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Author/s:
Uljarević, M;Carrington, SJ;Hardan, AY;Leekam, SR

Title:
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Date:
2022-05-01

Citation:
Uljarević, M., Carrington, S. J., Hardan, A. Y. & Leekam, S. R. (2022). Subdomains of restricted and repetitive behaviors within autism: Exploratory structural equation modeling using the diagnostic interview for social and communication disorders. Autism Research, 15 (5), pp.861-869. https://doi.org/10.1002/aur.2687.

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Received: 13 July 2021 | Accepted: 15 January 2022

DOI: 10.1002/aur.2687

SHORT REPORT

Subdomains of restricted and repetitive behaviors within autism: Exploratory structural equation modeling using the diagnostic interview for social and communication disorders

Mirko Uljarević[1] | Sarah J. Carrington[2] | Antonio Y. Hardan[3] | Susan R. Leekam[4]

[1]Faculty of Medicine, Dentistry, and Health Sciences, Melbourne School of Psychological Sciences, The University of Melbourne, Melbourne, Australia

[2]School of Psychology, College of Health and Life Sciences, Aston University, Birmingham, UK

[3]Department of Psychiatry and Behavioral Sciences, Stanford University, Stanford, California, USA

[4]School of Psychology, College of Biomedical and Life Sciences, Cardiff University, Cardiff, UK

Correspondence
Mirko Uljarević, Faculty of Medicine, Dentistry, and Health Sciences, Melbourne School of Psychological Sciences, The University of Melbourne, Victoria, Australia.
Email: mirko.uljarevic@unimelb.edu.au

Funding information
National Institute of Mental Health, Grant/Award Number: R21MH121876-01; Leverhulme Emeritus Fellowship, Grant/Award Number: EM-2021-053\10; Australian Research Council Discovery Early Career Researcher Award, Grant/Award Number: DE180100632

Abstract

The current study aimed to explore the factor structure of a broad range of restricted and repetitive behaviors (RRB) within the autism spectrum. Exploratory structural equation modeling was conducted using individual item-level data from the Diagnostic Interview for Social and Communication Disorders (DISCO). DISCO is a comprehensive semi-structured interview used by clinicians to elicit information from caregivers about the individual's profile of development and behavior. Data from a sample of 226 individuals with a clinical diagnosis of autism spectrum disorder (ASD) (189 males; M_{age} = 11.82 years, SD_{age} = 7.87) were analyzed. The six-factor structure provided the most optimal and interpretable fit (comparative fit index = 0.944, Tucker–Lewis index = 0.923, root mean square error of approximation = 0.018). Derived factors were interpreted as repetitive motor behaviors (RMB), unusual sensory and object focused interests (USOI), sensory sensitivity (SS), insistence on sameness (IS), circumscribed interests (CI) and stereotyped language (SL). Age was significantly negatively associated with RMB, USOI and SL but not with SS, IS or CI factor scores. None of the factors were associated with sex. ASD individuals with intellectual disability (ID) had the highest RMB, USOI, SS and SL scores while those without ID had the highest IS and CI scores. Our findings provide preliminary evidence for the utility of the DISCO as a comprehensive measure of several distinct RRB domains in both research and clinical contexts. Importantly, the current investigation highlights crucial areas for measurement development.

Lay Summary

The diagnostic Interview for Social and Communication Disorders (DISCO) is a detailed caregiver report clinical interview designed to capture a wide range of key features associated with autism spectrum disorder, including restricted and repetitive behaviors (RRB). This paper provides initial evidence that the DISCO is a promising measure for assessing a wide range of RRB including repetitive motor behaviors, insistence on sameness, circumscribed interests, unusual interests in sensory stimuli, sensory sensitivity and stereotypic language.

KEYWORDS
circumscribed interests, diagnostic interview for social and communication disorders, factor analysis, insistence on sameness, repetitive behaviors, sensory sensitivity

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INTRODUCTION

Despite a long-standing interest in how best to categorize restricted and repetitive behaviors (RRB) in autism spectrum disorder (ASD), our field still lacks a robust and comprehensive empirically derived RRB taxonomy. Current views of the classification of RRB have been mainly dictated by factor analytic investigations of diagnostic interviews such as the Autism Diagnostic Interview-Revised (ADI-R; Rutter et al., 2003) and dedicated RRB questionnaires such as the Repetitive Behavior Scale-Revised (RBS-R; Bodfish et al., 2000), most of which rely on caregiver reports. Factor analyses using both types of measures, consistently yielded Repetitive motor behaviors (RMB), encompassing a range of motor stereotypies, and insistence on sameness (IS; Bishop et al., 2013; Cuccaro et al., 2003; Georgiades et al., 2010). In addition, several studies using the ADI-R (Bishop et al., 2013; Honey et al., 2008; Lam et al., 2008) and the RBS-R (Bishop et al., 2013; Hooker et al., 2019; Lam & Aman, 2007; Mirenda et al., 2010) have identified an additional factor representing intense focus on specific topics, objects and/or activities, labeled circumscribed interests (CI).

However, several limitations are evident with regards to RMB, IS, and CI subdomains derived across the RBS-R and the ADI-R. First, there is inconsistency in the items classified within these three factors across studies. For instance, several ADI-R items, including unusual preoccupations, abnormal response to specific sensory stimuli, and unusual attachment to objects, have loaded onto the RMB (Bishop et al., 2006; Bishop et al., 2013; Shao et al., 2003), IS (Smith et al., 2009) and CI factors (Honey et al., 2008; Lam et al., 2008), or were not included in the final factor solution (Cuccaro et al., 2003; Hundley et al., 2016; Richler et al., 2010). Second, the derived factors are dictated by the item content of a given measure. The ADI-R and the RBS-R each have only three items covering different aspects of atypical sensory behaviors (such as unusual sensory interests and sensory sensitivity [SS]). In addition, both have only one CI item that simultaneously captures two different aspects—the unusual nature of the interest in terms of focus or subject (e.g., interest in traffic lights, license plates, etc.) and in terms of intensity even when subject-focus is typical or age-appropriate. Such limited number of items may constrain the identification of more fine-grained domains. Although RBS-R has been shown to provide self-injurious behaviors and compulsions subscales (e.g., Bishop et al., 2013; Uljarević et al., 2021a), given the noted limitations and limited item pool, it is possible that additional, clinically relevant RRB categories could emerge when using measures with more varied items. Two recent cross-measurement studies (Grove et al., 2021; Uljarević et al., 2021b) provide support for the suggestion that lack of item coverage is an issue that can limit the ability to identify more fine-grained factors. More specifically, by combining items across different instruments, both Grove et al. (2021) and Uljarević et al. (2021b) were able to identify a SS factor. Further, in a study by Uljarević et al. (2021b) items capturing interests and related behaviors that were unusual in terms of content loaded onto separate unique factor when compared to items capturing interests unusual in terms of intensity and/or inflexibility rather than content.

The current study utilized exploratory structural equation modeling (ESEM; Asparouhov & Muthén, 2009; Marsh et al., 2014) to investigate the RRB factor structure of the Diagnostic Interview for Social and Communication Disorders (DISCO; Leekam et al., 2002; Wing et al., 2002). The DISCO is a comprehensive interview schedule designed to capture a wide range of developmental skills and behaviors based on a broad concept of a spectrum of autistic disorders. It contains RRB items capturing RMB, vocal stereotypies, unusual sensory interests and atypical responses to sensory stimuli, routines and IS, and CI. When compared to the most widely used instruments such as the ADI-R and the RBS-R, DISCO provides a more detailed capture of (i) SS (two items in the ADI-R and no items in the RBS-R), (ii) sensory related behaviors (three items in the RBS-R and one item in the ADI-R), and (iii) restricted interests (three items in the ADI-R and two items in the RBS-R). A small subset of DISCO RRB interview items is included in a parent-report questionnaire format, the repetitive behavior questionnaire (RBQ-2; Leekam, Tandos, et al., 2007), and self-report questionnaire format, the repetitive behavior questionnaire-adult version (RBQ-2A; Barrett et al., 2015; Barrett et al., 2018). Analysis of the RBQ-2 reveals two broader factors (RSMB and IS) in neurotypical children, based on caregiver reports (Leekam, Nieto, et al., 2007; Leekam, Tandos, et al., 2007; Uljarević et al., 2017) and adults, based on self-reports (Barrett et al., 2015; Jia et al., 2019) and in autistic children and adolescents, based on caregiver reports (Lidstone et al., 2014) and adults, based on self-reports (Barrett et al., 2018). However, the range of DISCO RRB interview items goes well beyond the RBQ-2 item subset, including additional items relevant to CI, sensory responsiveness, and language. Given current questions about the role of CI and sensory behaviors within the broader RRB domain, more specifically, whether CI domain is best conceptualized as a single domain, encompassing both interests that are unusual in terms of intensity and inflexibility but not content and interests unusual in terms of content, or whether these two aspects of CI are best represented as two separate factors and whether sensory behaviors form a separate domain or are best seen as part of a more general factor (for instance, sensory-motor behaviors), this study conducted a comprehensive exploration of the DISCO RRB factor structure using a broader range of RRB items in their original interview form. In addition, we examined the relationship of the derived factors with age, sex, and intellectual disability (ID) status.

METHOD

Participants

The sample comprised 226 individuals with a clinical diagnosis of DSM-IV Autistic Disorder or ICD-10 Childhood Autism (189 males, 37 females; $M_{age} = 11.82$ years, $SD_{age} = 7.87$, range = 2.67–38.0). The sample used in this study comprised samples from two independent studies. Sample 1 (Leekam et al., 2002; Wing et al., 2002) comprised 36 individuals with ASD (31 males, five females; $M_{age} = 7.12$ years, $SD_{age} = 2.58$, range = 2.83–11.08) recruited through clinical services and special schools. Sample 2 (Leekam et al., 2000; Leekam, Nieto, et al., 2007; Leekam, Tandos, et al., 2007) comprised 190 individuals with ASD (158 males, 32 females; $M_{age} = 12.71$ years, $SD_{age} = 8.22$, range = 2.67–38.0) recruited through the specialist referral centre for diagnosis and assessment. Diagnoses in both samples were made by qualified clinicians. Eighty-eight (39%) of the total sample had ID (16 in Sample 1 and 72 in Sample 2), defined at the time of recruitment as IQ below 70 (ASD-ID) and 138 had IQ above 70 (ASD-no ID). The grouping into ASD-ID and ASD-no ID subgroups was based on either the Leiter international performance scale (Leiter, 1979) or the Bayley scale for infant development (Bayley, 1993) scores. Recruitment and data collection for Sample 1 took place between 1996 and 1997 and for Sample 2 between 1992 and 1997. The use of the anonymized UK datasets for secondary data analysis of all variables was approved by Cardiff University, School of Psychology Ethics Committee.

Measures

The DISCO is a 320-item semi-structured interview used by clinicians to elicit information from caregivers about the individual's profile of development and behavior. Across different samples, it has been shown to have good sensitivity and specificity (Carrington et al., 2014, 2015; Kent et al., 2013; Maljaars et al., 2012), internal consistency (Cronbach's $\alpha = 0.95$) and interrater reliability ($\kappa \geq 0.7$) (Wing et al., 2002) and criterion validity (Leekam et al., 2002; Maljaars et al., 2012; Nygren et al., 2009). Fifty-three DISCO items were included in the initial RRB factor analysis. Following Wing's scoring guidance (Wing et al., 2002), each item is rated on 3-point Likert severity scale (0 = Not present, 1 = Minor, 2 = Severe or marked). Analysis used scores of current behavior only, with "Marked" ratings separated from other ratings. Items were selected for inclusion based on the manual that specifies which items are part of the RRB domain. In addition, authors reviewed all individual DISCO items to ensure that any potentially relevant items were not missed.

Data analysis

We utilized ESEM (Asparouhov & Muthén, 2009) with geomin rotation, given that constructs were likely to be correlated (Marsh et al., 2014). Models with 1–7 factors were estimated and the weighted least square estimator was used. Optimal model identification was guided by a combination of the comparative fit index (CFI), the Tucker–Lewis index (TLI), the root mean square error of approximation (RMSEA), and the chi-square test model indices and interpretability. CFI and TLI values of >0.90 and >0.95 and RMSEA values of <0.08 and <0.06 indicate adequate and excellent fit, respectively (Bentler, 1998). In addition, the 90% confidence interval for the RMSEA was used to test significance with a threshold of <0.08, with the close fit-test significance level set at a p value of >0.05. ESEM was conducted with MPLUS 8.0 (Muthén & Muthén, 2007). Associations between factors represent correlations between latent variables with geomin rotation derived through ESEM. Comparison of the derived RRB factor scores in the ASD-ID, ASD-no ID was conducted using univariate models with age as a covariate due to age differences between groups. All comparisons were supplemented with ω^2 and post-hoc comparisons with Cohen's d effect sizes. Correlational and comparison models were conducted using the statistical package for the social sciences (SPSS v. 25.0, New York, NY; IBM Corp, 2016) and were performed through bootstrapping using 5000 resamples to provide more robust statistics and account for the potential skewness of the data (Efron & Tibshirani, 1993).

RESULTS

The ESEM models are presented in Table 1. One- to four-factor solutions had unsatisfactory fit based on the CFI and TLI (both <0.90) and although the five-factor solution had CFI of 0.924, indicating adequate fit, TLI was slightly below 0.90. The six- and seven-factor solutions both had adequate to excellent fit across all indices, however, the additional 7th factor only consisted of items that showed significant cross-loading across at least two different factors. Therefore, the six-factor solution, reported in Table 2 was retained as optimal. Factors were interpreted as repetitive motor behaviors (RMB; seven items), unusual sensory and object focused interests (USOI; 14 items), sensory sensitivity (SS; six items), insistence on sameness (IS;seven items), circumscribed interests (CI;(seven items) and stereotyped language (SL; three items). Four items did not significantly load on any of the six factors, three other items showed correlation of 1 with several other items, and two items showed significant cross-loading across several factors and were therefore eliminated. Detailed information about eliminated items is included in Table 2. Individual item endorsement

TABLE 1 Summary of goodness of fit statistics across all tested models

Model	χ^2 (df)	CFI	TLI	RMSEA (90%CI)
ESEM 1 factor	1227.324** (860)	0.594	0.573	0.043 (0.038; 0.049)
ESEM 2 factors	1021.108** (818)	0.775	0.752	0.033 (0.026; 0.040)
ESEM 3 factors	901.24** (777)	0.863	0.840	0.027 (0.018; 0.034)
ESEM 4 factors	833.612** (737)	0.893	0.869	0.024 (0.013; 0.032)
ESEM 5 factors	768.509* (698)	0.922	0.899	0.021 (0.007; 0.030)
ESEM 6 factors	710.85 (660)	0.944	0.923	0.018 (0.037; 0.054)
ESEM 7 factors	652.229 (623)	0.968	0.953	0.014 (0.000; 0.026)

Abbreviations: CFI, comparative fit index; ESEM, exploratory structural equation modeling; RMSEA, root mean square error of approximation; TLI, Tucker–Lewis index.
*< 0.01. **< 0.001.

across four different age groups (aged 2–6, 7–12, 13–17 and 18+ years) divided by the ID/No ID status is provided in Table S1.

Figure 1 shows correlations between the RRB latent variables. The RMB factor was weakly related to IS ($r = 0.14$, $p = 0.031$) and SS ($r = 0.23$, $p < 0.001$), and moderately related to USOI ($r = 0.41$, $p < 0.001$). IS was weakly associated with SL ($r = 0.14$, $p = 03$), USOI ($r = 0.21$, $p = 0.001$) and CI ($r = 0.23$, $p < 0.001$) and moderately with SS ($r = 0.33$, $p < 0.001$). Finally, SS was associated with USOI ($r = 0.22$, $p = 0.001$), and showed weak relationships with other factors.

None of the factors were associated with sex. Age was significantly negatively associated with RMB ($r = -0.23$, $p < 0.001$), USOI ($r = -0.26$, $p < 0.001$) and SL ($r = -0.24$, $p < 0.001$) but not significantly associated with SS, IS nor CI factor scores. Detailed comparison between ASD individuals with (ASD-ID), and without ID (ASD-No ID) across all RRB factors is shown in Table 3. Univariate linear models with age as a covariate showed significant group effects across all domains with the ASD-ID group showing higher RMB, USOI, SS and SL scores and the ASD-No ID group higher IS and CI scores.

DISCUSSION

In an exploratory structural equation modelling analysis of the factor structure of RRB items from the DISCO, a six-factor structure emerged as the best fit to the data. Overall, this factor structure confirms the stability of the RMB and IS factors previously reported in studies using the ADI-R (Bishop et al., 2013; Cuccaro et al., 2003; Richler et al., 2010), RBS-R, RBQ, and RBQ-2 (Barrett et al., 2018; Bishop et al., 2013; Honey et al., 2008; Hooker et al., 2019; Lam et al., 2008). Our analysis further identified a factor that mostly captured behaviors and interests that could mainly be described as typical or age-appropriate in theme or subject (for instance, collecting facts on a specific subject, collecting objects), but which were unusually intense or marked in nature. Therefore, the current CI factor appears more conceptually homogeneous than the CI factor emerging from the ADI-R (Honey et al., 2008; Lam et al., 2008; Smith et al., 2009) and RBS-R (Bishop et al., 2013; Hooker et al., 2019; Lam et al., 2008; Mirenda et al., 2010) that include items such as fascination with metal objects, lights or street signs (ADI-R), and fascination/preoccupation with movement and part(s) of objects (RBS-R item) that could also be described as having a sensory component. In the current analysis, items relating to parts of objects or unusual focus or theme of sensory interest formed a separate USOI factor. However, this factor also included two object-focused stereotypies ("Elaborate repetitive actions with objects", "Aimless and repetitive manipulation of objects") that although potentially sensory in nature might also be more related to specific routines. Further, one of the items "Spins self around" showed similar loading onto the RMB and USOI factors, which is not surprising given that that this item has both sensory and motor component. Future research is needed to further explore the stability of USOI factor. In particular, it is of crucial importance to study the continuities and discontinuities between repetitive motor behaviors and behaviors that achieve sensory feedback through motor repetition and how USOI factor identified here corresponds to sensory interests, repetitions, and seeking behaviors (Ausderau et al., 2014) and to a lesser extent sensory seeking (Dunn & Brown, 1997) factors commonly derived in the sensory features literature. Multi-trait multi-method factor analytic studies across different instruments will be needed to address this question. In the current analysis, in addition to USOI, a separate SS factor encompassing items capturing hyper- and hypo-sensitivity to sensory stimuli also emerged. The final factor was the SL factor that included items such as immediate and delayed echolalia and interest in letters and words. It is possible that fascination with the sound of particular words/phrases could explain the shared loading. It is important to highlight that this factor includes items reflecting interest that can have an adaptive element (Mottron, 2017), or at least inherent reward value for the individual. Therefore, this factor should be

TABLE 2 ESEM factor loadings for six-factor solution

	RMB	USOI	SS	IS	CI	SL
Jumps up and down with excitement	**0.441**	0.243	−0.662	0.02	0.108	0.114
Unusual movements of hands or arms (e.g., flap)	**0.829**	−0.061	−0.2	0.122	0.062	−0.112
Midline hand stereotypies	**0.457**	0.011	0.27	−0.007	0.278	0.135
Rocks sitting down	**0.554**	−0.089	0.37	−0.08	−0.169	−0.135
Rocks standing up	**0.602**	0.077	0.559	0.043	−0.345	−0.001
Complex twisting or rocking movements	**0.305**	0.273	−0.002	−0.032	0.205	−0.165
Unusual facial grimaces (no obvious reason)	**0.537**	0.12	0.103	0.108	−0.041	−0.182
Aimless and repetitive manipulation of objects	−0.241	**0.742**	0.237	0.129	0.085	−0.222
Likes being spun around	−0.016	**0.546**	−0.179	0.215	−0.29	0.093
Spins self around	0.391	**0.393**	−0.318	0.196	−0.084	0.141
Elaborate repetitive actions with objects	−0.18	**0.696**	−0.091	0.064	0.133	−0.001
Interest in bright lights and shiny things	0.149	**0.63**	−0.022	−0.189	−0.03	−0.119
Interest in watching things spin	0.23	**0.777**	−0.068	−0.054	−0.087	−0.193
Twists hands or objects near eyes	0.188	**0.481**	0.309	−0.053	−0.039	−0.04
Studies objects from different angles	0.141	**0.603**	−0.091	0.035	−0.002	0.139
Shrieks and other odd noises	0.404	**0.457**	−0.04	0.058	−0.029	0.143
Unusual interest in the feel of surfaces	0.212	**0.358**	0.03	0.011	−0.184	−0.092
Scratches and taps surfaces	−0.22	**0.563**	0.085	0.171	0.114	−0.058
Interest in parts of objects	0.232	**0.3**	0.076	0.272	−0.072	−0.031
Interest in the abstract properties of objects	−0.345	**0.71**	0.102	−0.195	−0.004	0.298
Fascination with sounds	0.356	**0.49**	0.389	−0.292	0.352	0.245
Unusual reaction to gentle touch	0.083	0.036	**0.692**	0.292	−0.024	−0.164
Unusual reaction to firm touch	−0.13	0.25	**0.772**	0.117	0.001	−0.182
Dislikes being washed	0.093	0.065	**0.354**	0.103	0.076	0.246
Indifference to pain, heat, cold	0.268	0.201	**0.376**	0.107	−0.019	−0.088
Distress caused by sounds	0.221	−0.085	**0.412**	0.275	0.023	0.295
Acuteness of hearing	0.242	0.001	**0.405**	−0.112	0.101	0.298
Eats only a small range of foods	0.119	0.092	−0.169	**0.352**	0.096	0.316
Insists on sameness in the environment	0.125	−0.06	0.086	**0.714**	−0.011	0.021
Insists on perfection	−0.095	−0.122	0.12	**0.468**	0.161	0.047
Insists on sameness in routines	−0.131	0.114	0.191	**0.707**	−0.021	0.15
Clings to home or familiar place	0.136	−0.21	0.119	**0.767**	0.123	−0.192
Arranges objects in patterns	0.073	0.178	0.047	**0.407**	0.106	0.004
Clings to objects	−0.038	0.34	0.014	**0.377**	0.165	0.103
Interest in specific pictures	0.374	−0.081	0.101	0.024	**0.426**	0.269
Fascinated with a specific object	0.247	0.291	−0.13	−0.07	**0.452**	0.142
Collects facts on a specific subject	−0.157	−0.144	0.083	0.079	**0.624**	−0.353
Asks repetitive questions	−0.177	0.059	0.165	0.206	**0.366**	0.129
Collects objects (no apparent purpose)	−0.13	0.15	−0.162	0.23	**0.384**	−0.086
Repetitive actions related to special skills	−0.079	−0.122	0.02	0.135	**0.693**	−0.108
Repetitive theme	−0.038	0.072	0.014	0.019	**0.877**	0.204
Immediate echolalia	0.057	0.227	0.028	−0.005	−0.268	**0.607**
Delayed echolalia	−0.071	−0.018	0.072	0.273	−0.064	**0.681**
Interest in letters/words	−0.231	−0.046	0.001	−0.048	0.204	**0.696**

Note: Eliminated items: Four items did not significantly load on any of the six factors ("Smells objects or people (explores by smelling)", "Other repetitive routines", "Idiosyncratic use of words, signs", "Speaks in unusual tone of voice"), three items showed correlation of 1 with several other items ("Makes sudden jerky movements", "Fascinated with particular TV/video/films", "Limited pattern of self-chosen activities") and two items showed significant cross-loading across several factors ("Mouthing or swallowing objects", "Longwinded pedantic speech") and were therefore not included in the final factor solution.

Abbreviations: CI, circumscribed interests; IS, insistence on sameness; RMB, repetitive motor behaviors; SL, stereotyped language; SS, sensory sensitivity; USOI, unusual sensory and object focused interests.

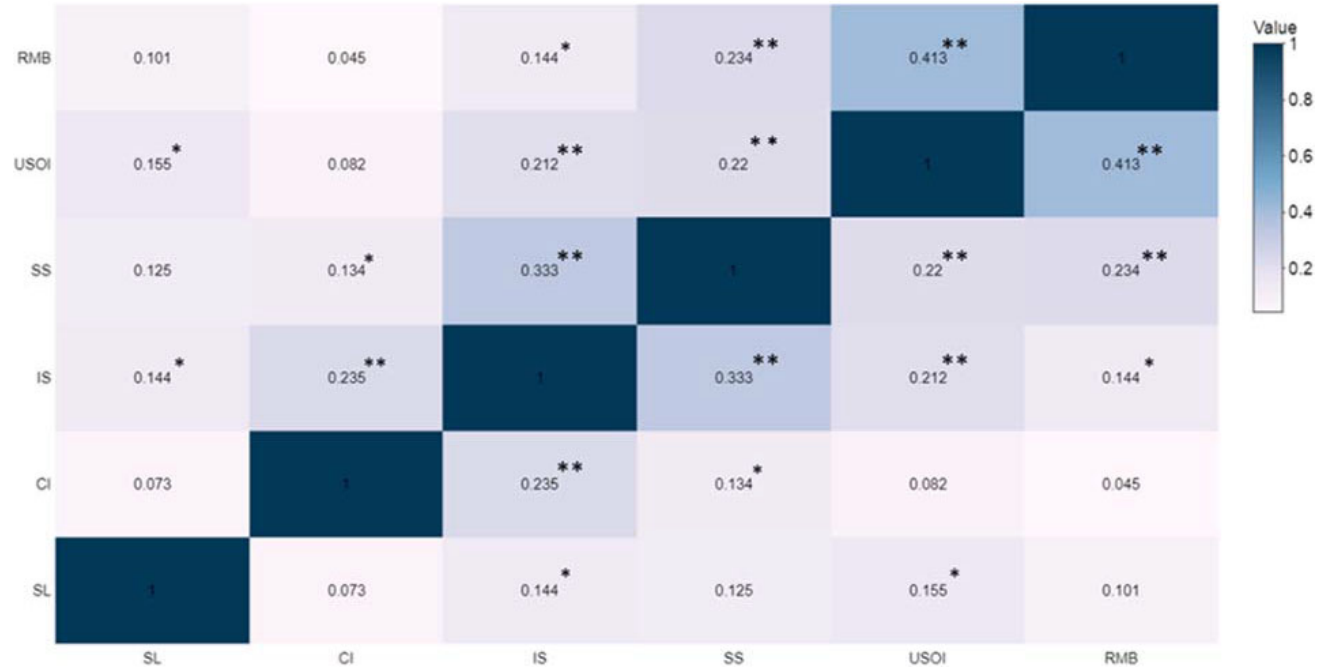


FIGURE 1 Heatmap of association between DISCO RRB factors. *Note*: *$p < 0.05$; **$p < 0.01$; CI, circumscribed interests; IS, insistence on sameness; RMB, repetitive motor behaviors; SL, stereotyped language; SS, sensory sensitivity; USOI, unusual sensory and object focused interests. Associations between factors represent correlations between latent variables with geomin rotation derived through ESEM

TABLE 3 Comparison of RRB factor scores

	ASD-ID	ASD-no ID	
	M(SD)	*M*(SD)	Statistics
RMB	2.36 (1.76)	1.30 (1.42)	$F = 24.87$, $p < 0.001$, $\omega^2 = 0.16$
USOI	2.62 (2.6)	1.72 (1.99)	$F = 11.43$, $p < 0.001$, $\omega^2 = 0.08$
SS	1.69 (1.59)	1.39 (1.33)	$F = 6.77$, $p = 0.001$, $\omega^2 = 0.05$
IS	1.69 (1.55)	2.33 (1.71)	$F = 16.07$, $p < 0.001$, ω^2 0.11
CI	1.06 (1.09)	1.50 (1.23)	$F = 7.52$, $p < 0.001$, $\omega^2 = 0.06$
SL	0.76 (0.92)	0.60 (0.73)	$F = 7.40$, $p = 0.001$, $\omega^2 = 0.05$

Note: DISCO RRB items are rated on a 3-point Likert severity scale (0 = Not present, 1 = Minor, 2 = Severe or marked), for the purpose of this analysis they were collapsed into binary scoring (scores or 1 and 2 were collapsed into 1).
Abbreviations: CI, circumscribed interests; IS, insistence on sameness; RMB, repetitive motor behaviors; SL, stereotyped language; SS, sensory sensitivity; USOI, unusual sensory and object focused interests.

considered as preliminary and further research is needed to clarify the nature and validity of the item loadings.

For both the RMB and USOI factors, negative associations with age and higher scores among ASD individuals with ID support proposals that repetitive sensory-motor behaviors are related to younger age and lower IQ (Bishop et al., 2013; Cuccaro et al., 2003). Out findings also support the majority of studies that failed to find a significant relationship between age and either IS or CI (Hus et al., 2007; Lam et al., 2008; South et al., 2005), or between age or ID status and SS (Baranek et al., 2013; Lane et al., 2014). Furthermore, no significant sex differences on any of the RRB domains were found, supporting a number of studies using ADI-R and RBS-R (Hus et al., 2007; Lam et al., 2008; Sutherland et al., 2017) as well as the RBQ-2 (Barrett et al., 2015; Barrett et al., 2018). However, given sex differences in CI found by other studies (Frazier & Hardan, 2017; Hiller et al., 2014; Knutsen et al., 2019), further research should assess potential moderating and mediating variables (e.g., developmental level) and potential measurement-related biases. When considering the lack of sex differences with regards to the DISCO CI subscale, it is important to highlight that while more comprehensive than CI subscale of the ADI-R and RBS-R, DISCO CI subscale was nevertheless still limited in terms of the interests that

were captured. Indeed, several previous studies have suggested that sex differences only emerge for specific CI, rather than overall domain (e.g., Hiller et al., 2014; Nowell et al., 2019). Therefore, it will be important for future studies to supplement general diagnostic or RRB instruments (e.g., DISCO or RBS-R) with dedicated CI measures such as the special interests motivation scale (Grove et al., 2016) or the Yale survey of special interests (Klin et al., 2007) in order to refine our understanding of sex differences in specific aspects of this RRB subdomain.

The current study has several limitations. It is important to acknowledge that the study utilized two samples diagnosed according to previous iteration of diagnostic criteria. Given the somewhat modest sample size, it is possible that a larger sample size would have resulted in an even more fine-grained RRB structure. Therefore, findings reported here should be considered as somewhat preliminary and further replication is essential. This is particularly relevant to the USOI factor, which, as noted, potentially encompasses both unusual sensory interests and object-focused stereotypies. In addition, given the sample size, it was not possible to evaluate invariance of the derived factor structure across age, sex and ability level. In particular, number of female participants was low. Further, given the predominance of children in the sample utilized here, it is possible that some of the findings might not fully replicate in older adolescence and adulthood. Therefore, future studies should replicate and potentially refine factors identified here, and identify items that might perform differently in particular subgroups (e.g., males vs. females; ID vs. no ID; children vs. adolescents vs. adults). Finally, the nature of the associations between RMB and sensory items and the nature of the language factor needs further clarification.

Despite limitations, this is the first study to evaluate the factor structure of the DISCO RRB domain, using its original items in interview form. Results indicate potential benefits in using a greater range of RRB items to facilitate capture of more fine-grained, conceptually homogeneous factors. Importantly, the identified RRB categories also supported previous findings for age and ability level. Our findings provide preliminary evidence for the utility of the DISCO as a comprehensive measure of several distinct RRB domains in both research and clinical contexts. Importantly, the current investigation highlights crucial areas for measurement development to better capture and characterize the heterogeneous nature of RRB. In particular, it highlights the need for more comprehensive assessment of different aspects of restricted interests, broader coverage of stereotyped language and detailed sampling of repetitive motor behaviors and sensory related behaviors in order to clarify the nature of the overlaps and distinctions between these two aspects of RRB.

ACKNOWLEDGMENTS

This research was supported grant R21MH121876-01 (Hardan & Jo), Australian Research Council Discovery Early Career Researcher Award DE180100632 (Uljarević), and grant EM-2021-053\10, Leverhulme Emeritus Fellowship (Leekam). We are grateful to Dr. Judith Gould, the late Dr. Lorna Wing, Sarah Libby and Michael Larcombe for their role in the original primary data collection.

CONFLICT OF INTEREST

Authors report no conflict of interest.

ETHICS STATEMENT

The original recruitment of samples had ethical approval from relevant regional ethics committees with the resulting datasets anonymised upon study completion. Use of these datasets in the current analyses was approved by Cardiff University's School of Psychology Research Ethics Committee.

ORCID

Mirko Uljarević https://orcid.org/0000-0002-7481-3923

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How to cite this article: Uljarević, M., Carrington, S. J., Hardan, A. Y., & Leekam, S. R. (2022). Subdomains of restricted and repetitive behaviors within autism: Exploratory structural equation modeling using the diagnostic interview for social and communication disorders. *Autism Research*, *15*(5), 861–869. https://doi.org/10.1002/aur.2687