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Assessment in Children with ASD: Does Testing Modality Matter?

by

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To the Graduate Faculty:

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List of Abbreviations

APA   American Psychiatric Association

ASD   Autism Spectrum Disorder

ASHA   American Speech and Hearing Association

C   Computer-mediated format

CELF-5   Clinical Evaluation of Language Functioning, Fifth Edition

S   seconds

SLP   Speech-Language Pathologist

List of Symbols

®   Registered Trademark

Abstract

The current study discusses the potential effect testing modality has on receptive language test scores, testing duration, and amount of atypical behaviors observed on school-aged children with autism spectrum disorder (ASD). Twenty-two children recruited from public schools and a private speech-language clinic participated in the study. The *CELF-5 Word Classes* subtest was administered in two modalities, computer-mediated and speech language pathologist (SLP)-mediated formats. Participants' raw scores and total amount of behaviors per interval were not significantly difference. However, a significant difference was observed in testing duration and the mean number of atypical behaviors in 30 s interval. This demonstrated that the format of assessment administration may impact children with ASD's performance. Clinical implication for assessment of testing modality for students with ASD are discussed.

Key words: autism spectrum disorder, computer-mediated assessment, speech-language pathologist-mediated assessment, receptive language assessment

Introduction

Typical limitations for school age children with autism spectrum disorder (ASD) are reduced receptive language communication and social interaction (*Diagnostic and Statistical Manual of Mental Disorders* [DSM-5], 2013). Receptive language is the ability to understand information that is being communicated (verbally or non-verbally). These language skills are vital during the school-age years because information is provided via natural speech. To provide adequate treatment for students with limited receptive language abilities, clinicians assess current levels of functioning through various means, the most common being standardized measures (Muller & Brady, 2016). Accurate assessment is important for the school age population to determine eligibility for services (Kover, McDuffle, Hagerman, Abbeduto, 2013). However, current standardized testing measures are often administered in formats that do not make adjustments for anxieties, behavioral issues, and comprehensive limitations children with ASD may exhibit (Ellerbeck, Smith, & Courtemanche, 2015). Currently, the most common format to administer tests requires direct interaction with a speech-language pathologist. As a result, the individual's performance may not be accurately reflected on standardized tests (Nordahl-Hansen, Kaale, & Ulvund, 2014).

Typically, children with ASD have a greater likelihood of having social anxiety than their typically developing peers. Social anxiety can be manifest through preoccupations, repetitive behaviors (e.g., obsession and compulsive behavior), separation anxiety, panic, and avoidance of social situations (van Steensel, Bogels, & Wood, 2013). These atypical behaviors can complicate the SLP-mediated verbal response testing procedure more difficult. Anxiety concerns are among the most prevalent difficulties that school-age children with ASD present (Ghaziuddin, 2002). A systematic review of 31 studies, revealed that 39.6% of the 2,121

participants (<18 years of age) with ASD exhibited at least one characteristic of anxiety disorder as classified by the DSM-5 (van Steensel, Bogels, & Perrin 2011).

Although children with ASD have difficulty interpreting facial expressions and understanding theory of mind (i.e. perceiving other's feelings and emotions), research has discovered that their visual processing skills "may be superior to (neurotypical) people" (Costandi, 2011, p. 3). On a low-level acuity test, 15 individuals with ASD had better visual acuity (20:7) in comparison with 15 neurotypical individuals (20:13). This level is in the visual region reported for birds of prey. These skills are seen in detecting patterns and symmetry that are digitally presented which lends to individuals with ASD being drawn to and having improved performance with computer-based intervention (Ashwin, Ashwin, Rhydderch, Howells, & Baron-Cohen, 2009). There are also behavior limitations attributed to visual acuity, such as hyper-focusing on minute details, preferring to look down and sensitivity to bright lights (Simmons et al., 2009). These traits, along with a tendency to be attracted to lights generated from digital screens and social avoidance, attribute to individuals with ASD preferring digital technology. This also makes a strong case for computer-based intervention and testing.

Another behaviorally related limitation is inattentiveness to undesirable tasks. Limited research is available related to the reduction of time an individual with autism takes to complete a task when computer-based as opposed to SLP-mediated, which is often attributed to inattentive or hyper-focusing behaviors. However, related research has found that computer-based training was effective in improving attentiveness for school-age children with ASD, which in turn improved math (pre-training 38.92, post-training 53.13) and reading skills (Spaniol, Shalev, Kossyvaki, & Mevorach, 2017). Results also found a significant interaction between time and groups that used the computerized attention training.

Often the responsibility for effective communication is placed on the child despite the many barriers (e.g., assessment modality) they may experience. According to the Systems Model of Language Disorders (Prizant & Wetherby, 2005), communication is a two-way system with both parties being equally responsible for communication. Therefore, if there are breakdowns in the transmission or, in the case of this study, the comprehension of standardized assessment information, the partners need to change either how they communicate or the environment. Thereby justifying the need to alter traditional assessment methods that have been shown to be difficult for children with ASD (Santhanam & Hewitt, 2015).

As children with ASD demonstrate limitations in language and communication, accurate assessment is a critical element to develop effective intervention (Santhanam & Hewitt, 2015). Although extensive research has been conducted on diagnosing autism, limited information is available to guide appropriate clinical practice for language and communication. In a systematic review of scholarly databases between 1995 and 2003, only 54 articles were found that related to assessment of speech and/or communication for individuals with ASD.

Few speech-language standardized tests have been made available in computerized format, other than scoring referents. Research investigating the effects of testing modality is in its infancy, but a recent uptick in the efficacy of computerized testing with individuals with speech-language deficits has occurred secondary to the proliferation of digital technology (Alt & Moreno, 2012; Williams, Wright, Callaghan, Coughlan, 2002; Constantin, Johnson, Smith, Lengyel, & Brosnan, 2017). Computer-assisted technology "holds the promise of being effective where other treatment methods have failed" (Ploog, Scharf, Nelson, & Brooks, 2013, p. 302).

The purpose of this paper is two-fold. First, this investigation will compare the efficacy of computerized and SLP-mediated testing modality measuring the receptive language abilities

of school-age children with ASD. Second, to determine whether a difference in modalities affect

the behaviors exhibited by the children, which also impacts the duration on the test

administration.

Characteristics of ASD

Currently the cause of ASD is unknown despite the increase in reported occurrence; as is

the reason for males to more likely exhibit autistic-like traits. The prevalence of individuals with

ASD has risen from 1 in 68 in 2014 to 1 in 59 individuals in 2018, as reported by the 2018

Centers for Disease Control and Prevention report (Baio et al., 2018). In the 2006 report, which

cited the occurrence at one in every 150 individuals, at which time, it was quoted as "an urgent

public health issue." Some researchers debate that the increase is the result of an increased

awareness of the disorder and accuracy of diagnosing (Damiano, Mazefsky White, & Dichter,

2014). Whatever the case may be, additional research regarding this population is needed to

obtain information regarding useful treatments.

Autism spectrum disorder (ASD) is a group of developmental disorders with a wide

range of characteristics, skills, and levels of abilities (National Institute of Mental Health

[NIMH], 2016). Characteristics of ASD are limitations in social communication, social

interaction, restrictive and repetitive behaviors, and receptive language delay (DSM-5, 2015)

Typically, individuals with ASD appear to have an extensive vocabulary and syntax. This may

be a reflection of echolalia that may not be used in appropriate context. Also, the depth of

meaning for the words used may be restrictive and not generalized.

The persistent deficits in social communication (verbal and non-verbal) across multiple

contexts is problematic due to limitation in reciprocity, figurative language, theory of mind, and

recognizing contextual elements of conversation (Vicker, 2009). Social communication involves

appropriate greetings and sharing information appropriate to the context. Also, the ability to adjust their communication to the subject, audience, and environment. An example of this would be talking with the same vocal intensity in class that they would on the playground. Difficulties inferring and understanding non-literal language is another subset of the criteria.

The second criterion is restrictive and repetitive patterns of behavior (DSM-5, 2013). This can be manifest by obsessing about events or ideas, resistive to change in routine or environment, or concrete thinking. To receive a diagnosis of ASD, these traits must have been exhibited in early developmental stages and cause significant impairment in daily living. Early diagnosis and early treatment have resulted in reduced special education services in the school age years (Clark, Vinen, Barbaro, & Dissanayake, 2018).

Third, deficits manifested by the individual cannot be explained by other intellectual disabilities or delays; despite the frequent co-occurrence of ASD and intellectual disability. Some level of supervision or support must be needed to perform some area of daily living skills (Vicker, 2009).

In addition to the social interaction and language deficits, are concomitant behavioral and psychological impairments, which was included in the diagnosis of autism in the DSM-IV. This is no longer required according to the DSM-5. Common behaviors reported in children with ASD were manifestation of social anxiety (Maddox & White, 2015). Social anxiety is described as the fear of embarrassment in social situations and as a result often leads to social avoidance. Several standardized and non-standardized assessments of social anxiety are available to measure avoidance, persistence of crying, tantrums, withdrawing, and repetitive movements (e.g. arm or hand flapping, pacing, repeating phrases) among other variables. These tests included the (a) Social Phobia and Anxiety Inventory for Children (SPAI-C; Beidel et al., 1998), (b) Social

Anxiety Scale for Children-Revised (SPAIK; Melfsen et al., 2001), and (c) Child Behavior

Checklist (CBCL; Achenback & Eldelbrock, 1983). Previous research administered these tests

to 54 high-functioning children and adolescents with ASD and 305 neurotypical individuals.

The results indicated that social anxiety was greater in high-functioning adolescents than in the

typically developing population (Kuusikk et al., 2008). An age effect was also found indicating

that avoidance behaviors of children with ASD increased with age, while typically developing

children's avoidance behavior decreased with age. Social avoidance behaviors and restricted

social skills can make testing difficult for these individuals (Loftin, 2003). These findings

validate the need to examine if testing modality affects behaviors for children with ASD.

Receptive Language

Despite general communication deficits, children with ASD have been found to have

greater difficulty with receptive language skills (Nordahl-Hansen et al., 2014). Receptive

language provides the foundation for developing expressive language and literacy skills (Muller

& Brady, 2016). In typically developing children, receptive language is generally stronger than

expressive language. However, this is not always the case in children with ASD. A longitudinal

language development study contrasted non-verbal intelligence and receptive and expressive

language abilities between 257 young children with ASD and 69 children with developmental

disabilities (not including ASD) (Ellis Weismer, Lord, & Esler, 2010). Participants were

reassessed at 2, 3, 5, and 9 years of age. Consistency was noted across performance measures.

Results revealed that children with an ASD diagnosis exhibited more extensive delays on each

language assessment. Specifically, children with ASD exhibited 20-23 months delay in

chronological age (CA) while children with a general developmental disabilities (DD)

demonstrated 1-9 months CA delay. Additionally, there was a significant main effect in the

differences between the groups (*p*=.001). A significantly greater deficit in receptive language skills was reported in the group of children with ASD, while those with DD had greater abilities in receptive language, *r*=.568, *p*=.001. These results demonstrate the importance to analyze receptive and expressive language separately and provide visual and sensory stimulation during testing (Loftin, 2003; Nordal-Hansen et al., 2014).

Similarly, in a previous study, receptive language delays in vocabulary and syntax were assessed to determine the level of difference between children with ASD and neurotypical peers (Kover et al., 2013). Participants consisted of 49 boys (4-11 years) with ASD and 80 typically developing boys (2-11 years), were administered the *Peabody Picture Vocabulary Test-4*[th] *Edition* (*PPVT-4;* Dunn and Dunn 2007). Results indicated a significant delay in receptive semantics in boys with ASD and growth was slower in comparison with their neurotypical peers. These findings may suggest that the SLP-mediated testing format can negatively impact test scores or underestimate an individual with ASD's true skill.

Research has been limited in its scope of testing receptive language, relying on methods that fail to measure higher level receptive language (Kover et al., 2013). This may be due to the limiting behaviors that individual's with ASD display during testing. To effectively measure an individuals' receptive language abilities, compliance and the ability to attend to testing instructions are necessary. Using parent-reports and modify testing format has helped to alleviate some of these challenges (Nordahl-Hansen et al., 2014).

Standardized Testing

The goal of norm-referenced, standardized tests is to compare the speech-language functioning between the individual tested and their same aged peers. From this comparison, developmental norms can be extrapolated and used as reference points for designing therapy

targets that are age and gender appropriate according to evidence-based research. Tasks that are assessed have been carefully selected to reliably and validly measure individual characteristics (Paul & Norbury, 2012).

A general purpose of speech-language standardized testing for school-aged individuals relates to determining eligibility for funding sources and additional school services. Many states require evidence that a student performs below a certain criterion to qualify for special education services. Testing also allows for diagnosis of speech and language disorders (Paul & Norbury, 2012).

Although standardized testing is the most prevalent assessment measurement in determining speech and language needs, various studies have found limitations in standardized testing for children with DD (Nordahl-Hansen et al., 2014; Santhanam & Hewitt, 2015; Ellis Weismer et al., 2010). Limitations include reliance on developmental norms, which children with ASD do not typically adhere. Another limitation in standardized testing is the level of accuracy in measuring individual abilities and limitations (Friberg, 2010). Research has shown that children with ASD are developing at a rate below other children with DD in receptive language (Ellis Weismer et al., 2010). Also, children with ASD may lack skills that are required in the test situation (e.g. social skills, attention, etc) (Loftin, 2009).

Another limitation is that most available assessments are not specific to ASD. Also, standardized tests are normed against a predetermined population of children, few of whom are individuals with autism (Santhanam & Hewitt, 2015). For example, the *PPVT-4* is viewed as well-constructed and high validity. However, out of 3,540 cases for an age norm sample, but only four individuals with autism were included in the norming sample (Dunn & Dunn, 2007, p. 44).

While standardized testing is the most "valid, reliable, and fair way to establish that a child is significantly different from other children" (Paul & Norbury, 2012, p. 44), the tests do not account for the cognitive and social deficits of children with ASD. A literature review of 54 articles which conducted research assessing children with ASD using norm-referenced assessments, found that there are few standardized test that are normed for use with children with ASD (Santhanam & Hewitt, 2015).   This analysis also revealed that alternative sources assisted in more accurately determining a child with ASD's language abilities. These consisted of use of familiar people (i.e., parent report) or collection of language samples in naturalistic environments.

Difficulties in testing administration relate to social impairments typically manifested in individuals with ASD, especially in children (i.e., short attention span and lack of cooperation and/or motivation). As these tests are designed to measure their language abilities, it in turn does not accurately depict their functioning (Alt & Moreno, 2012; Nordahl-Hansen et al., 2014). Therefore, alternative testing modalities for children with ASD may be required to provide a more accurate depiction of their abilities (Tager-Flusberg et al., 2009). Based on these reports, preference of children with ASD, and strength in motion processing, digitally administered tests may be more appropriate for children with ASD (Alt & Moreno, 2012).

Computer-assisted technology

Research indicates that individuals with ASD are attracted to digital technologies (Elicin & Kaya, 2016; McCoy, Holloway, Healy, Rispoli, & Neely, 2016). This is attributed to typically manifested impairments in social communication and mental-health disorders. Computer interaction provides an outlet to reduce social stressors (Constantin et al., 2017). A study of social deficits using the *Social Phobia and Anxiety Inventory for Children* (*SPAI-C*) in 52

children and adolescents with ASD aged 8-15 revealed that 69.4% of participants rated themselves as withdrawn/social avoidance. Younger children (mean of 10 years) scored higher on Fear of General Conversation questions on the *SPAI-C* when compared to adolescents. Further, awareness of communication impairments increases anxiety when confronted with an unfamiliar person, situation, or environment (Kuusikko et al., 2008). A literature analysis discovered that technology is beneficial for individuals with ASD who experience social anxiety. Specifically, that technologies can focus on their strengths and weaknesses by creating a controlled environment for use as support tools in therapy (Aresti-Bartolome & Garcia-Zapirain, 2014).

Since children with ASD have a tendency towards inattentiveness, professionals have struggled to find means of maintaining their attention. A previous study investigated the attention, motivation, and learning of words in children with ASD using a computer-mediated teaching program or a teacher-administered program (Moore & Calvert, 2000). The study looked at vocabulary acquisition. Fourteen children with ASD were 97% more attentive in the computer-mediated condition and 57% wanted to continue treatment. In contrast results from the teacher-administered condition indicated that 0% wanted to continue the program. Participants in the computer-mediated program learned targeted vocabulary words at a greater rate (74%) compared to the participants in the teacher-administered condition (41%). The study demonstrated individuals with ASD respond more appropriately to information delivered digitally than through an administrator. These findings were consistent with research implementing educational material on computers as opposed to written material. Children with ASD, ranging in ages from 3 to 5-years old, were randomly assigned to each format in two sessions. Findings demonstrated that the children were engaged for longer periods of time; a side

result being a greater acquisition of target words over those who learned through book reading (Williams et al., 2002). Similarly, through a systematic review of computer-assisted technology research, eight studies found that children identified more words, spent more time reading, and exhibited less resistance to the material when presented in a computerized format (Ploog et al., 2013).

Studies have demonstrated improvement in communication and literacy when computer-based intervention has been implemented. In a systematic review of 10 reports regarding 70 autistic individuals with a communication deficit (expressive, receptive, and/or pragmatics) utilizing computer-based intervention (CBI) revealed the efficacy of such treatment (Ramdoss, Lang, Mulloy, Franco, O'Reilly, Didden, & Lancioni, 2011). All studies reported overall communication improvement for all participants with computer-based intervention, with an effect size of 1.015, demonstrating the strong correlation. Specifically, an increase in spelling accuracy and frequency of spontaneous speech productions and general academic skills (math, reading, writing, social studies, and science) were reported.

A positive correlation was found between improved communication skills and the use of digital technology (Allen, Hartley, & Cain, 2016). A review of 17 studies found that when a digital device was used in communication treatment, with minimally-verbal children with ASD, 93% improved in their ability to communicate intent. Although more studies have been done to test the role of computer technology to improve skills related to adaptive functioning (language, emotion recognition, theory of mind, and social skills), they are still few in number and lack contrast between computer and non-computer-based intervention (Ploog et al., 2013).

Testing Children with ASD

Communication and social skill abilities vary greatly between individuals with ASD. These variations have a drastic impact on the scores obtained through standardized testing. One method to control performance variability is through the use of computerized testing. This was observed in a systematic review which sought to determine the efficacy of video-modeling, role-play, and/or computer-based instruction as a social skills intervention method for children and adolescents with high-functioning ASD. Peer-reviewed studies that were included through randomized computer selection, included 330 participants, ages 3-17 years, across 29 reports. Analysis revealed no significant improvement through the use of video-modeling or role-playing. However, computer-based methods reported positive outcomes for social skills training with an effect size of .84 (range of .69-.99), "reflecting a treatment of medium effect" (McCoy et al., 2016, p. 63).

Presentation of material on standardized testing may affect the ability of a child to correctly identify it. For example, a study by Preissler (2008) discovered that children with ASD and concomitant cognitive impairment, were able to label black and white pictures but not able to extend the label to similar referents. However, other studies have found that a similar group of children extended labels twice as often when color pictures were introduced as compared with non-color pictures. In comparison, the typically developing control group was only able to generalize new words learned to items that matched in shape, where the children with ASD generalized based on shape or color. These results demonstrated that the children with ASD were influenced by the type of picture shown (Hartley & Allen, 2015). Suggesting also that there may be an atypical route of word learning through pictures and symbols. Demonstrating

that the way pictures are presented may be beneficial or detrimental in testing for children with ASD (Allen et al., 2016).

Muller and Brady (2016) assert, through systematic reviews, that an important strategy for clinicians to implement, in testing children with ASD, is to modify standardized testing to meet the needs of the individual. One method suggested was to provide alternative formats, such as modifying the pages in such a way to draw the child's attention toward the item in question or presenting the pictures in a larger or eye-catching format. Others suggest that computer-based intervention formats are engaging and motivating for children and adolescents with ASD (Allen et al., 2016; Alt & Moreno, 2011; McCoy et al., 2016; Perlman, 2016; Ramdoss et al., 2011).

Contrasting Computer-mediated and SLP-mediated Test Administration

As noted previously, many studies have focused on the efficacy of computer-based intervention and education. Alt and Moreno (2012) and Perlman (2016) are among the few researchers to contrast the results of SLP-mediated with computer-mediated norm-referenced expressive language testing on 18 children with ASD and 18 neurotypical peers. The research also looked at the behavior of the individuals, hypothesizing that the participants with ASD would experience more stress while taking the traditional version. Participant's parents completed a preliminary questionnaire, classifying the children's type of ASD (relative to the DSM-4) as well as their functioning level (low, moderate, or high). Functioning level referred to the children's language, social interactions, and cognition. No previous standardized measures were employed in the study. There were no children functioning at the "low" level in the study; five were moderate and 13 were high functioning.

Tests that were implemented consisted of the one-word picture vocabulary tests that measured expressive and receptive measures (Alt & Moreno, 2012). Computerized format

consisted of a scanned version of the same tests. The clinician was able to move the slide remotely from a separate laptop from the one the child was seated in front of. A recording was made to ask the child what the depiction on the laptop represented. Other screens with feedback responses was also programmed into the test administration (e.g., "Good job. Keep going"). Both the interactive and computerized version were administered in the standardized manual depicted by the testing manual. Each child attended two sessions set one week apart. During each session, a child was administered two out of four possible test combinations (i.e., receptive-paper; receptive-computer; expressive-paper; expressive-computer) but was given one a paper format and the second in a computer format. Selection of the tests was randomized and administered by an unfamiliar individual (the author and a research assistant).

Alt and Moreno (2012) also developed a behavioral rating scale to categorize the reactions of the children during testing. Some areas that were gauged were: amount of fidgeting, distractibility, inability to answer, self-stimulating behavior, lack of motivation, inability to follow directions, and others. The rational for hypothesizing that individuals with ASD would experience greater stress during administration of paper testing was based on other research. Previous research has found that individuals with ASD have demonstrated improved learning when using computer technology (Moore & Calvert, 2000). Also, individuals with ASD typically experience social anxiety which could result in falsely low scores. However, there was not a significant difference in behavior between tests.

The researchers proposed that the lack of a significant improvement in scores was the result of three things (Alt & Moreno, 2012). The first being the simplicity of the task. Simple one-word vocabulary tests were administered to both groups with SLP-mediated and electronic versions. This type of testing has predictable results that lack a higher level of communication

skills. A second possibility relates to the diagnostic severity of the participants with ASD. The 13 children participating in the study were classified, by parent report, as highly functioning. Five of those participants were classified as moderately impaired. Third, the rating scale used to determine behavior changes was novel, though it measured behaviors commonly reported by research. Children with ASD, despite social impairments, performed similarly on the SLP-mediated format and computer-administered method. It was hypothesized that the regularity, simplicity, and predictability of the task mitigated social anxieties that may have otherwise be demonstrated. Other research has suggested that the structured dynamics of standardized testing fits well with the learning profiles of individuals with ASD as long as it is modified appropriately to meet their needs (Alt & Moreno, 2012).

Studies have been conducted evaluating the correlation between individuals with ASD being tested on simple learning tasks on a computer-mediated in contrast to SLP-mediated methods (Alt & Moreno, 2012; Constantin et al, 2017; Ramdoss et al., 2010). However, limited studies have investigated the effects of traditional standardized testing with computer-mediated testing formats for children with ASD (Alt & Moreno, 2012; Skwerer, Jordan, Brukilacchio, & Tager-Flusberg, 2016). Alt and Moreno (2012) advocated for research comparing standardized language scores from these two testing modalities because of the limitations in assessing children with ASD using only SLP-mediated formatting (Loftin, 2009; Moore & Calvert, 2000; Nordahl-Hansen et al., 2011). Also, other researchers have demonstrated the need for effective means to more accurately measure receptive language in children with ASD (Nordahl-Hansen et al., 2014; Ellis Weismer et al., 2010). Therefore, the aim of this research is to further explore a possible correlation between testing format (computer-mediated and SLP-mediated) and receptive language scores for school-age children with ASD. As well as an observable difference in

restrictive behaviors that are typical of the individual child and if those behaviors impact the duration of testing (e.g. inattentiveness, hyper focusing, obsessing, etc).

Methods

Hypothesis 1: A difference in receptive language scores will be observed based on the testing modality (computer or SLP-mediated) for school-age children with autism spectrum disorder (ASD).

Null Hypothesis: No significant difference will be observed based on testing format (computer or SLP-mediated).

Hypothesis 2: Behavior differences and the time of testing administration will be observed in school-age children with ASD depending on the type of testing format (computer and SLP-mediated).

Null Hypothesis: No significant differences in behavior will be observed based on testing format (computer or SLP-mediated).

Variables Defined

The independent variable is testing modality: computer and SLP-mediated.

- Computer-mediated format was defined as the *CELF-5 Word Classes* subtest administered through a laptop computer and without direct interaction from the primary examiner. For this condition, 16 scanned pages of the picture stimuli were shown from the laptop (12 scored pages and 3 example pages). Twenty-seven subsequent slides, alternating solid brown and green, were displayed one at a time with audio overlay. The laptop was remotely operated by the clinician from a wireless mouse. Instructions were played through the laptop via a pre-recorded wav file dictated by the administrating clinician. The clinician observed

the participants' responses from a distance and recorded them as the participant

responded.

- SLP-mediated format was defined as direct test administration by the clinician

  with the use of the *CELF-5 Word Classes* subtest picture flipchart. Instructions

  were given directly from the clinician and responses were recorded at the time of

  administration.

For the hypothesis 1, the dependent variable was the receptive language scores earned by the

student with ASD.

- Receptive language score were determined by use of the *CELF-5 Word Classes*

  subtest, administration and scoring manual.

For hypothesis 2, the dependent variables were the behavior demonstrated by the participant and

the duration of time of testing administration.

- Behavior was defined as the number of atypical behaviors in regard to stimulus,

  environment, interaction, or the testing condition. The most common behaviors

  limiting each participant's test taking ability were gathered from a parent and/or

  teacher report.

- Time of testing duration was measured by time stamps from video recording.

  Duration of test taking was measured from the moment the scored portion of the

  test began (after the example was provided) until the last question was answered,

  a ceiling, or a basal was reached. If the child did not respond to the last question,

  10 s of silence was given to allow for a response to be given. If the child

  requested, a second instructional prompt (identical to the first) was given.

Participants

Participants were solicited from Facebook® (see Appendix B), public schools, and private clinics. Responses were received from public schools and private clinics in the Idaho Falls district. Permission to seek for participants through teachers was given by school district 91 and 93 Special Services administrators. The primary investigator also received permission from the principals of the participants' schools. One private speech-language clinic Human Services personnel gave permission to contact their SLPs. Forty-four parent permission letters (see Appendix A) were dispersed by teachers and private SLPs, 22 were returned. The 22 school aged children, ranging from 6 to 12 years of age (first through sixth grade), 3 females, 19 males, participated in the study. Each was determined by the teacher or SLP to be a fluent English speaker and have no uncorrected vision or hearing problems. Fourteen of 22 students were enrolled in special education full-time, three were mainstreamed full-time, five attended both intermittently through the day. Each participant was selected by their teacher or private SLP based on his/her ability to participate in testing. This increased the participants' likelihood of completing the experimental assessment.

Each participant had a preexisting diagnosis of ASD from a qualified professional. Concomitant behavior challenges were mild to severe, as indicated by student examiner and teacher or private speech-language pathologist (SLP) completion of the *Child Autism Rating Scale Questionnaire, second edition standard edition (CARS2-ST;* Schopler, Van Bourgondien, Wellman, & Love, 2010). Fifteen out of 22 participants scored between 30 to 36.5, for an autism severity rating of mild-to-moderate. Seven scored 37 or higher for an autism severity rating of severe.

Materials

The materials for this study included the following items:

1. All participants were assessed using the *Word Classes* subtest of the *Clinical Evaluation of Language Fundamentals-Fifth Edition* (*CELF-5*; Wiig, Semel, & Secord, 2013), which is standardized and norm-referenced. This test was chosen for the age range (5-10) and with the aim of testing higher-level receptive language skills that are required in academics.

2. *CELF-5 Word Classes* subtest scoring sheets were used to record the responses of the participant of each test administered. The raw scores of each participant's tests were used to assess the difference.

3. *CARS2-ST* was completed by the student examiner and the participant's teacher/private SLP to determine the level of ASD severity and behaviors manifested.

4. PowerPoint® was used to present 13 slides of the scanned subtest pictures with audio directions inserted on each slide. Twenty-seven additional solid colored slides were presented with audio overlay presenting word choices.

5. A wireless mouse was used to manually move the slides or repeat if necessary.

6. A laptop was used to present the PowerPoint® for the computer-mediated version. The keys were locked to insure the participant did not tamper with the program.

7. Each session was recorded from two recording sources/cameras when the setting provided room to set up two cameras. There were six locations that had no extra space to prop up a second camera. The purpose of recording sessions was for validity checks of scoring methods, time stamp, and number of behaviors recorded.

8. Behavior checklists were generated by the administrating clinician from the information that was provided by the participant's teacher/SLP and individualized for each child. The most common behaviors that were reported to impact testing were recorded.

9. Consent forms were generated by the administrating clinician and completed by the participants' parents/guardians prior to starting the sessions.

Testing Modality

SLP-mediated. The stimuli flipchart was situated in front of the participant seated at a table. The score sheet was obstructed from the participant's view to reduce answering bias based on recording methods (e.g. the client recognizing + meant a positive response). The administrating clinician verbalized the instructions and turned the pages according to the manual's instructions.

Computer-mediated. The *CELF-5 Word Classes* subtest stimuli was scanned and uploaded to a laptop and inserted into PowerPoint®. A pre-recorded audio wav file was uploaded on slides that provided the participant with instructions and demonstrations (demo). The instruction provided on the demo was "I am going to say some words and show you some pictures, two of the words go together. Look and listen as I say the words, puppy, frog, dog. Two of the words go together best, do you know which ones they are?" This instruction was provided for both the SLP-mediated and computer-mediated demos.

Procedures

Participants were randomly assigned to a testing modality (i.e., computer-mediated or SLP-mediated). The assignments were counterbalanced to ensure equal distribution between

conditions. The sessions were scheduled a week apart for each modality. For three of the

children the second modality was extended from two to three weeks due to circumstances outside

of the primary examiner's control. One student refused to be retested on the scheduled day. The

other two were retested due to computer power failure.

Consent forms were completed by parents of participants prior to conducting

research. The clinician spent time, prior to the first testing session, to become acquainted with

each participant. This was done in their classroom or private clinic.

Each session was recorded using a video camera provided by the clinician. Prior to

administering the test, the clinician assigned a random number to label the test and video

recording to remove identifying information.

The SLP-mediated format was administered according to the manual instructions. A

demonstration and two trial visual stimuli were presented to the participant according to the

CELF-5 Word Classes subtest directions. The first three slides were example slides. The

primary examiner provided an attention phrase, "look and listen." The primary examiner then

stated what each picture was and which two were alike: "On this page there is a puppy, a stick,

and a dog. The dog and the puppy are the most alike." After the 13 scored visual stimuli pages,

27 groups of words were presented verbally (e.g., running, jumping, eating, hearing), with no

visual stimulus. A basal score was determined according to the manual recommendations for the

child's chronological age. The ceiling also dictated by the manual, was achieved when the child

answered incorrectly or gave no response four consecutive times, or if the test was completed.

The participant could request the primary examiner to repeat the instructions or they would be

repeated after 10s elapsed.

Administration of the computer-mediated modality followed the same procedures as the SLP-mediated modality. Each slide played pre-recorded directions that corresponded with the stimuli. A 10 s delay was programmed into the audio feedback, and then the instructions were repeated if the participant did not respond or responded incorrectly. An additional 27 PowerPoint® slides, with the groups of words presented verbally, were shown on alternating backgrounds of brown and green. Research has shown that these are colors that children with ASD prefer and are not sensory overloading (Grandgeorge & Masataka, 2016). Each participant was seated in front of the laptop. The timing schedule and wait time was the same as during the SLP-mediated format. The instructions were also repeated if the participant requested a repetition or paused for 10 s with no response. The administrator sat at a distance from the student but close enough to see the response. Each session was filmed for procedural integrity and reliability data.

The duration of time it took for the participant to complete the test or reach a ceiling was determined from the time-stamp on the video recording. Time of test taking started once the first scored page was presented until the end of the test or the participant missed four questions in a row.

Each participant's five most common atypical behaviors were determined by each participant's teacher or private SLP. These behaviors were noted by the primary examiner during the testing as well as observed at a later date through video recording. If the participant displayed frustration, discomfort, or stress by their demeanor or actions, the sessions were discontinued. In the case of one student, whose behaviors on the day of the second session did not allow for testing, a follow up session was scheduled and conducted. The student at that time was willing to participate in testing.

Precautions were made to ensure that the child's name and identifying information were not used by assigning a number to the materials and recorded sessions. Documentation and recordings were kept in a locked cabinet in the faculty advisor's office at ISU and will be destroyed after six years.

Scoring Methods

CELF-5 Word Classes subtest forms were used to score the participants' responses for each test format given. Responses were recorded during the test, with the form out of view of the participant to account for recognition of correct/incorrect scores which might skew the answers or behavior.

The time required for the participants to take the test was recorded on their *CELF-5 Word Classes* subtest score sheet after the test was completed and compared to the second test that was administered. Testing duration was timed by reviewing time stamps on the video recording.

Atypical Behaviors were recorded during the sessions and tallied at a later time using the video recording. Interval recording was used to determine the frequency of behavior occurrence. Using the testing start and end time shown on the video time stamp, a chart was developed by the student examiner using 30 s intervals. The interval time was determined as an appropriate time frame to provide enough data points for atypical behavior analysis for the shortest to longest test durations.

Through video analysis, the student examiner recorded if the behavior occurred during the interval for each of the five behaviors unique to the participant. The number of atypical behaviors was then tallied using 30 s intervals during the testing duration, as determined through the video recording. A score of "1" was earned for behaviors observed during the 30 s interval.

The total number of atypical behaviors were then calculated and divided by the number of 30 s intervals to determine the percentage of behaviors per intervals. One participant's video recording of the computer administered test was lost. However, the primary examiner noted the behaviors that occurred in correspondence with the *CELF-5 Word Classes* subtest questions during the test. This recorded information was used to approximate the number of atypical behaviors per interval. Scores were also calculated during the testing session. The time duration could not be accurately determined without the video recording and this participant was eliminated from the analysis of testing duration.

Reliability

Inter-rater reliability for all variables was assessed on approximately 20% (8/22) of the *CELF-5* subtest assessments. A random number generator, in Microsoft Excel ®, was used to select eight videotaped samples, four from the 22 face-to-face administrations and four from the 22 computer mediated administrations.

Two speech-language pathology graduate students were trained, and each one scored four of the selected samples on *CELF-5* protocols. These protocols were compared to those of the primary investigator. The variables considered were receptive language scores, testing duration, and atypical behaviors.

Receptive language scores were defined as the raw score (number of correct answers) provided by the participant in each modality on the *CELF-5*, Word Classes subtest. For receptive language scores, the range of disagreement was 0 to 2 points, with a mean of 0.375. A point-by-point analysis was for test scores was computed and an overall agreement was 75% (6/8) exact match in test scores. Two samples differed in scoring, indicating a high level of agreement.

Testing duration was defined as the time the test began to the time that the participant provided the last answer for a ceiling (four incorrect responses) or after a repetition and a 10-second delay. Test times were delineated by video recordings. Reliability of testing duration was assessed through the video recording time stamp. The range of disagreement was 0 to 9 s, with a mean of 2.25 s. The 9 s discrepancy was due to an interrupted start time (external noise) that the primary examiner excluded from the total time, but the reliability tester did not, having not been informed. After the 9 s discrepancy, the next highest was 3 s. Overall this is judged to be good agreement.

The number of atypical behaviors exhibited during the testing sessions was assessed using interval recording of 30 s periods. These intervals corresponded with the start and end time depicted on the video recording. The primary investigator provided the reliability testers with a chart displaying the timed intervals and the 5 atypical behaviors that had been identified for each participant. The range of disagreement was 3 to 16 points difference for interval discrepancy, with a mean of 8.5. Equating to an agreement 87% (68/515) for exact match of behaviors per interval. Many areas of disagreement were related to a slight time discrepancy. A behavior was noted by the reliability examiner but at the next time interval, which differed from the primary investigator. The range of total reported atypical behaviors was from 0 to 6 points, with a mean of 2.87. Equating to 96% (23/515) exact match for total atypical behavior tally.

Discrepancies in reliability checks for test scores were due in large part to the background noise picked up by the audio recording. Available spaces were not always optimum, and there were noises from a microwave and soda machine, and from the intercom system. This made it difficult to decipher words that sounded similar (ex: affirming vs achieving, and attitude vs

latitude). Time differences were attributed to discrepancy of when the picture stimuli were opened or when the audio started with the video.

In total, reliability was judged to be acceptable for all variables. The primary investigator's scores were retained as the most accurate, because they were based on data collected in live interaction instead of the videotaped scoring of the reliability scorers.

Data Analysis

The study used a within-in group repeated measures design. Data were analyzed using a non-parametric Wilcoxon Signed-Rank Test (Wilcoxon, 1945) due to the small participant size. This test requires that pairs of scores are converted to different scores, which may be positive or negative. The difference scores are then submitted to analysis to determine if the scores are clustered near a mean of zero, or if the scores are significantly different from 0. This test is used to detect a difference between conditions (the paired scores) when the sample size is small and the variability between participants is large compared to the expected difference between conditions.

In testing the first hypothesis, the score of the SLP-mediated format was compared with the computer-mediated format. The difference score was the score for the computer-mediated format minus the score for the SLP-mediated format. The difference scores were analyzed for statistical and clinical significance.

In testing the second hypothesis, the number of events, in 30 s intervals, that the teacher/SLP reported atypical behaviors occurred were converted to total behaviors per 30 s intervals. Since the time duration proved to be greater in the computer-mediated format, the mean number of atypical behaviors in 30 s intervals were analyzed. The modalities were then

compared and analyzed to determine if more positive scores were derived and thus resulted in a significant difference.

Results

The purpose of this study was to determine whether testing modality (computer-mediated or SLP-mediated) would impact testing conditions for school-aged children with autism. The dependent variables tested under the two modalities were: receptive language score, testing duration, and atypical behaviors.

A comparison analysis was performed using Excel® software and the Wilcoxon Signed Rank Test (Wilcoxon, 1945) on-line computation (Lowry, n.d.), a non-parametric statistical test to test the duration of testing, scores from the *CELF-5 Word Classes* subtest and five observable atypical behaviors.

Receptive Language Scores

Receptive language scores were determined by the *CELF-5 Word Classes* subtest, administration and scoring manual. Each modality was administered using the same visual stimuli and verbal prompts. Repetitions were provided when the participant requested or according to the manual's direction. This consisted of repeating after waiting 10 s for a response. According to the *CELF-5 Word Classes* subtest scoring manual, correct answers received a score of one. An incorrect answer or no answer was reported as a score of zero. Raw scores (the number of correct answers) were tallied and used for data analysis. Score comparison and modality administration for all 22 participants are depicted on Table 1 and Figure 1.

Table 1

CELF-5 Word Classes Raw Score

Participant	SLP	Computer	*Difference	First modality
1	5	5	0	SLP
2	5	6	1	SLP
3	12	11	-1	Computer
4	0	0	0	Computer
5	24	26	2	SLP
6	25	25	0	Computer
7	9	2	-7	Computer
8	24	25	1	SLP
9	14	13	-1	Computer
10	22	26	4	Computer
11	12	15	3	SLP
12	17	15	-2	SLP
13	11	9	-2	Computer
14	17	15	-2	Computer
15	30	33	3	SLP
16	29	29	0	SLP
17	26	29	3	SLP
18	17	22	5	SLP
19	16	19	3	SLP
20	29	30	1	SLP
21	22	23	1	SLP
22	0	0	0	Computer

Note. SLP=SLP-mediated, computer=computer-mediated

*Difference is the result of the computer-mediated minus the SLP-mediated format for each participant.
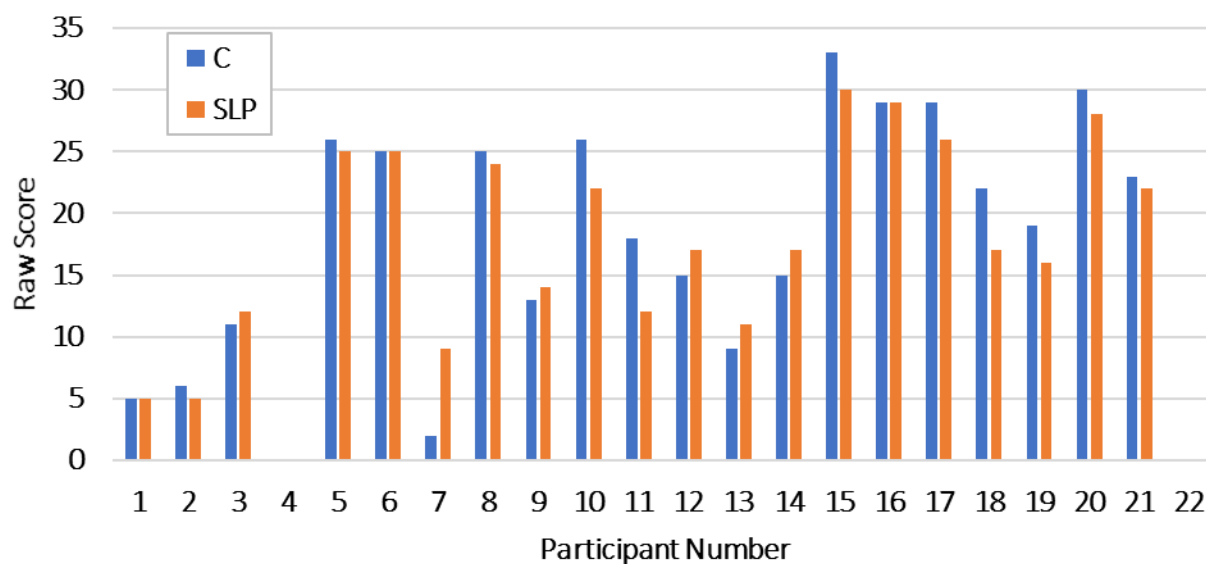
Figure 1. CELF-5 Word Classes Subtest Score

Note. C=computer modality; SLP=SLP-mediated modality.

Table 2

Summary of Descriptive Data for the CELF-5 Word Classes Subtest Scores

	Total	SLP	Computer
Mean	17.0	16.6	17.3
SD	9.7	9.2	10.4
Range	0-33	0-30	0-33

Note. SD=standard deviation, SLP=SLP-mediated, computer=computer-mediated

Excel ® spreadsheets were used to calculate means and SD for all participants in each modality. Scores for 22 participants for the SLP-mediated modality were from 0 to 30 with a mean of 16.6 and a standard deviation (SD) of 9.17. Scores for 22 participants for the computer-mediated modality were from 0 to 33 with a mean of 17.3 and a SD of 10.37. Total score differences consisted of a range of scores from 0 to 33 with a mean of 17.0 and a SD of 9.7. Summary of descriptive data for receptive language scores are depicted on Table 2.

The difference scores between the two modalities were submitted to the Wilcoxon Signed Rank Test (Wilcoxon, 1945). This test takes the directional difference between the two paired scores for each participant and determines whether the scores are statistically different than a random distribution around zero.

Based on the procedure for the Wilcoxon Signed Rank Test, 5 of the 22 participants' difference scores were disregarded in the score analysis, because the scores were equal for both modalities. No significant difference was noted between test modalities for the remaining 17 participants. Calculations derived the probability for a 2-tailed test, demonstrating no significant difference for the type of modality administration (p=0.20).

A significant difference was not observed for the order of modality administration, shown on Table 1. The SLP-mediated format was administered first 13 out of 22 times. Two of those resulted in a 0-score difference. For the 11 scores considered, 10 were higher in the SLP format. Difference for the SLP-mediated format included a range of -5 to 8, and a mean of -1.63 (computer-mediated minus SLP-mediated). The computer-mediated format was administered first 9 out of 22 times. Two of those resulted in 0-score difference. For the 7 scores considered, 2 of them were higher in the computer-mediated format. Score difference range for the computer-mediated format being higher was between -7 and 4, with a mean of -1.

Testing Duration

Testing duration for the *CELF-5 Word Classes* subtest, were determined by time stamps depicted on individual video recordings. Start time was determined by the second the audio began on the computer-mediated format or when the primary examiner began the directions for the test. Start and end time for 22 participants in the SLP-mediated modality is shown in Appendix C. Start and end time for 21 participants in the computer-mediated format is also depicted in Appendix C. The computer-mediated video for one participant was lost and therefore his test duration could not be calculated, therefore, it was discounted in the analysis.

End time was determined when the participant gave the answer to the last question or the test manual requirement of a 10 s delay and repetition was provided, and no response from the participant was given. Testing duration in minutes and seconds for each participant, testing modality shown, is depicted on Table 3 and

Figure 2.

Excel ® spreadsheets were used to calculate means and SD for duration times for all participants in each modality. Testing duration was converted to seconds for data analysis purposes. For the 22 participants for the SLP-mediated modality, durations ranged from 59 to 468 s with a mean of 273.6 s and a SD of 109.72 s. Twenty-one testing durations for the computer-mediated modality ranged from 66 to 677 s with a mean of 451.4 s and a SD of 191.24 s. Duration score differences for 21 participants consisted of a range of scores from 59 to 677 s with a mean of 362.5 s and a SD of 178.4 s. Summary of descriptive data for testing duration are depicted on Table 4.

Table 3

Participant Testing Duration in Minutes and Seconds

Participant	SLP	Computer	*Difference	First modality
1	3:17	6:26	3:09	SLP
2	5:23	7:57	2:34	SLP
3	4:14	10:53	6:39	Computer
4	1:20	3:20	2:00	Computer
5	6:13	11:17	5:04	SLP
6	3:49	7:00	3:11	Computer
7	2:25	6:17	3:52	Computer
8	5:34	No data**	No data**	SLP
9	3:30	5:59	2:29	Computer
10	7:48	12:17	4:29	Computer
11	3:07	7:13	4:06	SLP
12	5:18	5:26	0:08	SLP
13	4:39	6:38	1:59	Computer
14	2:40	10:56	8:16	Computer
15	6:14	10:45	4:31	SLP
16	5:37	7:48	2:11	SLP
17	7:21	10:00	2:39	SLP
18	6:29	8:03	1:34	SLP
19	3:47	9:26	5:39	SLP
20	5:55	10:01	4:06	SLP
21	4:40	6:43	2:03	SLP
22	0:59	1:06	0:07	Computer

Note. SLP=SLP-mediated, computer=computer-mediated.

* Difference is the result of the computer-mediated minus the SLP-mediated format for each participant.

** Participant 8's video recording for the computer-mediated format was lost; the testing duration could not be computed in this format.
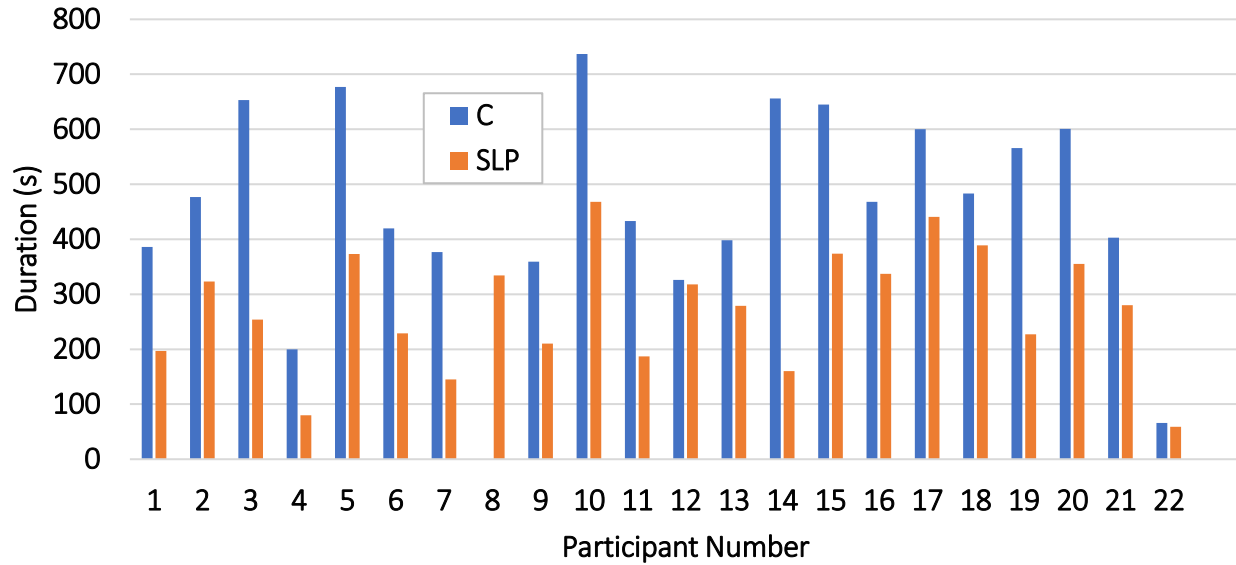
Figure 2. Testing duration in seconds. Participant 8's video recording for the computer-mediated format was lost; the testing duration could not be computed in this format. C=computer-mediated, SLP=SLP-mediated.

Table 4

Summary of Descriptive Data for Testing Duration in Seconds

	Total	SLP	Computer
Mean	362.5	273.6	451.4
SD	178.4	109.72	191.24
Range	59-677	59-468	66-677

Note. SD=standard deviation, SLP=SLP-mediated, computer=computer-mediated

The duration difference scores between the two modalities were submitted to the Wilcoxon Signed Rank Test (Wilcoxon, 1945). Comparison analysis was conducted on the testing duration taken from the time stamp on the video recording. There was a significant deviation towards the computer version taking a longer time to administer than the SLP-mediated mode, as can be seen in

Figure 2 and specific time durations for each participant in Table 2. Probability rating for a two-tailed test for 21 participants resulted in $p<.001$, with a sum of ranked scores $W=-231$. Although this difference is statistically significant, it is thought to be an artifact of the methods which will be explored further in the Discussion.

Atypical behaviors

Atypical behaviors to be recorded were pre-determined by the participant's teacher or private SLP. For each participant, five visually recognizable atypical movements, sounds, and/or actions were identified by those familiar with the participant, and these were described as commonly exhibited by the participant when faced with a task that was viewed as undesirable by the student.

Occurrence of atypical behaviors were tallied during the session by the primary examiner and while watching the participant's video recorded session using 30 s interval recording. During each 30 s interval, a score of "1" was recorded for each reported behavior if it occurred at all during that interval. Scores were reported for each of the five identified atypical behaviors; therefore, the highest possible total would be 5 times the number of 30 s intervals. Each behavior was tallied for each 30 s interval and added together for a total number of atypical behavior occurrences.

Total number of atypical behaviors was greater in the computer-mediated format, depicted on Table 5 and Figure 3. Nine participants demonstrated more atypical behaviors in the SLP-mediated compared with 10 in the computer-mediated format, demonstrating no significant difference.

Excel ® spreadsheets were used to calculate means and SD for all participants in each modality. One participant's computer-mediated video recording was lost; therefore, the tallied behaviors could not be computed and was discounted. Total atypical behaviors observed per 30 s interval for 21 participants for the SLP-mediated modality were from 7 to 23 with a mean of 13.8 and a SD of 5.54. Total atypical behaviors observed per 30 s interval for 21 participants for the computer-mediated modality were from 0 to 33 with a mean of 14.4 and a SD of 6.65. Total behavior differences consisted of a range of scores from 0 to 33 with a mean of 14.1 and a SD of 6.0. Summary of descriptive data for mean atypical behaviors are depicted on Table 6.

The difference scores between the two modalities were analyzed using the Wilcoxon Signed Rank Test (Wilcoxon, 1945). Three participants were deleted from the analysis. Two were due to equal scores and the other due to lost computer-mediated video footage, leaving 19 scores for comparison. Comparison analysis revealed a statistically significant difference in observable behaviors from the participants between the testing modalities. Probability rating for two-tailed test was not significant (p=0.70). Testing duration may have potentially skewed the results for the computer-mediated format.

Table 5

Total Number of Atypical Behaviors

Participant	SLP	Computer	*Difference	First Modality
1	16	18	2	SLP
2	18	23	5	SLP
3	21	33	12	Computer
4	7	13	6	Computer
5	17	15	-2	SLP
6	9	13	4	Computer
7	9	10	1	Computer
8	22	No Data**	No Data**	SLP
9	16	13	-3	Computer
10	20	17	-3	Computer
11	12	14	2	SLP
12	9	13	4	SLP
13	6	6	0	Computer
14	9	14	5	Computer
15	13	16	3	SLP
16	17	10	-7	SLP
17	23	23	0	SLP
18	14	9	-5	SLP
19	14	12	-2	SLP
20	18	17	-1	SLP
21	16	13	-3	SLP
22	8	0	-8	Computer

Note. SLP=SLP-mediated, computer=computer-mediated.

* Difference is the result of the computer-mediated minus the SLP-mediated format for each participant.

** Participant 8's video recording for the computer-mediated format was lost; the testing duration could not be computed in this format.
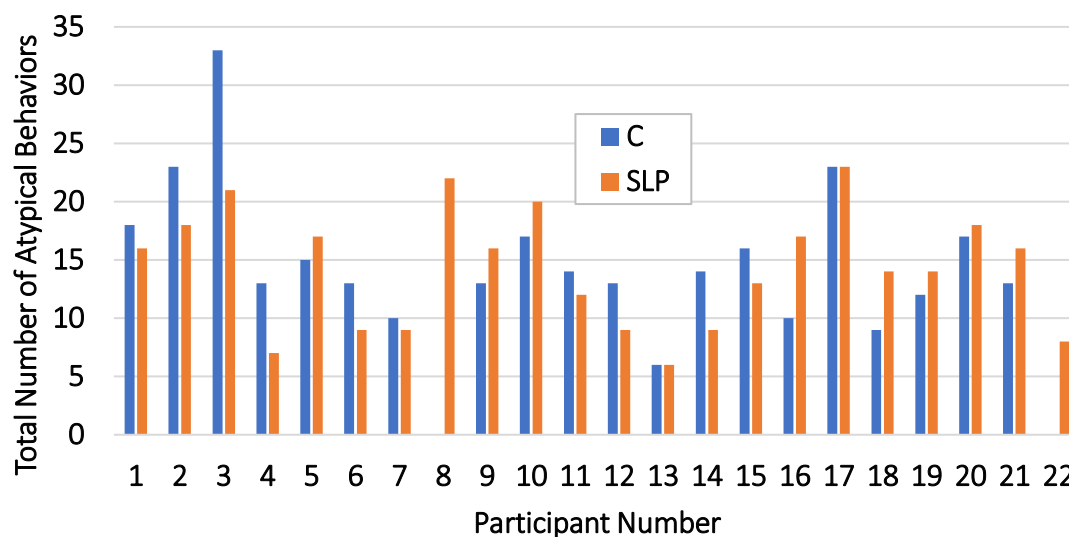
Figure 3. Total number of atypical behaviors in 30 s intervals. Participant 8's video recording for the computer-mediated format was lost; the total number of atypical behaviors could not be tallied in this format. C=computer-mediated, SLP=SLP-mediated.

Table 6

Summary of Descriptive Data for Total Number of Atypical Behaviors

	Total	SLP	Computer
Mean	14.1	14.4	13.8
SD	6.0	6.65	5.54
Range	0-33	7-23	0-33

Note. SLP=SLP-mediated, computer=computer-mediated, SD=standard deviation

Because testing duration was consistently longer for the computer-mediated format, the average mean of behaviors were analyzed. That is, the total number of behaviors per event were divided by the total number of 30 s events (behaviors/events). This resulted in the mean number of atypical behaviors per 30 s score seen on Table 7. A visual comparison of the testing modality formats can be seen on Figure 4. Atypical behaviors observed and tallied for each participant are noted in Appendix D.

Excel ® spreadsheets were used to calculate means and SD for all participants in each modality. One participant's computer-mediated video recording was lost; therefore, the tallied behaviors could not be computed and was discounted. Behavior per 30 s intervals for 21 participants for the SLP-mediated modality were from 0.67 to 4 with a mean of 1.7 and a SD of 0.72. Behavior per 30 s interval rating for 21 participants for the computer-mediated modality were from 0 to 1.86 with a mean of 0.9 and a SD of 0.41. Total score differences consisted of a range of scores from 0 to 4 with a mean of 1.3 and a SD of 0.7. The summary of descriptive data for mean atypical behaviors is depicted on Table 8.

The difference scores between the two modalities were analyzed using the Wilcoxon Signed Rank Test (Wilcoxon, 1945). Comparison analysis revealed a statistically significant difference in observable behaviors from the participants between the testing modalities. A positive skew was observed in the direction of the computer format for all but one of the participants. Probability rating for two-tailed test was significant ($p<.001$).

Table 7

Mean Number of Atypical Behaviors per 30 s Interval

Participant	SLP	Computer	*Difference	First Modality
1	2.67	1.38	-1.29	SLP
2	1.64	1.44	-0.2	SLP
3	2.33	1.5	-0.83	Computer
4	2.33	1.86	-0.47	Computer
5	1.31	0.65	-0.66	SLP
6	1.13	0.93	-0.2	Computer
7	1.8	0.77	-1.03	Computer
8	2	No Data**	No Data**	SLP
9	2.29	1.08	-1.12	Computer
10	1.25	0.68	-0.57	Computer
11	2	1	-1	SLP
12	0.82	1.18	0.36	SLP
13	0.67	0.46	-0.21	Computer
14	1.80	0.64	-1.16	Computer
15	1	0.76	-0.24	SLP
16	1.55	0.63	-0.92	SLP
17	1.53	1.15	-0.38	SLP
18	1.08	0.56	-0.52	SLP
19	1.75	0.63	-1.12	SLP
20	1.5	0.85	-0.65	SLP
21	1.78	0.93	-0.85	SLP
22	4	0	-4	Computer

Note. SLP=SLP-mediated, computer=computer-mediated

* Difference is the result of the computer-mediated minus the SLP-mediated format for each participant. A negative number denotes a positive skew towards the computer-mediated format.

** Participant 8's video recording for the computer-mediated format was lost; the testing duration could not be computed in this format**.**
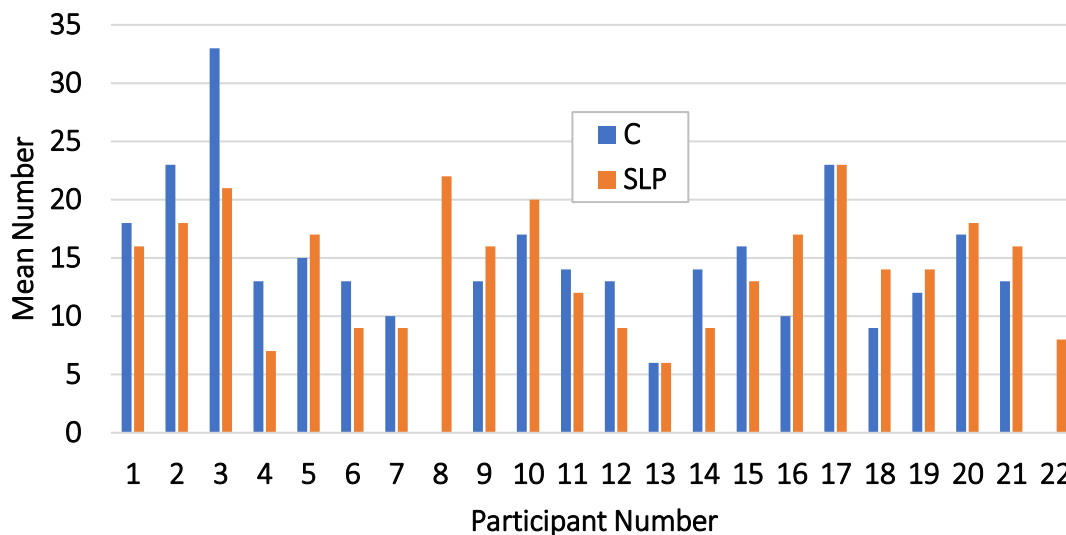
Figure 4. Mean number of atypical behaviors per 30s intervals. Participant 8's video recording for the computer-mediated format was lost. The mean number of atypical behaviors per 30 s interval could not be tallied in this format. C=computer modality; SLP=SLP-mediated modality.

Table 8

Summary of Descriptive Data for Mean Number of Atypical Behaviors per 30 s Intervals

	Total	SLP	Computer
Mean	1.3	1.7	0.9
SD	0.7	0.72	0.42
Range	0-8.14	1.7-8.14	0-3.03

Note. SD=standard deviation, SLP=SLP-mediated, computer=computer-mediated

Discussion

The purpose of the study was to determine whether testing modalities would impact the receptive language score, testing duration, and observable atypical behaviors for children with ASD. Receptive language scores did not differ in the two conditions. The mean of atypical behaviors occurrence of atypical behavior was significantly less when using the computer-mediated format in comparison with the SLP-mediate format. Also, the time duration was significantly reduced in the SLP-mediated format, although there were procedural factors that influenced the numbers, which is discussed in Limitations.

Receptive Language Scores

The *CELF-5 Word Classes* subtest was administered to determine whether a change in receptive language scores would be noted in computer-mediated compared with SLP-mediated format. Receptive language scores were defined as raw scores that the participant earned through responses given without external prompts.

Participant's scores were not significantly affected by the formatting of the test. The participants generally performed about the same in both formats. This can be seen by visual inspection of the data (refer to the chart comparing the scores) as well as by the result of the Wilcoxon Sign-Ranked Test.

Justification for using the *CELF-5 Word Classes* standardized test is its target audience (ages 5 to 21 years of age) which corresponded to the subject design of school-aged children kindergarten to sixth grade. It is also designed to "identify language strengths and weaknesses, determine service eligibility, provide intervention strategies, and measure intervention efficacy (Coret & McCrimmon, 2015, p. 495), which is functional for clinical implications. Also, it has

been reported as having very good to excellent sensitivity and specificity for Receptive

Language Index scores: at -1 SD the standard cut score is 85, sensitivity of 1.0, and specificity of

.91 (Wiig, Semel, & Secord, 2013). The *CELF-5 Word Classes* subtest is normed and designed

to assess an individual's ability to understand the relationship between words and determine

those that are categorically similar as a comprehension (receptive language) task, delivering

options through visual stimuli and verbal cues. An example of visual stimuli is providing the

participant with three pictures. The participant than points, or verbally states, which two are the

most similar: marker, pencil, or strawberry (marker and pencil are the most alike). An example

of verbal cueing is providing four words verbally. The participant verbally states which two

words are the most alike: bed, garage, pool, car (garage and car being the most alike). It should

be noted that this subtest was not designed to be used alone as a measure of receptive language.

It is one of nine subtests that would form the Receptive Language Composite score.

The purpose for assessing receptive language is that, as stated in the introduction chapter,

receptive language is an area of limitation for children with autism spectrum disorder (ASD)

(Mody & Belliveau, 2013; Nordahl-Hansen et al., 2014). In this study, the *CELF-5 Word*

Classes subtest was used to assess one area of receptive language ability in children with ASD,

specifically word relationships. The results of the study were designed to determine 1) if school-

aged children with ASD would perform better on a receptive language test on a computer-

mediated format or an SLP-mediated format or 2) if no difference was observed.

It is clinically relevant to note that there was not a difference in the receptive language

scores based on test modality. This suggests that the computer-mediated format is at least as

good as the SLP-mediated format with regard to the assessment of language skills. This finding

would support additional research and test development using a computer-based modality for children with ASD.

However, the results for the testing scores support the research conducted by Alt and Moreno (2012) and Sansosti, Doolan, Remaklus, Krupko, and Sansosti (2015) who reported no significant change in testing scores in the administered picture vocabulary tests (*ROWPVT and EOWPVT*, 2000).

Testing Duration

Testing duration in both formats was measured by the start of the test to the end of the test, then subtracting the difference. The start and end times were derived from the time stamps on individual video recorded sessions. Start time was determined as the time verbal direction for the test began. End time was determined by the last response or 10 s wait time after a repetition was given as required by the *CELF-5 Word Classes* administration manual.

The purpose for exploring the test duration time was to determine whether testing modality would impact the amount of time it took a child with ASD to complete the test, or the length of time that each child would attend to the testing task. Other research has demonstrated that children with ASD engage in a task for longer periods of time in computer-mediated learning (Williams et al., 2002). This was found to be the case in the present study. Despite being consistently longer in duration, the participants continued to attend to the computer-mediated task. However, this finding might not be valid due to external factors.

One video recording, for a participant's computer-mediated format was not found, therefore, the testing duration could not be estimated and was discarded. As a result, 21 out of 22 participants testing durations were analyzed.

According to Excel ® data comparison analysis, 21 out of 21 participants' testing duration was longer in the computer-mediated format than the SLP-mediated format. Only two of the participants testing times were less than a 10 s difference (7 and 8 s difference). All others were between 33 to 496 s greater in the computer-mediated format.

Large discrepancies in time duration were related to failure of the primary investigator to discount multiple interruptions that occurring while testing. During the largest time difference between modalities, administrative personnel entered the testing area, talking to the primary investigator and participant two different times during the computer modality. This did not happen during the SLP-mediated version.

Time discrepancy overall was related to pre-set verbal pacing on the recorded verbal prompts provided on the computer-mediated format. It did not change based on the participant's performance, resulting in the computer version proceeding more slowly, disallowing the primary investigator to adjust the speed in response to the child. In contrast, the SLP-mediated format allowed the primary investigator to modulate pace, rhythm, and vocal intensity to match the participant's rate of response.

Although we have discounted the time duration difference between the two formats, it is worth noting that the participants continued to attend to the computer mediated version, which was consistently longer. The fact of attending and participating, even when the task is slower than the child needs, may suggest at least an acceptance of the computer mediated format. This is consistent with research reported in the introduction chapter of the attraction children with ASD have for digital technology (Ploog et al., 2013).

Atypical Behaviors

The occurrence of atypical behaviors during testing was compared across the two modalities. Atypical behaviors were defined by teachers or private SLPs and the primary investigator as behavior manifested by the participant that is not usual for neurotypical peers. These behaviors, by the participants, were reported to occur during undesirable tasks, and they were presumed to be in order to avoid or make the task tolerable for the participant (e.g. self-stimulatory behavior or distractibility) as mentioned in the introductory chapter (Alt & Moreno, 2012).

Atypical behaviors that were reported by participants' teachers or SLP were similar. They fit into the following categories: attention, repetitive movements, irregular noises, sensory fixation, and low-level self-injurious behavior.

Repetitive body movements and finger movements were the most common behavior reported (22/22) by teachers/private clinicians observed in the students. Repetitive body movements were defined as large/whole body movements. Some students had specific areas targeted such as: leg shaking, feet swinging, rocking, arm flapping, and head thrashing. These areas are included in this discussion of body movements. Repetitive finger movements include drumming in the air or on the table, rubbing fingers against each other, and playing with fingers.

Lack of attention and requiring redirection includes the following areas that were mentioned by teachers/SLP: requiring additional prompts, verbal redirection to attend to task, moving away from the task, talking about unrelated topics, or discontinuing task. These were viewed by the referring teacher/SLP to be the result of inattentiveness or withdrawing from the task. Refusal to complete task was defined as the student physically moving away from the task and refusing to respond to test questions. Repetitions were provided when requested or after 10 s

of no response. Two other participants moved away from the task but continued to respond to questions. Requiring redirection occurred in 77% (17/22) of participants. Reduced ability to attend to a required task was often reported by teachers as an element of non-compliance and a source of frustration. However, as was observed during testing, inattention and refusal to attend to tasks may have been correlated to the interest and level of the students' visual engagement in the task (Loftin, 2009).

Repetitive sounds, such as echolalia is a common atypical vocalization exhibited by individuals with ASD (van Santen, Sproat, & Hill, 2013). Irregular noises that were reported by teachers and SLPs as repetitive and disruptive during structured tasks included: echolalia, yelling, glottal noise, repetitive throat clearing, or other unusual vocal productions not resembling a communication gesture. There was a small number of participants (8/22) who exhibited these behaviors. Echolalia was observed in three students. They repeated back the options that were verbally presented to them. The primary examiner had to explain several times that only two of the options were to be given as an answer.

An acute sensitivity or lack of sensitivity is often exhibited by people with ASD and can be observed across severity levels (Gillott, Furiss, & Walter, 2001). Sensory fixation was reported by teachers and SLPs as: picking at clothing, paper, or other materials, a heightened reaction to external noise (alarms, machines, intercom), or a fixation on the feeling of their clothing, chair, or back rest. In the case of at least five participants, this heightened awareness of made it difficult for them to participate in the testing sessions. One individual continued to talk about the vending machine noise that intermittently hummed. Another child was unable to be tested on the assigned day; he was absent, having known beforehand that there would be a fire drill that day. He was unable to tolerate the loud noise. Three other children could not focus on

the non-picture questions due to being fixated on the feel of their chair, clothing, or texture of the wall. Sensory fixation was reported in 55% (12/22) of participants.

Self-injurious behavior, of low-severity, are often considered self-stimulatory behaviors that are stereotypical in children with ASD (Edelson, Taubman, & Lovass, 1983). They are reported as low-severity since they did not draw blood or put the child at risk of injury. However, they may also be behaviors that have communicative intent. Teachers reported observing these types of behaviors prior to an escalation in frustration and anger. The self-injurious behaviors reported by teachers and SLPs were biting at hands and/or fingers, hitting head, picking at skin, biting hands or fingers, poking or pushing hard on the face, and flicking the face. Approximately half (12/22) of the participants exhibited one or more of these behaviors in both modalities, increasing with the discontinuation of the picture stimuli.

Results revealed a similar amount of total number of atypical behaviors in both formats. Nine participants exhibited more behaviors in the SLP-mediated format compared with 10 who displayed more behaviors in the computer-mediated format. Although the testing duration was consistently longer for the computer-mediated format, this did not increase the number of behaviors for many of the participants.

Due to the discrepancy in testing duration, behaviors per testing duration was assessed to determine whether the mean number of atypical behaviors in 30 s intervals increased for either format.

Results demonstrated a greater amount of mean number of atypical behaviors for 30 s intervals in the SLP-mediated format. If the atypical behaviors do, in fact, occur due to negative emotions such as anxiety or a desire to avoid, then the difference would suggest that the

participants were more accepting and more comfortable in the computer-mediated task. This supports findings in other studies, reported in the introductory chapter, which demonstrated a marked preference for computer-based intervention in people with ASD (Moore & Calvert, 2000). Additional research has also found a marked reduction in negative behaviors with the use of computerized instruction (Whalen, Liden, Ingersoll, Dallaire, & Liden, 2006).

It was observed by the investigator that when the pictures discontinued, attention waned, body posture changed (moving in chair, looking away) other behaviors increased. There was consistency in these observations in both modalities. This response is not surprising and validates what is commonly known regarding children with ASD and their propensity towards visual stimuli as reported in the introductory chapter (Allen et al., 2016; Hartley & Allen, 2015; Preissler, 2008). The information is clinically important by further validating that in testing children with ASD, visual-aids are more engaging and have a higher likelihood of encouraging participation.

Participant preference

Modality administration was not observed to influence the scores on the Word Classes subtest, but there were some indications that the participants had a preference for one modality over the other. One participant, with severe ASD, as determined by teacher and clinician report through the *CARS2-ST*, refused to attend to the SLP-mediated format. Although she did not answer correctly on the computer-mediated format, she pointed to pictures presented on the screen for four of the presented visual stimuli, until reaching the assigned ceiling of four incorrect answers. In contrast, another student, also rated as having severe ASD, responded seemingly to the best of his ability during the SLP-mediated format. However, during the longer duration of the computer-mediated format, he seemed impatient, incorrectly guessing at words

before all four options had been stated. ASD severity level, although reported for each

participant, did not have an impact on the scores reported. Severity level was based on social

awareness, social communication, physical sensation and reactions to them, and unique areas of

intelligence.

Limitations

Results of the study may have been impacted by limitations to the methods of

administration. It is possible that task selection, testing format, and testing environments could

have influenced the outcomes of the study. The research method was designed to reduce threats

to internal and external validity; however, an element of threat remained.

The selection of the *CELF-5 Word Classes* subtest may also have impacted the results

and should be considered a limitation in the study. It is not solely a receptive language task as it

requires a verbal response for the end portion of the test. Furthermore, it tests one aspect of

receptive language, but is not comprehensive by itself. Although normative data are provided for

this subtest, it was not designed to be used in isolation.

Testing format inconsistencies are also a limitation of the study. The computer format

having been pre-programmed with set verbal cues with a speed that could not be altered, was

different that the SLP-mediated format where the primary examiner could alter speed and rate of

voice to meet the needs of the participant. Testing duration was variable due to extraneous

circumstances. Therefore, testing duration was not assessed in a meaningful way in this study. A

different approach to comparing the two conditions would be needed to determine if speed in

taking the test or the length of time attending to the task would be different across modalities.

One way to remediate pre-set verbal cueing could be to have the instructions and the verbal

stimuli programmed on different wav files. Therefore, when a repetition is required, the

instructions would not be replayed and extend the testing time. Also, the SLP-mediated prompts could be delivered at the same rate as the pre-programmed computer-mediated format.

Computer malfunctions may have impacted four participants. Speakers cut out on certain words and the child did not ask for clarification, choosing to guess or not respond to the choices provided. Although the speaker volume was at maximum capacity, it was in competition with outside noise (soda machine, extra people—teachers coming in and out), requiring repetitions, causing delays, or influencing participants to guess incorrectly. These were all the challenges that may have influenced some test scores and the display of behaviors; however, these are also realistic limitations when using technology in elementary school or clinical settings.

Future research

Learning more about how individuals with ASD respond to computer-based assessment tasks remains a worthwhile area for further inquiry. The Centers for Disease Control and Prevention (CDC) reported in 2018 an estimate of ASD's prevalence in the United States, based on an analysis of 2014 medical and educational records of children 8-11 years of age. The new estimate reveals a 15% increase in prevalence across the nation. This represents a rise from 1 in 68 children two years previously to 1 in 59 children currently (Baio et al., 2018). Due to the increase in the prevalence of ASD (King & Bearman, 2009), the characteristic of language delay, necessitating standardized language testing, continuing research to better serve this population in this area is important (Autism Speaks, 2018).

Previous research has revealed that children with ASD respond positively to instruction administered through a computer modality (Alt & Moreno, 2012; Constantin et al., 2017; Ramdoss et al., 2010; Whalen, 2006). However, testing requires set methods with clearly worded

stimuli. Replicating the current study would be worthwhile, as would extending the study to account for the limitations identified.

The current study used only one subtest to assess receptive language. Future research should include a variety of tasks to assess receptive language. Also, the current study looked at participant's ability to understand the relationship between words. Another area for future research is to investigate whether testing modality (computer-mediated or SLP-mediated) would influence scores of complex expressive language tasks for children with ASD. Complex expressive language are more difficult to assess in this population due to behaviors limiting their focus, interest, and ability to respond during a highly structured task. Alt and Moreno (2014) tested expressive vocabulary and not finding significant difference in scores, also recommended this as a future area of study.

Clinical Implications

As technology continues to advance, it becomes a greater part of the life of students and clinicians. As society relies more on technologically related instruments for treatment and assessment of language disorders, it is important to learn about its efficacy and impact on the individuals whom it is designed to be used for. Specifically, with children with ASD, who, as it has been mentioned, have difficulty with testing in general. The current study found that a computer-mediated task was equal to the SLP-mediated task for assessing receptive language. Furthermore, the less frequent occurrence of atypical behaviors suggested that the participants were more comfortable in the computer mediated assessment modality. These findings should encourage clinicians to consider using computer-mediated tasks when appropriate.

According to a recent survey with 98 respondents, 12% of them being SLPs and 59% teachers, technology is prevalent in classrooms and clinic settings. Results revealed that 93.4%

of respondents used a tablet and 91.2% used a computer. Devices were used the most in intervention related to communication/language, motivating a student to engage in the class/session, and learning about a topic. Due to the proliferation of technology, future research is needed to study the benefit and potential limitations of technology and how it compares to traditional techniques (Laurie, Manches, & Fletcher-Watson, 2018).

Testing duration results revealing a shorter testing duration suggests the importance of SLP presence during assessment administration. This was further validated by participants who verbally stated preference for verbal cues from the primary examiner. The SLP is able to adapt extraneous variables (rate of speech, intensity, and address behaviors) and assessment formatting to meet the needs of the client.

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Appendix A:

Parental Permission Letter

Dear Parent,

Your child has been invited to participate in a research study conducted by a speech and language therapy (SLP) graduate student. The purpose of this research is to determine if a difference would be seen in comprehension test scores and/or behaviors based on administration style (computerized contrasted with clinician administered) for children with autism. The goal is to provide further information for professionals to best serve these children.

If your child participates, he/she will be involved in three brief (approximately 20 minutes) testing sessions. The first session is a general conversation/play session for your child to become acquainted with me in their classroom/clinic. The second session involves taking one modality (computerized or clinician administered) of a language test that measures comprehension. The alternate format will be administered approximately a week later during the third session. The comprehension language test is one subtest of the *Clinical Evaluation of Language Fundamentals, Fifth Edition* (*CELF-5*) that is about your child's ability to understand word categories (ex: "puppy, apple, dog. Puppy and dog are the most alike."). In response to questions, your child can verbalize the answer or point to a picture. I will work with your child's teacher and/or speech-language pathologist to find the time that would be least restrictive for you child.

The computerized format consists of pictures from the subtest, scanned and put into a PowerPoint® presentation with the audio directions inserted on each slide and displayed on a laptop. The clinician administered version is the traditional paper format given face-to-face. Behaviors and the time that it takes for the test to be administered will also be observed.

Information I will need about your child will be age (months and years), gender, and school placement (special education or mainstream classroom). To determine whether the test format affects the child's behavior and duration of test taking, input from you would be greatly beneficial. If you are willing to participate, I will ask you to complete the *Child Autism Rating Scale (CARS-2)* which describes the autism related behaviors. I will also ask you and your child's teacher to list the child's most frequently occurring behaviors that would interfere with test taking.

Each session will be recorded from two separate video cameras to capture your child's responses and behaviors. These recordings will only be reviewed by myself, my advisor and possibly one other graduate student. The purpose is to ensure that I have scored the responses correctly. The videos will not be used for any other purpose. Precautions will be made to ensure that the child's name and identifying information are not used by assigning a number to the materials and recorded sessions. Documentation and recordings will be kept in a locked cabinet in the faculty advisor's office at ISU. It will then be destroyed after six years.

Your child may or may not feel frustrated, uncomfortable, or stressed during the sessions having their routine disrupted, leaving the classroom, and undergoing testing. If your child displays signs of frustration, stress, or discomfort at any time during the sessions, testing will be discontinued. If you desire him/her to continue testing, another attempt can be made, if not he/she will be removed from the study. If your child chooses not to participate or discontinues the study early, their grades and relationship with the school, teachers and classmates will not be affected.

There are no direct benefits to your child for taking part in this study. You may request a result of the test results, but they are not a diagnostic tool, nor do they determine eligibility for services. By participating, you and your child would be increasing the awareness that children with autism spectrum disorder may need accommodations made to standardized testing to effectively measure their skills. Based on the results from this study, it could impact the clinical field, increase the production of computerized tests, providing clinicians with more diverse methods of assessing language for children with autism.

You should be receiving two copiers of this letter. If you choose to have your child participate in this study, please sign the form below and return to his teacher/clinician. Keep the other copy for your records. If you have any questions or concerns, please contact Linda Robinson, the primary investigator at robilind@isu.edu or Dr. Kathleen Kangas at kangkath@isu.edu; 208-282-4196. You may also contact a representative of the ISU Human Subjects Committee, Tom Bailey at (208)282-2179; email humsubj@isu.edu. Participation in this study is voluntary and you may withdraw your child at any time by contacting me, my adviser, or your child's teacher/clinician.

Thank you,

Linda Robinson B.S.

Graduate Student

FOR THE PARENT:

I have read the above informed consent form. The purpose, risks, and benefits of the study have been explained to me. I understand that I may ask questions and that I am free to withdraw my child from the study at any time without incurring ill will or penalty. I also understand that this consent will be filed separately from the data collected in the project to maintain anonymity.

Access is to be restricted to the investigator and her faculty advisor. A copy of this form will be given to me.

____Yes   _____No   My child may take part in the project.

_____

Child's Name

_____

Parent's/Guardian's Signature   Date

_____

Parent/Guardian Printed Name

Appendix B

Facebook ® Solicitation

I am a graduate student in speech-language therapy at Idaho State University conducting a research project. The purpose of the study is to determine whether testing modality (computerized or face-to-face) would affect school-age children with autism's receptive language test scores and/or behaviors. The goal is to provide professionals with more knowledge of the best testing format for children with autism. The subtest that will be administered, will ask the child to identify two out of three or four pictures that are in a similar category. Participants that are eligible for this study are: school-age children ages 6-10, with a diagnosis of mild-moderate autism, typical hearing, and would be able to verbalize answers or point to a picture. The child will be asked to attend three sessions. One for the clinician to meet the child and the other two to take the test in each format. The child will be asked to respond, verbally or by pointing, to the questions. They will be video recorded for reliability purposes at each session. Those eligible for participation are children with a diagnosis of autism ages 6-10 who would be able to participate in the three sessions and attend to the test for approximately 15-20-minutes. The sessions will be conducted at the ISU speech-language clinic in Pocatello. If you know someone who meets these requirements and would like to participate, please respond on this site. I would be happy to answer any questions you may have. I appreciate your help.

Linda Robinson,
Idaho State University
Graduate student

Appendix C:

Descriptive Summary of Subjects

Participant	Age M/F	Education	*CARS2-ST* Rating	Test Duration per Modality	Raw score	Total Atypical Behaviors	Mean Atypical Behaviors	Ceiling
1	8/M	SpEd	33: mild/mod	SLP: 0:32-3:49=3:17	SLP: 5	16	2.67	12
				C2: 0:00-7:59=7:59	C2: 5	18	1.38	13
2	9/M	SpEd	31: mild/mod	SLP: 0:25-5:48=5:23	SLP: 5	18	1.64	15
				C2: 0:00-7:57=7:57	C2: 6	23	1.44	15
3	8/M	SpEd	31.5: mild/mod	SLP2: 1:10-5:24=4:14	SLP2: 12	21	2.33	18
				C: 0:44-11:37=10:53	C: 11	33	1.5	17
4	7/F	SpEd	40.5: severe	SLP2: 0:37-1:57=1:20	SLP2: 0	7	2.33	4
				C: 0:05-3:25=3:20	C: 0	13	1.86	4
5	10/M	SpEd	30.5: mild/mod	SLP2: 0:25-6:38=6:13	SLP2: 25	17	1.31	35
				C: 0:05-2:41=2:36	C3: 26	15	0.65	37
6	11/M	SpEd	30: mild/mod	SLP2: 1:03-4:52=3:49	SLP2: 25	9	1.13	31
				C: 0:27-7:27=7:00	C: 25	13	0.93	*30
7	9/M	SpEd	38: severe	SLP2: 0:17-2:42=2:25	SLP2: 9	9	1.8	13
				C: 0:00-6:17=6:17	C: 2	10	0.77	12
8	10/M	MS	30: mild/mod	SLP: 0:25-5:59=5:34	SLP: 24	22	2	29

				C2: unknown	C: 25	no data	no data	*30
9	8/M	Both	38: severe	SLP2: 0:08-3:38=3:30	SLP2: 14	16	2.29	*16
				C: 0:22-6:21=5:59	C: 13	13	1.08	17
10	9/M	SpEd	31: mild/mod	SLP2: 0:37-8:25=8:00	SLP2: 22	20	1.25	32
				C: 52-13:09=12:17	C3: 26	17	0.68	35
11	8/M	Both	30: mild/mod	SLP: 0:04-3:11=3:07	SLP: 12	12	2	16
				C2: 0:52-7:55=7:13	C2: 18	14	1	27
12	8/M	Both	36.5: mild/mod	SLP: 0:22-5:40=5:18	SLP: 17	9	0.82	24
				C2: 0:56-6:22=5:26	C2: 15	13	1.18	19
13	6/M	Both	36: mild/mod	SLP2: 0:00-4:39=4:39	SLP2: 11	6	0.67	16
				C: 0:00-6:38=6:38	C: 9	6	0.46	14
14	11/M	SpEd	56: severe	SLP2: 0:48-3:28=2:40	SLP2: 17	9	1.80	23
				C: 0: 47-11:43=10:56	C: 15	14	0.64	24
15	12/M	Both	39: severe	SLP: 1:19-7:33=6:14	SLP: 30	13	1	37
				C2: 0:00-10:45=10:45	C2: 33	16	0.76	38
16	12/F	MS	30: mild/mod	SLP: 0:22-5:59=5:37	SLP: 29	17	1.55	*40
				C2: 0:45-8:33=7:48	C2: 29	10	0.63	35
17	10/M	SpEd	35: mild/mod	SLP: 0:42-8:03=7:21	SLP: 26	23	1.53	32
				C2: 0:15-10:15=10:00	C2: 29	23	1.15	35
18	10/M	SpEd	30.5: mild/mod	SLP: 0:32-7:01=6:29	SLP: 17	14	1.08	27
				C2: 1:06-9:09=8:03	C2: 22	9	0.56	27

19	7/M	SpEd	34: mild/mod	SLP: 0:23-4:10=3:44	SLP: 16	14	1.75	24
				C2: 0:23-9:49=9:26	C2: 19	12	0.63	27
20	12/F	MS	31: mild/mod	SLP: 0:52-6:47=5:55	SLP: 28	18	1.5	35
				C2: 0:11-10:12	C2: 30	17	0.85	34
21	8/M	SpEd	44: severe	SLP: 0:37-5:17=4:40	SLP: 22	16	1.78	31
				C2: 0:20-7:03=6:43	C2: 23	13	0.93	29
22	8/M	SpEd	55: severe	SLP2: 0:10-1:09=0:59	SLP2: 0	8	4	*0
				C: 0:17-1:23=1:06	C: 0	0	0	4

Note. M/F=male or female, SpEd=special education, MS=mainstream classroom, Both=a combination of special education and mainstream education, SLP=SLP-mediated format, C=computer-mediated format, C2/SLP2=second modality administered.

*A ceiling was not achieved, due to the participant discontinuing the task.

Appendix D:

Participant Atypical Behavior Tallies

Table 1a

Participant 1 Atypical Behavior Tally

	SLP-Mediated						Computer-Mediated*				
				Repetitive Movement						Repetitive Movement	
Elapsed Time	Require Repetition	Refusal	Echolalia	Finger	Body	Elapsed Time	Require Repetition	Refusal	Echolalia	Finger	Body
0:32-1:02			1	1	1	0:36-1:06	1			1	
1:02-1:32				1	1	1:06-1:36	1			1	
1:32-2:02			1		1	1:36-2:06	1			1	
2:02-2:32			1	1	1	2:06-2:36				1	
2:32-3:02			1	1		2:36-3:06				1	
3:02-3:49	1		1	1	1	3:06-3:36				1	
						3:36-4:06				1	
						4:06-4:36					
						4:36-5:06				1	1
						5:06-5:36	1				1
						5:36-6:06					1
						6:06-6:36				1	
						6:36-7:02	1				1

Note. mvmt=movement. Repetitions were given after requested by the child, misheard, or no response was made after 10 s. Refusal meant verbally stating unwillingness to continue task, not approaching the task, or leaving before it is finished.

*administered second

Table 1b

Participant 2 Atypical Behavior Tally

SLP-Mediated

Elapsed Time	Require Redirection	Face Picking	Echolalia	Repetitive Movement	
				Hand	Body
0:25-0:55					1
0:55-1:25					1
1:25-1:55		1	1		1
1:55-2:25	1				1
2.25-2.55					1
2.55-3.25					1
3.25-3.55					1
3.55-4.25			1		
4.25-4.55	1			1	1
4.55-5.25					1
5.25-5.48	1		1		1

Computer-Mediated*

Elapsed Time	Require Redirection	Face Picking	Echolalia	Repetitive Movement	
				Hand	Body
0:00-0:30					1
0:30-1:00					
1:00-1:30					
1:30-2:00					
2:00-2:30	1	1			1
2:30-3:00					1
3:00-3:30	1				
3:30-4:00	1				1
4:00-4:30					
4:30-5:00		1			1
5:00-5:30		1		1	1
5:30-6:00		1			
6:00-6:30		1		1	1
6:30-7:00			1		1
7:00-7:30	1				1
7:30-7:57		1	1		

Note. SLP=SLP-mediated, C=computer-mediated, C2=computer-mediated administered second, mvmt=movement. Requiring redirection meant a verbal cue was required to encourage the student to participate. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements.

*administered second

Table 1c

Participant 3 Atypical Behavior Tally

SLP-Mediated*				Repetitive Movement		Computer-Mediated				Repetitive Movement	
Elapsed Time	Require Repetition	Excessive Talking	"I don't know"	Finger	Body	Elapsed Time	Require Repetition	Excessive Talking	"I don't know"	Finger	Body
1:10-1:40		1		1		0:44-1:14	1			1	
1:40-2:10		1		1		1:14-1:44	1			1	
2:10-2:40		1	1	1		1:44-2:14	1			1	
2:40-3:10		1		1	1	2:14-2:44					
3:10-3:40				1		2:44-3:14	1			1	
3:40-4:10				1	1	3:14-3:44				1	
4:10-4:40	1	1	1	1		3:44-4:14				1	1
4:40-5:10			1	1		4:14-4:44				1	
5:10-5:24			1	1		4:44-5:14				1	
						5:14-5:44				1	1
						5:44-6:14				1	1
						6:14-6:44				1	
						6:44-7:14				1	1
						7:14-7:44					
						7:44-8:14	1			1	
						8:14-8:44				1	
						8:44-9:14	1			1	
						9:14-9:44	1			1	
						9:44-10:14	1			1	
						10:14-10:44				1	1
						10:44-11:37	1			1	

Note. mvmt=movement. A statement of "I don't know" by the participant was determined to be a means of avoiding the task rather than attempting to provide an answer. Requiring repetitions referred to inattentiveness. Excessive talking referred to the participant talking about non-related things in an attempt to discontinue the task.

*administered second

Table 1d

Participant 4 Atypical Behavior Tally

SLP-Mediated*			Repetitive Movement				Computer-Mediated			Repetitive Movement		
Elapsed Time	Require Redirection	Irregular Noises	Finger	Leg	Body		Elapsed Time	Require Redirection	Irregular Noises	Finger	Leg	Body
0:37-1:07	1	1	1				0:05-0:35		1	1		
1:07-1:37	1		1				0:35-1:05		1	1		
1:37-1:57	1		1				1:05-1:35	1		1		
							1:35-2:05		1	1		
							2:05-2:35					
							2:35-3:05	1	1	1		1
							3:05-3:25	1				

Note. mvmt=movement. Irregular noise is an unusual and brief change in vocal quality (high, low, glottal fry). Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements. Requiring redirection meant a verbal cue was required to encourage the student to participate.

*administered second

Table 1e

Participant 5 Atypical Behavior Tally

SLP-Mediated*

Elapsed Time	Playing w/Shirt	Complain About Task	Leave Task	Chewing Hands/ Fingers	Repetitive Body Mvmt
0:25-0:55					
0:55-1:25					1
1:25-1:55	1			1	
1:55-2:25	1			1	
2:25-2:55					
2:55-3:25				1	1
3:25-3:55				1	
3:55-4:25					1
4:25-4:55					1
4:55-5:25				1	1
5:25-5:55				1	1
5:55-6:25		1			1
6:15-6:38					1

Computer-Mediated**

Elapsed Time	Playing w/Shirt	Complain About Task	Leave Task	Chewing Hands, Fingers	Repetitive Body Mvmt
0:51-1:21					
1:21-1:51				1	
1:51-2:21				1	
2:21-2:51					
2:51-3:21					
3:21-3:51					
3:51-4:21					
4:21-4:51					1
4:51-5:21					
5:21-5:51					1
5:51-6:21				1	
6:21-6:51					1
6:51-7:21		1			1
7:21-7:51					1
7:51-8:21					
8:21-8:51					1
8:51-9:21					
9:21-9:51					1
9:51-10:21					1
10:21-10:51					1
10:51-11:21			1		
11:21-11:51			1		
11:51-12:08					

Note. mvmt=movement. Complaining entailed asking more than once when the task was done or commenting in a negative way about the task.

*administered second
** computer-mediated task was administered again later due to computer power failure during the first computer-mediated test

Table 1f

Participant 6 Atypical Behavior Tally

SLP-Mediated*							Computer-Mediated					
Elapsed Time	Exaggerate Body Mvmt	Complain	Refusal	Playing w/Objects	Leaving Task		Elapsed Time	Exaggerate Body Mvmt	Complain	Refusal	Playing w/Objects	Leaving Task
1:03-1:33							0:27-0:57	1				
1:33-2:03							0:57-1:27					
2:03-2:33			1		1		1:27-1:57	1				
2:33-3:03	1						1:57-2:27		1		1	
3:03-3:33	1						2:27-2:57					
3:33-4:03				1			2:57-3:27	1				
4:03-4:33	1			1			3:27-3:57					
4:33-4:52	1						3:57-4:27	1				
							4:27-4:57	1	1			
							4:57-5:27					1
							5:27-5:57	1	1			
							5:57-6:34	1				
							6:27-6:57					
							6:57-7:27					1

Note. mvmt=movement. Exaggerated body movements consist of throwing arms in the air, big movements back/forward in his chair, turning dramatically, different than normal shifts in chair. Complaining entailed asking more than once when the task was done or commenting in a negative way about the task. Refusal was defined as moving away from the task or verbalizing unwillingness to participate or complete task.

*administered second

Table 1g

Participant 7 Atypical Behavior Tally

	SLP-Mediated*						Computer-Mediated				
Elapsed Time	Redirect	Repetitive Body Mvmt	Yelling	Complain	Chewing on Shirt	Elapsed Time	Redirect	Repetitive Body Mvmt	Yelling	Complain	Chewing on Shirt
0:17-0:47	1			1	1	0:0-0:30	1				
0:47-1:17					1	0:30-1:0	1				
1:17-1:47					1	1:0-1:30	1				
1:47-2:17			1		1	1:30-2:0	1				
2:17-2:42		1			1	2:0-2:30	1				
						2:30-3:0	1				
						3:0-3:30					
						3:30-4:0	1				
						4:0-4:30					1
						4:30-5:0					
						5:0-5:30	1				
						5:30-6:0		1			
						6:0-6:17					

Note. mvmt=movement. Complaining entailed asking more than once when the task was done or commenting in a negative way about the task. Redirect consisted of verbal prompts to attend to the task. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements.

*administered second

Table 1h

Participant 8 Atypical Behavior Tally

	SLP-Mediated							Computer-Mediated*				
Elapsed Time	Leave Task	Repetitive Body Mvmt	Chewing Fingers	Picking Skin	Playing w/Shirt		Elapsed Time	Leave Task	Repetitive Body Mvmt	Chewing Fingers	Picking Skin	Playing w/Shirt
0:25-0:55		1		1								
0:55-1:25		1		1			**No data					
1:25-1:55		1		1								
1:55-2:25		1		1								
2:25-2:55		1										
2:55-3:25		1		1								
3:25-3:55		1			1							
3:55-4:25		1										
4:25-4:55		1		1								
4:55-5:25		1		1	1							
5:25-5:59		1		1	1							

Note. mvmt=movement. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements.

*administered second
**Video recording for the computer version could not be found; behaviors could not be tallied.

Table 1i

Participant 9 Atypical Behavior Tally

SLP-Mediated*						Computer-Mediated					
				Repetitive Movement						Repetitive Movement	
Elapsed Time	Repetition	Irregular Noise	Complain	Leg	Body	Elapsed Time	Repetition	Irregular Noise	Complain	Leg	Body
0:08-0:38						0:22-0:52					
0:38-1:8						0:52-1:22					
1:8-1:38		1			1	1:22-1:52					
1:38-2:8		1	1	1		1:52-2:22		1			1
2:8-2:38	1	1		1		2:22-2:52					1
2:38-3:8	1	1		1	1	2:52-3:22					1
3:8-3:38	1	1	1		1	3:22-3:52			1		1
						3:52-4:22					
						4:22-4:52			1		
						4:52-5:22			1		1
						5:22-5:52	1		1		
						5:52-6:21		1	1		

Note. mvmt=movement. Irregular noise is an unusual and brief change in vocal quality (high, low, glottal fry). Repetitions were given after requested, misheard, or no response was made after 10 s. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements.

*administered second

Table 1j

Participant 10 Atypical Behavior Tally

	SLP-Mediated*			Repetitive Movement			Computer-Mediated**			Repetitive Movement	
Elapsed Time	Playing w/Shirt	Complain	Excessive Talking	Finger	Body	Elapsed Time	Playing w/Shirt	Complain	Excessive Talking	Finger	Body
0:37-1:07			1			0:52-1:22			1		
1:07-1.37						1:22-1:52					
1.37-2.07						1:52-2:22					
2.07-2.37						2:22-2:52			1		1
2.37-3.07	1					2:52-3:22					
3.07-3.37	1					3:22-3:52					1
3.37-4.07				1		3:52-4:22					1
4.07-4.37				1		4:22-4:52					
4.37-5.07		1		1		4:52-5:22					
5.07-5.37			1	1	1	5:22-5:52					
5.37-6.07			1	1	1	5:52-6:22					1
6.07-6.37			1			6:22-6:52					
6.37-7.07				1		6:52-7:22					1
7.07-7.37			1			7:22-7:52			1		
7.37-8.07			1	1		7:52-8:22					
8.07-8.25			1	1		8:22-8:52					1
						8:52-9:22			1		
						9:22-9:52					1
						9:52-10:22					1
						10:22-10:52			1		1
						10:52-11:22					1
						11:22-11:52					
						11:52-12:22					1
						12:22-12:52					
						12:52-13:09					1

Note. mvmt=movement. Complaining entailed asking more than once when the task was done or commenting in a negative way about the task. Repetitive hand/finger movement consisted of drumming fingers, playing with fingers, rapidly moving them. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements.

*administered second
 **computer-mediated format administered again due to computer power failure (administered third)

Table 1k

Participant 11 Atypical Behavior Tally

	SLP-Mediated						Computer-Mediated*				
Elapsed Time	Redirection	Picking Face	Repetitive Body Mvmt	Complain	Excessive Talking	Elapsed Time	Redirection	Picking Face	Repetitive Body Mvmt	Complain	Excessive Talking
0:04-0:34		1	1		1	0:42-1:12					
0:34-1:04					1	1:12-1:42					
1:04-1:34	1		1			1:42-2:12		1			
1:34-2:04		1	1			2:12-2:42					
2:04-2:34		1	1		1	2:42-3:12		1			
2:34-3:11					1	3:12-3:42					
						3:42-4:12	1			1	
						4:12-4:42		1			
						4:42-5:12		1			
						5:12-5:42	1	1			1
						5:42-6:12		1			
						6:12-6:42					1
						6:42-7:12				1	1
						7:12-7:55			1		

Note. mvmt=movement. Complaining entailed asking more than once when the task was done or commenting in a negative way about the task. Repetitions were given after requested, misheard, or no response was made after 10 s. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements.

*administered second

Table 11

Participant 12 Atypical Behavior Tally

	SLP-Mediated			Repetitive Movement			Computer-Mediated*			Repetitive Movement	
Elapsed Time	Complain	Playing w/Objects	Leave Task	Finger	Body	Elapsed Time	Complain	Playing w/Objects	Leave Task	Finger	Body
0:22-0:52						0:56-1:26		1			
0:52-1:22						1:26-1:56					
1:22-1:52						1:56-2:26				1	
1:52-2:22						2:26-2:56					
2:22-2:52		1		1	1	2:56-3:26					
2:52-3:22		1				3:26-3:56		1	1		
3:22-3:52		1				3:56-4:26			1		
3:52-4:22		1				4:26-4:56			1		
4:22-4:52		1		1		4:56-5:26		1	1		
4:52-5:22		1				5:26-5:56		1	1		
5:22-5:40		1				5:56-6:22		1	1	1	

Note. mvmt=movement. Complaining entailed asking more than once when the task was done or commenting in a negative way about the task. Repetitive finger movement consisted of drumming fingers, playing with fingers, rapidly moving them. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements.

*administered second

Table 1m

Participant 13 Atypical Behavior Tally

	SLP-Mediated*						Computer-Mediated				
Elapsed Time	Repetitive Body Mvmt	Facial Grimace	Flicking Face	Complain	Excessive Talking	Elapsed Time	Repetitive Body Mvmt	Facial Grimace	Flicking Face	Complain	Excessive Talking
0:00-0:30						0:00-0:30					
0:30-1:00						0:30-1:00					
1:00-1:30						1:00-1:30					
1:30-2:00						1:30-2:00	1				
2:00-2:30				1		2:00-2:30			1		
2:30-3:00						2:30-3:00					
3:00-3:30		1		1		3:00-3:30					
3:30-4:00	1			1		3:30-4:00					
4:00-4:39	1					4:00-4:30	1				
						4:30-5:00					
						5:00-5:30	1				
						5:30-6:00					
						6:00-6:38		1		1	

Note. mvmt=movement. Facial grimace constituted repetitive eye blinking, scrunching face repetitively, poking his tongue in his cheek. Complaining entailed asking more than once when the task was done or commenting in a negative way about the task. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements.

*administered second

Table 1n

Participant 14 Atypical Behavior Tally

SLP-Mediated*

Elapsed Time	Repetition	Picking Fingers	Repetitive Body Mvmt	Picking Face	Irregular Noise
0:48-1:18					
1:18-1:48		1	1	1	
1:48-2:18		1	1		
2:18-2:38			1		1
2:38-3:28			1		1

Computer-Mediated

Elapsed Time	Repetition	Picking Fingers	Repetitive Body Mvmt	Picking Face	Irregular Noise
0:47-1:17					
1:17-1:47					
1:47-2:17					
2:17-2:47				1	1
2:47-3:17					1
3:17-3:47			1		1
3:47-4:17			1		
4:17-4:47			1		1
4:47-5:17					1
5:17-5:47					1
5:47-6:17	1				
6:17-6:47					
6:47-7:17	1				
7:17-7:47					
7:47-8:17					
8:17-8:47					
8:47-9:17					
9:17-9:47	1				
9:47-10:17					1
10:17-10:47					
10:47-11:17					
11:17-11:43					

Note. mvmt=movement. Repetitions were given after requested, misheard, or no response was made after 10 s. Irregular noise is an unusual and brief change in vocal quality (high, low, glottal fry, change in voice intensity). Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements.

*Administered second

Table 1o

Participant 15 Atypical Behavior Tally

SLP-Mediated

Elapsed Time	Sensory Fixation	Playing w/Object	Pushing on Face	Repetitive Movement Finger	Repetitive Movement Body
1:19-1:49					
1:49-2:19					
2:19-2:49			1		
2:49-3:19			1		
3:19-3:49					
3:49-4:19				1	
4:19-4:49				1	
4:49-5:19	1			1	
5:19-5:49		1			1
5:49-6:19					
6:19-6:49		1		1	1
6:49-7:19	1				1
7:19-7:33					

Computer-Mediated*

Elapsed Time	Sensory Fixation	Playing w/Object	Pushing on Face	Repetitive Movement Finger	Repetitive Movement Body
0:0-0:30					
0:30-1:0					
1:0-1:30			1		
1:30-2:0				1	
2:0-2:30					
2:30-3:0				1	
3:0-3:30				1	
3:30-4:0			1	1	
4:0-4:30			1		
4:30-5:0			1		
5:0-5:30				1	
5:30-6:0				1	
6:0-6:30					
6:30-7:0		1			
7:0-7:30				1	
7:30-8:0			1		
8:0-8:30				1	
8:30-9:0					
9:0-9:30				1	
9:30-10:0			1		
10:0-10:45					

Note. mvmt=movement. Fixation on tactile and auditory sensation was considered as prolonged attention to it, talking about it repeatedly, covering ears for a long period of time. Pushing on face was a repetitive act by the participant using his hands to pull and push the skin on his face. Repetitive finger movement consisted of drumming fingers, playing with fingers, rapidly moving them. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements.

*administered second

Table 1p

Participant 16 Atypical Behavior Tally

	SLP-Mediated						Computer-Mediated*					
Elapsed Time	Repetitive Body Mvmt	Playing w/Object	Sensory Fixation	Repetition	Picking Fingers	Elapsed Time	Repetitive Body Mvmt	Playing w/Object	Sensory Fixation	Repetition	Picking Fingers
0:22-0:52		1				0:45-1:15					
0:52-1:22		1				1:15-1:45					
1:22-1:52		1				1:45-2:15					
1:52-2:22		1				2:15-2:45					
2:22-2:52		1				2:45-3:15					
2:52-3:22		1	1			3:15-3:45	1				
3:22-3:52	1	1				3:45-4:15	1				
3:52-4:22	1	1				4:15-4:45	1				
4:22-4:52	1	1				4:45-5:15					
4:52-5:22	1	1				5:15-5:45					
5:22-5:59	1	1				5:45-6:15			1		
						6:15-6:45	1				
						6:45-7:15	1				
						7:15-7:45	1				1
						7:45-8:15	1				
						8:15-8:33	1				

Note. mvmt=movement. Sensory fixation on noise was considered as prolonged attention to it, talking about it repeatedly, covering ears for a long period of time. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements.

*administered second

Table 1q

Participant 17 Atypical Behavior Tally

	SLP-Mediated			Repetitive Movement			Computer-Mediated*			Repetitive Movement	
Elapsed Time	Playing w/Object	Apply Pressure	Picking Skin	Finger	Body	Elapsed Time	Playing w/Object	Apply Pressure	Picking Skin	Finger	Body
0:42-1:12		1			1	0:15-0:45					
1:12-1:42		1			1	0:45-1:15				1	
1:42-2:12		1			1	1:15-1:45				1	
2:12-2:42		1			1	1:45-2:15					
2:42-3:12		1				2:15-2:45		1			1
3:12-3:42				1		2:45-3:15		1			
3:42-4:12	1					3:15-3:45				1	
4:12-4:42						3:45-4:15		1		1	1
4:42-5:12		1			1	4:15-4:45		1			1
5:12-5:42		1			1	4:45-5:15		1			1
5:42-6:12		1			1	5:15-5:45					1
6:12-6:42	1			1		5:45-6:15	1				
6:42-7:12	1			1		6:15-6:45	1				
7:12-7:42	1			1		6:45-7:15	1				
7:42-8:03						7:15-7:45	1				
						7:45-8:15	1				
						8:15-8:45	1				
						8:45-9:15	1				
						9:15-9:45		1			
						9:45-10:15				1	

Note. mvmt=movement. Repetitive finger movement consisted of drumming fingers, playing with fingers, rapidly moving them. Applying pressure meant the participant pushed his hands together or used force while pushing his hands against his legs. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements.

*administered second

Table 1r

Participant 18 Atypical Behavior Tally

SLP-Mediated

Elapsed Time	Repetitive Sounds	Repetitive Body Mvmt	Scratching	Picking Skin	Sensory Fixation
0:32-1:02				1	
1:02-1:32				1	
1:32-2:02		1	1	1	
2:02-2:32				1	
2:32-3:02				1	
3:02-3:32			1		
3:32-4:02				1	
4:02-4:32		1			
4:32-5:02	1				
5:02-5:32		1			
5:32-6:02					
6:02-6:32					
6:32-7:01	1			1	

Computer-Mediated*

Elapsed Time	Repetitive Sounds	Repetitive Body Mvmt	Scratching	Picking Skin	Sensory Fixation
1:06-1:36					
1:36-2:06			1		
2:06-2:36					
2:36-3:06					
3:06-3:36		1			
3:36-4:06					
4:06-4:36					
4:36-5:06	1				
5:06-5:36	1				
5:36-6:06	1				
6:06-6:36			1		
6:36-7:06					
7:06-7:36					1
7:36-8:06	1				
8:06-8:36	1				
8:36-9:09					

Note. mvmt=movement. Repetitive sounds consisted of throat clearing, trilling, and blowing air out of his mouth. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements. Scratching was self-scratching of his arms and legs. Fixation on noise was considered as prolonged attention to it, talking about it repeatedly, covering ears for a long period of time.

* administered second

Table 1s

Participant 19 Atypical Behavior Tally

| | SLP-Mediated | | | | | | Computer-Mediated* | | | | |
| | | | | Repetitive Movement | | | | | | Repetitive Movement | |
Elapsed Time	Repetition	Complain	Picking Skin	Finger	Body	Elapsed Time	Repetition	Complain	Picking Skin	Finger	Body
0:23-0:53				1	1	0:23-0:53					1
0:53-1:23				1	1	0:53-1:23					
1:23-1:53				1	1	1:23-1:53					
1:53-2:23	1				1	1:53-2:23					
2:23-2:53	1				1	2:23-2:53					
2:53-3:23	1				1	2:53-3:23				1	
3:23-3:53					1	3:23-3:53			1		
3:53-4:10					1	3:53-4:23			1		
						4:23-4:53	1				
						4.53-5.23	1				
						5.23-5.53	1				
						5.53-6.23	1				
						6.23-6.53	1				
						6.53-7.23					
						7.23-7.53					
						7.53-8.23					
						8.23-8.53	1	1			
						8.53-9.23					
						9.23-9.49				1	

Note. mvmt=movement. Repetitive finger movement consisted of drumming fingers, playing with fingers, rapidly moving them. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements. Repetitions were given after requested, misheard, or no response was made after 10 s. Complaining entailed asking more than once when the task was done or commenting in a negative way about the task.

* administered second

Table 1t

Participant 20 Atypical Behavior Tally

	SLP-Mediated						Computer-Mediated*				
Elapsed Time	Repetition	Playing w/Object	Biting Fingers	Repetitive Body Mvmt	Picking Fingers	Elapsed Time	Repetition	Playing w/Object	Biting Fingers	Repetitive Body Mvmt	Picking Fingers
0:52-1:22						0:11-0:41					
1:22-1:52				1		0:41-1:11				1	
1:52-2:22				1		1:11-1:41				1	
2:22-2:52				1		1:41-2:11					
2:52-3:22	1			1		2:11-2:41				1	
3:22-3:52	1			1		2:41-3:11				1	
3:52-4:22	1					3:11-3:41				1	
4:22-4:52				1		3:41-4:11				1	
4:52-5:22	1	1		1		4:11-4:41				1	
5:22-5:52	1	1			1	4:41-5:11					
5:52-6:22	1				1	5:11-5:41				1	
6:22-6:47	1					5:41-6:11		1			
						6:11-6:41				1	
						6:41-7:11	1				
						7:11-7:41	1	1			
						7:41-8:11	1				
						8:11-8:41					
						8:41-9:11	1				
						9:11-9:41				1	
						9:41-10:12				1	

Note. mvmt=movement. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements. Repetitions were given after requested, misheard, or no response was made after 10 s. Picking at fingers consisted of the participant picking at the skin on his fingers.

* administered second

Table 1u

Participant 21 Atypical Behavior Tally

SLP-Mediated						Computer-Mediated*					
				Repetitive Movement						Repetitive Movement	
Elapsed Time	Repetition	Playing w/Objects	Complain	Finger	Body	Elapsed Time	Repetition	Playing w/Objects	Complain	Finger	Body
0:37-1.07					1	0:20-0:50					
1.07-1.37					1	0:50-1:20					
1.37-2.07	1				1	1:20-1:50					
2.07-2.37					1	1:50-2:20					
2.37-3.07					1	2:20-2:50				1	1
3.07-3.37	1			1	1	2:50-3:20					
3.37-4.07				1	1	3:20-3:50					1
4.07-4.37				1	1	3:50-4:20					1
4.37-5.17	1			1	1	4:20-4:50					
						4:50-5:20			1	1	
						5:20-5:50		1			1
						5:50-6:20		1		1	1
						6:20-6:50		1			
						6:50-7:03				1	

Note. mvmt=movement. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements. Repetitions were given after requested, misheard, or no response was made after 10 s. Picking at fingers consisted of the participant picking at the skin on his fingers. Complaining entailed asking more than once when the task was done or commenting in a negative way about the task.

*administered second

Table 1v

Participant 22 Atypical Behavior Tally

SLP-Mediated*							Computer-Mediated					
Elapsed Time	Yelling/ Crying	Throwing Objects	Head Thrashing	Repetitive Body Mvmt	Apply Pressure		Elapsed Time	Yelling/ Crying	Throwing Objects	Head Thrashing	Repetitive Body Mvmt	Apply Pressure
0:10-0:40	1	1	1	1			0:17-0:47					
0:40-1:09	1		1	1	1		0:47-1:17					
							1:17-1:23					

Note. mvmt=movement. Repetitive body movement was considered as rocking, swaying, flapping arms, or other whole-body movements. Head thrashing was considered as only moving his head violently back and forth. Applying pressure consisted of the participant exerting force on his face with his hands.

*administered second