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Avery Hampton March 28, 2021

Examining the Reliability of an Online Assessment of Autism-Related Traits in Adults

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An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
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Bachelor of Science with Honors

Neuroscience and Behavioral Biology

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Abstract

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Importance: For adults with autism spectrum disorder (ASD), access to healthcare services is sparse and limited. As ASD grows in prevalence, the need for reliable but rapid assessments is becoming increasingly acknowledged.

Objective: To investigate the reliability of an online assessment of ASD in an adult population.

Participants: A 65% female participant group aged 18 to 80 (average age = 36.3; SD=14.3) were categorized into three subgroups: those reporting an official diagnosis of ASD (n=11), those reporting a suspected diagnosis of ASD (n=17), and those reporting no concerns of ASD (i.e., neurotypical controls, n=33).

Measures: Brief Assessment of Autism Symptoms for Adults (BAASA), Hospital Anxiety and Depression Scale (HADS), HEXACO Personality Inventory- Revised (HEXACO-PI-R) and a background information questionnaire.

Results: The BAASA demonstrated good interrater reliability (% agreement = 88.9) and ROC curve analysis showed it was extremely accurate in identifying those with ASD from neurotypical controls (area under the curve = 1, specificity = 1, sensitivity =1). Significant correlations were observed between BAASA scores and HADS subtest scores for anxiety (r =0.463, $p < 0.001$) and depression (r = 0.332, p = 0.009), as well as HEXACO-PI-R subtest scores for extraversion (r = -0.668, $p < 0.001$).

Conclusion: The BAASA is a reliable and accurate remote assessment of ASD for adults. Self-report of emotions and personality traits (specifically extraversion) showed moderate overlap with the report of ASD-related symptoms and provided supplemental information. A remote platform may be especially useful in providing practical and accessible health care services for adults with ASD.

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Acknowledgements

I would like to thank all of my friends at Wheelhouse Pub for keeping me grounded and always covering my shifts when a deadline approached.

I would also like to thank my parents, Shawn and Ryan Hampton, for pushing me to succeed and reminding me to have fun every once and awhile.

I would like to thank Professor Lori Teague and Doctor Jennifer Mascaro for their engaging ideas and priceless insight.

I would like to extend a special thanks to Dr. Opal Ousley for her time, expertise and constant support since day one.

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Table of Abbreviations

Abbreviation	Explanation
ADI-R	Autism Diagnostic Interview-Revised
ADOS-2	Autism Diagnostic Observation Schedule, Second Edition
AMT	Amazon's Mechanical Turk
ASD	Autism Spectrum Disorder
BAASA	Brief Assessment of Autism Symptoms for Adults
CARS	Childhood Autism Rating Scale
CI	Confidence Interval
DSM	Diagnostic and Statistical Manual of Mental Disorders
EPQ-BV	The Eysenck Personality Questionnaire-Brief Version
GARS-3	Gilliam Autism Rating Scale, Third Edition
HADS	Hospital Anxiety and Depression Scale
HADS-A	HADS Subtest for Anxiety
HADS-D	HADS Subtest for Depression
HEXACO-PI-R	HEXACO Personality Inventory-Revised
HEXACO-H	HEXACO Subtest for Honesty-Humility
HEXACO-E	HEXACO Subtest for Emotionality
HEXACO-X	HEXACO Subtest for eXtraversion
HEXACO-A	HEXACO Subtest for Agreeableness
HEXACO-C	HEXACO Subtest for Conscientiousness
HEXACO-O	HEXACO Subtest for Openness to Experience
IQR	Interquartile Range
ROC Analysis	Receiver Operating Characteristic Analysis

Chapter 1. Introduction

Brief Description of Autism Spectrum Disorder (ASD)

Autism spectrum disorder (ASD) is a neurodevelopmental disorder that is characterized by deficits in social communication and reciprocity, as well as repetitive or routine patterns of behaviors and interests. Neurotypically defined social norms are often challenging for people with ASD to master and this can lead to significant detriments in their social or occupational life (American Psychiatric Association, 2013). ASD-related symptoms are present throughout the entirety of an individual's lifespan; however, they may become more apparent as social demands increase (Hodges et al., 2020). ASD manifests differently in individuals, resulting in great heterogeneity of behaviors and degrees of functioning (Emberti Gialloreti & Curatolo, 2018). Common comorbidities include social anxiety disorder, attention-deficit/hyperactivity disorder (ADHD), intellectual disabilities, epilepsy, immune system disorders etc. (Masi et al., 2017).

ASD is influenced by a multitude of genetic and environmental factors; however, one distinct "cause" has not yet been identified (Hodges et al., 2020). Research suggests that ASD is highly heritable (Rapin & Tuchman, 2008) and over 1000 genes have been linked to ASD (Sealey et al., 2016). A multitude of environmental factors have also been implicated in ASD etiology. Some environmental risk factors for ASD include prenatal exposure to pesticides or air pollution, maternal immune system disorders, advanced parental age at time of conception, prematurity, and oxygen deprivation at birth (NIEHS, 2020).

Prevalence

Although reports of ASD-related behaviors have been recorded as early as 1943 (Masi et al., 2017), it was not largely recognized by clinicians until 1980, when it was published in the *Diagnostic and Statistical Manual of Mental Disorders, Third Edition* (DSM-III) (Christensen et

al., 2018). Since its recognition, ASD has increased in prevalence within the United States. Broadening of diagnostic criteria, widening of screenings, younger age of identification and intervention and increased public awareness have likely contributed to this growth (Neggers, 2014). Today, around 1 in 54 children are diagnosed with ASD. ASD is not restricted to any one race, ethnicity, gender, or socioeconomic group; however, it is four times more likely to be identified in males than females (CDC, 2020). This 4:1 ratio may be due to an under identification of ASD in women, rather than heightened male proneness (Beeger et al., 2012; McDonald, 2020).

It is estimated that 1 in 45 adults ages 18 to 84 years are living with ASD (Dietz et al., 2020). For several reasons, adults often remain unrecognized and undiagnosed (Fusar-Poli et al., 2020). Many are no longer enrolled in public services (i.e., school, primary care providers, community-based organizations, etc.) that aid in the identification of those who show ASD-related symptoms; some adults were children prior to the expansion of clinical recognition, public awareness and access to assessment in the 1980s and were excluded from identification (Lai & Baron-Cohen, 2015; McDonald, 2020). Resource disparities, such as access to care and ASD specialists, also puts racial minority groups, those of lower socioeconomic status and those who live in rural areas at risk of going unidentified (Bishop-Fitzpatrick & Kind, 2017; Mandell et al., 2005). Those who are unidentified may engage in compensatory behaviors, such as "camouflaging," to increase the likelihood of social success (McDonald, 2020). These compensatory behaviors and the high frequency of comorbid disorders often mask ASD-related symptoms and can preclude diagnosis (Lai & Baron-Cohen, 2015; McDonald, 2020).

Diagnostic Process

ASD can be detected in infants 18 months and younger (CDC, 2020); however, many are not diagnosed until the age of three or four years (Webb & Jones, 2009). Early screening is recommended at ages 9, 18 and 30 months in order to discern those who may be showing early signs of ASD (Autism Research Institute, 2020). After identification, a formal evaluation by a licensed healthcare professional is required for a diagnosis (Huerta & Lord, 2012).

Many clinical techniques are used in the diagnosis of ASD. A typical, "gold-standard" evaluation involves the usage of a standardized assessment tool that analyzes an individual using a "multidisciplinary" approach. A multidisciplinary approach assesses individuals in various domains of functioning (Huerta & Lord, 2012). DSM criteria typically underlie these domains and provide guidelines for behavioral analysis. (Thabtah & Peebles, 2019). In addition to a clinical assessment, a description of past behaviors (usually provided by the individual's caregiver) is also required for a comprehensive evaluation (Huerta & Lord, 2012). The gold-standard process is often time consuming as both past and current reports of behaviors must be analyzed to determine a diagnosis (Falkmer et al., 2013).

Diagnostic Criteria

The American Psychiatric Association has defined DSM criteria as the clinical standard for evaluations and specifications must be fulfilled for an official diagnosis of ASD (CDC, 2020). The most recent DSM, the *Diagnostic and Statistical Manual of Mental Disorders, 5th edition: DSM-5* (2013), outlines five major criteria for ASD diagnosis:

A. Individuals experience "persistent deficits in social communication and social interaction across multiple contexts." Individuals with ASD often misinterpret verbal cues, such as tone of voice, and nonverbal cues, such as facial expressions and body

language. Individuals may also engage in verbal and nonverbal behaviors that are incongruent with their social context. Those with ASD may also struggle with reciprocal behaviors, such as joint attention (i.e., the ability to share attention and interest with another person). Deficits in social communication often result in difficulties developing and maintaining relationships and can lead to isolation.

B. Individuals engage in "restricted, repetitive patterns of behavior, interests, or activities." This often manifests as stereotypies, or repetitive movements (i.e., rocking, hand flapping, echolalia) that do not serve a direct purpose. Individuals with ASD often adhere to a strict routine or pattern of behaviors and experience distress when routines or patterns are disrupted. Individuals may also experience sensory sensitivities (i.e., adversities to particular lights, sounds, smells, etc.) or seek out particular sensory stimuli.
C. An individual's symptoms "must be present in the early developmental period."
D. An individual's symptoms must cause "clinically significant impairment in social, occupational, or other important areas of current functioning." Impairments in functioning can result in social isolation, bullying, trouble with coworkers, or getting fired from jobs.
E. An individual's symptoms cannot be attributed to an intellectual disability or global developmental delay.

***** Complete DSM-5 diagnostic criteria for ASD can be viewed at https://www.cdc.gov/ncbddd/autism/hcp-dsm.html.

Assessments of ASD

There are many diagnostic tools used in the assessment of ASD. Trained healthcare professionals use these measures to aid in their evaluation of an individual's past and current behaviors (Baghdadli et al., 2017). Diagnostic tools are often used in concordance with one other to build a complete behavioral profile of the individual in question. These measures examine individuals of a particular age group and employ varying questions and methods for observation. Information gathered using these tools is compared to DSM-5 criteria to determine a diagnosis of ASD. Here are some commonly used diagnostic tools (CDC, 2020):

A. Autism Diagnostic Interview-Revised (ADI-R): ADI-R is a 93-item assessment that evaluates an individual's functioning in three domains: language and communication, reciprocal social interactions, and restricted, repetitive and stereotyped behaviors and interests. This assessment is structured as an interview and caregiver recall of past behaviors is required. This measure can be used to evaluate both children and adults. Administration of the assessment may take between 1.5 to 2.5 hours. (Kim et al., 2013)

B. Autism Diagnostic Observation Schedule, Second Edition (ADOS-2): ADOS-2 assessment employs various activities to allow for the observation of social and communication behaviors. Each activity is structured to mimic a common social context. The ADOS-2 takes approximately 30 to 45 minutes to administer and can be delivered to both children and adults. It is broken into four modules that are based on levels of speech, with Module 4 used to assess adults and adolescents with fluent speech (Carr, 2013).

C. Childhood Autism Rating Scale (CARS): CARS is a 15-item behavior rating scale. Each item is related to the following domains: relationships with people, imitation, affect, use of body, relation to non-human objects, adaptation to environmental change, visual and auditory responsiveness, near receptor responsiveness, anxiety reaction, verbal and nonverbal communication, activity level, intellectual functioning, and general impression for ASD. The CARS takes 30 to 40 minutes to complete and can be used to assess anyone over the age of two years (Volkmar, 2013).

D. Gilliam Autism Rating Scale- Third Edition (GARS-3): The GARS-3 is a 42-item rating scale that can be completed by parents, teachers or clinicians. The items are separated into three subscales: stereotyped behaviors, social interaction and communication (Volker et al., 2016). GARS-3 takes five to ten minutes to complete and can be used to assess anyone between the ages of 3 and 22 years (Karren, 2017).

The ADI-R and ADOS-2 are commonly used diagnostic measures; however, they are time consuming and require a clinician with great experience and knowledge of ASD (Carr, 2013; Kim et al., 2013). Although CARS is less time consuming, a highly trained clinician is still required (Volkmar, 2013). With the increasing prevalence of ASD and demand for assessment (Neggers, 2014), these measurements that are lengthy and require expertise of ASD may no longer be feasible. Because of these feasibility issues, there has been greater dependence on rating scales such as the GARS-3. GARS-3 can be used by those who do not have much experience with ASD but are knowledgeable of the individual's behaviors and functioning (i.e., parents, teachers, general practitioners, etc.) (Volker et al., 2016).

Resource Disparity in Adults

Although great progress has been made in the research and development of health care services available for children, services available for adults are lacking (Murphy et al., 2016). Only two percent of all ASD-related funding is dedicated towards adult issues and services (Shattuck et al., 2020). As a result, many services available are underdeveloped leaving many adults undiagnosed. (Shattuck, 2012). This is especially concerning as undiagnosed adults are more likely to experience functional and emotional impairments (Mandy et al., 2018), as well as comorbid disorders such as anxiety, depression, bipolar disorder, etc. that may lessen their quality of life (Calleja et al., 2019). Appropriate diagnosis will not only allow for relevant treatment of symptoms, but also benefits individuals in other areas of their livelihood. Those diagnosed as adults report 'improved access to services, greater self-understanding and self-acceptance, more understanding from others, and the chance to join a community of adults with ASD (Mandy et al., 2018). Benefits of appropriate diagnosis and risks associated with missed diagnoses emphasize the need for research into reliable assessments for adults with ASD.

Utility of Remote Assessment

As technology becomes more pervasive in day-to-day life, researchers have begun exploring online routes of healthcare provision, or 'telehealth.' Telehealth includes many facets of typical health care services, such as assessment and diagnosis (Kichloo et al., 2020), and is slowly becoming more accepted in both patient and professional spheres (Santesteban-Echarri et al., 2018). The push for exploration and acceptance of telehealth has been further exacerbated by the COVID-19 pandemic. Social distancing mandates have inhibited many from in-person assessment and placed an increasing demand on high quality, remote health care services (Kichloo et al., 2020).

Telehealth may be especially useful in the identification and assessment of those with ASD. Previous studies show great success in the implementation of telehealth procedures in commonly used measures of ASD (Schutte et al., 2015). Remote administration of ASD assessments may also lessen observed health care disparities by reducing costs and providing access to clinicians in areas without specialized facilities (Alfuraydan et al., 2020). Individuals with ASD may especially benefit from remote assessment because it allows them to decide their environment for evaluation and therefore control for their sensory sensitivities. Adults with ASD have reported reduced feelings of anxiety during remote communications in comparison to those that take place in person (Jordan, 2010). Telehealth shows great promise to significantly improve the diagnostic process for adults with ASD and further integration of remote procedures should be explored.

Development of Remote Assessment

Commonly used assessments, such as the ADI-R and ADOS-2, may no longer be feasible due to an increase in demand for diagnostic evaluation (Volker et al., 2016). This is especially concerning for adult populations in which access to healthcare services is sparse and limited (Murphy et al., 2016). In response to these feasibility issues and disparities in healthcare services, our research team utilized an online platform to develop an accessible assessment of ASD: The Brief Assessment of Autism Symptoms for Adults (BAASA). BAASA is a diagnostic aid that allows for open-ended, self-report of social abilities and autism-related symptoms. It is brief (between 20 to 30 minutes) and can be easily administered by those with limited experience with ASD. It was used in tandem with three other questionnaires: Hospital Anxiety and Depression Scale (HADS), HEXACO Personality Inventory-Revised (HEXACO-PI-R) and a background information questionnaire.

The HADS is a brief, yet reliable measure of anxiety and depression (Bjelland et al., 2002). Because adults with ASD are more likely to experience comorbidities such as anxiety and mood disorders (Calleja et al., 2019), we expect to observe correlations between BAASA total scores and HADS subscale scores. If a trend can be established, HADS subscale scores may be helpful in discerning between adult participants with ASD and neurotypical controls. HADS subscale scores may also lend insight into overall functioning of participants which may be helpful in the holistic evaluation of symptom severity and impairment.

The HEXACO-PI-R measures the six major domains of personality: honesty-humility (H), emotionality (E), extraversion (X), agreeableness (A), conscientiousness (C) and openness to experience (O). Certain personality traits may be more strongly associated with ASD. For example, previous research indicates that individuals with ASD may be less extraverted, agreeable, conscientious and open to experiences (Schriber et al., 2011; Suh et al., 2016). If a correlation between certain personality traits and ASD-related symptoms can be established, HEXACO-PI-R subtest scores may be helpful in differentiating those with and without ASD. We expect to observe correlations between BAASA total scores and HEXACO-PI-R subtest scores for extraversion, agreeableness, conscientiousness and openness to experience in those who have an official diagnosis of ASD.

Thesis Aims & Hypotheses

The overall aim of this thesis is to examine the reliability of BAASA as a quick and remote assessment of ASD for adults. Using data from questionnaires, I will examine symptoms of ASD and their relationship with emotions and personality traits. I will also use data to provide insight into potential future applications of remote assessment for adults with ASD.

Hypotheses for Testing

H_A: $p \neq 0$

- Total BAASA scores will differentiate suspect & diagnosed ASD subgroups from neurotypical controls.

H_B: % agreement ≥ 0.8

- The BAASA can be reliably scored by non-expert raters.

H_C: $p \neq 0$

- There will be a significant association between BAASA total scores and HADS subscale scores for anxiety and depression.

H_D: $p \neq 0$

- There will be a significant association between BAASA total scores and HEXACO-PI-R subtest scores for extraversion.

H_E: $p \neq 0$

- There will be a significant association between BAASA total scores and HEXACO-PI-R subtest scores for agreeableness.

H_F: $p \neq 0$

- There will be a significant association between BAASA total scores and HEXACO-PI-R subtest scores for conscientiousness.

H_G: $p \neq 0$

- There will be a significant association between BAASA total scores and HEXACO-PI-R subtest scores for openness to experience.

H_H: area = 0.7

- The BAASA will show moderate diagnostic accuracy.

Null Hypotheses for Testing

H_{0A}: $p = 0$

- Total BAASA scores will not differentiate suspect & diagnosed ASD subgroups from neurotypical controls.

H_{0B} % agreement ≤ 0.8

- The BAASA cannot be reliably scored by non-expert raters.

H_{0C}: $p = 0$

- There will be no association observed between BAASA total scores and HADS subscale scores for anxiety and depression.

H_{0D}: $p = 0$

- There will be no significant association between BAASA total scores and HEXACO-PI-R subtest scores for extraversion.

H_{0E}: $p = 0$

- There will be no significant association between BAASA total scores and HEXACO-PI-R subtest scores for agreeableness.

H_{0F}: $p = 0$

- There will be no significant association between BAASA total scores and HEXACO-PI-R subtest scores for conscientiousness.

H_{0G}: $p = 0$

- There will be no significant association between BAASA total scores and HEXACO-PI-R subtest scores for openness to experience.

H_{0H}: area = 0.5

- The BAASA will show no diagnostic accuracy.

Chapter 2. Methods

Study Population & Recruitment Procedures

A total of 66 participants completed the study. Participants were categorized into three subgroups: those with a diagnosis of ASD (*n*=11), those who suspect they may have ASD (*n*=17) and neurotypical controls (*n*=38). Anyone who was an adult (i.e., 18 years or older), could provide their own consent and had access to the internet and a smart device was eligible to participate. Participation was not compensated. Participants were recruited through advertisements on social media platforms, flyer distribution, and through contact with local ASD-related groups, clinics, or organizations.

Participants were also recruited through Amazon's Mechanical Turk (AMT). AMT is a crowdsourcing platform that assists in participant outreach and recruitment. Our remote assessment was uploaded as a Human Intelligence Task (HIT) and was available to anyone who met eligibility requirements and was registered as an AMT worker. AMT was used because of its success in accessing a rich and diverse population (Levay et al., 2016). A diverse population is imperative in order to capture the heterogenous displays of behaviors and degrees of functioning commonly associated with ASD.

Study Design

Eligible participants engaged in an online assessment which included four questionnaires. The questionnaires were delivered through REDCap, a secure web-based application designed to support data acquisition. Non-expert raters reviewed participant answers and provided scores and diagnostic impressions using standardized scales. Scores were compared between raters to investigate the reliability of BAASA. Data

gathered from questionnaires was analyzed and compared to determine if self-report of social abilities, personality traits, and emotions can help distinguish population subgroups (i.e., those with a diagnosis or suspect a diagnosis of ASD and neurotypical controls).

Rater Training

Two raters were used to assess and score participant responses to the BAASA. Raters included a co-author of the BAASA, as well as an independent rater. The independent rater had little to no experience with ASD diagnosis and assessment prior to this study. To train the independent rater, they were provided a brief overview of ASD and were familiarized with BAASA questions and their respective coding scale. They then participated in a trial scoring session in which they observed the gold-standard ratings (provided by the co-author rater) for three sample participants. After the trial scoring session, the independent rater scored three sample participants. Scores were compared to the gold-standard ratings. Once the independent ratings met 90% agreement with the gold-standard ratings, training was complete.

Measures

The remote assessment included four questionnaires: the BAASA, the Hospital Anxiety and Depression Scale (HADS), the HEXACO Personality Inventory-Revised (HEXACO-PI-R), and a background information questionnaire.

Brief Assessment of Autism Symptoms for Adults (BAASA):

The BAASA is an assessment tool that can aid in initial and confirmatory diagnosis of ASD. The BAASA allows for open-ended, self-report of social abilities and autism-related symptoms. It assesses individuals in six domains: social-emotional reciprocity,

social relationships, routines and repetitive behaviors, sensory processing, cognition and general impression. Some examples of questions include:

- How would you describe your current social life?
- Do you have any hobbies or interests that you engage with every day?
- Do you ever plan your day around your sensory sensitivities?

The BAASA was developed by our research team which included a clinical research assistant, an adult with ASD and an expert clinician. Each domain of assessment, except for cognition, extends from DSM-5 diagnostic criteria for ASD. Questions were created to reflect these criteria and their implications in adult life, while also assessing secondary attributes that arise as a result of social impairments (i.e., stress, conflict with others, isolation, etc.).

We decided to include questions relating to cognition because of the increasing evidence supporting individuals' with ASD have a unique, systemized approach to their environment and social situations. Individuals with ASD are often described as having 'excellent attention to detail' in regard to their environment (Baron-Cohen et al., 2009) and this often interfere with the ability to perceive surroundings on a more global level (Rinehart et al., 2001). Insistence of sameness and intolerance of uncertainty may also disincline individuals with ASD from participating in social events in which there are many unknowns (Jenkinson et al., 2020). Individuals with ASD also engage in camouflaging behaviors, such as the development of social strategy, to increase chances of social success (Schneid & Raz, 2020). To assess these behaviors, we included questions such as, "Do you tend to notice details about objects, people, etc. that other people don't notice?" and "Before a social event, do you ever form lists of conversation topics you understand as being "typical?".

The BAASA was structured to evaluate autism-related traits in around 20-minutes. BAASA comes equipped with an in-depth training manual to enable healthcare professionals with varying levels of experience with ASD to score symptoms. Based on responses to the BAASA assessment, 14 codes are rated using a 0 to 2 scale which are then converted to a dichotomized scale. An additional 4-point rating of overall impression is also made, then dichotomized and summed, to create a total BAASA score which ranges from 0 to 15. The impressions range from 0, which indicates high unlikelihood of ASD, to 3 which indicates high likelihood of ASD.

Hospital Anxiety and Depression Scale (HADS):

The HADS is a 14-item measure of anxiety and depression that examines self-report of symptoms experienced within the past week. The questionnaire takes two to five minutes to complete. Each item is rated by the participant on a 4-point (0-3) scale, with 0 indicating little to no occurrence of symptoms and 3 indicating a more severe occurrence of symptoms. Scores are analyzed within anxiety and depression subscales (seven items each), with possible scores ranging between 0 to 21 for each subscale. For either subscale, scores within the 0 to 7 range are considered typical, scores within the 8 to 10 range are considered borderline atypical, and scores of 11 or higher are suggestive of a potential mood disorder. Examples of items measured include:

- I feel tense or ‘wound up’
- I still enjoy the things I used to enjoy
- I get sudden feelings of panic

Across general and clinical populations, HADS has been reported to have good to excellent psychometric properties. Good sensitivity (Major Depressive Disorder [MDD]: mean = .82, range: .73–.89; Generalized Anxiety Disorder [GAD]: mean = .72, range: .62–.80),

specificity (MDD: mean = .74, range: .60–.84; GAD: mean = .86, range: .79–.90) and internal consistency (HADS-A: .82–.84; HADS-D: .60–.72) has been observed in both the anxiety and depression subscales. The total score of HADS subscales has also been successful in identifying more subtle expressions of anxiety and depression (Uljarević et al., 2017). This may be especially useful in the assessment of adults with ASD, where anxiety and depression may stem from social impairments related to their ASD-related symptoms.

HEXACO Personality Inventory-Revised (HEXACO-PI-R)

The HEXACO-PI-R is a 60-item measure of personality that includes subtests for honesty-humility (H), emotionality (E), extraversion (X), agreeableness (A), conscientiousness (C) and openness to experience (O). The questionnaire takes around ten minutes to complete. Participants rate how well a statement describes themselves on a 5-point rating scale, with 1 indicating strong disagreement and 5 indicating strong agreement. Subtest scores are totaled and averaged. Average subtest scores range between 3 to 4 and anything outside of this range may be considered atypical. Examples of items measured include:

- I would be quite bored by a visit to an art gallery
- I clean my office or home quite frequently
- I rarely hold a grudge, even against people who have badly wronged me

* The complete HEXACO-PI-R assessment can be viewed at https://hexaco.org/.

High reliability of scores has been observed in all HEXACO-PI-R subtests. Significant associations ($p< 0.05$) have also been reported between subtests for extraversion, conscientiousness, agreeableness and openness to experiences (Bashiri et al., 2011). These four domains of personality may be inextricably linked in all populations, including those with ASD,

and previous data suggests a negative correlation is likely to be observed between subtest scores and ASD-related symptoms (Schriber et al., 2011; Suh et al., 2016).

Background Information Questionnaire

The background information questionnaire includes basic questions regarding age, gender, race and ethnicity, zip code, prior autism diagnosis and chronic medical problems. It was constructed by our research team to gather general demographic data of the study population.

Data Screening

All data was screened prior to statistical analysis. BAASA responses were examined for nonsensical answers and data was eliminated from analysis if both raters independently flagged data for quality concerns. In total, data from four participants in the control group was discarded due to concerns for quality. Data was also screened for the presence of extreme outliers (i.e., BAASA total score ≥ 3* IQR) within subgroups. One extreme outlier was discovered, and scores were discarded for analysis (Figure 1).

Statistical Analyses

Power Analysis

We used SciStat (https://www.scistat.com/samplesize/) to conduct an *a priori* power analysis for comparison of means between subgroups. The difference of means was set to 5 points (SD= 3.75), with alpha = 0.05 and power = 0.8, to determine the necessary sample size. Assuming a 3.1 to 1 ratio (i.e., control: diagnosed ASD), it was estimated that a sample size of 26 (control = 19, diagnosed ASD = 7) is needed. Thus, our proposed sample size for the control group (n=33) and diagnosed ASD group (n=11) is adequate. Assuming a 2 to 1 ratio (i.e., control: suspect ASD), a sample size of 21 (control= 14, suspect ASD = 7) was also estimated. Our proposed sample size of 50 (control= 33, suspect ASD = 17) is adequate. For comparison of

means between control and suspect + diagnosed ASD groups, a sample size of 27 (control = 11, suspect + diagnosed ASD = 10) was estimated, assuming a 1.2:1 ratio (i.e., control: suspect + diagnosed ASD. Our proposed sample size of 61 (control = 33, suspect + diagnosed ASD = 28) is adequate. Assuming alpha = 0.05 and power = 0.08, difference of means was set to 3 points (SD=3.75) to determine the sample size needed for diagnosed ASD and suspect ASD subgroups. Assuming a ratio of 1.5:1 (suspect ASD: diagnosed ASD), a sample size of 54 (suspect ASD = 32, diagnosed ASD = 22) was estimated. Our proposed sample size (*n*=8, suspect ASD = 17, diagnosed ASD = 11) will be less than adequate for comparison of means.

We used SciStat to also conduct an *a priori* power analysis to determine the sample size needed to examine correlations between BAASA total scores and HADS and HEXACO-PI-R subtest scores. Assuming alpha = 0.05 and power = 0.8, a sample size of 29 is necessary to detect a moderate association ($r = 0.5$) between scores. Our proposed sample size of 61 is adequate.

We again used SciStat to conduct a final power analysis to determine the sample sizes needed for ROC curve analysis. Assuming alpha = 0.05, power = 0.8, the area under the ROC curve was set to 0.8 and the null hypothesis value was set to 0.5. Using a ratio of 3.1:1 (control: diagnosed ASD), a sample size of 37 (control= 28, diagnosed ASD = 9) was estimated. Our proposed sample size (*n*= 44, control = 33, diagnosed ASD = 11) is adequate. Using a ratio of 1.2:1 (control: suspect & diagnosed ASD), a sample size of 27 (control = 15, suspect and diagnosed ASD = 12) was also estimated. Our proposed sample size (*n*=61, control = 33, suspect & diagnosed ASD = 28) is adequate.

Correlation Analysis

We used SPSS to measure Pearson's correlation between ASD-related symptoms, emotions and domains of personality. BAASA scores were plotted on the x-axis against HADS

subtest scores for anxiety (HADS-A) and depression (HADS-D), as well as HEXACO-PI-R subtests for honesty-humility (HEXACO-H), emotionality (HEXACO-E), extraversion (HEXACO-X), agreeableness (HEXACO-A), conscientiousness (HEXACO-C) and openness to experience (HEXACO-O). Strength of the relationship was determined by Pearson's correlation coefficient (r) and significance was measured using a two-tailed test for p-value.

Interrater Reliability

The reliability of BAASA was evaluated by comparing percentage agreement between two raters. Each rater reviewed answers from participants (n=12) and provided scores and diagnostic impressions using the standardized coding scale. Dichotomized scores were used for analysis. Agreement between raters for each item of the BAASA was summed across participants to create a total agreement score. To find percentage agreement, the total agreement score was divided by 180 (agreement + disagreement) and multiplied by 100 (Araujo & Born, 1985). Percentage agreement ≥ 80% shows strong interrater reliability (McHugh, 2012).

Receiver Operating Characteristic (ROC) Curve Analysis

A receiver operating characteristic (ROC) curve analysis used BAASA total scores to determine a potential cutoff score for ASD diagnosis or risk. ROC analysis plots sensitivity against 1-specificity, using the BAASA total score as a predictor of ASD diagnosis. Two different state conditions were used for ROC curve analysis: 1) in which the positive state included both suspect and diagnosed ASD subgroups and 2) in which the positive state only included the diagnosed ASD subgroup. The highest sum of sensitivity + specificity was used to determine optimum cutoff score. Area under the ROC curve was also examined to determine the accuracy of BAASA as a diagnostic measure (Mandrekar, 2010).

Chapter 3. Results

Sample Demographics

Data from 61 participants was examined. Participants were categorized into 3 subgroups: those with a diagnosis of ASD (*n*=11), those who suspect they may have ASD (*n*=17) and neurotypical controls (*n*=33). The study sample was majority female (65%) with 29% male, 5% nonbinary and 2% transgender also reported. The sample included individuals ranging from 18 to 80 years old (average age = 36.3, SD = 14.3). The sample was predominantly white (74%), but also included Asian (16%), Hispanic (6%), black (2%) and 'other' (2%) ethnicities (Table 1).

Descriptive Statistics

The remote assessment in its entirety took on average 35 minutes to complete (*n*=50, SD = 31.1). Average score for control equaled 2.21 (SD = 2.043; 95% CI [1.49, 2.94]), for suspect ASD equaled 13.18 (SD = 2.555; 95% CI [11.86, 14.49]) and for diagnosed ASD equaled 14 (SD = 1.673; 95% CI [12.88, 15.12]). Control BAASA scores differed significantly from suspect ASD ($p < 0.001$) and diagnosed ASD ($p < 0.001$) subgroups. No significant difference ($p = 0.354$) was observed between suspect and diagnosed ASD subgroups. See Table 2 for HADS and HEXACO-PI-R subtest averages between subgroups.

Correlations

Using a sample of 61 participants, bivariate correlations were observed between BAASA total scores and total HADS subtest scores for anxiety (HADS-A) and depression (HADS-D). Significant and moderately positive correlations were observed between BAASA and subtest scores for HADS-A ($r = 0.463$, $p < 0.001$) and HADS-D (*r*

= 0.332, p = 0.009) (Figure 2). Using a sample of 50 participants, bivariate correlations were also observed between total BAASA scores and average HEXACO-PI-R subtest scores. No significant correlation was observed between BAASA total scores and HEXACO-PI-R average scores for honesty-humility (r = 0.197, p = 0.17), emotionality (r = 0.012, p = .933), agreeableness (r = -.171, p = .235), conscientiousness (r = 0.244, p = 0.088) and openness to experience (r = .211, p = 0.142) subtests. A significant and large negative correlation was observed between BAASA total scores and HEXACO-PI-R average scores for extraversion (r = -0.668, p < 0.001) (Figure 3).

Interrater Reliability

Percent agreement between raters was used to determine the reliability of BAASA scores. A sample of 12 participants was scored independently, yielding 88.9% agreement between raters (Figure 4).

ROC Curve Analysis

Assuming suspect & diagnosed ASD subgroups as the positive state, area under the ROC curve was determined to equal 0.996 (95% CI [0.987, 1]). Sensitivity (1) + specificity (0.939) was used to compute an optimal cutoff score of *greater than or equal to* 6, which means that any score above or equal to 6 indicates a diagnosis of ASD and any score less than 6 indicates no diagnosis of ASD (Figure 5A). Further ROC analysis used only diagnosed ASD as the positive state. A perfect ROC curve was found (area under the curve = 1, 95% CI [1,1]) and sensitivity (1) + specificity (1) determined an optimum cutoff score to be *greater than or equal to* 9 (Figure 5B).

Chapter 4. Discussion

Adults with ASD face many challenges regarding assessment and diagnosis, including underdeveloped and impractical measures, lack of access to specialists and resource disparities. Recent exploration and implementation telehealth procedures motivated our research team to combat these challenges using an online platform. We developed a brief and accessible assessment of ASD which included measures of social abilities (BAASA), emotions (HADS) and domains of personality (HEXACO-PI-R). Our aim was for this assessment to be a reliable evaluation of ASD that could be easily scored by those with limited training and experience. Interrater reliability and diagnostic accuracy of this assessment were examined, as well as relationships between ASD, symptoms of anxiety and depression, and specific personality traits.

HADS Correlations

Symptoms of anxiety and depression are commonly observed amongst adults with ASD (Calleja et al., 2019) and, in line with our hypothesis (H_A), it is no surprise that significant associations were observed between BAASA total scores, and HADS-A (r =0.463, $p < 0.001$) and HADS-D ($r = 0.332$, $p = 0.009$) subtest scores (Figure 2). Anxiety and depression are often a result of adversity and isolation brought on by social impairments (Calleja et al., 2019) and it is likely that the correlation observed is a consequence of this. However, symptoms of anxiety and depression seem to especially affect those who suspect they may have ASD but have not yet received a diagnosis (Table. 2). Appropriate diagnosis has been reported to improve self-acceptance, access to support and overall quality of life (Mandy et al., 2018). It is likely those in the suspect ASD subgroup have not benefited from this support system, and therefore experience greater impairments. Our results indicate the HADS is useful in providing insight into overall well-being as well as identifying those who experience greater ASD-related symptoms,

specifically those who suspect a diagnosis, and it should continue to be included in the remote assessment of ASD.

HEXACO-PI-R Correlations

In the examination of personality traits within our sample, a significant relationship (r = -0.668, $p < 0.001$) was observed between BAASA total scores and HEXACO-PI-R subtest scores for extraversion (Figure 3) and we were able to reject the null hypothesis (H_{0D}). This finding is no surprise, as individuals with ASD tend to avoid social situations as they report they can be stress-inducing (Bishop-Fitzpatrick et al., 2014). The HEXACO-X subtest shows good reliability (Bashiri et al., 2011) and its negative association with BAASA scores indicates concurrent validity of the BAASA as a measure of sociability, specifically in the domain of extraversion. Correlations between HEXACO-X subscales (i.e., social self-esteem, social boldness, sociability & liveliness) should be explored to further examine the BAASA as a measure of sociability. The 100-item and 200-item versions of HEXACO-PI-R may also be considered in future adaptations of our remote assessment to provide a more thorough examination of personality domains. Additional use of robust measures of extraversion, such as the Eysenck Personality Questionnaire-Brief Version (EPQ-BV), may further improve our understanding of the relationship between extraversion and BAASA scores.

BAASA Reliability and Diagnostic Accuracy

In line with our hypothesis (H_A), the BAASA was able to determine that suspect and diagnosed ASD subgroups differed significantly from the control ($p < 0.001$) (Table 2). No significant difference in BAASA scores was observed between suspect ASD and diagnosed ASD subgroups (Figure 1), indicating that both subgroups experience similar degrees of ASD related traits. We used ROC curve analysis to examine the diagnostic accuracy of BAASA and also to

determine a potential cutoff score for ASD diagnosis or risk. We examined the ROC curve under two state conditions (i.e., positive state = suspect + diagnosed ASD, positive = diagnosed ASD) and found in both cases we were able to reject the null (H_{0H}). The BAASA surpassed our expectations as it was found to be highly accurate in identifying those with a high occurrence of ASD-related traits (area under the curve > 0.99) (Figure 5). Sensitivity + specificity was greater than 1.9 in both state conditions, indicating the BAASA can correctly identify those with/suspect and without ASD.

Depending on the state condition, a cutoff score of ≥ 6 (positive = suspect and diagnosed ASD) or ≥ 9 (positive = diagnosed ASD) was observed. Due to the heterogenous display of symptoms commonly associated with ASD (Emberti Gialloreti & Curatolo, 2018), we expected to observe a wide degree of scores within suspect and diagnosed ASD subgroups. The cutoff score used in future applications of BAASA may depend on its specific function. A cutoff score of 6 may be more appropriate for a broad screener of ASD-related symptoms so that it may capture the wide variety of behaviors and degrees of functioning. A cutoff score of 9 may be more indicative of a diagnosis of ASD, in which the symptoms are present enough to meet DSM-5 criteria. Further research is required to determine the range of scores associated with general impressions of ASD symptomatology.

Reliability of BAASA scores was examined through percentage agreement between two raters. Raters independently evaluated 12 participants and 88.9% agreement was observed between scores, indicating the BAASA demonstrates good reliability, and we were able to reject the null hypothesis (H_{0B}). We considered this a major success of our study, as it demonstrated the BAASA is able to be dependably scored by non-expert raters. However, we do aim to improve reliability to show percentage agreement as greater than or equal to 90%. We intend to conduct

an itemized reliability analysis to determine which questions and their respective coding scales may need to undergo further operationalization. Based on our consensus coding conversations, we developed a coding training manual which may also help improve interrater agreement and serve as a guide raters can consult with when considering scores. Interrater reliability should also be examined using Cohen's kappa, which takes into consideration the occurrence of a chance agreement between two raters (McHugh, 2012).

Limitations

We acknowledge several limitations of our study. First, we were unable to confirm a diagnosis of ASD in those who reported it. However, the BAASA was able to discern these individuals from neurotypical controls and these individuals had significantly higher scores which also indicate a heightened presence of symptoms. We intend to expand our recruitment from clinicians and specialized facilities in order to gather more information regarding an official diagnosis. Second, we were unable to score non-verbal communicative behaviors through a written format of the BAASA. The assessment of non-verbal behaviors is required for an official diagnosis of ASD, as suggested by DSM-5 criteria. A written form of the BAASA may assist in the diagnostic process; however, it must be used in tandem with other measures for an official diagnosis to be made.

Future Directions

For future investigation of a remote assessment of ASD, we plan to examine the relationship between ASD-related symptoms and specific personality traits within a greater population those with an official diagnosis. We will continue to use the HEXACO-PI-R and will consider introducing a scale that specifically measures extraversion, such as the EPQ-BV. We will gather more information regarding official diagnosis by expanding recruitment from

clinicians and specialized facilities. We plan to conduct itemized analysis of BAASA reliability and will examine reliability using Cohen's kappa.

We also intend to adapt the BAASA into a video-interview. A video-interview adaptation of BAASA will allow for the observance and assessment of non-verbal communication, including eye contact, tone of voice, facial expression, repetitive motions and echolalia. This will also allow administrators to ask follow-up questions to clarify symptom experience and prevalence. A video-interview adaptation of BAASA would provide greater information relevant to DSM-5 criteria and may prove to be a more useful tool when making an official diagnosis of ASD.

Conclusion

Our results suggest that the BAASA is a reliable and accurate, remote assessment of ASD for adults. Self-report of emotions and personality traits (specifically extraversion) showed moderate overlap with the report of ASD-related symptoms and provided supplemental information. Because the BAASA is a brief measure of ASD that can be scored by non-expert raters, it may be more feasible than other diagnostic tools, such as the ADI-R and ADOS-2. A more practical, accessible option for assessment for adults is imperative, as they face many disparities in available health care resources. A remote platform may be especially useful in reducing these disparities and should be further explored as an option for ASD-related healthcare provision.

Tables and Figures

Table 1.

Population Subgroup Demographics

	ASD Diagnosis	Suspect ASD	Control
Subgroup Size (*n*)	11	17	34
Male *n*(%)	5 (45.5)	1 (5.9)	12 (35.3)
Female *n*(%)	6 (54.5)	12 (70.6)	22 (64.7)
Nonbinary *n*(%)	0	3 (17.6)	0
Transgender *n*(%)	0	1 (5.9)	0
Age (mean ± SD)	36.5 ± 14.3	33.4 ± 11	37.7 ± 15.9
White *n*(%)	10 (90.9)	16 (94.1)	20 (58.8)
Asian *n*(%)	0	1 (5.9)	9 (26.5)
Hispanic *n*(%)	1 (9.1)	0	3 (8.8)
Black *n*(%)	0	0	1 (2.9)
Other Ethnicity *n*(%)	0	0	1 (2.9)

Table 2.

Means and Standard Deviations for BAASA, HADS and HEXACO-PI-R Assessments Organized by Population Subgroups

Assessment	Control			Suspect ASD			Diagnosed ASD		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
BAASA	33	2.2	2	17	13.2**	2.6	11	14.2**	1.3
HADS-A	33	8.4	4.5	17	11.9*	3.6	11	10.1	3
HADS-D	33	4.9	2.4	17	7.6*	3.8	11	4.9[a]	2.3
HEXACO-H	33	3.5	0.7	10	3.85	0.7	6	3.8	1
HEXACO-E	33	3.4	0.6	10	3.4	0.4	6	3.3	1
HEXACO-X	33	3.5	0.8	10	2.2**	0.7	6	2.6*	0.5
HEXACO-A	33	3.1	0.7	10	2.6	0.5	6	3.1	0.7
HEXACO-C	33	3.6	0.6	10	3.8	0.6	6	4.2	0.7
HEXACO-O	33	3.4	0.7	10	3.5	0.5	6	3.6	0.6

Note. The stars indicate significant differences observed in comparison to the control subgroup.

** $p < 0.001$

* $p < 0.01$

Note[a]. Suspect ASD and diagnosed ASD subgroups significantly differed in HADS-D scores ($p = 0.049$).

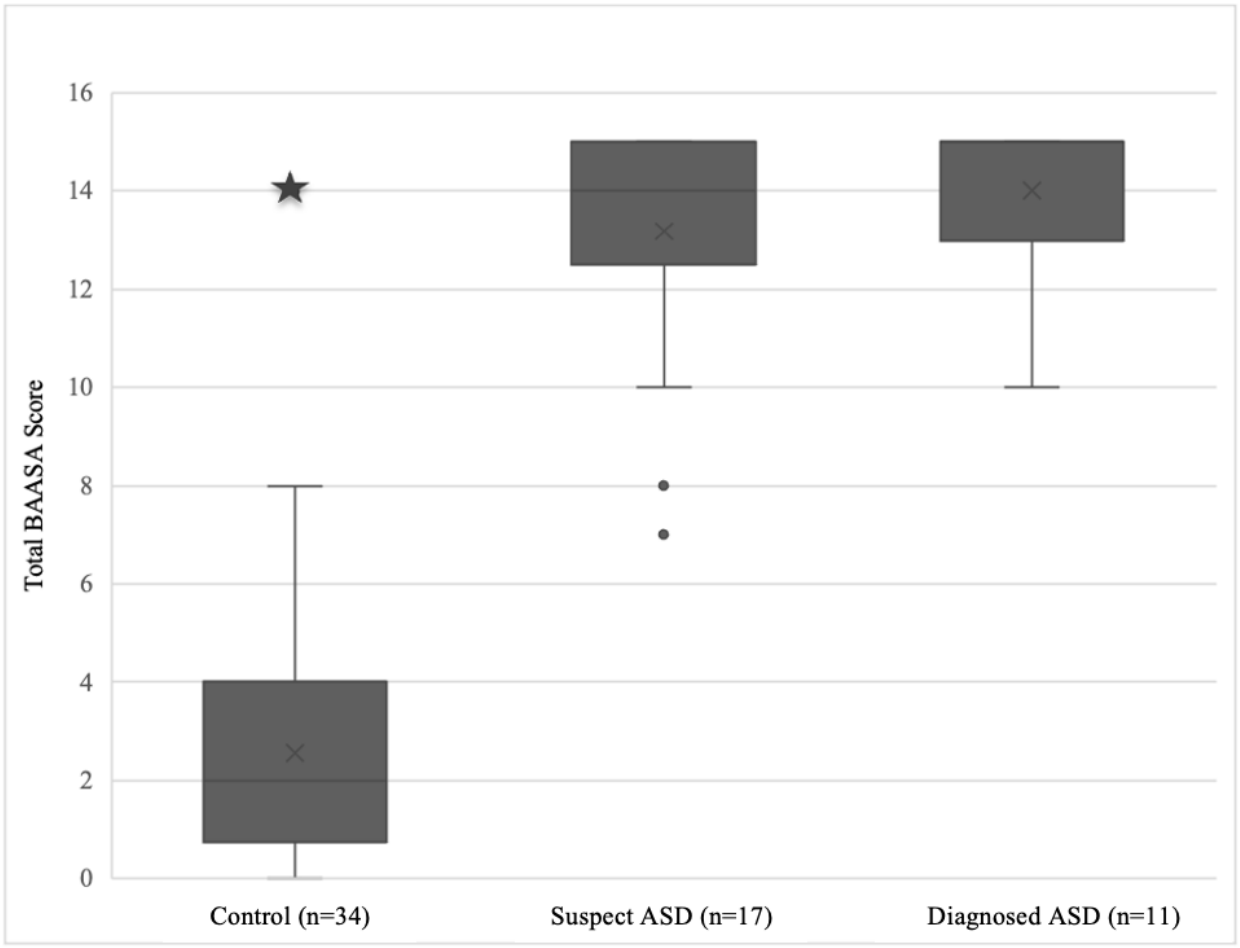
Table 3.

Summary of Tested Null Hypotheses

Hypothesis	Statement	Results
$\mathbf{H_{0A}}$	Total BAASA scores will not differentiate suspect & diagnosed ASD subgroups from neurotypical controls.	reject
$\mathbf{H_{0B}}$	The BAASA cannot be reliably scored by non-expert raters.	reject
$\mathbf{H_{0C}}$	There will be no association observed between BAASA total scores and HADS subscale scores for anxiety and depression.	reject
$\mathbf{H_{0D}}$	There will be no significant association between BAASA total scores and HEXACO-PI-R subtest scores for extraversion.	reject
$\mathbf{H_{0E}}$	There will be no significant association between BAASA total scores and HEXACO-PI-R subtest scores for agreeableness.	failed to reject
$\mathbf{H_{0F}}$	There will be no significant association between BAASA total scores and HEXACO-PI-R subtest scores for conscientiousness.	failed to reject
$\mathbf{H_{0G}}$	There will be no significant association between BAASA total scores and HEXACO-PI-R subtest scores for openness to experience.	failed to reject
$\mathbf{H_{0H}}$	The BAASA will show no diagnostic accuracy.	reject

Figure 1.

Distribution of BAASA Scores between Subgroups



Note. Range of BAASA scores was plotted and compared within subgroups to determine the presence of outliers. Interquartile range (IQR) for control, suspect ASD and diagnosed ASD subgroups was determined to equal 3, 3 and 2 respectively. A total of three outliers were found: two mild outliers (dots) and one extreme outlier (star).

Figure 2.

Relationship between Scores: BAASA and HADS Subtests for Anxiety and Depression

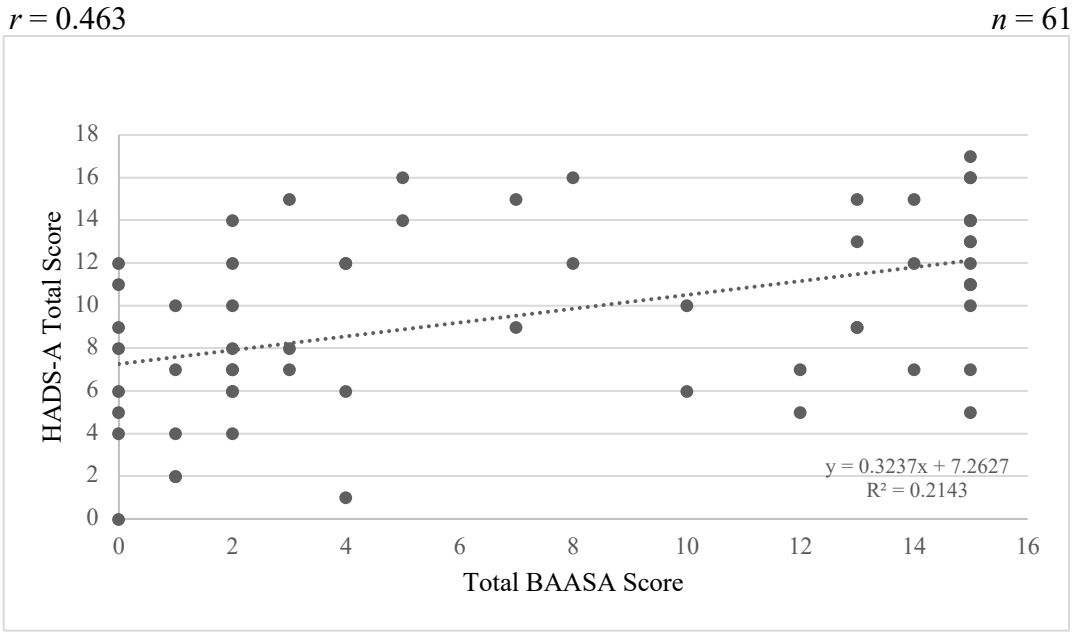


Figure 2A.

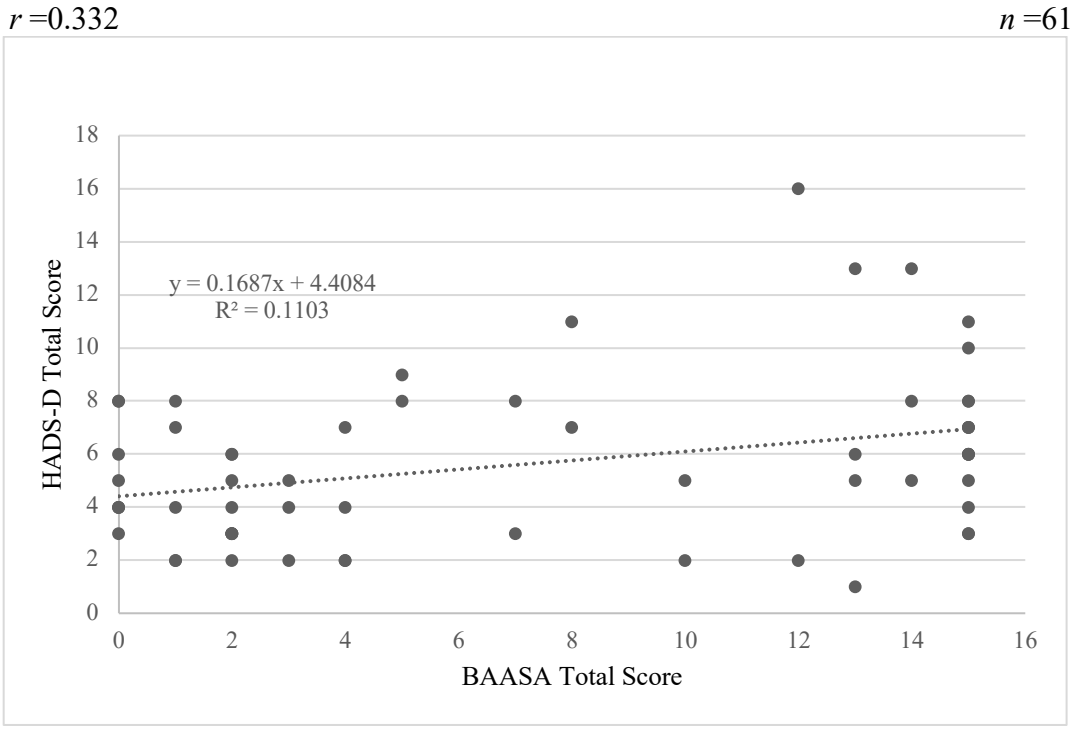


Figure 2B.

Figure 3.

Relationship between Scores: BAASA and HEXACO-PI-R Subtest for Extraversion

r = -0.668 n = 50

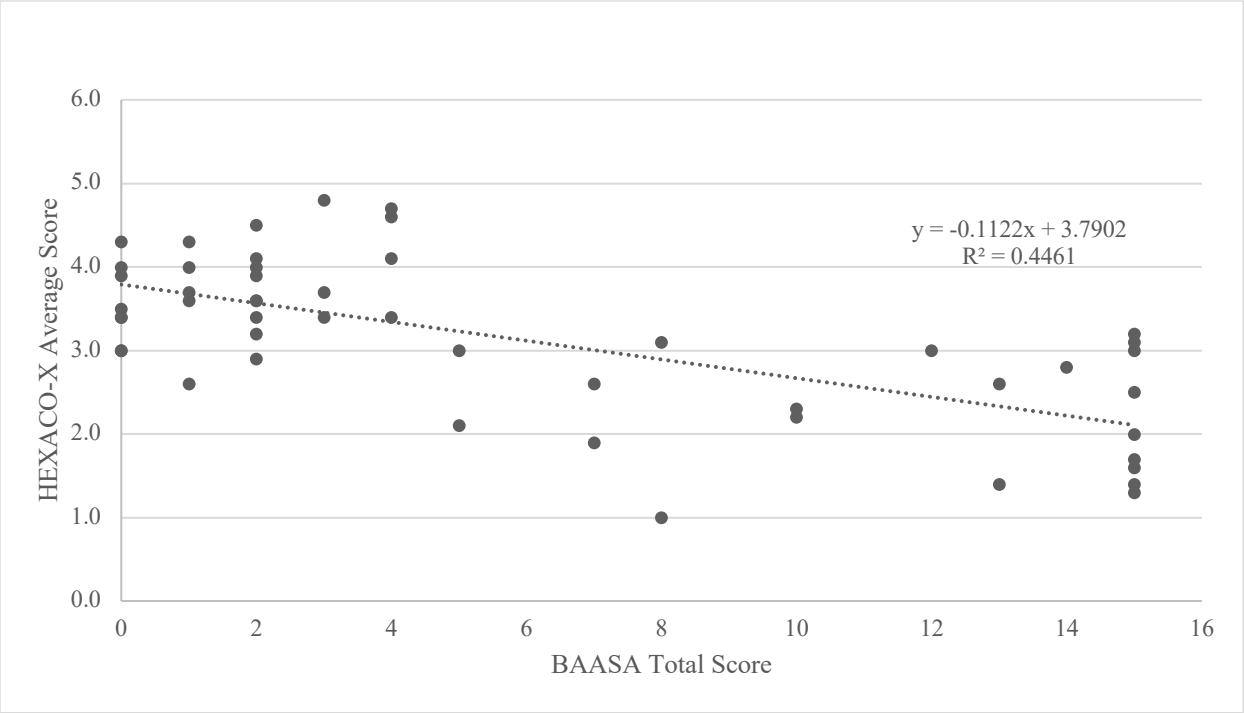


Figure 4.

Agreement in BAASA Scores between Two Raters

% agreement = 88.9

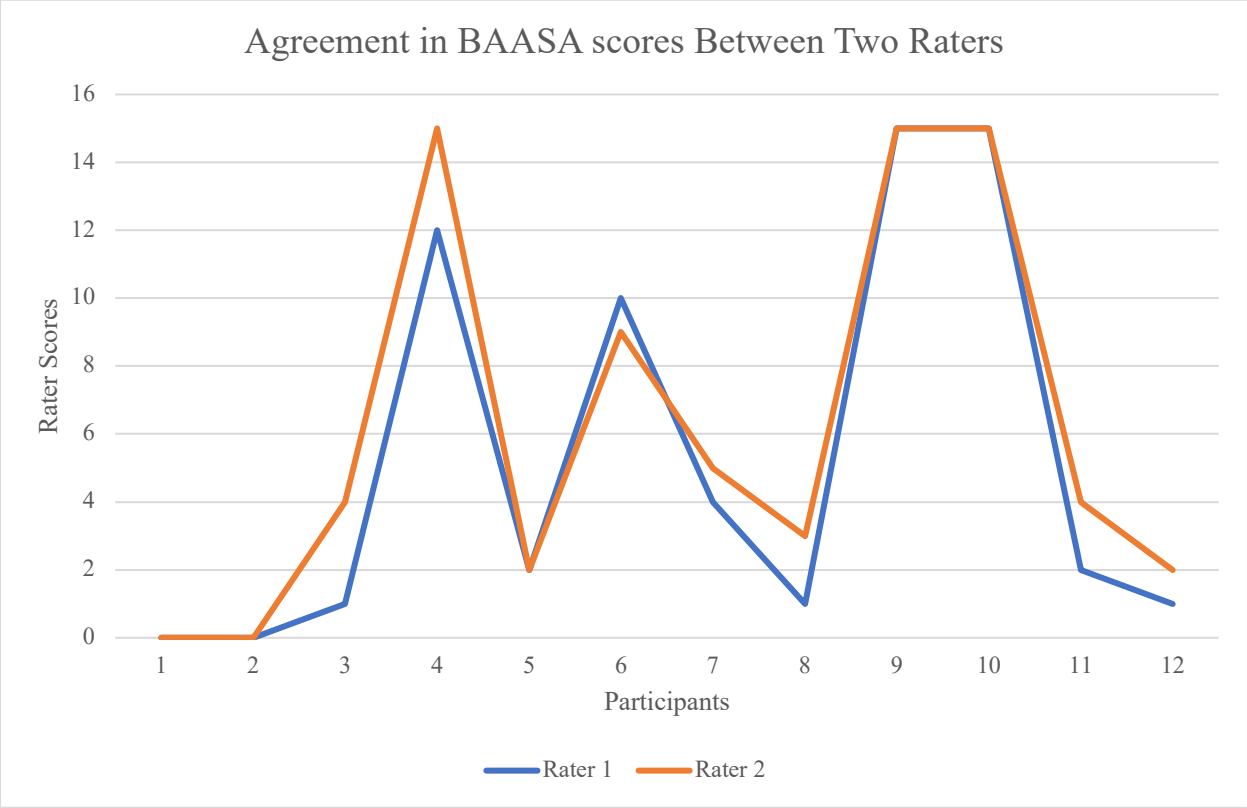


Figure 5.

ROC Curve Analysis

Figure 5A.

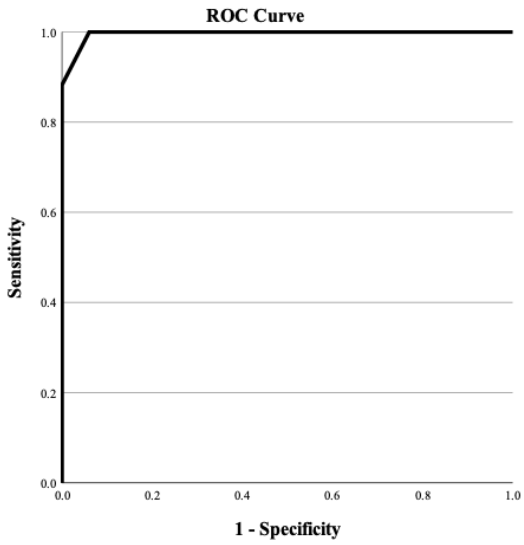
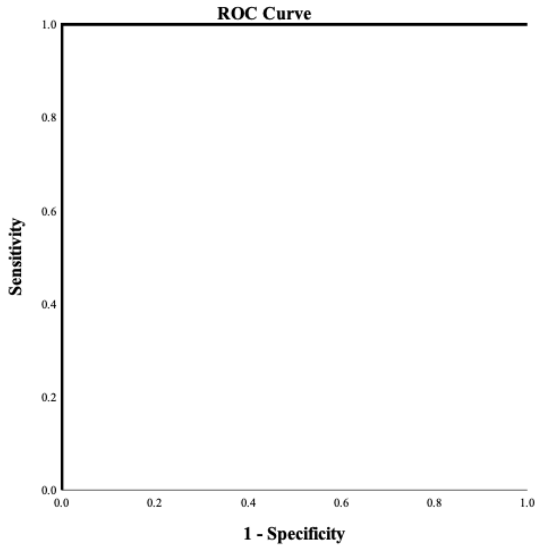


Figure 5B.



Note. For Figure 5A, area under the ROC curve (area = 0.996, 95% CI [0.987, 1]) was found using both suspect and diagnosed ASD subgroups as the positive state. Figure 5B depicts a perfect ROC curve, in which area under the curve is equal to 1 (95% CI [1, 1]). For this analysis, data from the suspect ASD subgroup was not used (i.e., positive state = diagnosed ASD).

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