to tell in his own words what a person meant when saying an expression in a given situation; the participant then chose which of four expressions was closest in meaning to the conversational statement. Because normed scores are only provided through age 18 years, the raw scores were used for statistical analysis.

Experimental tasks.

Experimental Task 1 was designed to assess flexibility for recognition of written words through an orthographic judgment task (which is the real word) based on Olson, Forsberg, Wise & Rack (1994) (Appendix 1). In this task individuals were shown two words on a laptop computer screen at the same time and the participant indicated which item in each pair was the real word by pressing a key on a button box. The nonwords were pseudo-homophones (such as rane and dreem) matched closely to the real words in length, ranging from one to four syllables. Stimuli were presented with CogLab, an experimental stimulus production and presentation software. The words were randomized after every trial. If the word on the left was correct, the subject needed to press the first button on the button box. If the word on the right was the correct word, the subject needed to press the third button on the button box. As soon as the words appeared on the screen, the computer began timing the participant. When the correct button was pressed, a number appeared on the screen indicating the length of time it took for the participant to respond. If the response was incorrect, the word "error" appeared on the screen. This task was composed of eighty word pairs. Prior to the start of the task, the subjects were given instructions and a set of 8 practice word pairs to establish that they understood the task and could perform it without difficulty. Difficulty with flexible processing of language is thought to give individuals with HFA a relative advantage on this type of task. They are thought to recognize the words visually rather than phonologically (Nation, Clarke, Wright & Williams, 2006) and, therefore, be less susceptible to thinking a nonword could be an actual word. This lack of confusion would be reflected by a shorter response time. Responses including correct/incorrect and response time were recorded automatically by the computer. Following the task, the participants were provided with the word list of real words to determine if they were familiar with the words used in the task. If a participant pronounced a word incorrectly and made an error when choosing the proper word, that word was removed from his or her respective score as it was assumed the participant was unfamiliar with the word. There was no time limit for reading the list of words and the examiner noted pronunciations that were in error.

Experimental Task 2 involved interpreting words within a context through a sentence-completion task that uses binomials (Appendix 2). This task was similar to a task used by Happé, Briskman, & Frith (2001), in which the parents of individuals with HFA were reported to perform poorer relative to the control group, who were normal-developing adults with no first- or second-degree relative with developmental disorders. Sentence stems were presented on the computer screen ending with the first member of the binomial. The participant read the sentence aloud and was asked to complete the sentence. For half of the sentences, answering with the second member of the binomial would result in a meaningful sentence. For the other half of the sentences, the use of the binomial would result in a meaningless sentence, requiring the participant to provide an ending that preserves the contextual meaning. The participant must inhibit the second member of the binomial pair in order to create a more appropriate sentence ending. The stimuli were created by compiling a list of common English-language binomials from a number of internet sources. Ninety-three sentence stimuli were then created and given to 12 adults with typical development to complete in written form. Forty-six of these sentences could be correctly completed by using the other member of the binomial pair. The other forty-seven needed to be completed using a novel response. From this original list, forty sentences that could be correctly completed with a member of a binomial pair (e.g. "Larry asked his dad to pass him the salt and pepper.") and forty sentences that would be meaningless if completed using the member of the binomial pair (e.g. "Seawater tastes like salt and pepper.") were selected. The sentences were randomized to assure that the subjects did not receive both sentences of a binomial pair directly following each other. Prior to the start of the task, instructions were provided and two practice items were administered. Responses were recorded by hand by the experimenter. Reaction time was recorded starting as soon as the first word of the binomial pair was read aloud by each participant. Each participant had 5 seconds to provide an answer before a buzzer rang indicating the completion of the test item. The dependent variables for the sentence completion task were choosing the commonly associated word and it was correct, choosing the commonly associated word and it was incorrect, or choosing a word not commonly associated that was contextually appropriate.

In Experimental Task 3, word fluency in which flexibility in linguistic knowledge is beneficial was measured using a word stem completion task (Appendix 3). This type of task involved a verbal working memory demand (because repeated words were not allowed) with a simultaneous word search, which subsequently required integrative semantic processing. In this task, the subject was given a 3-letter sequence (e.g., MOT___) and asked to name five words that begin with this sequence. The word stems were generated using a computer program that selected 3-letter word stems common to at least ten dictionary entries. The words could not be an alternate form of the same word (e.g., mother, mothering). All words that were found in the American Heritage Dictionary (Pickett, 2000) as separate entries were considered acceptable words. The participant had 15 seconds to provide five words. Instructions and eight practice stimuli were presented followed by the 60 test items. The word stems were randomized for each participant. The response measure was the total number of appropriate words provided. The time to provide all five words for each stem was also recorded.

Chapter 3

Results

Standardized Measures

Research question 1 as to whether individuals with HFA perform similarly to age and Verbal IQ-matched controls on standardized measures of receptive and expressive vocabulary was answered by performing a repeated measures analysis of variance (ANOVA) using the standard scores from the two vocabulary tests. No significant group difference was obtained ($F(1, 35) = 1.90$, $p = .177$). Table 2 contains the group comparisons for all of the standardized measures of basic level of language functioning.

Table 2. Standardized Test Scores on Vocabulary Tests

	Autism n=19		Control n=18				
	M	SD	M	SD	F	df	*p*
EVT Standard Score	99.00	18.673	106.11	13.907	1.898	1, 35	.177
PPVT Standard Score	104.53	12.039	107.72	8.784			

To address research question 2 as to whether individuals with HFA perform significantly more poorly than age and Verbal IQ-matched controls on each subtest of the Test of Language Competence—Expanded a repeated measures ANOVA using raw scores for each of the four subtests was performed (Table 3). The results indicated a statistically significant difference in the performance of the groups [$F(1, 35) = 16.03$, $p < .001$]. Post hoc analysis using a 2-tailed t-test indicated that the autism group's performance was significantly poorer than the performance of the controls on the Ambiguous Sentence subtest [$t(35) = -3.06$, $p = .004$], the Listening Comprehension subtest [t (35) = -2.692, p =.011], the Oral Expression subtest [t (35) = -3.33, p = .002] and the Figurative Language subtest [t (35) = -3.30, p = .002].

Table 3. TLC-E Data Analysis

	Autism n=19		Control n=18				
	M	SD	M	SD	t	df	*p*
AmbSent. Raw Score	24.53	8.235	31.72	5.809	-3.055	35	.004
LisComp Raw Score	30.63	3.419	33.17	2.121	-2.692	35	.011
OralExp Raw Score	58.58	9.070	66.89	5.593	-3.332	35	.002
FigLang Raw Score	24.58	7.611	30.94	3.058	-3.303	35	.002

Experimental Tasks

Research question 3 as to whether individuals with HFA would have a faster reaction time than age and Verbal IQ-matched controls when judging words versus nonwords was measured by performing an independent, two-tailed t-test using reaction time measures. One participant in the autism group was removed prior to the analysis as he had an excess number of skips in his response pattern, making his data unusable. Even with removing the participant from the analysis, the groups were still matched on age and verbal IQ. Initial analysis (Table 4) revealed a significant difference between the groups with the controls having a faster reaction time than the individuals with autism when judging which word was the real word.

Table 4. Word Recognition Response Time

	Autism n=18		Control n=18				
	M	SD	M	SD	t	df	*p*
Response Time	1324.50	388.61	939.24	179.18	3.82	34	.001

A secondary analysis was conducted to determine if word length affected reaction time including only the words that were comprised of 6 or more letters. This was done to determine if the autism group had an advantage for longer words which may have presented more of a phonological processing challenge (and, therefore, ones on which the control group might have had more difficulty). The two-tailed t-test showed a significant difference between the groups in reaction time, but not the predicted difference. The individuals with autism performed with significantly longer reaction time than the controls on the word recognition task [t (34) = 3.798, p = .001]. To determine whether or not the autism group had a generally longer reaction time than the control group, an additional t-test was run for mean finger tapping scores from a finger tapping test (Strauss, Sherman, & Spreen, 2006), a general measure of reaction time which measures the number of taps per trial with each trial lasting ten seconds. This data had been gathered from the participants for previous studies. No significant difference was found between the two groups [t (34) =-1.504, p = .142] on this general reaction time measure. A Pearson correlation test was conducted with the group of individuals with autism to determine if there was a relationship between mean reaction time on the word recognition task (M=1486.50, SD = 416.57) and the mean number of finger taps (M=47.58, SD= 6.97). For the individuals with autism, no correlation was found between the finger tap measure and reaction time, [r (16) = -.168, p=.505]. A Pearson correlation was also tested with the controls between mean reaction time (M=1057.50, SD=236.92) and number of finger taps (M= 51.17, SD= 7.34). No correlation was found for the controls between reaction time and finger taps, [r (16) = -.118, p= .642]. The longer reaction time of the autism group on the word recognition task did not appear to be related to difference in motor abilities. Language measures were also used to determine if there were correlations between language functioning and reaction time. A Pearson correlation was completed using the TLC-E composite raw score and the reaction time, which showed there was no significant difference for the individuals with autism, [r (16) = -.307, p= .215]. With the controls, a lower score on the TLC-E was marginally correlated with reaction time, [r (16) = -.436, p=.070]. A Pearson correlation also showed no significant difference between reaction time and Verbal IQ scores for individuals with autism, [r(16)= -.274, p=.271]. For the controls, a Pearson correlation showed there was a correlation between Verbal IQ scores and the reaction time for the word recognition task, [r(16)=-.524, p=.025]. For the word recognition task, the group with autism had a longer reaction time than their age and verbal IQ matched peers; their performance did not appear to be related to motor abilities, as determined by finger tapping measure, or related to their language or verbal abilities.

The differences between numbers of correct and incorrect responses between the groups on the word recognition task were also analyzed. The individuals with autism had a mean of .872 for correct responses with a standard deviation of .119 and the controls had a mean of .915 for correct responses with a standard deviation of .081. The group of individuals with autism had a mean of .092 for incorrect responses with a standard deviation of .098 while the controls had a mean of .084 for incorrect responses with a standard deviation of .0796. Additional t-test analyses were completed which showed there were no differences between groups in correct responses [t (34) =-1.258, p=.217] or incorrect responses [t (34) =.280, p=.781] on the word recognition task.

Research question 4 addressed differences between the groups on the binomial task. Prior to analysis, one item from the task was removed as the majority of the participants were responding inappropriately to that item, leaving 40 sentences that could be completed correctly with the commonly associated binomial and 39 sentences that would be incorrect if the binomial was used. Only those individuals who had 85% usability (which indicated they had knowledge of binomials as part of their language system) were included in this analysis. Following these constraints, three individuals with HFA and two controls were removed with the remaining groups consisting of thirteen individuals with HFA and sixteen controls. Even after removing these participants, the two groups were matched on age and Verbal IQ. Table 5 provides the demographic information of this subgroup.

Table 5. Demographic Data for Sentence Completion Binomial Task

	Autism n=13		Control n=16				
	M	SD	M	SD	t	df	*p*
Age	21.00	7.024	23.38	5.439	-1.027	27	.314
Verbal IQ	106.77	9.714	108.00	7.376	-.388	27	.701

The question as to whether individuals with HFA would complete the sentences with a binomial irrespective of the meaning of the sentence at a greater rate than age and Verbal IQ-matched controls was answered by performing an independent, two-tailed t-test using the measure “number of commonly associated words and incorrect.” Performance on this task is provided in Table 6. There was no significant difference between groups in using the correct binomial; however, analysis revealed that, as predicted, the individuals with autism provided the binomial that was not contextually appropriate more often than the controls [t(27) = 2.056, p=.05].

Table 6. Sentence Completion Binomials

	Autism n=13		Control n=16				
	M	SD	M	SD	t	df	*p*
Binomial Correct	37.62	1.660	37.56	1.590	.087	27	.931
Binomial Incorrect	5.92	2.842	3.50	3.386	2.056	27	.050

Research question 5 as to whether individuals with HFA would have fewer responses for the items in a word stem completion task as compared to age and Verbal IQ-matched controls was answered by performing an independent, two-tailed t-test using the measure of mean number of words given for all of the word stems (Table 7). Analysis revealed that there was no significant difference (t (35) = -1.450, p=.156) between groups for mean number of words given.

Table 7. Word Stem Task

	Autism n=19		Control n=18				
	M	SD	M	SD	t	df	*p*
Mean Word Stems	2.6274	.6949	2.9206	.5163	-1.450	35	.156

In summary, the individuals with autism performed similar to their age and IQ matched peers on standardized tests of basic language including the PPVT-III and the EVT. The individuals with HFA demonstrated significantly poorer performance on the TLC-E, a test of higher order language skills. The individuals with autism had a significantly longer reaction time when choosing real word versus nonword compared to the control group. On the word stem completion task the individuals with autism performed significantly similar to the controls in verbal fluency by providing a similar mean number of words for each word stem. Finally, on the sentence completion task, the individuals with HFA responded significantly more often than controls with the commonly associated word pair that was not contextually appropriate.

Chapter 4

Discussion

This study was an investigation of the semantic processing of individuals with HFA when completing tasks that required varying levels of integrative processing. Based on previous studies, it was predicted that the autism group would perform relatively more poorly on more complex language tasks and language tasks that required integration of contextual information and flexibility but would perform similarly to the controls on simpler language tasks such as vocabulary. It was also thought that individuals with autism might have an advantage in word recognition due to the use of a visual strategy rather than a phonologically based strategy in word reading. Findings from this study provide further evidence for strengths and weaknesses in the semantic system of individuals with autism.

As predicted, the individuals with autism performed similarly to their age and verbal IQ matched peers on the standardized measures of basic language functioning as measured by the PPVT-III and the EVT in terms of receptive and expressive vocabulary. The current findings support those in previous research (Tager-Flusberg, 1985), that individuals with autism have a relatively intact vocabulary, which is considered a simple language task.

Although the vocabulary of individuals with autism is intact, there is evidence that their semantic language is impaired, as shown by the TLC-E in the current study. As predicted, on the more complex tasks of language functioning, such as those measured by the subtests of the TLC-E, the individuals with autism had increased difficulty and performed worse than their age and IQ matched peers. This test appears to be more sensitive than the other standardized language measures of vocabulary to the language functioning differences in autism. The TLC-E requires a high degree of interpretation, inferencing and integration which are all considered complex language skills that are thought to be deficient in individuals with autism.

Problems with integration were assessed through the experimental task that required the completion of cloze sentences with and without binomials. In this task, the individuals with autism provided the correct binomial as often as their age and verbal IQ matched peers; however, they failed to inhibit the commonly associated word when it was not semantically appropriate more often than the controls. The current findings demonstrate that the individuals with autism failed to use the context of the sentence when choosing a word to complete the sentence, and rather completed the sentence with the most commonly associated word. These findings support previous research (Happé, Briskman, & Frith, 2001) and provide additional evidence that individuals with autism process and store information through associated learning, that is, learning and storing a word by associating it to a word by which it is most often accompanied. In order to inhibit the most commonly associated word, it was necessary to integrate the context of the sentence into the word choice. This integration is, once again, a complex cognitive task (Minshew et al., 1995). This finding further demonstrates the poor integrative functioning of the individuals with autism.

Individuals with autism are typically thought to have difficulty with flexibility of language. To assess this problem with respect to the semantic language system, the current study used a word-stem completion word fluency task. Word fluency tasks are traditionally used in language research as measures of flexibility within the semantic system. Rather than the predicted difficulty with this task, the individuals with autism were found to perform with no significant difference from the controls. This finding suggested that at the word-level, this group of high-functioning individuals with autism were no less fluent or flexible than their age and verbal IQ matched peers on this type of word retrieval measure. This result would suggest that basic word learning (i.e., one meaning associated with one word) and word retrieval mechanisms are relatively unimpaired in verbally fluent individuals with autism. Therefore, the difficulties indivdiuals with autism have with semantic processing are not necessarily because of a lack of flexibility in their semantic systems.

It was originally hypothesized that the individuals with autism, due to their strengths in processing using a visual, whole word strategy rather than a more analytical, phonological strategy, would perform better when recognizing a word versus a nonword in the word recognition experimental task. This hypothesis was not supported, however, as the individuals with autism did not have a shorter reaction time, and in fact, had a relatively longer reaction time than the controls when judging words versus nonwords. This task should not have been difficult for the individuals with autism as it was not above their language abilities nor was it outside of their reaction time abilities. After analyzing the possible correlations including verbal IQ, language scores, and finger-tapping reaction times, a conclusion was drawn that an additional factor associated with the task itself and the requirements placed on the participants to make judgments may have influenced the performance of the individuals with autism. This task required the participants to judge which word is the real word and choose quickly and correctly. The requirement to make a forced choice under a time constraint appeared to result in a longer reaction time.

Based on the longer reaction time, rather than the task being easier for the individuals with autism, it was obviously more difficult. This means they may not have been using the visual-based strategy and may actually have had difficulty reading the words. In a study conducted by Nation et al., (2006), many children with autism participating in the study were able to decode real words, but had difficulty deciphering nonwords, which was thought to be a relative strength (Minshew et al., 1994) due to the visual whole word processing strategy. Nation et al., (2006) suggest the advantage for reading real words may be due instead to memorization of words. If the participants were unable to decode the nonword presented, this may have caused a longer reaction time while they attempted to decipher the words. Additionally, there may have been features of the task that made it more difficult for the individuals with HFA. They may have had more difficulty with a speed/accuracy trade-off required for the task as reported in studies of autism such as one that investigated the performance on dual-tasks (Garcia-Villamisar & Della Sala, 2002).

If the time constraint demands of this simple word choice task caused a statistically significant slowing of response for the individuals with autism, this raises concern about the performance of individuals with autism in other learning environments when the cognitive demands placed on them are much greater. The reaction time difference in terms of seconds between the controls and the individuals with autism may seem trivial, but the impact it has on children in a school setting or adults in an employment setting may affect the success of these individuals in situations where a shorter reaction time is beneficial. For example, in a classroom, if a child requires extra time to react to a direction by a teacher, in the amount of time that he or she takes to process and react, the other children in that classroom will have moved on to the next direction. If this continues to occur, the child with the longer processing time will begin to fall behind his or her peers. This results in academic problems even if the child with the longer reaction has the same IQ as his or her peers. Clinicians working with children with autism who are experiencing academic difficulties should include an assessment of the language abilities of the children within the classroom environment, where demands to simultaneously process multiple stimuli are greater. The pitfall of the currently available standardized assessments is that they do not measure a child's online ability to handle and process information nor do not they control for processing speed. Thus, it is difficult to predict how the child's processing speed is affecting performance in the real-world environment of the classroom unless the assessment occurs in that environment.

Additional evidence for autism as a disorder of complex information processing is apparent based on the present results of the standardized language measures. The individuals with autism performed as well as peers on the basic measures of language processing such as vocabulary, and performed worse on the more integrative language skills measured by the TLC-E, such as figurative language and interpreting ambiguous sentences. These standardized measures demonstrated that there is a difference in overall language abilities between individuals with HFA and their age and verbal IQ matched peers. These findings, along with the results of the experimental tasks suggest that at the basic level of language functioning, such as at the word-level, individuals with autism do not experience a difference in semantic processing. It is at a more complex level, such as when tasks require interpretation or semantic integration that the individuals with autism have difficulty. Clinically, working with individuals with autism, it is important to understand their level of language functioning and the point at which the cognitive demands placed on them cause them to experience a cognitive overload and subsequent breakdown. To further understand the level at which breakdowns occur, it is imperative for clinicians to have a reliable assessment measure that will determine language functioning at various levels of complexity.

Limitations

The TLC-E, although a standard measure and scored by consensus in this study, tends to have an objective component and therefore should have a reliability measure completed. The sentence completion word association task was scored by consensus as well, but should also have a reliability measure completed to assure no examiner biases were present. In this study, researchers were not blinded to group membership. In order to control for the possible bias, a reliability measure with a blinded researcher could be conducted for the TLC-E subtests and for the sentence-completion task. For this reliability measure, the researcher should re-check these tasks and score 20% of the standardized tests and experimental tasks independently.

Future Research

The findings of this study provide further support for the model of autism as a disorder of complex information processing (Minshew, Williams & McFadden, 2008); however, the level that a task becomes too “complex” is difficult to identify. This indicates a need for measures to determine when a language processing task becomes too complex for an individual with autism. Further studies should be conducted that systematically vary the levels of processing to assess at which level of complexity the individuals with autism begin to have difficulty. A levels of processing approach begins with a low level perceptual task (e.g., deciding whether the words are written in lower or upper case letters) and then gradually adds higher levels of semantic processing (e.g., deciding whether a word is a concrete or abstract noun). Using at least two such tasks that are equal with respect to the time constraints and the demand for making a judgment also might clarify the effect of these variables on the performance of the individuals with autism. If the problem is primarily with making judgments under a time constraint, then the expectation would be that the performance of the individuals with autism would be relatively worse than matched controls in both tasks (with a possible additive effect in the second task with the addition of the semantic processing demand). If the problem is primarily with semantic processing, then the performance of the autism group in the first task, with its extremely low processing demand, should not be affected.

Another direction for future research is using a task such as the word-stem completion task to look at the integrative functioning and cooperation of the frontal and posterior language areas in the brain. The word stem completion task in the current study was apparently not challenging enough for the individuals with autism and they performed no different than the controls. This task was a verbal fluency and word retrieval task and primarily related to the question of flexibility in semantic processing. It would be interesting to modify this task and create a more complex and integrative version. For example, asking the participants to complete a cloze sentence using a word that begins with a given word stem. The words chosen would then have two constraints that would need to be managed, the form of the word and the integration of the meaning of the word with the context. The individuals with autism might have more difficulty with a task such as this as it requires processing the words and then integrating the context and meaning of the sentence to choose the most appropriate word.

Further investigation into the associated learning that was evident in the sentence completion binomial task should be completed to create a better picture of how individuals with autism are storing, processing, and retrieving words in their lexicon. Even though individuals with autism may be processing words at a basic level, this study provides evidence that they have a deficit with processing words at a more complex, integrative level. Future research is necessary to determine different measures for assessing semantic processing difficulties in individuals with autism because the findings of studies looking at this level of lexical organization will provide evidence for new treatment approaches in how professionals teach language to individuals with autism.

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Appendix 1

INSTRUCTIONS

Word Recognition Task

In this task, 2 items will appear on the screen at the same time. Both of these would sound like a real word, but only one is a real word.

You will show me which item is a real word by pressing a key on the button box. Push the key that is on the same side as the real word. Press the 1^{st} button if the word on the left is the real word. Press the 3^{rd} button if the word on the right is the real word.

A number will appear on the screen if you answer correctly. The faster you answer, the smaller the number will be. If you were wrong, “error” will appear on the screen. Try to answer as quickly and as accurately as you can while making as few errors as possible.

Now we will do some words for practice. Which one is a real word?

Do you have any questions?

INSTRUCTIONS

Word Reading Task

Look at the list of words. Read the words in each column so I can hear you. When you finish the first column, go to the top of the next column, and so on until you finish reading all the words.

Read slowly and say each word clearly.

Do you have any questions?

Let's try a few practice words.

Appendix 2

INSTRUCTIONS

Sentence Completion Task

In this task, you will be presented with a sentence. Please read each sentence aloud and then complete the sentence with the first word or phrase that comes to your mind.

There is a time limit on this task, so please respond with a word or a phrase as quickly and as accurately as you can.

Do you have any questions?

Let's try a few practice sentences.

Appendix 3

INSTRUCTIONS

Word Stem Completion Task

In this task, you will be presented with a word stem: the first 3 letters of a word.

Using each word stem, please form **5** English words that come to your mind, excluding proper nouns. Please try to form five different words. Plurals and different tenses of a word will be considered as incorrect.

For example, if the word stem is PRI-, print would be an acceptable answer. However, prints, printing, printed would be incorrect. Please try to form 5 DIFFERENT words.

There is a time limit on this task, so please try to answer as quickly and as accurately as you can.

Do you have any questions?

Now we will do some for practice. Form **5** words that come to your mind.