ASSERT – The Autism Symptom SElf-ReporT for adolescents and adults: Bifactor analysis and validation in a large adolescent population

Maj-Britt Posserud [a,b,e,*], Kyrre Breivik [b], Christopher Gillberg [c], Astri J. Lundervold [b,d,e]

[a] Department of Child and Adolescent Psychiatry, Haukeland University Hospital, 5021 Bergen, Norway
[b] Regional Centre for Child and Youth Mental Health and Child Welfare, Uni Health, Uni Research, P.O. Box 7800, 5020 Bergen, Norway
[c] Gillberg Neuropsychiatry Centre, Institute of Neuroscience and Physiology, University of Gothenburg, 411 19 Göteborg, Sweden
[d] Department of Biological and Medical Psychology, University of Bergen, P.O. Box 7800, Bergen, Norway
[e] K.G. Jebsen Centre for Research on Neuropsychiatric Disorders, University of Bergen, P.O. Box 7800, Bergen, Norway

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ABSTRACT

With a view to developing a brief screening instrument for autism symptoms in a general population of adolescents, seven items from the Asperger syndrome (and high-functioning autism) diagnostic interview were adapted for use as self-report in an online questionnaire for youths aged 16–19 years ($N = 10,220$). The selected items target lack of social understanding (4 items) and rigid and repetitive behavior and interests (RRBI; 3 items). Factor analyses were performed, and the seven items were also validated against self-reported ASD diagnosis. Best statistical model fit was found for a bifactor model with one general factor and two domain specific factors tied to social difficulties and RRBI. Both the general and the domain specific factors were associated with self-reported ASD diagnoses. The scale (referred to as the Autism Symptom SElf-ReporT for Adolescents and Adults – ASSERT) had good screening properties with a receiver operating curve-area under the curve (ROC-AUC) of 0.87 and a diagnostic odds ratio (DOR) of 15.8. Applying a modified scoring of the scale further improved the screening properties leading to a ROC-AUC of 0.89 and a DOR of 24.9. The ASSERT holds promise as a brief self-report screen for autism symptoms in adolescents, and further studies should explore its usefulness for adults.

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1. Introduction

The concept of autism has evolved from the description of severe cases of infantile autism affecting about 0.02% (Kanner, 1943), to the modern day autism spectrum disorder (ASD) encompassing an estimated 1% of the population (Baird et al., 2006; Brugha et al., 2011; Posserud, Lundervold, Lie, & Gillberg, 2010). Needless to say, the "1% ASD" is not the same as "0.02% infantile autism". The majority with ASD functions at normal or next to normal levels cognitively, and many also lead independent lives in adult age. The broadening of the concept and growing public awareness has led to a situation where

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* Corresponding author at: PBU, Haukeland University Hospital, 5021 Bergen, Norway. Tel.: +47 97641843.
 E-mail addresses: maj-britt.posserud@uni.no (M.-B. Posserud), kyrre.breivik@uni.no (K. Breivik), christopher.gillberg@gnc.gu.se (C. Gillberg), astri.lundervold@psybp.uib.no (A.J. Lundervold).

adults, who have not been diagnosed in childhood, seek help for their problems with (Brugha et al., 2011) isolation and feelings of inadequacy. Adult services have not yet developed to meet the needs for adults with ASD, and few support programs are in place that target the specific needs of those individuals (Howlin, Alcock, & Burkin, 2005). Adults may therefore access services that are at loss as what to do, sometimes even outright uncooperative, due to lack of knowledge, and a dearth of adequate tools and interventions for this group. The research community and public services need to adapt to the new reality of a relatively large group of people with ASD, or autism symptoms that perhaps do not quite surpass the level required for a disorder diagnosis, who, with just a bit of support and adequate understanding, might function well with their social disability, but who, if not properly understood, might suffer greatly.

Given that autism has traditionally been conceptualized as a childhood disorder, there is a lack of instruments to screen for, assess and diagnose autism in adults. Most diagnostic interviews are intended for completion/interview by/with a parent or someone else with intimate first-hand knowledge about the person affected, including information about his/her first years of life. Given that adults with suspected ASD may not even have a living parent, it may be very difficult to assess the social skills before the age of three (diagnostic requirement in the DSM-IV, but less stringently defined under the DSM-5) (Diagnostic and statistical manual of mental disorders: DSM-IV, 2011). When it comes to self-rating instruments, the autism quotient (AQ) and its shorter version (AQ-Short) are the important exceptions to the lack of such instruments (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Hoekstra et al., 2011; Woodbury-Smith, Robinson, Wheelwright, & Baron-Cohen, 2005). Although the AQ exists for adolescents, this version is to be filled in/completed by parents of affected individuals (Baron-Cohen, Hoekstra, Knickmeyer, & Wheelwright, 2006). To the best of our knowledge, there are no ASD self-report instruments for adolescents. Most adolescents, at least in theory, do have an adult to answer for them, but there are instances where an adult may not be available, as it is typically difficult to get hold of and be able to cooperate with patients and parents together in the later teenage years and young adulthood (Sanci, Sawyer, Kang, Haller, & Patton, 2005). In fact, the large majority of adolescents report that the lack of confidential health services impedes them from seeking help for their problems (Thrall et al., 2000).

The goal of the present study was therefore to formulate and evaluate a set of self-report items that would validly capture the lack of social understanding and rigid and repetitive behavior and interests (RRBI) that signal ASD in adolescents and young adults (and throughout the life-span). Items from the Asperger syndrome (and high-functioning autism) diagnostic interview (ASDI) (Gillberg, Rastam, & Wentz, 2001) were adapted for this purpose. Although the ASDI is an investigator-rated interview, items had already been adapted for self-report and compared to the parental ASDI in a previous study of young adults males with Asperger syndrome (AS), showing good agreement on these items across parent and patient ratings (Cederlund, Hagberg, & Gillberg, 2010). We further adapted seven items covering social impairment (4 items) and RRBI (3 items) to fit our Norwegian population-based adolescent survey using an online questionnaire and renamed the scale Autism Symptom SElf-ReporT for Adolescents and Adults (ASSERT) to reflect the intended use of these items. The aims of the current study was to investigate the psychometric properties of the ASSERT and its usability as a screening instrument for the presence of autistic symptoms.

Previous studies have tended to find support for the fact that ASD consists of two or more dimensions/factors that are only modestly correlated with each other (Happe & Ronald, 2008; Mandy & Skuse, 2008; Shuster, Perry, Bebko, & Toplak, 2013). These findings have contributed to the "fractionable autism" hypothesis where proponents argue that the ASD dimensions are largely independent of each other with largely separate causes. The relationship between ASD, social difficulties and RRBI must be said to be unclear (Mandy & Skuse, 2008), but in spite of this, the two domains have now been inseparably linked to ASD in the DSM-5, as a diagnosis of ASD cannot be made without having RRBI symptoms (McPartland, Reichow, & Volkmar, 2012). Many factor analyses have been performed on ASD symptoms, but to our knowledge, a bifactor model has not been applied (Shuster et al., 2013). A potential advantage with the bifactor model over the correlated factor model (where the dimensions are treated as correlated but separate) is that it provides information about what all of the items have in common as well as unique symptom dimensions. It thereby provides a rational structure explaining both overlap and separability between dimensions in a model, and could thus be useful to explore the contradictory findings regarding ASD, RRBI and sociability. To this aim and to examine the psychometric properties of the scale, we applied both a conventional exploratory factor analysis (EFA) and a confirmatory factor analysis (CFA) using a bifactor model. We were also interested in whether the general factor predicted self-reported ASD diagnosis up and above what was predicted from the unique variance tied to the subdomains (controlled for the general factor).

2. Material and methods

2.1. Population sample

The backdrop of the study was the fourth wave of the longitudinal Bergen Child Study (BCS). In this wave, the original target population was extended to include all young people born in 1993–1995 (age 16–19 years at the time of the study) residing in the county of Hordaland where Bergen city is situated ($N = 19\ 121$). This cross-sectional study of a larger group of adolescents was named "ung@hordaland" (young@hordaland). The collection of data was performed in the spring of 2012, and 10,220 young people participated (with a corresponding response rate of 54%). All youths were invited to participate, but the great majority of responses came from adolescents attending schools (97.8%), where a school lesson was set aside to allow for the completion of the online questionnaire (both private and public schools).

Table 1
The seven self-report items of the Autism Symptom SElf-ReporT (ASSERT) adapted from the Asperger syndrome and high functioning autism diagnostic interview (ASDI).

Item abbreviation and translated content of original Norwegian item	
S1	Do you find it difficult to socialize with, or to get in touch with people, especially people your own age?
S2	Do you prefer to be alone rather than being together with other people?
S3	Do you have difficulties perceiving social cues?
S4	Do other people tell you that your behavior or your emotional responses are inappropriate or hurtful?
R1	Do you have a strong interest or hobby that absorbs so much of your time that it hampers other activities?
R2	Do you or do other people feel that you have very set routines or that you are very immersed in your own interests?
R3	Do you or do other people feel that you impose your routines or interests on others?

Further details about the BCS/ung@hordaland protocol are available online at www.unghordaland.no.

2.2. Instruments

The ung@hordaland questionnaire was developed specifically for this study with a view to covering a wide range of mental health problems and associated issues. To screen for autism symptoms, seven items from the Asperger syndrome (and high-functioning autism) diagnostic interview (ASDI) (Gillberg et al., 2001) were adapted together with the main developer of that instrument, Christopher Gillberg. The ASDI is a semi-structured investigator-based diagnostic interview including 20 items, and has been used in previous studies as a valid and reliable tool to diagnose Asperger/high-functioning autism in adults (Gillberg et al., 2001). Some of the items are rated by the investigator according to observed behavior during the interview. The items from the ASDI that are not investigator-rated were adapted for an earlier study of young adult males with Asperger syndrome (AS) in which they were used as self-report items and compared to parental reports on the same items (Cederlund et al., 2010). The authors found that many were quite aware of their own difficulties in some areas, and argued for increased consideration of the patient's own report in the diagnostic work-up and intervention planning for patients with ASD. The same seven items were translated into Norwegian and adapted for use in the online self-report questionnaire for adolescents 16–19 years of age. Four items targeting social symptoms (items 1–4 in the ASDI) and three items targeting rigid and repetitive behavior and interests (RRBI; items 5, 8 and 9 in the ASDI) were included (Table 1). Response options were "not true" (score 0) – "somewhat true" (score 1) – "certainly true" (score 2), leading to a score range of 0–14 p. on the ASSERT.

The adolescents were also asked to report on the presence of psychiatric diagnoses: "Have you been diagnosed with any mental health problems? (e.g. ADHD, anxiety, depression, autism)".

2.3. Statistical analyses

Reports missing more than one of the seven ASDI items were not included in the analyses ($N = 228$). Receiver operating curve (ROC) analyses were performed using all seven items combined into one scale (ASSERT) with self-reported ASD as state variable. Descriptive analyses, Cronbach's alpha (α) and ROC analyses were performed using IBM SPSS Statistics 19. Mplus version 6.0 was used for other correlation analyses and factor analyses (Muthén & Muthén, 1998–2012). The robust-weighted least square estimator (WLSMV) was used in the factor analyses because of the skewed categorical data (ordinal data with three options). Using polychoric correlations for estimation, the WLSMV seems relatively robust to violations of normality (Dumenci & Achenbach, 2008; Flora & Curran, 2004). The chi-square value is not reported as measure of model fit as this is not exact when using the WLMSV estimator. Therefore, we used Bentler's comparative fit index (CFI; Bentler, 1990), Tucker–Lewis index (TLI; Tucker & Lewis, 1973) and the root-mean-square error of approximation (RMSEA; Steiger & Lind, 1980) with cut-off values for CFI ≥ 0.96, TLI ≥ 0.95 and RMSEA ≤ 0.05 to indicate goodness of fit (Yu, 2002). EFA was performed with geomin rotation (default oblique rotation in Mplus). Missing data on one ASSERT item was replaced with the mean of the remaining six items and included in the ROC analyses and correlation analyses of the entire scale. In the remaining analyses, missing values were treated with pairwise deletion for the analyses performed in Mplus (default) and with listwise deletion for analyses performed in SPSS (default).

3. Results

3.1. Responses

The mean score for the entire scale was 2.60 (SD 2.22, $N = 9992$). Distribution of responses is shown in Fig. 1 and item response frequencies in Table 2.

Most individuals had very low scores on the ASSERT, and 55% scored ≤ 2 points. Forty-five individuals reported having been diagnosed with an ASD (11 autism, 29 Asperger syndrome, 4 atypical autism/PDD-NOS, 1 possible autism), corresponding to a prevalence of 0.45% self-reported diagnosed ASD.
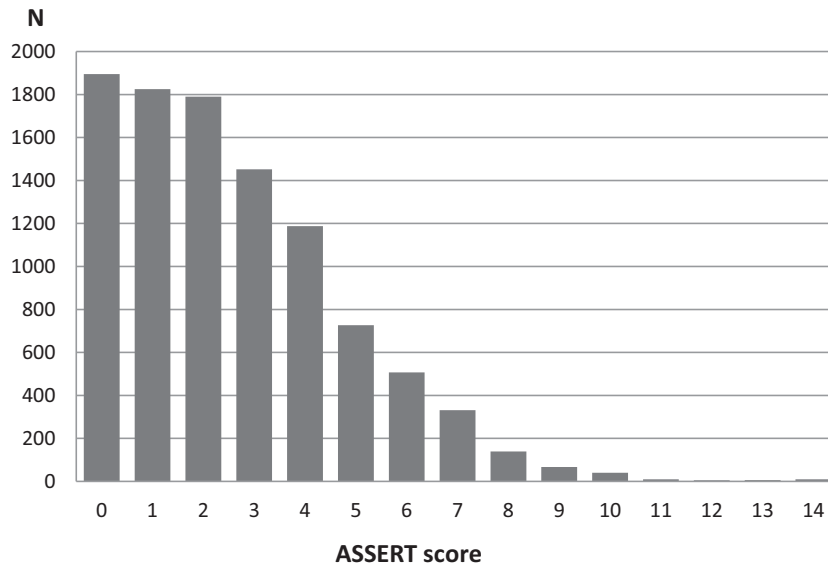
Fig. 1. Distribution of ASSERT scores in adolescents 16–19 years old ($N = 9992$).

3.2. Factor analyses

The three-factor EFA solution showed excellent fit (CFI = 1.00, TLI = 1.00, RMSEA = 0.00) for a solution including a one-item factor (Table 3). The two-factor model almost met pretest criteria (CFI = 0.98, TLI = 0.94, RMSEA = 0.06) and had higher item loadings (Table 2) while the one-factor model was definitely discarded (CFI = 0.67, TLI = 0.51 and RMSEA = 0.18). Table 3 shows the item loadings for all three EFA factor models. The correlation between the first (social) and second (RRBI) factor in the two-factor model was $r = 0.23$.

The bifactor model with one general factor and two subdomains (social and RRBI) showed very good statistical model fit with CFI = 0.996, TLI = 0.987 and RMSEA = 0.030. The model with item loadings is shown in Fig. 2. Even if all item loadings were significant ($p < 0.001$, except S4 loading onto the social subdomain, with $p = 0.019$), several of the loadings were rather weak (<0.50). The items assessing difficulty socializing with people, strong interest or hobbies and having very set routines all had loadings lower than 0.40 on the general factor. The factors were correlated with the self-reported diagnosis of ASD to

Table 2
Response frequencies for each ASSERT item in percentages and numbers.

Item	Not true	Somewhat true	Certainly true
S1	70.6% ($N = 7051$)	25.1% ($N = 2506$)	4.4% ($N = 435$)
S2	65.3% ($N = 6523$)	28.9% ($N = 2885$)	5.8% ($N = 581$)
S3	82.7% ($N = 8262$)	14.8% ($N = 1479$)	2.5% ($N = 248$)
S4	79.6% ($N = 7950$)	18.5% ($N = 1844$)	1.9% ($N = 192$)
R1	48.3% ($N = 4824$)	32.8% ($N = 3277$)	18.9% ($N = 1887$)
R2	54.0% ($N = 5394$)	34.3% ($N = 3422$)	11.7% ($N = 1172$)
R3	85.7% ($N = 8560$)	13.0% ($N = 1298$)	1.3% ($N = 129$)

Table 3
Exploratory factor analysis – item loadings for the one-factor (F1), two-factor (F2) and the three factor (F3) solutions. Loadings above 0.45 are high-lighted (signaling 20% overlapping variance).

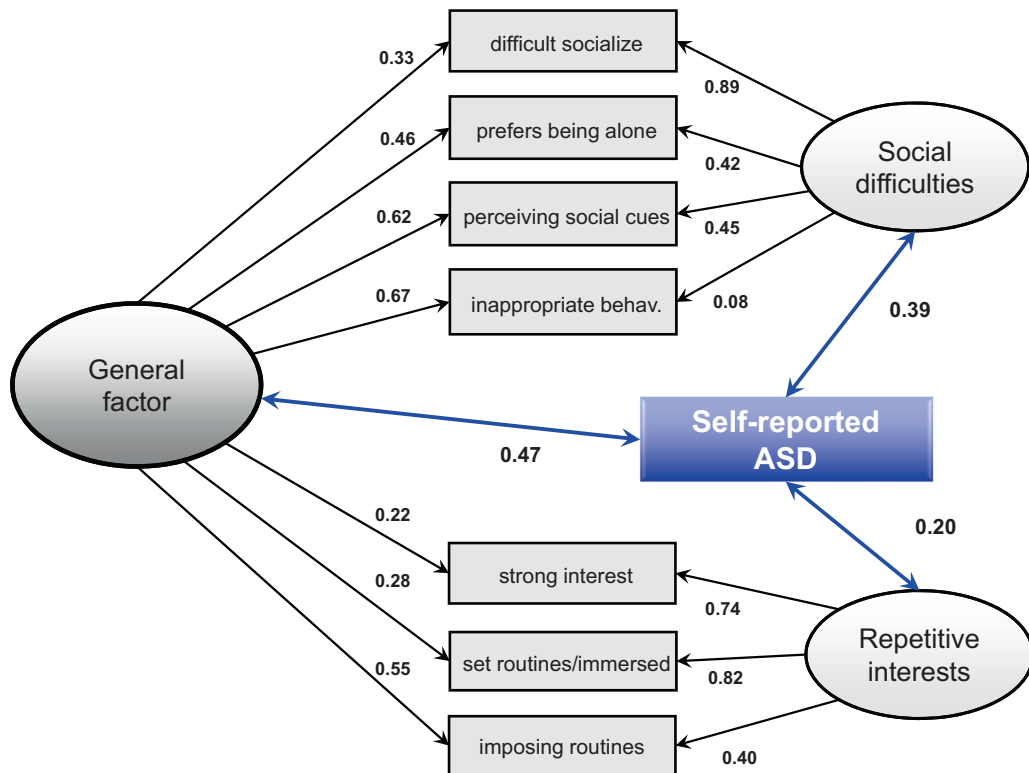| Item	F1	F2		F3		
		First factor	Second factor	First factor	Second factor	Third factor
S1	**0.55**	**0.78**	−0.10	**0.87**	−0.04	−0.02
S2	**0.52**	**0.63**	0.04	**0.55**	0.08	0.11
S3	**0.66**	**0.80**	0.00	**0.55**	0.00	0.35
S4	**0.46**	**0.48**	0.12	0.00	−0.01	**0.78**
R1	**0.65**	−0.03	**0.78**	−0.04	**0.76**	0.01
R2	**0.70**	0.01	**0.85**	0.01	**0.88**	−0.02
R3	**0.60**	0.29	**0.50**	0.00	**0.46**	0.39

Fig. 2. Bifactor model with item loadings and correlations between factors and self-reported ASD.

examine their relevance for a diagnosis of ASD. Both the general factor and the social factor had moderate correlations with the ASD diagnosis (0.47 and 0.39 respectively), indicating that they both contribute uniquely to predicting the presence of an ASD, while the RRBI factor only correlated 0.20 with self-reported diagnosis of ASD.

3.3. ASSERT scale properties

Cronbach's alpha (α) for the entire scale was 0.62, probably reflecting the multidimensionality of the scale. Cronbach's alpha was 0.63 for both the social subscale (ASSERTsoc) and the repetitive and stereotype behavior/interests subscale (ASSERTrrbi), partly an indication of the rather few items included in the subscales (4 and 3 respectively).

3.4. Validity of ASSERT

The ASSERT showed good screening properties versus self-reported diagnosis of ASD, with an area under the curve (AUC) in the ROC-analysis (receiver operating curve) of 0.87 (95% CI 0.83–0.92) (Fig. 3 and Table 4). Scoring ≥5 points on the ASSERT had a sensitivity of 0.80 and specificity of 0.81 for self-reported ASD. Nine adolescents with self-reported ASD scored <5, but only one of these adolescents scored exclusively on the ASSERTrrbi items, whereas 33% of the adolescents without self-reported diagnosis of ASD and a score of 2–4 endorsed exclusively on those items. The correlation pattern between the factors in the bifactor solution and self-reported diagnosis of ASD indicated that the ASSERTrrbi items are important mainly in conjunction with the social items. Based on these results we decided to explore the effect of differential weighting of the items in the ASSERT, by doubling the score of the social items while maintaining the scoring of the ASSERTrrbi items. This improved the screening properties further leading to an AUC of 0.89 (95% CI 0.84–0.93), sensitivity of 0.80 and specificity of 0.86 for a score of ≥8 (Table 4 and Fig. 3). The ROC analyses were rerun with the youths who had responded "yes" to the item "Have you been diagnosed with any mental health problems? (e.g. ADHD, anxiety, depression, autism)" (*N* = 724) to examine the discriminative power of the ASSERT for ASD vs. other mental health disorders. AUC for this group was 0.80 (95% CI 0.74–0.86), and the ROC indicated a score of ≥8 (modified scoring) to be optimal also in this group.

3.5. Screening utility of ASSERT

To further evaluate the utility of ASSERT as diagnostic test we calculated the diagnostic odds ratio (DOR). This measure is more informative than the predictive value of a test, which is influenced by the base prevalence in the sample investigated.
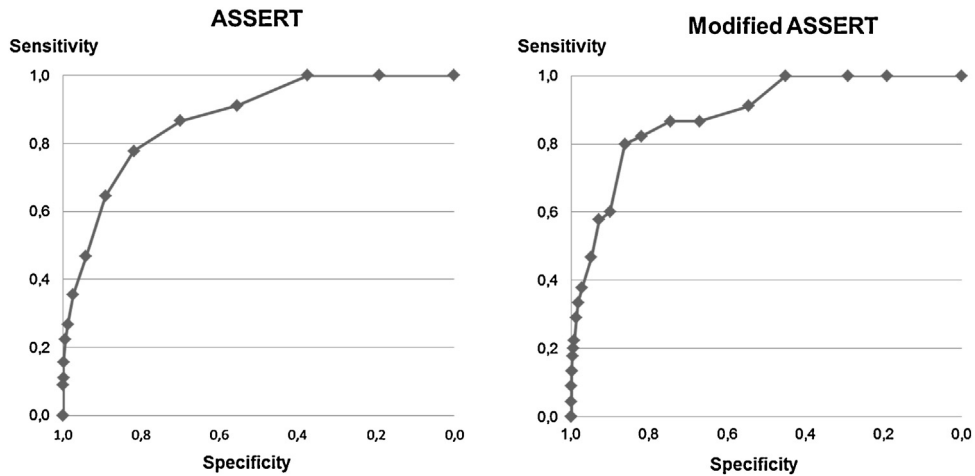
Fig. 3. Receiver operating curves for ASSERT and modified ASSERT versus self-reported presence of ASD (*N* = 9992).

The DOR is a measure of a diagnostic test's overall accuracy, and is generated by dividing the number of correctly classified by the number of incorrectly classified individuals (Glas, Lijmer, Prins, Bonsel, & Bossuyt, 2003; Haynes, 2006). In other words, it tells you how good the "sieve" you are using actually is. Another advantage of reporting the DOR is that it facilitates the comparisons of tests for meta-analyses (Glas et al., 2003). A DOR value of 20 or more indicates that an instrument has useful screening properties (Fischer, Bachmann, & Jaeschke, 2003). Using the cut-off of ≥5 on the ASSERT produces a DOR of 15.8, while using the cut-off of ≥8 on the modified ASSERT score gives a DOR of 24.9. This clearly shows that although the change in specificity of using the modified ASSERT may seem modest, it was improved with intact sensitivity, thereby much increasing the correct classification rate of the scale.

4. Discussion

The present study showed that ASSERT seems to work well as a self-report screen for autistic symptoms in this large population-based sample of adolescents age 16–19 years old. The items seemed to be readily understood, with a response rate of 98.8%. Furthermore, the AUC for the ROC analysis using self-reported diagnosis of ASD as outcome was as high as 0.89, with a sensitivity of 0.80 and a specificity of 0.86 for scores ≥8, supporting the validity of the ASSERT as a screening instrument of ASD symptoms in adolescents and young adults. Using self-reported ASD diagnosis for validation of ASSERT was not ideal, but the overall rate of 0.45% of self-reported ASD is almost identical to one of the previously reported estimates from the Bergen Child Study (BCS) of 0.44% based on the DAWBA (development and well-being assessment) (Heiervang et al., 2007), and self-reports have proven valid for a range of mental health disorders (Halmoy et al., 2010). As the present figure is based on self-reports from mainly high-school students, we assume that the figure of 0.45% only includes high-functioning individuals with an ASD, and that the rate of adolescents with any ASD should be higher (Brugha et al., 2012).

Table 4
Sensitivity and specificity for the ASSERT scores.

Score	ASSERT		Modified ASSERT	
	Sensitivity	Specificity	Sensitivity	Specificity
1	1.00	0.19	1.00	0.19
2	1.00	0.37	1.00	0.29
3	0.92	0.55	1.00	0.45
4	0.88	0.69	0.91	0.55
5	0.80	0.81	0.87	0.67
6	0.65	0.89	0.87	0.75
7	0.47	0.94	0.82	0.82
8	0.35	0.97	0.80	0.86
9	0.26	0.99	0.60	0.90
10	0.22	0.99	0.58	0.93
11	0.14	1	0.47	0.95
12	0.10	1	0.38	0.97
13	0.08	1	0.33	0.98
14	0.00	1	0.29	0.99
15	–	–	0.22	0.99
16	–	–	0.20	0.99
≥17	–	–	0.18	1.00

ASDs are conceptualized in the DSM-5 as containing two core groups of symptoms, viz. social impairment and RRBI. Many factor analyses have been performed in the field of autism, both in clinical samples and larger population-based samples (Shuster et al., 2013), but no previous study (to our knowledge) has applied a bifactor model, in spite of research indicating both separability of the domains in ASD (genetically and in the population) and unity of domains (the ASDs). The bifactor model had good statistical fit, confirming that the social and RRBI dimensions both share and have unique variance tied to them. Despite the modest correlation ($r = 0.23$) between the two sub dimensions (social and RRBI) when modeled as two correlated factors, the general factor (reflecting the shared variance) predicted self-reported ASD diagnosis ($r = 0.47$) over and above what was predicted from the two domain specific factors. This underscores the importance of not treating the ASD dimensions as totally separate dimensions even if they are not strongly correlated. A traditional correlated factor model would only have explored how well each of the two subdimensions would have predicted self-reported ASD diagnosis by itself or controlled for each other (their unique prediction). This information is also given by the bifactor model showing that the domain specific social difficulties factor had a stronger association with self-reported ASD diagnosis ($r = 0.39$) than the RRBI domain specific factor (0.20). However, the bifactor model further indicates that the shared variance between the two ASD subdimensions seems to be equally important as the unique contribution from social difficulties dimensions in predicting self-reported ASD diagnosis.

We are hesitant to regard the general factor as representing the overarching ASD concept. The bifactor model has often been applied when representing multidimensional constructs such as ADHD and intelligence where it is hypothesized to be a dominant/overarching general factor in addition to some smaller domain specific factors (Ullebo, Breivik, Gillberg, Lundervold, & Posserud, 2012). The present study gives some support to the fractionable autism hypothesis as such a dominant factor does not seem to exist regarding ASD in this general population sample. Our general factor was rather weak with low loadings of several items, including core ASD symptoms, such as having difficulties socializing with other people. The three items with strongest loadings onto the general factor suggest it could represent theory of mind (ToM) related difficulties more specifically (difficulties perceiving social cues (S3), and other peoples responses to the respondents behavior (S4, R3)). More research is needed to bring conceptual clarity to what the general factor represents and whether the rather weak loadings could be due to applying the model of a narrow disorder to a general population. The model should be replicated in other populations and using other ASD instruments before any strong conclusions can be drawn.

Although the relationship between ASD, social difficulties and RRBI is unclear and insufficiently explored (Mandy & Skuse, 2008), in the DSM-5, the ASD diagnosis cannot be made in the absence of RRBI (McPartland et al., 2012). Simultaneously, a disorder of social communication is introduced. This change has raised criticism and concern among researchers, clinicians and parents, as some children with a clear social handicap but without RRBI will no longer belong within the ASD category, with implications for research and treatment. Some studies have shown that a number of children with ASD according to the DSM-IV criteria, do not meet DSM-5 criteria for ASD (Mayes, Black, & Tierney, 2013). Some of them will meet criteria for the new social communication disorder. It is uncertain what the difference between ASD and the new social communication disorder is, apart from not including RRBI (Skuse, 2012; Tanguay, 2011). The correlation between the ASSERTsoc and ASSERTrrbi was low ($r = 0.23$) but identical to other population-based studies (Ronald, Happe, & Plomin, 2005; Ronald et al., 2006), suggesting a low degree of overlap between the two factors. The higher correlation with an ASD diagnosis of the general factor and the social factor may indicate that the overlap between the social and the RRBI domains may be rather specific to ASD problems. However, the specific social factor still showed a moderate correlation ($r = 0.39$) with the self-reported ASD diagnosis, after accounting for the general factor. This suggests that an ASD diagnosis may be justified also in the absence of clear RRBI symptoms. If one belongs to the "splitter"-advocates within the diagnostic system (rather than "lumpers") (McKusick, 1969), one could also argue that it supports the use of a separate disorder including only social difficulties, but then at least in this study they are not distinguishable at the symptom level, other than not including RRBI symptoms.

The DSM-5 has replaced the separate ASDs with one category. In line with this framework shift, the self-reported autism diagnoses in the present study were combined and dichotomized into presence or absence of ASD. The DSM-5 furthermore indicates that having ASD and its severity is signaled by the presence and degree of impairment. This introduces a categorical element which is situational and not (necessarily) directly related to the underlying trait. Similar to other large population-based studies (Constantino et al., 2003; Posserud, Lundervold, & Gillberg, 2006) the distribution of autism symptoms in this sample of adolescents shows a gradual shift from no symptoms up to high symptoms, supporting a dimensional distribution. However, the good fit of the bifactor model in combination with a weak general factor could mean that there are separate populations within the population following different distributions. The dimensional model may thus be insufficient in explaining the structure and nature of ASD symptoms, and models allowing for both categorical and dimensional distributions could be more adequate.

Although the target sample in this study was 16–19 years of age, the same items could most likely successfully be used across the adult age span, as indicated by a previous study showing good properties of the same items in young adults (Cederlund et al., 2010). A self-report instrument for ASD validated from the age of 16 is important as youths at that age can access health services independently and deny parents contact with the same services. Although most adolescents do have a living parent who could fill out a questionnaire for them, it is not always easy to achieve as many adolescents do not desire parental involvement (Thrall et al., 2000).

More than 50% responded positively to the item "Do you have a strong interest or hobby that absorbs so much of your time that it hampers other activities?" indicating poor discriminatory properties for this item versus ASD. When formulating

this item we considered other wording including "narrow" or "circumscribed" interest to convey the autistic nature of the interest. While it might have improved its discriminatory properties, it made the item difficult to understand. As autistic interests are not necessarily circumscribed, and the borderline between the intensity of an autistic interest and an intense normal interest may be hard to define, we opted for readability rather than high specificity. An intense interest in the absence of social difficulties is not to be regarded as an autistic symptom, and a low ASSERT score where all scores stem from R1 to R3 can probably be disregarded. The bifactor model solution supports this, as RRBI when included in the general factor was related to an ASD, but after accounting for the general factor only correlated 0.20 with reported ASD. Furthermore, modifying the scoring of the ASSERT by weighing the social items more than RRBI items also improved specificity with intact sensitivity for ASD.

4.1. Limitations

The study relied exclusively on the self-reported diagnosis of ASD. While not likely to produce false positives, this procedure very likely produces false negative answers, e.g. from individuals who indeed have an ASD but do not report it or who have not yet been diagnosed. Undiagnosed adolescents may also be less aware of their own problems (thus scoring low on the ASSERT). The present procedure could, in theory, therefore both underestimate and inflate the properties of the scale. Future studies should include clinical assessment of ASD to evaluate the screening properties of ASSERT.

The few items included may have increased the likelihood of spurious or distorted findings in the factor analyses. This also applies to the screening properties of the scale; more items could have increased the screening properties and increased its usefulness as an informative measure of ASD symptoms as well. However, brevity can also be of merit, especially regarding adolescents and individuals with cognitive or mental health problems, where staying focused on a task at length is often a problem. However, further development of the scale including items targeting for instance social communication could be advantageous.

The prevalence of 0.45% for ASD is probably an underestimate only including higher functioning individuals with ASD, but this is also the most prevalent kind of ASD and the group where self-report probably would be most useful.

5. Summary

The present study presents and validates the use of a self-report screen for autism symptoms in adolescents – the Autism Symptom SElf-ReporT (ASSERT). The scale is brief and easily comprehended, and seems to be valid and useful with discrimination for the presence of an ASD in both the general population of adolescents and among more clinically affected adolescents. Studies including clinical assessment are needed to determine its potential as a screen for ASD. A bifactor model of the scale supported a general factor and two independent factors of social difficulties and RRBI, but the general factor was weak. The model holds some promise in describing the structure of ASD traits in the general population but it and other models should be explored further.

Acknowledgements

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