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Comparison of *DSM-IV* and *DSM-5* Factor Structure Models for Toddlers With Autism Spectrum Disorder

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Abstract

Objective—The present study examined the factor structure of autism symptoms in toddlers, to aid understanding of the phenotype during the developmental period that represents the earliest manifestations of autism symptoms. This endeavor is particularly timely, given changes in symptom structure from the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition (DSM-IV) to the recently released Fifth Edition (DSM-5).

Method—Factor structure was examined in a sample of toddlers between 12 and 30 months of age (mean = 20.37 months, SD = 3.32 months) diagnosed with autism spectrum disorder (ASD) and recruited from community settings or referred for evaluation (N = 237). Confirmatory factor analyses were conducted comparing the relative fit of 4 distinct, previously proposed and validated models: *DSM-5*, *DSM-IV*, 1-factor, and an alternative 3-factor model proposed by van Lang *et al*.

Results—Findings revealed that the 1-factor model provided the poorest fit, followed by the *DSM-IV* model and the van Lang *et al*. model. The *DSM-5* model provided the best fit to the data relative to other models and good absolute fit. Indicators for the confirmatory factor analyses, drawn from the Autism Diagnostic Observation Schedule–Toddler Module (ADOS-T), loaded strongly onto the *DSM-5* Social Communication and Social Interaction factor and more variably onto the *DSM-5* Restricted/Repetitive Language and Behavior factor.

Conclusions—Results indicate that autism symptoms in toddlers, as measured by the ADOS-T, are separable and best deconstructed into the 2-factor *DSM-5* structure, supporting the reorganization of symptoms in the *DSM-5*. Consistency of the present results in toddlers with previous studies in older children and adults suggests that the structure of autism symptoms may be similar throughout development.

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Keywords

autism spectrum disorder (ASD); confirmatory factor analysis (CFA); *DSM-5*; factor structure

Although evidence suggests that autism spectrum disorder (ASD) is a neurodevelopmental disorder with genetic causes and biological consequences,[1,2] it is currently diagnosed solely on the basis of behavioral markers.[3] Although the behaviors comprising the autism phenotype are generally well understood, existing studies have failed to yield a consensus on the structure of these symptoms. Comprehensive examination of the factor structure of autism symptoms has important implications for application of diagnostic criteria when making clinical diagnoses and the study of change in symptoms over time, as well as investigations of pathophysiology and etiology.

The *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (*DSM-IV*-TR[4]) deconstructed autism symptoms into 3 distinct domains: (1) Reciprocal Social Interaction, (2) Communication, and (3) Restricted, Repetitive Behaviors and Interests. This structure has been criticized because symptom organization was based on clinical judgment of symptom similarity rather than empirical examination of factor structure. In fact, existing support for this 3-factor structure has been equivocal, with some studies supporting the *DSM-IV* model[5,6] and others finding simpler models to provide the best fit.[7–9] Revisions to diagnostic criteria and their structure have been made for the recently released *DSM-5* based on available research. The potential impact of these revisions has received a great deal of attention, with several groups examining sensitivity and specificity of the new criteria, as well as the proportion of children meeting 1 or both criteria sets.[10–14] However, very few studies have examined data related to the structure of the proposed diagnostic domains, particularly in young children.

DSM-5 diagnostic criteria include just 2 domains, achieved by merging most features described in the first 2 *DSM-IV*-TR domains into 1 Social Communication and Social Interaction domain. Delays in expressive language has been moved out of ASD, because these are not specific to individuals with ASD,[15] whereas the play criterion has been clarified to include only the social (i.e., sharing imaginative play), rather than developmental (i.e., imitative and make-believe play) aspects of play, although repetitive play can be captured in the Repetitive, Restricted Behaviors, Interests, and Activities domain. In addition, unusual language features are now classified in the Repetitive, Restricted Behaviors, Interests, and Activities factor, where unusual sensory interests and responses have been added. A 2-factor structure in general[16–18] and the *DSM-5* model in particular[10,11] have received initial empirical support in children using primarily parent-interview measures.

Despite these recent findings, the field has failed to converge upon 1 best-fitting model. In fact, very few models substantially different from *DSM-IV* and *DSM-5* have been proposed. Georgiades *et al*.[8] proposed a novel 3-factor model comprising 1 factor combining Social and Communication behaviors and 2 factors separating Inflexible Language and Behavior from Repetitive Sensory and Motor Behaviors. Kamp-Becker *et al*.[19] proposed 4 separate factors using the Autism Diagnostic Interview–Revised (ADI-R[20]) and 5 factors using the

Autism Diagnostic Observation Schedule (ADOS[21]). However, exploratory procedures were used in both studies, and neither model has been validated in an independent sample using confirmatory analyses. In a study, van Lang *et al*. proposed a novel model comprised of Social Communication, Repetitive Behavior/Language, and Play,[9] which was independently validated.[7] This model generally parallels the *DSM-5* structure but diverges in its omission of sensory interests and responses and its inclusion of a third Play factor, comprised of impairments in play and relationships with peers. This 3-factor model has been shown to fit better than or similar to other 2-and 3-factor models.[16] In contrast to these multidimensional structures, others have suggested that autism symptoms exist along just 1 dimension,[22,23] although the majority of studies find this 1-factor model to fit poorly.

Although a number of studies have attempted to describe the underlying factor structure of autism symptoms, very few have directly compared existing models. In addition, existing studies have differed in methodology, with wide variations in diagnostic composition and sampling method. Less variation exists in the measure used to index autism symptoms however, as most studies have used the ADI-R, yielding almost no information on the structure of symptoms measured by clinical observation tools (e.g., ADOS). Data analytic procedures represent another critical methodological issue. Many studies have used exploratory factor analysis or principal components analysis, rather than confirmatory analysis (CFA), a statistical approach substantially better suited to determine the best-fitting among existing models.[24] In addition, studies have tended to include very wide age ranges.[7,8,10,11,16,18,22] Although large sample sizes are optimal, analyses of very broad age ranges often fail to take into account the potential impact of developmental changes in symptom presentation on factor structure across the lifespan. Of the studies that compared structure across age or language level,[5,7,10,25] results have been mixed. In most of these studies, broad age groups were compared (e.g., <7 years and ≥7 years[10]), yielding little information on specific periods of development.

Only 1 study to date has examined factor structure in toddlers. Beuker *et al.* examined parent report of autism symptoms in a general population of 18-month-old children.[6] Items subjected to CFA were drawn from several distinct measures, including autism screening tools for toddlers and older children, a general developmental screener, and a measure of temperament. The authors concluded that a *DSM-IV* 3-factor model was marginally, but perhaps not meaningfully, better fitting than a 2-factor model, both of which fit substantially better than a 1-factor model. However, results indicated very similar model fit between the 2- and 3-factor models, with the significance level of the very small difference between the 2- and 3-factor models (i.e., comparative fit index [CFI] = 0.885 and 0.889) likely driven by very large sample size. Given ambiguity of the results, choice of the more parsimonious model (i.e., 2-factor) may also be defensible. The makeup of the sample is an additional consideration, as these data cannot provide evidence for factor structure in toddlers with ASD.

Given this paucity of evidence in very young children with ASD, the question of which model best characterizes toddlers remains unanswered despite the importance of the topic. Optimal diagnostic practices should be based on the presence of early symptoms within empirically derived domains. However, there is a clear need for improving diagnostic practices in toddlers, given the gap between the average age of diagnosis (i.e., 4–5 years[26]) and the earliest ages that stable diagnoses have been reported (i.e., 2 years [27–29]). Factor analytic studies in toddlers have the potential to help bridge this gap in diagnosis, as well as to improve study of early developmental trajectories, as both tasks are contingent upon an accurate understanding of the structure of autism symptoms as they first emerge and unfold across the lifespan.

The purpose of the present study was to examine the factor structure of autism symptoms in toddlers, by comparing existing models that have been previously proposed and independently validated (i.e., *DSM-IV*, *DSM-5*, van Lang *et al.*, and 1-factor models) to determine the model that provides the best fit. In line with the most recent studies in older children,[10,11] it was hypothesized that the *DSM-5* model would provide the best relative fit and provide adequate absolute fit.

Method

Participants and Procedure

The sample was comprised of children recruited from the Florida State University Autism Institute, University of Michigan Autism and Communication Disorders Center, and the Center for Autism and the Developing Brain at New York-Presbyterian Hospital. Children from the Florida State University Autism Institute were included from the FIRST WORDS® Project, a screening program to detect communication delays and ASD through pediatric primary care settings using the Communication and Symbolic Behavior Scales—Developmental Profile.[30] Additional details regarding these screening procedures are reported elsewhere.[31] In contrast, children recruited at University of Michigan Autism and Communication Disorders Center and the Center for Autism and the Developing Brain were referred because of parental or professional concern, or because they had an older sibling with ASD.

Children were included in the present study if they received an ADOS–Toddler Module[32] (ADOS-T) and a clinical diagnosis of ASD at the time of the ADOS-T assessment, with 237 toddlers meeting inclusion criteria. Clinical judgment was used to determine diagnosis, as this continues to be the gold standard in young children.[33,34] In cases in which children received more than 1 ADOS-T, the first was chosen to negate potential practice effects and to yield the youngest sample possible. The majority of children (58%) received a nonverbal developmental quotient (DQ) score within or above normal limits (i.e., ≥85), and most (85%) received a verbal DQ in the range of delay (i.e., <85). Developmental quotients (DQs) were calculated from Mullen Scales of Early Learning[35] subscale age equivalents. Table 1 lists sample demographic and diagnostic evaluation characteristics.

Measures

Autism Diagnostic Observation Schedule–Toddler Module—The ADOS-T is a standardized, semistructured observation of behaviors relevant to a diagnosis of ASD for use in minimally verbal children ages 12 to 30 months.[32] Forty-one items covering the full range of behaviors associated with ASD in toddlers are rated on a 4-point scale, with the 14 items that best distinguish children with ASD comprising the diagnostic algorithms. Although the algorithms mirror the *DSM-5* 2-factor structure, this instrument was developed previous to and independent from *DSM-5* efforts.

Statistical Analysis

Research Aim 1—A series of CFAs was conducted using Mplus software[36] to compare 4 models specified a priori. Maximum likelihood (ML) was used as the method of estimation, as it yields Akiake Information Criterion (AIC) and Bayesian Information Criterion (BIC) values that can be used to compare non-nested models. Using these information criteria, the lowest value in a comparison identifies the model that provides the best and most parsimonious fit relative to other specified models. With regard to interpretation of the degree of difference in values, Raftery suggested that a 10-point difference in BIC values provides very strong evidence (odds ratio, 150:1) that the model with the lowest value is the better-fitting model.[37]

Research Aim 2—Although ML provides the best method for comparison of non-nested models, it is not well suited for examination of absolute fit of the present data, as ML tends to underestimate indices of model fit when indicators are ordinal and yield fewer than 4 thresholds. Thus, the model identified in Aim 1 was reanalyzed using mean- and variance-adjusted weighted least squares (WLSMV) in order to report the least-biased measures of model fit. Indices included root mean square error of approximation (RMSEA) to which a cutoff value of ≤0.05 for good fit was applied, as well as Tucker–Lewis Index (TLI; cutoff ≥0.95) and Comparative Fit Index (CFI; cutoff ≥0.95 for excellent fit).

Model Specification and Indicator Variables—The following 4 models were specified a priori: *DSM-5* 2-factor; *DSM-IV* 3-factor; van Lang *et al.* 3-factor; and 1-factor. For ease of communication, factors are labeled distinctly across models despite similarities. Model 1 comprised a Social Communication and Social Interaction (SCI) factor and a Repetitive/Restricted Language and Behavior (RRLB) factor. Model 2 comprised a Communication (Com) factor, a Social Interaction (Soc) factor, and a Repetitive/Restricted Behavior (RRB) factor. Model 3 comprised a Social Communication factor (SC), a Play factor, and a Stereotyped Behaviors and Language (SLB) factor. Finally, model 4 comprised of 1 Autism factor.

ADOS-T items were used as indicators for the specified latent variables (i.e., factors). However, not all 41 items were included in the present analyses, as some do not directly index autism symptoms (e.g., Overactivity) and strict sample size guidelines indicate that the participant to indicator ratio should be 10:1[38] and the participant to estimated parameters ratio should be 5:1.[39] Thus, a subset of items was systematically chosen for inclusion. All items that appear on 1 or both of the diagnostic algorithms (n = 20) were included as well as nonalgorithm items that measure constructs specifically included in 1 of the models (n = 6; i.e., stereotyped language, play skills), yielding 26 total indicators. Table 2 list items, model specification, and descriptive statistics (also see Table S1, available online, for intercorrelations for all indicators). Missing data were generally minimal, as 22 items had 98.7% coverage. However, unusual language items are scored only for children with sufficient language.[40] Thus, data were missing on Unusual Intonation for 25% of the sample, Immediate Echolalia for 68%, and Stereotyped Language for 81%. The Functional and Symbolic task was not administered to a very small number of children, yielding 8% missing data for this item. Full information maximum likelihood was used to handle missing data in models using ML estimation, and pairwise deletion was used in WLSMV models, as these are the default methods of handling missing data in Mplus.

Results

Model Comparison: Relative Model Fit

A series of CFAs using ML estimation was conducted, comparing the *DSM-5*, *DSM-IV*, van Lang *et al.*, and 1-factor models. AIC and BIC values were used to directly compare relative model fit, with the lowest value in a comparison indicating the best fit. Differences of ≤10 were used to identify substantially better fit.[37] The 1-factor model provided the poorest fit, as AIC and BIC values were highest for this model, with BIC 33 points higher than the next-best–fitting model. The *DSM-IV* model provided the next best fit to the data. The van Lang *et al.* model provided even better fit, with BIC 80 points lower than *DSM-IV* and 113 points lower than the 1-factor model. The *DSM-5* model provided the best fit to the data, as it yielded the lowest AIC and BIC values, such that BIC values were 1,658 to 1,768 points lower than the other models.

Other model fit indices also pointed to the *DSM-5* model as the best fitting. Although RMSEA values were comparable for the *DSM-5* and van Lang *et al.* models, as their confidence intervals were largely overlapping, both CFI and TLI values were highest for the *DSM-5* model. Given the convergence across measures of fit (i.e., AIC, BIC, CFI, and TLI), the *DSM-5* model was identified as the best and most parsimoniously fitting model. See Table 3 for model fit indices.

Evaluation of the DSM-5 Model: Absolute Model Fit Indices of model fit were re-examined for the *DSM-5* model using WLSMV, in order to report the least biased fit indices. This allowed for the ordinal nature of the indicators to be taken into account when examining absolute model fit. Each index of model fit indicated that the *DSM-5* model provided good fit (RMSEA = 0.05, CFI and TLI = 0.96) to the data.

Factor Loadings

Standardized factor loadings are interpreted as regression coefficients representing the relationship between the symptom and the latent factor. Given that factor loading estimates are influenced by sample size and the pattern of loadings in the population,[41] criteria regarding the magnitude and significance level of the loading should be used to determining whether an indicator loads meaningfully. It has been recommended that significance be tested at a more conservative value of $\alpha = .01$ and that sample size be taken into account when interpreting the strength of loadings in factor analysis.[42] The recommended critical value for sample sizes of 200–250 of approximately 0.32 was used for interpretation.[42]

For the SCI factor, loadings ranged from 0.42 to 0.87, with all p values less than .001. In addition, all items specified to load onto this latent factor were found to be meaningful by meeting the minimum value specified a priori (.32). In fact, none of the 95% confidence intervals contained values below the minimum value, and the average loading onto the SCI factor (.66) was well above this cutoff. Among the indicators that provided the most robust fit (i.e., loading >.70) were Frequency of Vocalization, Eye Contact, Facial Expressions, Integration of Gaze and Other Communication, Requesting, Quality of Social Overtures, and Quality of Rapport, a group of symptoms that generally represents each of the 3 SCI diagnostic criteria found in *DSM-5* (i.e., A.1: social emotional reciprocity, A.2: nonverbal communication, A.3: relationships with others).

Standardized factor loadings for the RRLB factor were more variable, ranging from .19 to .72. All of the items that loaded onto this factor were found to be meaningful indicators, as the standardized parameters were above the cutoff of .32 and *p* values were less than .01, with the exception of Hand and Finger Movements. The average loading onto the RRLB factor (.47) was smaller than the average SCI factor loading (.66). Confidence intervals were generally wide and contained values lower than the minimum value of .32 for Immediate Echolalia, Stereotyped Language, Hand and Finger Movements, and Other Complex Mannerisms. However, confidence intervals for Unusual Intonation, Unusual Sensory Interests, and Repetitive Behaviors did not contain values below the minimum value. Interestingly, 2 of the best indicators (Unusual Intonation and Unusual Sensory Interests) are symptoms newly categorized into this domain for *DSM-5*. Table 4 lists all factor loadings.

Discussion

The present study compared the relative fit of 4 previously identified and validated models of symptom structure. The study focused on the earliest manifestations of autism symptoms by utilizing a sample of toddlers diagnosed with ASD. Results from the comparative analyses suggest that autism symptoms as measured by the ADOS-T are separable and best organized into the 2 factors described in *DSM-5*. These results are in contrast to the only other factor analytic study of children in this age range, which found equivocal support for the *DSM-IV* model over 1- and 2-factor models in a general population sample of 18-month-old toddlers.[6] As may be the case across all factor analytic studies in the field, methodological differences likely account for these disparate findings. In this case, differences in measures used to index autism symptoms (clinical observation from the ADOS-T vs. items from several different screening tools and symptom measures) and sample composition (clinical versus unselected nonclinical) likely explain differences in findings.

Superior fit of the *DSM-5* model in the current study lends support to the new symptom structure and its applicability to toddlers. SCI items loaded consistently and strongly onto the latent factor, a finding that supports the behaviors included in this domain for *DSM-5*, the combination of social and communication symptoms, and the overall consistency of this construct. The RRLB loadings were less consistent and lower on average, findings that reflect variability of these behaviors in young children and the wide range of behaviors classified here. The inconsistency of loadings on the RRLB factor points to the need for factor analytic studies of repetitive behaviors themselves in toddlers. Studies that separately model the Insistence on Sameness and Repetitive-Sensorimotor behaviors observed in older children[43–46] may improve the loadings of individual indicators in toddlers, when these putative relationships are taken into account. Surprisingly, Hand and Finger Mannerisms did not significantly load on the RRLB factor, despite being endorsed at a rate (40%) similar to Unusual Sensory Interests (49%) and Unusual Complex Mannerisms (44%) in this sample. This low loading may suggest that the hand movements commonly displayed by toddlers (e.g., finger posturing) do not represent the same construct as other behaviors included on this factor. Findings also support the reorganization of several symptoms in *DSM-5*, as Unusual Sensory Interests (a new symptom) and Unusual Intonation (a symptom previously classified under Communication) demonstrated robust loadings onto the RRLB factor.

These results are consistent with other studies demonstrating the superiority of the *DSM-5* model in older children and adults, [10,11,16–18] suggesting that the factor structure of autism symptoms may be similar throughout development. Although some have documented differences in strength of model fit across age[25] and language level,[5,18] the *DSM-5* model has shown metric and configural invariance across broad age groups[10,11] (i.e., <7 years and ≥7 years) when specifically tested within a CFA framework. The present results extend findings regarding fit of the *DSM-5* model to toddlers. Despite the consistency of initial findings across age groups, it is critical for continued examination of invariance across narrower developmental periods to lend further support to the use of the same structure model across the lifespan.

In addition to the downward extension of the age range of previous studies of symptom structure, a strength of the present research is the use of a relatively novel tool to index autism symptoms subjected to factor analysis. Although most previous research has used parent report interviews (i.e., ADI-R[20]) or screening tools (i.e., Social Responsiveness Scale[47]), the present research extends findings with these tools by using the ADOS-T,[32] a gold-standard clinical observation tool. Use of a novel tool serves to reduce the role of method variance across factor analytic studies with similar findings, and demonstrates that the structure of *DSM-5* is an appropriate framework when gathering information through clinical observation. However, it is important to note that ADOS administration controls for some variance through its use of different tasks and items according to age and language level (i.e., modules). Additional evidence from other measures, particularly tools other than screening and diagnostic measures, would bolster existing and present findings, as it is critical that consensus on the best model of autism symptom structure be achieved across specific tools.

Implications for factor analytic findings in toddlers are wide ranging. Factor structure should inform early screening and diagnosis, as these tasks rely on empirical understanding of both the nature and structure of symptoms. The present findings improve understanding of the structure of early symptoms of ASD, and indicate that measurement of symptoms in both domains, rather than only social communication difficulties, is critical even in very young children. This conclusion is in contrast with suggestions that restricted and repetitive behaviors do not typically emerge during the toddler years.[48,49] Six distinct behaviors and language features within this domain were found to be present and to cluster together, even during the relatively short observation period of the ADOS (i.e., 30–40 minutes). The present results may also inform other areas of research less closely tied to symptom structure. Developmental trajectory of the autism phenotype in infants and toddlers is a topic that has received increasing attention in the literature.[50,51] Examination of these early trajectories is contingent upon understanding which symptoms would be expected to covary and which would show relatively independent change. Given the distinction found between social communication and restricted, repetitive behaviors, it is critical to examine change in these separately, whereas social and communication behaviors may be best examined together.

Limitations of the present research should be considered. Although sufficient for the present analytic approach, the sample size was small relative to recent studies that use national databases. However, the strict inclusion criteria used in this study yielded a homogenous group and allowed for examination of 1 highly specific point in development of young children diagnosed with ASD. Many of the largest samples used for factor analysis come from large-scale databases (i.e., Autism Genetic Resource Exchange [AGRE]), which are limited by their inclusion of primarily multiplex families, who may not be representative of children with ASD from the general population. In contrast, the present sample was drawn from community-based and clinically referred populations, yielding a group of children with wideranging symptom severity and developmental abilities, with many having average or above average nonverbal skills. Using only 1 method of data collection to index a given construct is an important limitation. Consequently, future research should build upon the present findings, which indicated superiority of the *DSM-5* model in toddlers with ASD, by drawing indicators from several different measures including clinical observation and parent report, as well as novel approaches such as naturalistic home observations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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CG Clinical Guidance

- The structure of autism symptoms proposed for use in DSM-5 is an appropriate framework for toddlers with autism spectrum disorder (ASD). Specifically,these results support reduction of the number of domains and reorganization of symptoms proposed for DSM-5. Deficits in social interaction and communication are best conceptualized along 1 dimension, whereas restricted, repetitive behaviors and unusual language features are also best conceptualized on a distinct second dimension.
- Repetitive behaviors and unusual language features were found to be present in this sample of toddlers during a relatively short clinical observation (30—40 minutes), indicating the importance and feasibility of measuring these symptoms even in very young children.
- These findings advance our understanding of the earliest manifestation of clinical symptoms of ASD, which should inform early screening and diagnosis, as these tasks rely on empirical understanding of both the nature and structure of autism symptoms.

Table 1

Child Demographic and Diagnostic Evaluation Characteristics (N = 237)

Characteristic	Value
Gender, male, n (%)	193 (81.4)
Race, n (%)	
White	181 (76.4)
Black	24 (10.1)
Asian	3 (1.2)
Native American	1 (0.4)
Biracial	28 (11.8)
Ethnicity, Hispanic, n (%)	25 (10.5)
Maternal education, n (%)	224 (94.5)
HS graduate or higher	
Age, mo, mean (SD)	20.37 (3.32)
ADOS-T algorithm total, mean (SD)	17.26 (4.49)
MSEL nonverbal DQ, mean (SD)	88.39 (18.24)
MSEL verbal DQ, mean (SD)	62.76 (21.85)

Note: ADOS-T = Autism Diagnostic Observation Schedule—Toddler Module; DQ = developmental quotient; HS = high school; mo = months; MSEL = Mullen Scales of Early Learning.

Table 2

Models Specified and Item Descriptive Statistics

			Model 1 DSM-5 2-Factor		Model 2 3-Factor			Model 3 van Lang *et al*. 3-Factor			Model 4 1-Factor
Variable	**Mean**	**SD**	**SCI**	**RRLB**	**Com**	**Soc**	**RRB**	**SC**	**SLB**	**Play**	**Autism**
1. Frequency of Vocalizations	1.81	1.03	×		×			×			×
2. Pointing	1.91	1.06	×			×		×			×
3. Gestures	1.62	0.89	×			×		×			×
4. Eye Contact	1.45	0.66	×			×		×			×
5. Facial Expressions	1.57	0.82	×			×		×			×
6. Integration of Gaze and Communication	1.42	0.69	×			×		×			×
7. Shared Enjoyment	1.08	0.98	×			×		×			×
8. Requesting	1.14	0.97	×			×		×			×
9. Showing	2.16	1.03	×			×		×			×
10. Initiation of Joint Attention	1.56	1.24	×			×		×			×
11. Quality of Social Overtures	1.43	0.64	×			×		×			×
12. Amount of Social Overtures–Caregiver	1.45	0.80	×			×		×			×
13. Quality of Rapport	1.50	0.84	×			×		×			×
14. Response to Name	1.45	1.22	×			×		×			×
15. Response to Joint Attention	1.01	1.10	×			×		×			×
16. Ignore	1.68	1.08	×			×		×			×
17. Functional and Symbolic Imitation	1.76	1.00			×					×	×
18. Functional Play	1.40	0.71			×					×	×
19. Imagination and Creativity	2.02	0.93			×					×	×
20. Unusual Sensory Interests	0.89	1.05		×							
21. Unusual Hand and Finger Movements	0.75	1.01		×			×		×		×
22. Unusual Complex Mannerisms	0.89	1 .10		×			×		×		×
23. Unusually Repetitive Interests/Behaviors	1.44	0.83		×			×		×		×
24. Unusual Intonation	1.17	0.95		×	×				×		×
25. Immediate Echolalia	0.71	0.69		×	×				×		×
26. Stereotyped Language	0.75	0.75		×	×				×		×

Note: Com = Communication; RRB = Repetitive/Restricted Behavior; RRLB = Repetitive/Restricted Language and Behavior; SC = Social Communication; SCI = Social Communication and Social Interaction; SLB = Stereotyped Behaviors and Language; Soc = Social Interaction.

Table 3

Model Fit Indices for Maximum Likelihood Analyses

Model Fit Statistic	*DSM-5* Model	*DSM-IV* Model	van Lang *et al.*[9] Model	1-Factor Model
AIC	12301	13997	13918	14041
BIC	12543	14278	14198	14311
RMSEA (95% CI)	0.061 (0.052–0.069)	0.068 (0.060–0.075)	0.059 (0.051–0.067)	0.072 (0.065–0.079)
CFI	0.867	0.811	0.858	0.784
TLI	0.853	0.793	0.844	0.765

Note: AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; CFI = Comparative Fit Index; RMSEA = root mean squared error of approximation; TLI = Tucker–Lewis Index.

Table 4

Standardized Parameter Estimates

Characteristic	Loading on SCI	95% CI	Loading on RRLB	95% CI	SE
1. Frequency of Vocalizations	0.80***	0.75–0.85	—	—	0.03
2. Pointing	0.64***	0.56–0.71	—	—	0.04
3. Gestures	0.58***	0.51–0.65	—	—	0.04
4. Eye Contact	0.77***	0.72–0.83	—	—	0.03
5. Facial Expressions	0.71***	0.65–0.78	—	—	0.04
6. Integration of Gaze and Communication	0.87***	0.83–0.91	—	—	0.03
7. Shared Enjoyment	0.59***	0.51–0.67	—	—	0.05
8. Requesting	0.77***	0.71–0.83	—	—	0.04
9. Showing	0.55***	0.47–0.64	—	—	0.05
10. Initiation of Joint Attention	0.48***	0.39–0.57	—	—	0.06
11. Quality of Social Overtures	0.74***	0.68–0.80	—	—	0.04
12. Amount of Social Overtures–Caregiver	0.60***	0.52–0.67	—	—	0.05
13. Quality of Rapport	0.80***	0.75–0.85	—	—	0.03
14. Response to Name	0.42***	0.32–0.52	—	—	0.06
15. Response to Joint Attention	0.58***	0.50–0.68	—	—	0.05
16. Ignore	0.43***	0.34–0.53	—	—	0.06
17. Unusual Sensory Interests	—	—	0.68***	0.53–0.83	0.09
18. Unusual Hand and Finger Movements	—	—	0.19	0.02–0.36	0.10
19. Unusual Complex Mannerisms	—	—	0.43***	0.28–0.58	0.09
20. Unusually Repetitive Interests/Behaviors	—	—	0.47***	0.32–0.61	0.09
21. Unusual Intonation	—	—	0.72***	0.56–0.89	0.10
22. Immediate Echolalia	—	—	0.38**	0.16–0.61	0.13
23. Stereotyped Language	—	—	0.45**	0.21–0.69	0.14

Note: RRLB = Repetitive/Restricted Language and Behavior; SCI = Social Communication and Social Interaction; SE = standard error.

** p < .01

*** p < .001.