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ORIGINAL PAPER

Autism Spectrum Disorders and Self-reports: Testing Validity and Reliability Using the NEO-PI-R

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Abstract Although self-reported measures are frequently used to assess adults with autism spectrum disorders (ASD), the validity of self-reports is under-researched in ASD. The core symptoms of ASD may negatively affect the psychometric properties of self-reported measures. The aim of the present study was to test the validity and reliability of self-reported data using the NEO personality inventory-revised (NEO-PI-R). Forty-eight adults with ASD and 53 controls completed the NEO-PI-R and a psychiatric interview. Results indicate satisfactory internal consistency of the NEO-PI-R, a satisfactory factor structure, predicted correlations with clinician ratings in the ASD group, and predicted differences in personality between the ASD group and controls. In conclusion, the present results support the use of self-reported measures when assessing adults with ASD.

Keywords Autism spectrum disorders · Self report · Psychometrics · Validation · Personality tests

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Introduction

Autism spectrum disorder (ASD; i.e., autistic disorder, asperger disorder and pervasive developmental disorder—not otherwise specified) is characterized by impairments in social communication and social interaction and restricted repetitive and stereotyped patterns of behavior (American Psychiatric Association 2013). Overlapping psychiatric conditions, such as depression, anxiety disorders and attention-deficit/hyperactivity disorder (ADHD) are commonly observed in adults with ASD (Lugnegård et al. 2011). Such overlapping conditions need to be monitored and treated. Several valid and reliable self-reports are available for measuring these symptoms (Beck et al. 1996; Kessler et al. 2005; Steketee 1996; Zigmond and Snaith 1983), but their psychometric properties in adults with ASD are mostly unknown. Self-reports have been criticized with regard to their ability to obtain valid information because of the language deficits associated with ASD (Tantam 2014, p. 4). However, previous research supports the use of self-reports in ASD with regard to alexithymia (Berthoz and Hill 2005), quality of life, (Ikeda et al. 2014), anxiety and depression (Williams 2010) and autistic traits (Baron-Cohen et al. 2001; Hoekstra et al. 2008) when assessing individuals with ASD and intelligence within the average range. In contrast, many patients with ASD have intellectual disabilities or severely impaired language (e.g., no speech), resulting in the limited ability to self-report. Furthermore, much clinical work and research in the ASD field targets children, who also have limited abilities to self-report traits and symptoms. Thus, ratings by clinicians or caretakers are often the only available option for diagnosis and for assessing treatment efficacy. Nevertheless, self-assessments may add important information in the assessment process by providing data that reflect the

patients' own views. Furthermore, self-reported measures are widely used when assessing adults with ASD and intelligence within the average range. Evidently, there is a need to further evaluate the reliability and validity of self-reported instruments when assessing adults with ASD.

Operationalization of Self-reports: The NEO-PI-R

The present study examined the ability of patients with ASD to respond to self-reports that were not specifically developed for assessing ASD symptoms. The NEO Personality Inventory-Revised (NEO-PI-R; Costa and McCrae 1992) was chosen to operationalize self-reported measures for several reasons. It is lengthy (i.e., it contains 240 items) and thus quite difficult to complete, it measures a range of personality dimensions and has few ceiling and floor effects. The NEO-PI-R is based on a widely utilized model of personality assessment, the five-factor model of personality, which states that each individual's personality can be described according to the levels of five basic personality factors or dimensions, including Neuroticism, Extraversion, Openness, Conscientiousness and Agreeableness (Costa and McCrae 1992). The shortcomings of the NEO-PI-R include its sensitivity to distortion effects related to respondents' tendencies to present themselves in a positive manner (Griffin et al. 2004).

The NEO-PI-R comprises 240 items and measures five dimensions of personality. If an individual with ASD can complete such a complex instrument in a valid and reliable way, then they should be able to complete shorter and less complex self-rated questionnaires, such as depression inventories or an ADHD rating scale.

NEO-PI-R and Psychiatric Conditions

The dimensions of the NEO-PI-R appear to correlate with autistic traits (Teunisse et al. 2013; Wakabayashi et al. 2006). Wakabayashi et al. (2006) found that autistic traits were positively correlated with the Neuroticism scale and negatively correlated with the Extraversion and Conscientiousness scales. However, the population examined in Wakabayashi et al. (2006) consisted of university students without ASD. Nevertheless, a conference presentation that discussed a clinical ASD sample reported similar results with a shorter version of NEO-PI-R (i.e., high Neuroticism, low Extraversion, low Openness, low Conscientiousness and low Agreeableness), but no comparisons were made with controls (Teunisse et al. 2013). Similar findings related to other psychiatric conditions have been reported. A meta-analysis of psychiatric conditions and their relationships to the NEO-PI-R found that psychiatric symptoms positively correlated with Neuroticism and negatively correlated with Extraversion, Conscientiousness and Agreeableness in clinical populations (Malouff et al. 2005). Moreover, depression appears to be correlated with Neuroticism in clinically depressed patients (Dunkley et al. 2009). However, it is unknown whether the findings of Wakabayashi et al. (2006), with regard to a relationship between autistic traits and personality in a healthy population, can be extended to adults with a diagnosis of ASD.

Aims of the Present Study

The aim of the present study was to test whether adults with ASD and intelligence within the average range can self-report personality in a valid and reliable way in terms of reliability and validity of the five dimensions of the NEO-PI-R and criterion validity of the Neuroticism dimension.

Methods

Participants

The participants consisted of a group of adults with ASD and no detected intellectual disability and a control group of adults without ASD or any other developmental disorder. Recruitment occurred within a study that examined gender roles, sexuality and anthropometric measures in ASD (Bejerot et al. 2012; Bejerot and Eriksson 2014). The inclusion criteria in both groups were white Swedish decent, no detected intellectual disability and age between 20 and 47 years. The exclusion criteria were psychosis, any neurological or genetic syndrome, any disease or medication that affects androgen status and any congenital syndrome. Informed consent was obtained from all of the participants and the regional ethics committee of Stockholm, Sweden approved the study. Reimbursement of approximately €100 was offered to the participants. The demographic data of both groups are shown in Table 1.

ASD Group

Participants with ASD were recruited through an outpatient tertiary psychiatric unit for diagnosing ASD, a community-based facility for ASD and a Swedish ASD website. Prior to the present study, all of the participants were carefully examined by expert teams in tertiary outpatient psychiatric settings that specialized in diagnosing ASD in Stockholm, Sweden. These teams included a senior psychiatrist, an experienced psychologist, and usually an occupational therapist and social worker. The assessments took approximately 18 h to complete over a period of 2–3 weeks and included an interview with a parent supporting ASD in childhood. For the present study, the ASD diagnosis was further confirmed by an autism diagnostic observation

Table 1 Demographic characteristics of participants with autism spectrum disorder (ASD) and controls

	ASD group		Control group	
Age, mean (SD)	29.8	7.2	30.4	7.5
Sex, N (%)				
Male	26	54 %	28	53 %
Female	22	46 %	25	47 %
Civil status, N (%)				
Co-habiting	7	15 %	26	49 %
Single	41	85 %	27	51 %
Sick-leave or disability, N (%)				
0	15	31 %	49	92 %
25	1	2 %	0	0 %
50	4	8 %	0	0 %
75	1	2 %	0	0 %
100	27	56 %	0	0 %
Independent living, N (%)				
No	13	27 %	4	8 %
Yes	34	71 %	49	92 %
Education, N (%)				
9 years	6	13 %	1	2 %
10–12 years	19	40 %	7	13 %
13–15 years	10	21 %	13	25 %
>15 years	12	25 %	32	60 %
Use of psychotropic medication, N (%)				
No	17	35 %	50	94 %
Yes	25	52 %	1	2 %

schedule (ADOS; Lord et al. 2000) interview by an ASD expert who was licensed to use the ADOS in research. Of the 85 participants recruited, 48 were included in the final sample (Bejerot et al. 2012; Bejerot and Eriksson 2014). See the flowchart in Fig. 1 for details on inclusion.

Control Group

The controls were recruited from the general population to match the age and gender distribution as the ASD group. Additional exclusion criteria were ASD or ASD in a family member. Recruitment was performed through advertisements. An initial telephone interview that described the study protocol and inclusion and exclusion criteria was conducted with all the participants in the control group before the assessments. Final participants (n = 53) were recruited from a nonprofit keep-fit organization (n = 23), a local university (n = 8), a student accommodation center (n = 5), private companies (n = 4), dentists and vaccination centers (n = 5), employment agencies (n = 2) and through recommendations from friends (n = 7) (Bejerot et al. 2012; Bejerot and Eriksson 2014).

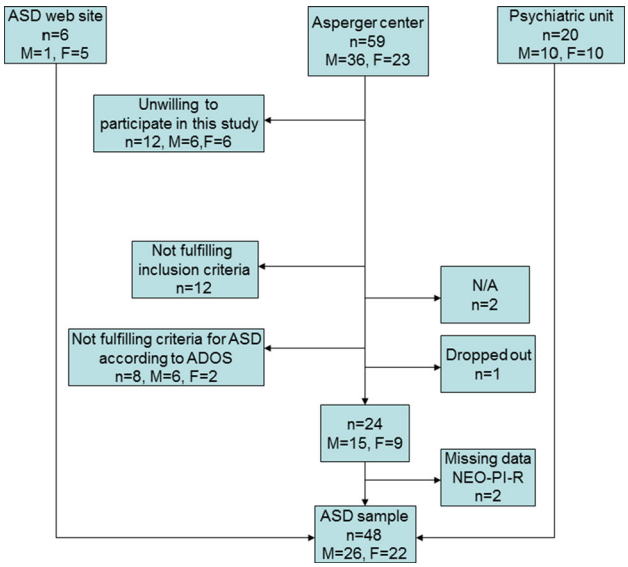

Fig. 1 Flowchart of inclusion of ASD participants

Materials

NEO-PI-R

The NEO-PI-R is a widely used instrument for assessing personality (Costa and McCrae 1992). It is a self-reported questionnaire that asks about self-perceived regularities of behavior, affect and preferences. A total of 240 individual items comprise 30 facets that describe the five dimensions—Neuroticism, Extraversion, Openness, Agreeableness and Conscientiousness—of personality. The five dimensions of the NEO-PI-R are, at least theoretically, orthogonal to one another and hence expected to not correlate with each other. Each of the five dimensions is measured with six facets, which in turn consist of eight items. For example, the Neuroticism dimension comprises the facets anxiety, angry hostility, depression, self-consciousness, impulsiveness and vulnerability. The individual items are statements that are rated on a 5-point Likert scale, ranging from "strongly agree" to "strongly disagree". The Swedish version of the scale has satisfactory psychometric properties, with Cronbach's α ranging from .75 to .85 for the five dimensions and .49–.82 for the 30 facets. Only three of the facets have a Cronbach's $\alpha < .6$ (Källmén et al. 2011). Schinka et al. (1997) proposed that inconsistent responses to items on the NEO-PI-R with identical meaning indicate low validity and developed a tool, the INC score, to measure such inconsistent responses. High scores reflect inconsistent responses to ten pairs of synonymous items. The INC score ranges from 0 to 40; a score <10 indicates low, or acceptable, inconsistency.

Mini-International Neuropsychiatric Interview (M.I.N.I. 5.0)

The Mini-International Neuropsychiatric Interview (M.I.N.I.; Lecrubier et al. 1997; Sheehan et al. 1998) was used to measure psychiatric morbidity. It is a structured screening interview based on the Diagnostic and Statistical Manual of Mental Disorders Fourth Edition (DSM-IV) criteria for numerous psychiatric disorders. The M.I.N.I. takes approximately 15 min–1 h to complete, depending on the range of symptoms. In the present study, all of the recognized disorders were summarized into one single variable, resulting in a possible sum score of 27 points. A high score reflects severe psychiatric morbidity. In this sample, Cronbach's α of the M.I.N.I. total score was .76.

Procedure

Demographic assessment and assessment prior to inclusion were made by a psychiatrist and medical student/research assistant. No time limit was imposed for completing the self-reports. All of the participants completed the Swedish version of the NEO-PI-R without assistance. Demographic data were collected through paper-based self-reports and interview. The M.I.N.I. and ADOS were administered according to the respective manuals of these clinical interviews.

To test whether the reliability of the NEO-PI-R was satisfactory when assessing adults with ASD, the internal consistency of the 30 facets of the NEO-PI-R was examined. Satisfactory internal consistency in an ASD sample that is not lower than in controls indicates satisfactory reliability. To further test the reliability and validity of the NEO-PI-R in the ASD sample, an evaluation of inconsistency of responses was made by calculating INC scores (Schinka et al. 1997). A higher INC score in the ASD group than in controls indicates low validity and reliability of ASD responses.

To test the validity of the NEO-PI-R, correlations were calculated between the five personality dimensions. Unexpected correlations between the five dimensions of the NEO-PI-R indicate low validity. To further test the validity of the NEO-PI-R in adults with ASD, a factor analysis was performed. If an ASD sample's responses to the NEO-PI-R provide a factor structure of the 30 facets that is similar to the control sample and Swedish normative data of the NEO-PI-R, then this would indicate satisfactory validity of the NEO-PI-R when assessing adults with ASD and no detected intellectual disability.

To test for possible common method bias and construct validity, the results of the NEO-PI-R were compared to clinician ratings and previous research on correlations between autistic traits and the NEO-PI-R. A positive correlation between the Neuroticism score and a measure of psychiatric morbidity indicates both satisfactory construct validity and a low risk for common method bias. Satisfactory construct validity is also indicated by expected results of the NEO-PI-R in the ASD sample, including high scores on Neuroticism and low scores on Extraversion and Conscientiousness.

Statistics

The internal consistency of the five dimensions and 30 facets of the NEO-PI-R was calculated using Cronbach's α. Cronbach's $\alpha > .7$ was considered acceptable internal consistency. An INC score, as proposed by Schinka et al. (1997), was calculated for each individual. Group differences in INC scores were calculated using *t* tests.

To mirror the Swedish validation study of the NEO-PI-R, an exploratory factor analysis was performed using the same method as Källmén et al. (2011), a principal axis factoring with promax rotation. The two groups were analyzed separately. Five factors were extracted and loading values >.4 were considered meaningful. The factor analyses were performed on the 30 facets and the predicted factors were the five dimensions of personality that are predefined by the NEO-PI-R. With only 48 and 53 participants in each group and 30 items in the factor analysis, the sample sizes were possibly inadequate (Costello and Osborne 2005). To test for sampling adequacy, the Kaiser–Meyer–Olkin (KMO) test Measure of Sampling Adequacy was used. High KMO test values (range 0–1) indicate greater sampling adequacy and values <.5 are considered unacceptable (Kaiser 1974). Bartlett's test of sphericity was used to test the homogeneity of variance.

Group differences in all of the subscale scores were calculated using *t* tests and Cohen's *d* was used to calculate effect sizes of the differences between groups. Correlations between total M.I.N.I. score and Neuroticism score were calculated using Pearson correlation. All of the statistics were calculated using SPSS 21.0 software for Macintosh.

Results

The reliability of the five NEO-PI-R dimensions was satisfactory in the ASD group, as predicted, with Cronbach's α ranging from .70 to .86, which was generally not lower than in the control group (see Table 2 for detailed data). Similarly, the internal consistency of the 30 facets had a similar range in the two groups (Table 3). Additionally, the analysis of INC scores revealed no differences between groups, although the ASD group had slightly higher scores (ASD: $M = 9.0$, $SD = 3.5$; controls: $M = 8.0$, $SD = 2.8$; $t = 1.5$, $p = .1$).

Table 2 Personality characteristics of participants measured with the NEO-PI-R, including means, reliability, and comparisons between adults with autism spectrum disorder (ASD) and controls

	ASD group (n = 48)				Control group (n = 53)				*T* test of difference between groups			
	α	Mean	SD	95 % CI	α	Mean	SD	95 % CI	*df*	t^b	*p*	*d*
N[a]	.86	113.6	27.0	(105.9–121.2)	.78	71.8	18.8	(66.7–76.8)	82.9	9.09	<.001	1.8
E	.78	88.3	24.1	(81.5–95.1)	.68	121.8	17.7	(117.1–126.6)	99	8.02	<.001	1.6
O	.70	112.4	22.6	(106.0–118.8)	.75	126.9	21.1	(121.2–132.5)	99	3.32	.001	.7
A	.73	121.3	20.4	(115.5–127.1)	.78	127.7	18.6	(122.7–132.7)	99	1.67	.1	.3
C	.80	106.4	23.3	(99.9–113.0)	.81	123.9	20.0	(118.5–129.2)	99	4.05	<.001	.8

d = Cohen's *d* calculated using pooled SD

α Cronbach's α, *CI* confidence interval of mean, *N* Neuroticism, *E* Extraversion, *O* Openness, *A* Agreeableness, *C* Conscientiousness

[a] variance not equal

[b] absolute t values

In the ASD group, Extraversion was found to correlate with Openness, and Conscientiousness correlated with Agreeableness. In the control group, however, Neuroticism was found to correlate with Extraversion, Agreeableness, and Conscientiousness, and Extraversion correlated with both Openness and Conscientiousness. The validity of the NEO-PI-R in the ASD group was not lower than in the control group, although the five dimensions were not orthogonal to each other. See Table 4 for details.

The extracted five-factor solution explained approximately 63 % of the covariance matrix in the ASD group and approximately 61 % in the control group. Mean communalities were satisfactory, .57 in the ASD group and .54 in the control group. Four facets had communalities <.5 in both groups: E2 Gregariousness, E5 Excitement seeking, O5 Ideas and O6 Values (see Table 5 for details). In the present article, the names of the dimensions of the NEO-PI-R are written in full (e.g., Neuroticism) and the extracted factors that are related to each dimension are written as an initial (e.g., N). The KMO test showed that the data collected were barely suitable for a factor analysis, with results of .54 in the ASD group and .61 in the control group, possibly because of the small sample size. However, Bartlett's test was significant in both groups ($p < .001$), lending support for the use of factor analysis in both groups, although some of the communalities were low. The ASD group provided a factor structure that did not have a poorer fit to the five-factor model than controls (Table 3).

The N factor, related to Neuroticism, was the strongest factor in both of the groups, explaining 19.9 % of the variance in the ASD group and 22.5 % in the control group. The facets related to Neuroticism and Conscientiousness loaded on predicted factors (i.e., N and C) in the ASD group and hence showed the best fit in relation to the dimensions of the NEO-PI-R. See Table 3 for details on the factor loadings and comparisons with the Swedish normative data (Källmén et al. 2011).

In both the Swedish normative sample and control group, some aspects of Agreeableness were negatively related to Extraversion, but this was not the case in the ASD group. The ASD factor solution showed that two facets that were expected to load in the factor related to Extraversion (E2 Gregariousness and E5 Excitement seeking) did not have a loading >.4 in any of the factors. In the factor solution in the control group, the facet E4 Activity did not have a loading >.4 in any factor. The factor O6 Values did not have a loading >.4 in any factor in the ASD group and in an unexpected factor in the control group, indicating low validity in both groups. Additionally, O6 Values had low Cronbach's α and low communalities in both groups, further suggesting that it may not be valid or reliable as a facet in any group. See Tables 3 and 5 for detailed data.

As predicted, the ASD group scored higher on Neuroticism and lower on Extraversion and Conscientiousness than the control group. Additionally, Openness was lower in the ASD group, which was not predicted. The largest effect sizes of between-group differences were found in Neuroticism ($d = 1.8$) and Extraversion ($d = 1.6$), which are considered large effect sizes (Cohen 1992). For detailed data, see Table 2.

Neuroticism ($M = 113.6$ $SD = 27.0$) positively correlated with the sum of M.I.N.I. ($M = 3.8$, $SD = 2.7$) in the ASD group ($r = .54$, $p \leq .001$, $n = 48$). The correlation was not computed for the control group because of skewed and low scores on the M.I.N.I. (62 % had a score of 0; range 0–4).

Discussion

The present study tested the personality inventory NEO-PI-R in a sample of individuals with ASD to assess its reliability and validity in this population. The ASD sample and a control sample completed the NEO-PI-R and were

Table 3 Pattern matrices of factor loadings of the principal axis factor analysis and Cronbach's α of the NEO-PI-R facets in adults with autism spectrum disorder (ASD), controls, and the Swedish normative sample

Factor	ASD group						Control group						Swedish normal group (Källmén et al. 2011)					
		N	E	O	A	C		N	E	O	A	C		N	E	O	A	C
Dimensions facets	α						α						α					
Neuroticism																		
N1 Anxiety	*.84*	**.84**					*.70*	**−.59**					*.82*	**.84**				
N2 Angry hostility	*.68*	**.46**			−.41		*.57*	**−.44**					*.71*	**.63**				
N3 Depression	*.78*	**.72**					*.71*	**−.53**					*.80*	**.86**				
N4 Selfconsciousness	*.70*	**.78**					*.63*	**−.75**					*.66*	**.75**				
N5 Impulsiveness	*.71*	**.75**	.54				*.78*	**−.52**	.53				*.63*	**.41**			−.48	
N6 Vulnerability	*.79*	**.59**					*.66*	**−.81**					*.75*	**.75**				−.45
Extraversion																		
E1 Warmth	*.81*		**.40**		.72		*.82*				.69		*.73*		**.74**			
E2 Gregariousness	*.80*						*.80*				.56		*.77*		**.64**			
E3 Assertiveness	*.75*		**.69**				*.78*	.50	**.45**				*.81*				−.55	
E4 Activity	*.46*		**.88**				*.56*						*.59*				−.44	
E5 Excitementseeking	*.65*						*.45*		**.45**				*.66*				−.53	
E6 Positive emotions	*.80*		**.60**				*.80*		**.43**		.51		*.80*		**.75**	−.42		
Openness																		
O1 Fantasy	*.84*			**.50**			*.74*			**.83**			*.72*			**.60**		
O2 Aesthetics	*.73*		−.41	**.94**			*.84*			**.92**			*.80*			**.69**		
O3 Feelings	*.75*			**.63**			*.68*				.55		*.74*		.59	**.72**		
O4 Actions	*.78*		.44				*.70*						*.66*		.48	**.56**		
O5 Ideas	*.74*			**.59**			*.78*			**.75**			*.72*			**.71**		
O6 Values	*.56*						*.42*				.45		*.49*			**.45**		
Agreeableness																		
A1 Trust	*.84*				**.74**		*.79*				**.58**		*.74*		.49			
A2 Straight forwardness	*.72*					.48	*.64*		−.58		**.48**		*.68*				**.69**	
A3 Altruism	*.76*				**.42**	.53	*.73*				**.77**		*.64*		.52		**.43**	
A4 Compliance	*.55*				**.83**		*.61*		−.63				*.74*				**.66**	
A5 Modesty	*.73*	.44					*.75*		−.75				*.62*				**.68**	
A6 Tendermindedness	*.53*				**.47**		*.70*				**.75**		*.63*				**.46**	
Conscientiousness																		
C1 Competence	*.69*					**.70**	*.59*	.42				**.44**	*.58*	−.53				**.63**
C2 Order	*.42*					**.71**	*.55*					**.62**	*.65*					**.62**
C3 Dutifulness	*.78*					**.80**	*.65*					**.59**	*.63*					**.65**
C4 Achievementstriving	*.67*					**.63**	*.61*					**.75**	*.79*					**.68**

Table 3 continued

Factor	ASD group						Control group						Swedish normal group (Källmén et al. 2011)					
	N	E	O	A	C		N	E	O	A	C		N	E	O	A	C	
C5 Selfdiscipline	*.81*	−.40			**.59**	*.85*					**.61**	*.78*					**.79**	
C6 Deliberation	*.76*		−.50		**.53**	*.77*	.59					*.77*				.47	**.50**	
Mean loading on predicted factor	.69	.64	.67	.61	.66	−.61	.44	.83	.64	.60		.71	.71	.62	.58	.64		
Eigen values	6.0	4.7	1.6	2.7	4.2	6.7	3.6	2.1	4.1	1.8		n/a	n/a	n/a	n/a	n/a		
% explained variance	19.9	15.7	5.4	8.9	14.1	22.5	12.0	6.9	13.7	6.0		n/a	n/a	n/a	n/a	n/a		

Loadings on predicted factors shown in bold

Cronbach's α values are shown in italics

α = Cronbach's α. Swedish normative data from Källmén et al. (2011)

interviewed using the M.I.N.I. neuropsychiatric interview. The results revealed that the internal consistency of the NEO-PI-R was satisfactory, that a satisfactory factor structure was obtained, and that Neuroticism correlated with psychiatric morbidity in the ASD group, as predicted. In summary, the NEO-PI-R appears to be as valid and reliable for assessing adults with ASD as when assessing non-ASD controls, thereby adding support for the use of self-reports when assessing adults with ASD and no diagnosed intellectual disability.

Our results showed satisfactory reliability of the five dimensions—Neuroticism, Extraversion, Openness, Agreeableness and Conscientiousness—of the NEO-PI-R in both groups. Additionally, no difference in the inconsistency of responses was found between adults with ASD and controls, further strengthening the reliability of the NEO-PI-R when assessing adults with ASD.

The five personality dimensions were not ideally orthogonal to each other in either of the groups. Nevertheless, the ASD group had fewer and smaller correlations than the control group, suggesting that the NEO-PI-R is not less valid for adults with ASD than controls. Some of the correlations between the five dimensions were expected because the Swedish normative data indicated negative correlations between Extraversion and Neuroticism and positive correlations between Extraversion and Openness (Källmén et al. 2011).

Similar to the factor analysis performed on the Swedish normative data (Källmén et al. 2011), our factor analysis revealed that the factors N and C, which are related to Neuroticism and Conscientiousness, were the strongest and had the best fit in relation to the NEO-PI-R. Although the ASD group produced more facets that did not load into any of the factors, fewer facets loaded on unexpected factors compared with both the control group and normative group. This result indicates that the validity of the NEO-PI-R is not weaker when assessing adults with ASD than when assessing controls.

Consistent with Wakabayashi et al. (2006), the ASD group scored higher in Neuroticism and lower in Extraversion and Conscientiousness than controls. Less expected were the lower Openness scores in the ASD group compared with controls. Only the ASD group had additional psychiatric disorders and, as predicted, Neuroticism in the ASD group was positively correlated with psychiatric morbidity. This further supports the notion that the personality structure of adults with ASD can indeed be validly assessed with the use of the self-reported NEO-PI-R.

Limitations and Methodological Discussion

The present study's main strength is the thorough assessment of all of the participants. The main limitation is that

Table 4 Pearson correlations of the NEO-PI-R dimensions in adults with autism spectrum disorder (ASD) and controls

		Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness
ASD (n = 48)	Neuroticism	1				
	Extraversion	−.22	1			
	Openness	.16	.49**	1		
	Agreeableness	−.13	.16	.02	1	
	Conscientiousness	−.26	.02	.08	.38**	1
Control (n = 53)	Neuroticism	1				
	Extraversion	−.32*	1			
	Openness	.10	.29*	1		
	Agreeableness	−.29*	.17	.16	1	
	Conscientiousness	−.53**	.46**	−.01	.15	1

* $p < .05$; ** $p < .01$

criterion validity of all of the dimensions of the NEO-PI-R was not thoroughly assessed. Additional limitations are the small sample sizes and that the study was part of a larger study on gender differences and sexuality that may have attracted a skewed sample of participants. People who choose to participate in research are not always representative of the group that they are presumed to represent (Gustavsson et al. 1997). However, any study that requires adults with ASD to come to the clinic to complete lengthy questionnaires on personality would presumably attract a skewed sample because people with social anxiety, which is common in ASD (Lugnegård et al. 2011; Bejerot et al. 2014), tend to avoid such situations. Nonetheless, reimbursements have shown to improve sample representativity in research (Schubert et al. 1984) and were offered to the participants in the present study.

Criterion Validity

The criterion validity of the NEO-PI-R in the ASD group was only evaluated by comparing Neuroticism scores to scores on the M.I.N.I., leaving the validity of the other four dimensions unstudied. This was a result of the initial data collection, which was not designed for this particular study. Furthermore, the analysis of the correlation between the M.I.N.I. and Neuroticism was not possible in the control group because of skewed scores on the M.I.N.I.. Because of these methodological weaknesses, interpretations of the criterion validity of the NEO-PI-R when assessing adults with ASD and intelligence within the average range should be made with some caution. The results for all five dimensions of personality in the ASD sample were nonetheless similar to Wakabayashi's findings of correlations between personality and ASD traits in a sample of university students (Wakabayashi et al. 2006), thus strengthening the validity of self-reported data in adults with ASD.

Generalization to Other Self-rated Instruments

Some generalized conclusions can be drawn from our results. If adults with ASD and no detected intellectual disability can respond validly and reliably to an instrument as lengthy and complex as the NEO-PI-R, then they should be able to respond to the much shorter questionnaires that are regularly used in clinical practice. The satisfactory construct validity of the Neuroticism dimension implies that this group is able to self-report general psychiatric symptoms. However, the ability to estimate traits that are less stable over time, such as emotions and changes in symptoms, was not tested in this study.

Sample Size

The sample size in the present study was sufficient to calculate Cronbach's α and Pearson correlations and perform *t* tests. This sample size, however, may be too small for factor analysis. A sample size with a 20:1 ratio of participants to items has been suggested to be needed to obtain satisfactory generalizability when performing exploratory factor analysis (Costello and Osborne 2005). In contrast, exploratory factor analysis is an exploratory method thus smaller sample sizes may be acceptable. The risk of a small sample size in a factor analysis implies a risk of not identifying any factor structure at all or a risk that the items are misclassified into the wrong factor (Costello and Osborne 2005). Nevertheless, the extracted factor solution suggests that adults with ASD and no detected intellectual disability respond to self-reports in a valid way. Because one risk of a small sample size is the generation of false negative results, our positive results suggest that the sample size was not an important confounder in this study.

Table 5 Extraction communalities of the principal axis factor analysis with promax rotation and five extracted factors in adults with autism spectrum disorder (ASD) and controls

NEO-PI-R facet	ASD	Control
N1 Anxiety	.78	**.33**
N2 Angry hostility	**.49**	.51
N3 Depression	.64	.50
N4 Self-consciousness	.60	.54
N5 Impulsiveness	.73	.63
N6 Vulnerability	.61	.64
E1 Warmth	.85	.59
E2 Gregariousness	**.48**	**.45**
E3 Assertiveness	.52	.59
E4 Activity	.56	**.38**
E5 Excitement seeking	**.25**	**.32**
E6 Positive emotions	.52	.62
O1 Fantasy	**.46**	.78
O2 Aesthetics	.85	.78
O3 Feelings	.58	.63
O4 Actions	.58	**.19**
O5 Ideas	**.35**	**.49**
O6 Values	**.14**	**.22**
A1 Trust	.66	.56
A2 Straight forwardness	.60	.61
A3 Altruism	.71	.68
A4 Compliance	.65	.55
A5 Modesty	.52	.57
A6 Tender mindedness	**.46**	.59
C1 Competence	.69	.54
C2 Order	**.50**	.53
C3 Dutifulness	.82	.66
C4 Achievement striving	**.43**	.64
C5 Self-discipline	.55	.58
C6 Deliberation	.67	.52
Mean communality	.57	.54

Communalities in bold are small (<.5)

The Extraversion Factor

The factor analysis revealed that three (E2 Gregariousness, E5 Excitement seeking and O6 Values) of the 30 facets of the NEO-PI-R did not load >.4 in any factor in the ASD group, weakening the validity of the NEO-PI-R in ASD. Intriguingly, two of the facets that did not load into any factor, E2 Gregariousness and E5 Excitement seeking, include items related to the symptoms of ASD. However, the factor solution of the control group produced even more facets with high loadings on unexpected factors. Because the ASD group did not produce a worse fit than the control group, the validity of the NEO-PI-R was unlikely weakened when assessing adults with ASD in relation to adults without ASD.

E2 Gregariousness

One possible explanation for the low validity of this facet in the ASD group is the item "I would rather go on a vacation to a popular resort than to a cabin in the woods." This item could be confusing to a person with impaired metonymy comprehension (i.e., understanding the meaning of the symbolic use of common words or phrases), which may be the case in ASD (Rundblad and Annaz 2010). Asking a person to choose between visiting a popular resort or cabin in the woods may make little sense if s/he is unable to grasp the concepts and generalize them into something more meaningful, such as "secluded and calm" or "social and busy." However, E2 Gregariousness had low communality and high internal consistency in both the ASD group and control sample, which speaks against the lower validity of this facet in adults with ASD than in controls. As predicted, the controls scored much higher on E2 Gregariousness (i.e., more gregarious and less socially reclusive) than the ASD group.

E5 Excitement Seeking

The theoretical underlying construct of E5 Excitement seeking is not particularly related to ASD. However, the individual items are based on the assumption that excitement is connected to social events and crowded places. Social events and crowded places require social relationships that commonly are sparse in ASD. Thus, the ambiguity of some items in this facet may have contributed to the low loading in the E factor (related to the Extraversion dimension) in the ASD group and was confirmed by low internal consistency and low communalities in both groups. This facet also had high loading on an unexpected factor in the Swedish normative data, speaking against a difference in the validity of this facet between adults with and without ASD.

The Openness Dimension

One unexpected result of the present study was higher scores in Openness in the control group than in the ASD group. The adults with ASD may have sought participation to a larger extent than controls because of reimbursement and interest in ASD, whereas the controls had other priorities, such as exploring gender issues, thus presumably attracting controls with high levels of Openness. In fact, the results on the Openness dimension of the ASD group fall within one standard deviation of the Swedish normative

sample (men: $M = 99.9$, $SD = 21.1$; women: $M = 109.1$, $SD = 20.7$), whereas the control group scored approximately one standard deviation above the Swedish normative sample. The high internal consistency and satisfactory factor loadings in the O factor suggest that the results unlikely stem from lower validity and reliability of the Openness dimension in the ASD group than in controls.

Self-reports in Clinical Practice

The present study lends support for the use of self-reported questionnaires in clinical settings. Notably, however, clinical and research settings differ. Experience from an earlier study of a clinical ASD population (Hesselmark et al. 2014) indicates that some patients with ASD find self-reported questionnaires difficult and tiring. False responses on self-reports may also occur in the ASD population for several reasons, such as negating symptoms because of fear of receiving an unwanted diagnosis or treatment or negating symptoms to avoid further questioning. Further studies in this field should include the self-reported measures that are used to assess psychiatric disorders that are common in ASD. Although this study has focused on adults with ASD, self-reported questionnaires may also be appropriate when assessing adolescents. Hence, studies on validity and reliability of self-reports in adolescents are warranted.

Conclusion

Adults with ASD did not respond to the NEO-PI-R in a less valid or reliable way than non-ASD controls, thus supporting the use of self-reports when assessing adults with ASD. Other researchers have previously stated that there is no reason to believe that adults with ASD and intelligence within the average range are unable to answer self-reported questionnaires that measure ASD traits (Baron-Cohen et al. 2001; Hoekstra et al. 2008), quality of life (Shipman et al. 2011) and alexithymia (Berthoz and Hill 2005). The present study adds personality measures to the list of valid and reliable self-reported questionnaires, thus narrowing the window for critiquing the use of self-reports in the adult ASD population with intelligence within the average range.

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Conflict of interest The authors declare that they have no conflict of Interest.

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