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BRIEF REPORT

The construction and validation of a short form of the developmental, diagnostic and dimensional interview

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Abstract We aimed to construct and validate a shortened form of the developmental, diagnostic and dimensional interview (3Di), a parent report interview for assessing and diagnosing autistic spectrum disorders (ASDs). Data from 879 children and young people were used. In half of the sample ($n = 440$) reliability analysis was used to identify 3Di items that best measured each dimension of the autism triad. This informed the construction of a shortened (53 item) 3Di, which was then validated on subjects not used in the reliability analysis ($n = 439$). This involved comparison with scores from the original 3Di algorithm and, in a subsample ($n = 29$), with the autism diagnostic interview-revised (ADI-R). Agreement of the new shortened 3Di with the 3Di's original algorithm was excellent in both dimensional and categorical terms. Agreement on caseness (27 out of 29) with the ADI-R was also strong. The new 3Di short version is less than half as long as the original version and outputs very similar scores. It will be useful to clinicians and researchers for obtaining a dimensional autism assessment in less than 45 minutes.

Keywords Autism · Autistic spectrum disorders · Interview · Assessment

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Introduction

Autism is coming to be conceptualised as a dimensional disorder, representing the extreme end of continuously distributed traits found in the general population [2]. In addition, there is increasing evidence that the majority of individuals with autistic spectrum disorders (ASDs) have IQs within the normal range [1]. These facts have influenced the design of the 3Di, a parent report, diagnostic interview for social communication disorders [5]. As a result, it is suitable for use with typically developing as well as clinical populations, offering a dimensional assessment of each element of the autistic triad, and can be used to measure autistic traits in children and young adults with a wide range of IQs.

In addition to these issues of the evolving conceptualisation of autism, more general concerns of reliability and validity have shaped the interview. The 3Di is semi-structured, drawing upon short questions, each of which aims to capture a very specific aspect of a subject's behaviour. Thus, rater inference is limited, promoting reliability and, in turn, validity. Such interview design is in contrast to the most widely used parent report autism assessment, the autism diagnostic interview-revised (ADI-R) [4], which requires interviewers to pose a range of questions relating to a particular area of impairment (e.g. 'social smiling' or 'quality of social overtures') and then to

decide upon a summary score to represent the overall content of the several answers received.

In the light of this, it is perhaps not surprising that the ASD algorithm of the 3Di, which was designed to emulate the ADI-R's diagnostic algorithm, has been shown to possess excellent psychometric qualities [5]. Test–retest and interrater reliability ICCs exceed 0.86. Discrimination between children with disorders on the autistic spectrum and those with non-autistic spectrum disorders is almost perfect (sensitivity = 1, specificity > 0.97). Criterion validity (a comparison with the ADI-R) was good.

The 3Di ASD algorithm is computerised and has a three-level hierarchy. At the lowest level, clusters of questions combine to give scores for specific autistic impairments described in the diagnostic manuals (e.g. 'failure to use eye contact'). These are then summed to yield scores for each sub-component of the autistic triad (e.g. 'use of non-verbal social cues'). Finally these sub-component scores are summed to give overall scores for each part of the triad (e.g. 'reciprocal social interaction'). The algorithm draws on 112 questions to give dimensional scores for the components of the autistic triad,[1] which means that the interview can take up to 2 h to complete. Many clinicians and researchers do not have the time for an interview of this length. As a result we sought to reduce the number of items contributing to the 3Di autism algorithm, whilst retaining its comprehensive hierarchical structure. This was done using reliability analysis to identify those items in the 3Di that increased or least reduced Cronbach's alpha when removed from the scale. This information was used to construct a short version of the interview (3Di-sv), which possessed similar scope and validity to the original, longer version. We were also interested to assess the 3Di-sv's criterion validity with respect to the ADI-R.

Methods

Participants

Most participants were patients from two clinics, one in London, England ($n = 562$) and the other in Tampere, Finland ($n = 269$). Interviews were conducted as part of a clinical assessment for autism by experienced psychiatrists trained in 3Di administration. We used multisample principal components analysis to assess the transcultural stability of the 3Di. These analyses, which are available on request from the authors, yielded strikingly similar factor solutions in the Finnish and UK samples, so data from both countries have been pooled for subsequent analyses. An additional 48 individuals were included, who were referrals to a general paediatric clinic in Sunderland, UK. These showed no behavioural problems, and had been recruited as a typically developing comparison sample. Of the total sample 500 (57%) met criteria for autism, Asperger syndrome or atypical autism according to the original 3Di ASD algorithm [5]. Mean verbal IQ was 92.0 ($N = 238$, SD = 20.6; range = 46–153). 87% of subjects for whom the appropriate data were available had a verbal IQ of 70 or above. Mean age was 9.9 years (SD = 3.3; range = 2.4–21.1).

Materials

In addition to the 3Di, the autism diagnostic interview-revised (ADI-R) [4] was used in the assessment of criterion validity. This semi-structured, investigator based interview was designed for the differential diagnosis of ASDs, and uses a diagnostic algorithm to generate scores for each element of the autistic triad.

Intellectual ability was measured by a variety of means, depending on the centre from which the child was recruited and their age. Instruments included the British picture vocabulary scale [3], the Wechsler abbreviated scale of intelligence [7] and the Wechsler intelligence scale for children—third edition [8]. Summary variables were computed, from these scores, for verbal IQ, standardized to have a mean of 100 and a standard deviation of 15.

Procedure

Of the 112 3Di ASD algorithm questions, 14 are not universally applicable, mostly because they involve comparison of the proband with a typically developing sibling. These were excluded from the analysis described below. In our data set, 494 individuals had data for each of the remaining 98 algorithm items, and were thus eligible for reliability analysis (RA). 440 of these (i.e. 50% of the overall sample) were selected randomly, with the remaining 439 participants being kept as a 'hold-out sample'. As is shown in Table 1, the RA sample did not differ from the hold-out sample in terms of verbal IQ, age, gender or rates of ASD diagnosis.

In the RA sample, for each domain of the autistic triad (social impairment, communication impairment and repetitive, stereotyped behaviour) Cronbach's alpha [6] was calculated. Within these domains contributory items were ranked according to the impact their removal would have on that domain's Cronbach's alpha. This information was used to select items for a shortened 3Di algorithm, whilst maintaining its original hierarchical structure. The new 3Di-short version (3Di-sv) comprised 53 items.

[1] Plus a further five questions about the age that particular milestones were reached. These are used to distinguish between disorders on the autistic spectrum.

Table 1 Characteristics of reliability analysis sample and 'hold-out' sample

	Reliability analysis sample ($n = 440$)	Hold-out sample ($n = 439$)	Test of group difference
Mean verbal IQ (SD)[a]	93.86 (20.08)	89.72 (21.11)	$t = 1.54$, $P = 0.12$
Mean age, years (SD)	9.99 (3.14)	9.79 (3.31)	$t = 0.89$, $P = 0.38$
Proportion males	79.0%	76.8%	$\chi^2 = 3.70$, $P = 0.16$
Proportion ASD	55.6%	58.2%	$\chi^2 = 0.61$, $P = 0.44$

[a] $N = 238$

In the hold-out sample, we assessed the extent of the association between outputs of the original 3Di and the 3Di-sv. Whilst item overlap made significant associations inevitable, we were interested to learn the extent of the agreement between the long and short forms of the 3Di. We used Pearson correlations to measure dimensional agreement. As a categorical measure of agreement, receiver operating characteristic (ROC) analysis was used to assess the 3Di-sv's ability to discriminate those scoring above or below threshold on the original (long) 3Di for each dimension of the autistic triad. Subsequently, optimal cut-offs were established for the 3Di-sv, which were used to calculate agreement on caseness with the ADI-R in a subsample ($n = 29$) for whom ADI-R and 3Di data had been obtained for the original 3Di validation study [5].

Results

In the reliability analysis (RA) sample internal consistency of the original 3Di's dimensional scores for social impairment ($\alpha = 0.94$), communication impairment ($\alpha = 0.91$) and repetitive, stereotyped behaviour ($\alpha = 0.81$) were in the good to excellent range.

In the hold-out sample, correlations between 3Di original algorithm scores and 3Di-sv scores for each of the triad of impairments were high and significant, all exceeding 0.92 ($P < 0.001$ (see Table 2)). The 3Di-sv was accurate in discriminating those scoring above threshold for abnormality on the 3Di original algorithm for each domain of the autistic triad of impairments, with areas under the curve all in excess of 0.98. The optimal thresholds, chosen to maximise sensitivity and specificity, were as follows: reciprocal social interaction = 11.5, communication = 8, repetitive stereotyped behaviour = 5. All sensitivities and specificities exceeded 0.85.

Agreement between the short and long forms of the 3Di algorithm in terms of overall caseness (ASD vs. non-ASD) was 92% (Kappa = 0.83, asymptotic standard error = 0.02, $P < 0.001$). The proportion of agreements between the 3Di-sv and 3Di original algorithm on overall caseness was examined in three age groups: 0 to <8, 8 to <12 and 12 and above. There was no association between age and level of 3Di-sv/original algorithm agreement (Chi-squared = 4.26, $P = 0.12$).

In order to test the hypothesis that the strong associations between the long and short 3Di algorithm scores merely reflect item overlap, we generated a random short algorithm. We used a random number generator to select items from within each domain of the original 3Di algorithm. This random algorithm was identical to the 3Di-sv in length: 26 reciprocal social items loading onto one scale; 19 communication items loading onto the next scale; and 8 repetitive stereotyped behaviour items loading onto the third scale. This random algorithm generated scores for each domain of the autistic triad and was identical to the 3Di-sv in length. Like the 3Di-sv it was constituted solely of items included in the original 3Di ASD algorithm.

We correlated scores on this random short algorithm with those from the original 3Di algorithm. For each domain of impairment, these correlations were significantly lower ($P < 0.001$) than the equivalent correlations between the 3Di-sv and original 3Di algorithm.

Table 2 Dimensional and categorical agreement between long and short versions of the 3Di

	N	3Di-sv and original 3Di correlation	Receiver operating characteristic analysis		
			Area under the curve	Sensitivity	Specificity
Reciprocal social interaction	439	0.94*	0.98	0.90	0. 96
Communication	439	0.96*	0.98	0.95	0.95
Stereotyped and repetitive behaviours	438	0.92*	0.98	0.96	0.85

3Di-sv thresholds for abnormality derived from ROC analysis: reciprocal social interaction = 11.5, communication = 8, repetitive and stereotyped behaviour = 5

* $P < 0.001$

Table 3 Criterion validity of the original 3Di and the 3Di short version

$N = 29$	Correlation	Agreement on threshold (%)	Kappa (asymptotic standard error)
Original 3Di/3Di short version			
Reciprocal social interaction	0.88**	90	0.61** (0.21)
Communication	0.91**	93	0.47* (0.31)
Stereotyped and repetitive behaviour	0.93**	93	0.85** (0.10)
Original 3Di/ADI-R			
Reciprocal social interaction	0.63**	86	0.52** (0.21)
Communication	0.65**	97	0.65** (0.21)
Stereotyped and repetitive behaviour	0.53*	76	0.50* (0.16)
3Di short version/ADI-R			
Reciprocal social interaction	0.69**	90	0.61** (0.21)
Communication	0.68**	97	0.78** (0.21)
Stereotyped and repetitive behaviour	0.54*	76	0.48* (0.17)

* $P < 0.01$

** $P < 0.001$

Agreement between the ADI-R and the 3Di-sv was high. There was agreement on overall caseness (ASD vs. non-ASD) for 27 out of 29 subjects (Kappa = 0.76, $P < 0.01$). As is shown in Table 3 agreement on threshold for each element of the autistic triad was fair to good (Kappas between 0.47 and 0.85, $P < 0.01$).

Discussion

This brief report describes the use of reliability analysis to inform the construction of a 3Di-sv, which has 53 items, in contrast to the original 112-item 3Di ASD algorithm. Scores on short and original forms of the 3Di were compared. Our analyses revealed a strikingly high degree of agreement between the two algorithms in both dimensional and categorical terms. The level of association surpassed what we would expect merely from the fact that the original and short 3Di algorithms share items.

Like the original 3Di, the 3Di-sv showed a good overall agreement with the ADI-R algorithm. It is a limitation of the study that these ADI-R analyses were based on a small number of cases compared to other analyses reported here. The criterion validity of the 3Di-sv should be further investigated using a larger sample. Nevertheless, the implication of our initial findings is that the 3Di-sv, like the original 3Di, has strong criterion validity. The 3Di's more structured design suggests that reliability and validity will be easier to achieve and maintain than on the ADI-R.

The 3Di is a well validated, reliable instrument for diagnosing autistic spectrum disorders. For those clinicians who wish to use the interview, but who do not have the time to carry out parent interviews that take 1–2 h, the short version should be useful. In addition, the 3Di-sv will be suitable for making thorough, dimensional and quick assessments of social communication difficulties in community and clinical samples for the purposes of research.

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Conflict of interest statement Dr. Skuse and Mr. Warrington are stockholders in IXDX Ltd., which owns exclusive rights to the interview software and the dissemination of 3Di technology and intellectual property.

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