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ORIGINAL PAPER

# Assessing Autism Spectrum Disorder in Intellectually Able Adults with the Personality Assessment Inventory: Normative Data and a Novel Supplemental Indicator

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**Abstract**
Differential diagnosis of autism spectrum disorder (ASD) among intellectually-able adults often presents a clinical challenge, particularly when individuals present in crisis without diagnostic history. The Personality Assessment Inventory (PAI) is a multiscale personality and psychopathology instrument utilized across clinical settings, but to date there are no published normative data for use of the PAI with adults with ASD. This study provides normative PAI data for adults diagnosed with ASD, with effect size comparisons to the PAI clinical standardization sample and an inpatient sample. Additionally, a discriminant function was developed and cross-validated for identification of ASD-like symptomatology in a clinical population, which demonstrates promise as a screening tool to aid in the identification of individuals in need of specialized ASD assessment.

**Keywords** Personality Assessment Inventory (PAI) · Differential diagnosis · Discriminant function · Autism Spectrum Disorder (ASD)

## Introduction

Although autism spectrum disorder (ASD) is typically first diagnosed in childhood, many individuals with ASD reach adolescence and adulthood either misdiagnosed or undiagnosed, particularly those who are intellectually able (Barahona-Corrêa 2017; Geurts and Jansen 2012; Raja and Azzoni 2010). The ASD prevalence rate in the adult general population is thought to be approximately 1% (Brugha et al. 2011), with slightly higher rates (1.4%) found in adult psychiatric populations (Nylander and Gillberg 2001). Individuals with ASD have impairments in social communication and interaction, including deficits in nonverbal communicative behaviors and social-emotional reciprocity, accompanied by restricted and repetitive patterns of behaviors or interests (American Psychiatric Association 2013). ASD is often comorbid with other clinical conditions, including depression, anxiety, and attentional deficit disorder (Happé et al. 2016), however distinguishing between these conditions and ASD can present a diagnostic challenge. For instance, the monotonous prosody and the muted emotional expression common among individuals with ASD may resemble a depressive disorder. Individuals with ASD may also struggle with verbalizing their emotional experiences, further contributing to difficulties with diagnosis (Barahona-Corrêa 2017). Furthermore, individuals with ASD experience difficulty with executive functioning abilities such as cognitive flexibility and emotional control; these difficulties are often also associated with attention-deficit/hyperactivity disorder (ADHD) (Craig et al. 2016).

Important to note is that prior to 2013, separate diagnoses for ASD and ADHD were not made, and often were not identified for comprehensive treatment. This is because features of ADHD/executive functioning disruption were subsumed in the Asperger's diagnostic category of the

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*Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*; American Psychiatric Association 1994). Symptoms of anxiety also were often neglected or solely identified instead of Asperger's Syndrome. Hartley and Sikora (2009) identified nuanced presentations of anxiety and executive function disruption which previously often were the sole focus of treatment rather than ASD/Asperger's Syndrome. The missed diagnosis of ASD/Asperger's Syndrome was often seen in childhood as simply ADHD and/or anxiety because these features were more readily noticed rather than the nuanced social communication differences in intellectually able persons with ASD.

Changes in diagnostic criteria in *DSM-5* (American Psychiatric Association 2013) allowed for inclusion of ADHD as comorbid with ASD. Additionally, clinicians are continually improving understanding of the role anxiety plays. Combined emphasis of comorbid ASD, ADHD and anxiety has thus has made for more comprehensive intervention. For example, Zaboski and Storch (2018) identified the importance of identifying and treating comorbid ASD and ADHD with cognitive behavioral therapy (CBT) and medication instead of just working to improve social communication differences. Avni, Ben-Itzchak and Zachor (2018) report that the combined impact of anxiety and ADHD on ASD results in greater weaknesses in daily living/adaptive skill development. Identifying the presence of comorbid ADHD and anxiety has improved comprehensive treatment for individuals with ASD. However, other features of ASD are sometimes wrongly confused with features of other psychological issues and begin a spiral of ineffective treatment approaches which can delay appropriate intervention.

One of the greatest difficulties in ASD differential diagnosis in adults is with severe mental illness. Adults with ASD, particularly those not previously diagnosed with ASD, are sometimes misdiagnosed due to overlap in symptomatology with disorders such as schizophrenia (Raja and Azzoni 2010; Tebartz van Elst et al. 2013). For instance, individuals with ASD may present with eccentric, highly specific interests, rigid or repetitive motor behaviors, limited emotional expression, or appear interpersonally cold, withdrawn or aloof, all of which are also common manifestations of schizophrenia spectrum disorders (Barahona-Corrêa 2017). Similarly, poor emotion regulation and emotional outbursts can lead to misdiagnosis of bipolar disorder in individuals with ASD, especially when they are hospitalized. Misdiagnosis of this type can have detrimental consequences, including unnecessary medication with antipsychotics or mood stabilizers, inappropriate hospitalizations, and poorly targeted psychological treatments. Further, since patients can experience mental illness together with ASD, mental health practitioners need ways to determine whether ASD could be part of the individual's presentation. This information can guide treatment and affect how signs of mental illness are interpreted and diagnosis is made.

If ASD is suspected in a previously undiagnosed adult, there are multiple structured diagnostic assessment tools specifically developed for ASD that can be used. The Autism Diagnostic Observation Schedule-2nd Edition (ADOS-2; Lord et al. 2012), which is a clinician-administered observational assessment given to the patient, is considered a gold standard instrument. If an appropriate informant is available, the Autism Diagnostic Interview-Revised (ADI-R; Lord et al. 1994), a comprehensive interview of a caregiver comprising diagnostic algorithms to support a diagnosis of ASD according to *DSM-IV-TR* criteria, can be used (American Psychiatric Association 1994). The Social Responsiveness Scale-2 (Constantino and Gruber 2012), which has a self-report as well as informant report version for adults, includes a Social Communication and Interaction (SCI) scale and a Restricted Interests and Repetitive Behaviors (RRB) scale, and is thus also useful in the diagnostic process. Other instruments designed to screen for ASD features in adults include the Autism Spectrum Quotient (Baron-Cohen et al. 2001), the Empathy Quotient (Baron-Cohen and Wheelwright 2004), and the Ritvo Autism Asperger Diagnostic Scale-Revised (Ritvo et al. 2011). It should be noted, however, that differential diagnosis concerns are apparent even with gold standard instruments. For instance, Maddox et al. (2017) found that although the ADOS-2 demonstrated perfect sensitivity in identifying adults with ASD in a community mental health setting, the ADOS-2 had a high false positive rate (30%) among participants with psychotic spectrum symptoms. These findings highlight the importance of not relying on any single diagnostic measure of ASD, given the complexities of disentangling ASD from other psychiatric disorders with similar symptom presentations.

Furthermore, diagnostic difficulties may be further exacerbated when individuals with ASD go to the hospital in crisis, and mental health personnel who do not specialize in adult ASD may not be well-equipped to identify possible ASD as part of the clinical picture. Administration of specialized instruments to assess for ASD in all clients who present in crisis would be time consuming, costly and inefficient, and for that reason, there is a need to determine whether indicators of possible ASD symptomatology can be identified on routinely-administered comprehensive psychological measures. The ability to identify profiles associated with adult ASD could help the mental health practitioner determine which patients require further assessment for possible ASD.

Given that previously undiagnosed adult ASD is often difficult to distinguish from other psychiatric disorders, understanding how ASD symptoms might manifest on broadband, multiscale personality and psychopathology instruments may help aid in identifying those in need of

more comprehensive ASD evaluation. Ozonoff, Garcia, Clark, and Lainhart (2005) examined the profiles of high-functioning adults with ASD on the Minnesota Multiphasic Personality Inventory-2nd Edition (MMPI-2) and found that when compared to a matched sample of college student controls, the ASD group demonstrated large effect size differences in the positive direction on scales L (Lie), 2 (Depression) and 0 (Social Introversion) and a medium effect size difference on scale 8 (Schizophrenia). A medium effect size difference was also observed on scale 9 (Hypomania), with the control sample producing higher mean scores than the ASD sample. These findings suggest that the most prominent differentiating features of ASD on multiscale psychological instruments as compared to the general population are likely to be interpersonal difficulties, social withdrawal and depressed mood, as well as greater rigidity or more limited insight in self-perception. Nevertheless, difficulties with differential diagnosis typically occur within the context of clinical settings, and thus college students may not be the best-suited contrast group for real-world clinical applications.

Like the MMPI-2, the Personality Assessment Inventory (PAI; Morey 1991) is a multiscale personality and psychopathology instrument that is widely used for clinical diagnosis and treatment planning. While the PAI does not explicitly assess for the presence of ASD symptomatology, the PAI does assess several personality and psychopathology domains relevant to ASD diagnosis, including social withdrawal and interpersonal difficulties, depression and anxiety symptoms, and unusual thought patterns. However, research examining use of the PAI in this population is limited. In a doctoral dissertation, Schwaiger (2014) reported that adults with ASD endorsed more schizophrenia-related symptoms (SCZ), poorer social support (NON), more interpersonal coldness (low WRM) and less interpersonal assertiveness (low DOM) as compared to clinical controls. Notably, mean differences were only reported at the full-scale level, and thus it is plausible that comparison at the subscale level may further illuminate the diagnostic profile of adult ASD. Similarly, a dissertation by Hooks (2017) found that compared with a community sample and a clinical sample from the PAI standardization, adolescents with ASD had a distinct profile on the PAI-A including elevations on anxiety-related disorders, depression, and schizophrenia scales.

Despite widespread and steadily growing use of the PAI in clinical practice settings (Piotrowski 2017), there appear to be no published studies to date examining use of the PAI among adults with ASD. However, the PAI offers a number of advantages over existing comprehensive psychopathology instruments, and thus research using the PAI in this population is warranted. For instance, the PAI is written at a lower reading level (i.e., 4$^{th}$ grade) than other widely used measures, and is relatively brief (e.g., 344 items on the PAI versus 567 items on the MMPI-2), which may be advantageous in settings in which comprehensive assessment is beneficial but time and resources are limited. Likewise, the 22 nonoverlapping scales on the PAI are content-driven rather than empirically-derived, thereby increasing ease of interpretation, and 10 of the scales include conceptually-derived subscales, offering greater breadth of coverage within content areas. The present study provides normative data for adults with high-functioning ASD across the PAI scales and subscales, with effect size comparisons to the PAI clinical standardization sample and an inpatient psychiatric sample. Furthermore, the current study introduces and provides initial validation for a novel discriminant function for identification of ASD-like symptomatology in a clinical population, thus offering a potential supplemental tool to aid in the identification of clients for whom further specialized ASD assessment is warranted.

## Method

### Participants

#### ASD Sample

A total of 169 participants (36.1% female) ranging from 18 to 66 years of age ($M = 33.33$, $SD = 12.04$) who had been seen at an outpatient clinic specializing in the diagnosis of ASD in adult clients were included as the ASD sample. Participants received the PAI as part of a larger battery to confirm or rule out ASD and associated psychopathology. Participants were predominantly White/Caucasian (75.1%), followed by Hispanic/Latino (11.2%), Asian (5.9%), Black/African-American (5.3%), and other (2.4%). All clients were diagnosed with ASD using a gold standard ASD-specific diagnostic instrument, the Autism Diagnostic Observation Schedule (ADOS-WPS; Lord et al. 1999) or the Autism Diagnostic Observation Schedule-2nd Edition (ADOS-2; Lord et al. 2012) together with other self- and informant-report questionnaires, including the Social Responsiveness Scale, 2nd Edition (SRS-2; Constantino and Gruber 2012), Autism Spectrum Quotient (AQ; Baron-Cohen et al. 2001), Empathy Quotient (Baron-Cohen and Wheelwright 2004), and the Ritvo Autism Asperger Diagnostic Scale-Revised (RAADS-R; Ritvo et al. 2011). For participants who had an informant present at the time of the evaluation who knew them early in life, the Social Communication Questionnaire (SCQ; Rutter et al. 2003), which was developed based on the Autism Diagnostic Interview-Revised (ADI-R; Lord et al. 1994), was also used to provide information to assist in diagnosis.

Current comorbid diagnoses included depressive disorders (62.1%), generalized anxiety disorder (63.3%), ADHD (59.2%), social phobia (13%), substance use disorder (6.5%),

bipolar disorder (1.2%), obsessive–compulsive disorder (1.2%), learning disability (2.4%), and other disorders not specified in the aforementioned categories (18.3%). Of these, the most prominent comorbidities were generalized anxiety disorder with depressive disorder ($n=74$), generalized anxiety disorder with ADHD ($n=62$), and depressive disorder with ADHD ($n=69$). It should be noted, however, that comorbid diagnoses of ADHD were not available for those whose records were obtained prior to 2013 due to diagnostic criteria at the time.

Most of the participants were employed (39.1% full-time, 6.5% part-time/underemployed) or a student (13.6%), with 40.2% of the sample unemployed and not in school. The majority of the sample were high-school graduates (92.3%), and a large proportion also had undergraduate (31.4%) or graduate (26%) college degrees.

### Contrast Samples

**Inpatient Sample** A sample of 72 participants (29.2% female) ranging from 18 to 60 years of age ($M=29.44$, $SD=10.33$) from an academic inpatient psychiatric hospital were included as a contrast sample. Inpatient group participants received the PAI upon admission to the hospital. Participants were fairly diverse in race/ethnicity: White/Caucasian (34.7%), Hispanic/Latino (30.6%), African-American (29.2%), and Asian (5.6%). Participant diagnoses included psychotic spectrum disorders (54.2%), substance use disorder (36.1%), depressive disorders (30.6%), bipolar disorder (30.6%), generalized anxiety disorder (6.9%), ADHD (5.6%), obsessive–compulsive disorder (4.2%), social phobia (4.2%), as well as other disorders not specified in the aforementioned categories (38.9%). One participant in the inpatient sample was diagnosed with ASD and thus was removed from the analyses.

**PAI Clinical Standardization Sample** The PAI clinical standardization sample (Morey 1991) included a total of 1,246 clients ranging from 18 to 90 years of age (38.6% female; 79% White/Caucasian; $M_{age}=37.1$ years, $SD_{age}=11.33$) from 69 clinical sites. The clinical sample was intended to be representative of individuals with a variety of diagnoses and across a variety of settings (e.g., outpatient mental health; inpatient mental health) where the PAI might be administered.

## Measure

### Personality Assessment Inventory (PAI)

The PAI (Morey 1991) is a 344-item structured, self-administered questionnaire that assesses a variety of personality and psychopathology domains. The PAI consists of 22 non-overlapping scales, including four validity scales, 11 clinical scales, five treatment scales, and two interpersonal scales. Response alternatives range from "totally false, not at all true" (1) to "very true" (4). All PAI scales and subscales are standardized against a census-matched community sample using *T*-scores, which have a mean of 50 *T* and a standard deviation of 10 *T*. These *T*-scores thus offer a rapid appraisal of patient group scores, as they compare to community norms. The PAI was administered to assess overall personality and emotional functioning in the ASD sample as part of an intake evaluation but was not used to establish ASD diagnosis. Although the PAI normative data were collected approximately thirty years ago, recent research has suggested that the PAI standardization sample appears to be broadly representative of the general population in the present day (McCredie and Morey 2018).

## Procedure

Data from the ASD sample and the inpatient contrast sample were accessed from archival records, and all data were de-identified prior to data analysis. The historical timeframe of the data collected for the ASD and inpatient clinical samples was approximately 2011–2018. For samples collected prior to 2013, when the *DSM-IV-TR* (4th ed., text rev.; American Psychiatric Association 2000) and the original version of the ADOS (ADOS-WPS; Lord et al. 1999) were being utilized, only cases which conformed to the ASD diagnostic criteria of the *DSM-5* (5th ed.; American Psychiatric Association 2013) and ADOS-2 (Lord et al. 2012) were included. Participants included in the ASD sample also met criteria per the *International Statistical Classification of Diseases and Related Health Problems (ICD) 10th edition* (*ICD-10*; World Health Organization 1992) and 11th edition (*ICD-11*; World Health Organization 2018).

# Results

Tables 1 and 2 present the means and standard deviations of the PAI scales and subscales, respectively, in the ASD and inpatient samples. Cohen's *d* effect size differences between the ASD sample and the two contrast samples are also reported. In general, the ASD sample tended to produce lower mean scores on the PAI scales and subscales in comparison to the two contrast samples, with a few notable exceptions. Across both contrast samples, the ASD sample demonstrated moderately higher social detachment (SCZ-S) and to a slightly lesser extent more phobic (ARD-P) behavior, likely social in nature, and cognitive and affective anxiety symptoms (ANX-A; ANX-C). Additionally, the ASD sample reported less interpersonal warmth (WRM) and dominance (DOM) as compared to the contrast samples,

**Table 1** Descriptive statistics and Cohen's d effect size comparisons of the PAI scales

| Scale | ASD | | Inpatient | | Cohen's *d* | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | Inpatient | PAI clinical |
| Inconsistency (ICN) | 52.35 | 7.98 | * | * | * | − 0.14 |
| Infrequency (INF) | 49.67 | 8.12 | * | * | * | − 0.26 |
| Negative Impression Management (NIM) | 56.74 | 12.87 | * | * | * | − 0.22 |
| Positive Impression Management (PIM) | 40.53 | 11.64 | * | * | * | − 0.26 |
| Somatic Complaints (SOM) | 57.51 | 13.07 | 64.58 | 13.12 | − 0.54 | − 0.05 |
| Anxiety (ANX) | 66.31 | 14.45 | 64.72 | 14.80 | 0.11 | 0.34 |
| Anxiety-Related Disorders (ARD) | 65.48 | 15.35 | 65.17 | 16.03 | 0.02 | 0.36 |
| Depression (DEP) | 64.75 | 14.50 | 69.99 | 17.19 | − 0.33 | 0.06 |
| Mania (MAN) | 56.08 | 12.49 | 59.32 | 14.47 | − 0.24 | 0.30 |
| Paranoia (PAR) | 58.37 | 13.13 | 67.37 | 15.76 | − 0.62 | 0.08 |
| Schizophrenia (SCZ) | 65.41 | 13.33 | 69.94 | 17.97 | − 0.29 | 0.45 |
| Borderline Features (BOR) | 61.38 | 12.39 | 66.77 | 15.95 | − 0.38 | − 0.15 |
| Antisocial Features (ANT) | 51.01 | 10.58 | 65.08 | 16.45 | − 1.02 | − 0.46 |
| Alcohol Problems (ALC) | 48.56 | 10.25 | 54.86 | 12.56 | − 0.55 | − 0.76 |
| Drug Problems (DRG) | 50.72 | 9.29 | 65.86 | 16.59 | − 1.13 | − 0.59 |
| Aggression (AGG) | 51.96 | 12.26 | 57.79 | 15.35 | − 0.42 | − 0.30 |
| Suicidal Ideation (SUI) | 60.03 | 15.64 | 73.51 | 20.87 | − 0.73 | − 0.11 |
| Stress (STR) | 56.08 | 11.13 | 64.51 | 12.86 | − 0.70 | − 0.64 |
| Nonsupport (NON) | 62.30 | 11.47 | 65.56 | 15.64 | − 0.24 | 0.21 |
| Treatment Rejection (RXR) | 40.59 | 10.88 | 40.51 | 10.08 | 0.01 | 0.05 |
| Dominance (DOM) | 40.96 | 11.68 | 48.59 | 11.75 | − 0.65 | − 0.59 |
| Warmth (WRM) | 33.79 | 11.52 | 45.96 | 11.47 | − 1.06 | − 1.04 |

*PAI* Personality Assessment Inventory (Morey 1991), *ASD* autism spectrum disorder sample, *Inpatient* psychiatric inpatient contrast sample, *PAI clinical* PAI clinical standardization sample

*Validity scale data were not available for the inpatient contrast sample

as well as less environmental stress (STR), less aggressive tendencies (AGG, AGG-A; AGG-V; AGG-P), fewer alcohol (ALC) and drug (DRG) problems, fewer antisocial behaviors (ANT; ANT-A), less impulsivity (BOR-S), and less stimulus-seeking behavior (ANT-S). As compared to the PAI clinical sample specifically, the ASD sample also demonstrated slightly more obsessive–compulsive tendencies (ARD-O) and irritability (MAN-I). Effect size differences tended to be larger and more negative when compared to the inpatient contrast sample, likely due to differences in symptom severity.

A series of discriminant analyses were utilized to derive a function that maximized group differences between the ASD sample ($n = 169$) and the two contrast samples ($n = 1317$). Two-thirds of the sample ($n = 1004$) was randomly selected as the function derivation sample. Within this subsample, two individual discriminant analyses were conducted to maximally differentiate the ASD sample from the two individual contrast samples (i.e., the PAI clinical standardization sample and the inpatient sample). All PAI scales and subscales, excluding the validity scales, were entered and non-significant ($F < 2.71$) indicators were removed in a stepwise fashion. This resulted in a total of 18 variables retained across the two discriminant analyses. To focus the discriminant function, these 18 variables were then simultaneously added as independent variables into a discriminant function analysis contrasting the ASD group with the combined clinical/inpatient contrast samples. The resulting unstandardized coefficients from this analysis were used to derive the Autism Spectrum Disorder-Discriminant Function (ASD-DF).[1] Descriptions of the PAI scales included in the ASD-DF are presented in Table 3. Means and standard deviations of the ASD-DF across the ASD, inpatient, and PAI clinical and community standardization samples are presented in Table 4, as well as Cohen's *d* effect size differences with respect to each contrast group.

Classification results of the discriminant analysis revealed that the ASD-DF significantly differentiated the ASD sample from the combined contrast sample (Canonical $r = 0.58$;

[1] ASD-DF = 3.126 − (0.024187 × taggp) + (0.019941 × tardo) − (0.038524 × tdom) + (0.026531 × tmani) − (0.009605 × tsui) − (0.043250 × twrm) − (0.024933 × tdepa) + (0.031364 × tdepc) − (0.029401 × tstr) + (0.054067 × tmang) − (0.021821 × tsczp) + (0.028959 × tsczs) − (0.010558 × talc) + (0.011066 × taggv) − (0.006408 × tanta) − (0.013 × tdepp) − (0.006156 × tparp) − (0.00369 × tdrg).

**Table 2** Descriptive statistics and Cohen's d effect size comparisons of the PAI subscales

| Scale | ASD | | Inpatient | | Cohen's *d* | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | Inpatient | PAI clinical |
| Conversion (SOM-C) | 54.98 | 13.20 | 65.24 | 17.55 | − 0.66 | − 0.23 |
| Somatization (SOM-S) | 56.59 | 12.29 | 61.89 | 13.27 | − 0.41 | − 0.05 |
| Health Concerns (SOM-H) | 57.77 | 12.73 | 61.13 | 10.94 | − 0.28 | 0.10 |
| Cognitive Anxiety (ANX-C) | 65.12 | 13.71 | 61.90 | 12.41 | 0.25 | 0.31 |
| Affective Anxiety (ANX-A) | 66.69 | 15.03 | 63.21 | 14.88 | 0.23 | 0.42 |
| Physiological Anxiety (ANX-P) | 62.28 | 14.19 | 65.11 | 16.80 | − 0.18 | 0.20 |
| Obsessive-Compulsive (ARD-O) | 58.91 | 12.96 | 57.66 | 12.28 | 0.10 | 0.43 |
| Phobias (ARD-P) | 61.33 | 12.68 | 57.04 | 14.82 | 0.31 | 0.60 |
| Traumatic Stress (ARD-T) | 62.73 | 16.74 | 67.37 | 16.04 | − 0.28 | − 0.06 |
| Cognitive Depression (DEP-C) | 65.55 | 14.97 | 69.85 | 19.92 | − 0.24 | 0.26 |
| Affective Depression (DEP-A) | 65.63 | 16.07 | 67.79 | 18.49 | − 0.12 | 0.07 |
| Physiological Depression (DEP-P) | 58.89 | 11.20 | 63.35 | 11.69 | − 0.39 | − 0.03 |
| Activity Level (MAN-A) | 52.53 | 11.34 | 57.06 | 13.33 | − 0.37 | 0.08 |
| Grandiosity (MAN-G) | 52.37 | 11.65 | 55.62 | 14.83 | − 0.24 | 0.22 |
| Irritability (MAN-I) | 58.78 | 13.56 | 59.21 | 16.13 | − 0.03 | 0.34 |
| Hypervigilance (PAR-H) | 58.86 | 13.35 | 63.85 | 15.91 | − 0.34 | 0.17 |
| Persecution (PAR-P) | 54.57 | 13.23 | 69.07 | 18.24 | − 0.91 | − 0.11 |
| Resentment (PAR-R) | 57.80 | 11.72 | 60.96 | 13.47 | − 0.25 | 0.16 |
| Psychotic Experiences (SCZ-P) | 50.69 | 12.24 | 65.48 | 18.56 | − 0.94 | − 0.11 |
| Social Detachment (SCZ-S) | 70.14 | 13.44 | 61.61 | 14.90 | 0.60 | 0.87 |
| Thought Problems (SCZ-T) | 61.67 | 14.49 | 68.32 | 18.02 | − 0.41 | 0.16 |
| Affective Instability (BOR-A) | 61.62 | 13.09 | 62.52 | 15.32 | − 0.06 | 0.05 |
| Identity Problems (BOR-I) | 61.05 | 11.54 | 64.30 | 14.18 | − 0.25 | − 0.08 |
| Negative Relationships (BOR-N) | 61.97 | 13.61 | 64.82 | 14.23 | − 0.20 | 0.03 |
| Self-Harm/Impulsivity (BOR-S) | 51.64 | 12.04 | 61.90 | 15.79 | − 0.73 | − 0.47 |
| Antisocial Behaviors (ANT-A) | 50.82 | 10.38 | 63.44 | 13.79 | − 1.03 | − 0.57 |
| Egocentricity (ANT-E) | 51.99 | 11.50 | 60.87 | 16.20 | − 0.63 | − 0.13 |
| Stimulus-Seeking (ANT-S) | 49.79 | 10.83 | 62.41 | 16.47 | − 0.91 | − 0.34 |
| Aggressive Attitude (AGG-A) | 52.70 | 12.47 | 56.08 | 13.71 | − 0.26 | − 0.22 |
| Verbal Aggression (AGG-V) | 47.55 | 11.83 | 51.10 | 12.32 | − 0.29 | − 0.32 |
| Physical Aggression (AGG-P) | 51.99 | 11.34 | 63.79 | 17.36 | − 0.80 | − 0.47 |

*PAI* Personality Assessment Inventory (Morey 1991), *ASD* autism spectrum disorder sample, *Inpatient* psychiatric inpatient contrast sample, *PAI clinical* PAI clinical standardization sample

*Validity scale data were not available for the inpatient contrast sample

Wilks' lambda = 0.67, $p < 0.001$). Receiver operating characteristics (ROC) analyses resulted in an area under the curve (AUC) of 0.936 ($SE = 0.01$, $p < 0.001$) in differentiating the ASD patients from the combined contrast patients in this derivation sample. A cutting score of 0.8407 yielded results that maximized the combination of sensitivity (87.6%) and specificity (86.9%).

To cross-validate the derived discriminant function across contexts, the remaining one-third ($n = 482$) of the sample (i.e., independent of the ASD-DF derivation) was divided into an ASD sample ($n = 48$) and two cross-validation samples: the PAI clinical standardization sample ($n = 416$) and the inpatient psychiatric sample ($n = 18$). Upon cross validation, the ASD-DF continued to be quite effective at discriminating between the ASD sample and both the PAI clinical standardization (AUC = 0.931, $SE = 0.02$, $p < 0.001$) and inpatient psychiatric (AUC = 0.934, $SE = 0.03$, $p < 0.001$) subsamples. At the cutting score of 0.8407 derived in the initial sample, the ASD-DF demonstrated comparable sensitivity (85.4%) and specificity (87.3% and 83.3% for the PAI clinical standardization and inpatient psychiatric samples, respectively) in the cross-validation samples to the values obtained in the derivation group. Furthermore, the *d* effect sizes presented in Table 3 represent very large effects, providing additional evidence supporting the ability of this function to distinguish ASD patients from other mental health patients, as well as from community adults.

**Table 3** Descriptions of PAI scales included in the ASD-DF

| PAI Scale | Description |
|---|---|
| DEP-A (–) | Affective experience of sadness, anhedonia (loss of pleasure in activities) |
| DEP-C | Negative thought patterns: thoughts of worthlessness, hopelessness, and personal failure; difficulties in concentration due to depressive thoughts |
| DEP-P (–) | Physiological symptoms of depression: physical functioning, activity level, energy, sleep disturbance, appetite, weight loss |
| ARD-O | Intrusive and/or obsessive thoughts or behaviors; rigid, perfectionistic tendencies |
| MAN-I | Irritability, frustration with others being unable or unwilling to keep up with the respondent's plans, demands, and ideas |
| MAN-G | Inflated self-esteem, expansiveness, belief in having special or unique skills or talents |
| PAR-P (–) | Thoughts or beliefs that one has been treated unequally or that others are determined to undermine the respondent |
| AGG-P (–) | Physically aggressive behaviors or displays of anger, such as damage to property, physical fights, threats of physical aggression |
| AGG-V | Verbally aggressive behaviors, such as expressions of anger or assertiveness towards others |
| SCZ-P (–) | Unusual thought patterns and/or sensations; delusional beliefs or unusual ideas |
| SCZ-S | Social isolation, discomfort, awkwardness in social interactions |
| ANT-A (–) | Involvement in illegal activities; engagement in impulsive or risky behaviors |
| ALC (–) | General assessment of behaviors or consequences related to alcohol use, such as alcohol abuse or dependence |
| DRG (–) | General assessment of behaviors or consequences related to drug use, such as drug abuse or dependence |
| SUI (–) | General assessment of suicidal ideation, ranging from thoughts of hopelessness to plans for suicide |
| STR (–) | General assessment of life stressors that respondent is currently experiencing or has previously experienced (family, health, employment, finances, etc.) |
| DOM (–) | Assessment of the extent to which respondent is controlling and independent in interpersonal relationships; ranges from submissive to dominating/overbearing |
| WRM (–) | Assessment of the extent to which respondent is supportive, empathic, and warm in interpersonal relationships; ranges from cold/few close relationships to extremely trusting/dependent |

*PAI* Personality Assessment Inventory (Morey 1991), *ASD-DF* Autism Spectrum Disorder-Discriminant Function

(–) PAI scales contributing negative weight to the ASD-DF

**Table 4** ASD-DF descriptive statistics and Cohen's *d* effect size differences from ASD sample

| Sample | *M* | *SD* | Cohen's *d* |
|---|---|---|---|
| ASD | 1.913 | 1.096 | – |
| Inpatient | | | |
| Derivation ($n=53$) | − 0.209 | 0.973 | 2.05 |
| Cross-validation ($n=18$) | − 0.203 | 0.925 | 2.09 |
| PAI clinical standardization | | | |
| Derivation ($n=830$) | − 0.264 | 0.988 | 2.09 |
| Cross-validation ($n=416$) | − 0.300 | 1.039 | 2.07 |
| PAI community standardization ($n=1000$) | 0.156 | 0.879 | 1.77 |

*ASD-DF* Autism Spectrum Disorder-Discriminant Function

Cohen's *d* effect sizes are calculated with respect to the ASD sample ($n=169$)

These findings do not appear to be attributable to the gender composition of the samples. ASD diagnosis significantly predicted the ASD-DF in the combined samples after covarying out the effect of gender ($F(1,1483)=659.68$, $p<0.001$), with a large effect size (Partial eta$^2=0.31$). Gender was determined to be a significant covariate, $F(1,1483)=9.66$, $p<0.01$), but the effect size was quite small (Partial eta$^2=0.006$). Likewise, the difference in ASD-DF scores between men (1.89) and women (1.95) was not significant in the ASD sample, $t(167)=0.31$, $p=0.759$.

## Discussion

Differential diagnosis of high-functioning adult ASD in the clinical setting presents an important but complex challenge, resulting in a problematic number of individuals with ASD being inappropriately diagnosed and treated, particularly when they present in crisis without prior diagnosis of ASD. The present study appears to offer the only published PAI normative data to date for adults diagnosed with high-functioning ASD. Compared to the PAI clinical standardization sample and an inpatient psychiatric sample, adults with high-functioning ASD reported more pronounced patterns of social alienation and interpersonal difficulties, including greater reported social withdrawal, less interpersonal warmth and assertiveness, and more phobic behavior, likely in part capturing fear or avoidance of social situations. Anxiety, particularly as manifested in cognitive and affective symptoms, also appears to be slightly higher among these individuals. Notably, however, adults with high-functioning ASD also demonstrate significantly lower levels of pathology in a variety of other areas

as compared to the average clinical respondent, including less perceived environmental stress, antisocial behavior, aggression, stimulus-seeking behavior, and reckless or impulsive behavior, as well as fewer issues with alcohol or drug use. Thus, individuals with high-functioning adult ASD appear to demonstrate a unique pattern of personality and psychopathology features on the PAI as compared to respondents with other clinical diagnoses.

In order to determine the extent to which the PAI may serve as a useful screening tool in the identification of adult ASD, a discriminant function was derived to maximally discriminate between the ASD sample and two independent clinical samples, including an inpatient psychiatric sample and the clinical standardization sample of the PAI. The inclusion of both these contrast groups allowed for differentiation of individuals diagnosed with ASD from clinical respondents across a range of psychiatric settings and degrees of symptom severity. The resulting index, the Autism Spectrum Disorder-Discriminant Function (ASD-DF), demonstrated large effect size differences in discriminating between the ASD sample and the other clinical groups, as well as high sensitivity and specificity. Likewise, it continued to perform well upon cross-validation in the two distinct clinical samples independent of the sample in which it was derived, thus offering compelling evidence for the index's cross-context generalizability. In light of these findings, the ASD-DF appears to show promise as a potential indicator of ASD symptomatology as assessed by the PAI.

While neurobiological work is not a part of this study, information herein may contribute to future Research Domain Criteria (RDoC)-centered research on determining features of ASD which change with development in interactions among differentially maturing brain systems. Casey et al. (2014) suggest the RDoC model of measuring developmental changes along with neurobiological ones at different parts of the lifespan can assist with classifying overarching domains of symptomology which may be present at different life stages for persons with ASD, and thus lead to more effective diagnosis. Because the PAI captures nuanced subscales along with clinical scales associated with various domains of ASD, it can lay framework for collaboration with neurobiological researchers who are studying similar features as they relate to ASD. Further, measures included in the present study (SRS, SCQ, etc.) assess behavioral symptoms across developmental periods and provide the opportunity for comparison of changes in brain development across the lifespan. The proposed discriminant function for the PAI might be a catalyst for further investigation into progression of development and could be useful in creating connections across scientific research modalities to provide more effective identification of ASD and subsequent earlier intervention.

However, some limitations to the current findings should be noted. The PAI was not developed as a measure to detect ASD symptomatology, and as such, the PAI should not be used as a diagnostic tool for ASD. There are several standardized assessments (e.g., ADOS-2, Lord et al. 2012) developed specifically to assess adult ASD, and such instruments should be used together with other relevant information such as developmental history for ASD diagnosis, if an elevated PAI ASD-DF is found. Nevertheless, given that the PAI is used as a comprehensive diagnostic tool across a variety of clinical settings, the ASD-DF may be useful in alerting evaluators to the potential need for more comprehensive ASD evaluation. Additionally, although the ASD-DF successfully cross-validated in a sample independent of the one in which it was derived, the cross-validation sample utilized in the present study was still a subsample of the derivation sample and as such might be expected to be similar. Likewise, the ASD-DF was used to discriminate between an ASD sample and a clinical sample with a variety of other mental health conditions, and it may be beneficial for future research to examine the discriminative capacity of the proposed function with respect to specific diagnostic groups, including both psychiatric and medical disorders (e.g., bipolar disorder, schizophrenia, seizure disorders). Further cross-validation of the ASD-DF in a variety of samples would allow for greater confidence in the indicator's validity across diverse samples and settings. If empirical evaluation continues to offer support for this novel indicator, settings that employ the PAI routinely may benefit from the ASD-DF as a useful aid in the identification of individuals who would benefit from assessment for high-functioning adult ASD.

**Author Contribution** KH conceived the initial study idea and piloted the archival data review. KL provided the autism spectrum disorder data. AK, AE, and YS assisted with reviewing and coding archival data. MR and LM provided the contrast sample data. MM conducted the data analysis and took the lead in writing the manuscript, in consultation with LM, KH, KL, and AK and KL supervised and provided feedback at all stages of the study process.

## Compliance with Ethical Standards

**Ethical Approval** Leslie C. Morey is the author of the Personality Assessment Inventory and derives royalties from its sale. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed Consent** No informed consent was required for the use of de-identified retrospective data.

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