



Development of Two Dimensional Measures of Restricted and Repetitive Behavior in Parents and Children

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Objective: Restricted and repetitive behaviors (RRBs) are a heterogeneous set of behaviors common across a wide range of neurodevelopmental disorders (NDDs) and neuropsychiatric disorders (NPDs) that extend well into the general population. This study introduces 2 dimensional measurements of RRBs for use in typical and clinical populations from infancy to adulthood.

Method: The Childhood Routines Inventory–Revised (CRI-R) and the Adult Routines Inventory (ARI) were created and administered online to a nationally representative cohort of 3,108 parents with 3,032 children (range 12 months to 17 years 11 months). Twenty-six percent of children and 36% of adults had at least 1 NDD or NPD.

Results: Principal axis factoring exploratory analysis showed a 2-factor structure for the 2 instruments (motor behaviors/compulsions and rigidity/insistence on sameness). Analyses for convergent and discriminant validity, internal consistency (Cronbach $\alpha \geq 0.94$), and test-retest reliability ($r \geq 0.87$) indicated strong psychometric properties. Item response theory analyses indicated strong

reliability across the score range for the 2 instruments. RRB rates varied across development, peaking between the preschool and school years. Children with NDDs or NPDs (particularly those with autism spectrum disorder, schizophrenia/bipolar disorder, or obsessive-compulsive disorder/tic disorders) had increased RRBs compared with those with no diagnosis. Parent–child (0.69–0.84) and sibling–sibling (0.76–0.87) intraclass correlations indicated high heritability. Children of parents with an NDD or an NPD exhibited more RRBs compared with children of parents without NDDs or NPDs.

Conclusion: The CRI-R and ARI are open-source instruments with excellent psychometric properties and will be useful for developmental, clinical, and family genetic studies and for the identification of prodromal conditions involving RRBs.

Key words: repetitive behavior, dimensional assessment, parents and children

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Restricted and repetitive behaviors (RRBs) constitute a broad range of behaviors, including simple motor stereotypies and tics and more complex ritualized and rigid behaviors, compulsions, and restricted interests that vary in frequency, intensity, and duration. RRBs are core diagnostic features of autism spectrum disorder (ASD; *DSM-5*)¹ but also appear in a range of other neurodevelopmental disorders (NDDs) and neuropsychiatric disorders (NPDs), such as intellectual and developmental disabilities, schizophrenia, obsessive-compulsive disorder (OCD), and tic disorders (e.g., Tourette's syndrome).^{2,3} Contrary to traditional categorical nosologic boundaries, recent findings have indicated that most of these NDDs and NPDs are overlapping syndromes⁴ that are best represented as a collection of dimensional traits that extend into the general population.^{5,6}

RRBs also are common throughout typical development.^{7,8} Strong preferences for sameness in the environment, lining objects in straight lines, rigid routines, and an acute

perceptual awareness of minute details are frequently observed in typically developing children 2 to 7 years of age.^{9,10} These typical RRBs can serve different adaptive roles, including motor^{11,12} and nervous system¹³ maturation and emotional and arousal regulation.^{10,14} However, in the context of NDDs and NPDs, RRBs adversely affect multiple aspects of functioning¹⁵ and therefore are important targets for clinical intervention.¹⁶ Distinguishing clinically significant behavior from typical behavior requires a clearer understanding of the normal variability of a broader range of RRBs across the lifespan.

In addition to the high rates of comorbidity in individuals with NDDs and NPDs,^{17,18} such disorders frequently co-occur within families.¹⁹ In some instances, family members can share a common diagnosis, or different symptoms might manifest as alternative phenotypes of a common genotype.²⁰ Therefore, it is important to understand the familial context of RRBs, to determine whether children of parents with at least 1 NDD or NPD show increased levels of RRBs that might signify prodromal states, and to enable early identification and intervention of problem behaviors.

Several reliable measurements of RRBs exist, including the Repetitive Behavior Questionnaire–2 (RBQ-2),⁸ the



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Repetitive Behavior Scale–Revised (RBS-R),²¹ the Childhood Routines Inventory (CRI),⁷ and the Yale-Brown Obsessive Compulsive Scale (Y-BOCS).²² However, most of these measurements (the CRI and RBQ-2 being the exceptions) were designed to assess RRBs in clinical populations and in consequence result in near floor effects when used in typical populations. Furthermore, because most of these existing scales were designed to assess behaviors specific to particular disorders, such as ASD and ID (RBS-R) or OCD (Y-BOCS), they do not assess the full range of RRBs that present across different clinical disorders. Moreover, none of these measurements captures RRBs across the entire range of development, precluding direct comparison of RRBs in adults (e.g., parents) and children.

This study presents 2 novel companion instruments inspired by the original CRI: the Childhood Routines Inventory–Revised (CRI-R) and the Adult Routines Inventory (ARI). The original CRI focused on habits and compulsive behavior, whereas the CRI-R and ARI capture a wider range of RRBs, including stereotypies, tics, compulsions, habits, sensory sensitivities, and focused interests, in the context of typical and atypical development in children and adolescents (CRI-R) and adults (ARI) across the entire lifespan. This study examined the factor structure and psychometric properties of these instruments and age-related differences from infancy to adulthood and derived age- and gender-normed *t* scores on a population-based cohort of more than 3,000 families. This study tested the discriminant validity of the scales by comparing individuals with and without NDDs or NPDs, explored the familial pattern of RRBs through an examination of shared variance between children and their parents, and conducted item response theory (IRT) analyses to assess reliability and sensitivity across the scale range.

METHOD

Participants

Participants were recruited through Survey Sampling International (Shelton, CT), which specializes in recruiting demographically representative samples for scientific research in the United States. Eligible participants were sent a link to a Qualtrics survey for completing the questionnaires online. Data were collected on at least 1 parent with at least 1 child. All participants received monetary compensation based on the median time to complete surveys across the entire sample. Complete data on the ARI were collected from 3,108 adults (966 men; mean age 38.15 years, standard deviation [SD] 9.85) and complete data on the CRI-R were collected from 3,032 children (1,574 boys; mean age 9.25 years, SD 4.82, range 1 year 0 months to 17 years 11 months). When available, data on siblings also were collected (*n* = 844, 51.5% boys, 48.5% girls; mean age 7.99 years, SD 4.14). Where possible, data also were collected from the second parent (*n* = 217, 55.8% men, 44.2% women; mean age 38.30 years, SD 9.79). Biological parents reported on their children for 89.6% of the dyads (1,914 mothers and 804 fathers), 10.4% were guardians (3.2% stepmother or stepfather, 2.1% adoptive mother or father, 3% grandmother or grandfather, and 1.7% legal guardian). Analyses on the familial nature of RRBs were explored only for those dyads constituted by the biological parent and child. Demographics were representative of the US population for race, income, education, and rural and urban populations,²³ albeit with slight but statistically significant skewing toward lower economic classes (Table 1). Because we recruited a representative sample of the

TABLE 1 Comparison of Socioeconomic Demographics Between Survey Participants and National Statistics

Race/Ethnicity	Survey, %	2010 US Census, %
White	70.2	72.4
African American	14.5	12.6
Hispanic/Latino	11.2	16.4
Asian	6.8	4.8
Asian or Pacific Islander	2.2	0.2
Native American	2.6	0.9
Other	1.2	
Total Household Income	Survey, %	2014 Congressional Research, %
<\$10,000	24.3	7.3
\$10,000–\$19,999	10.0	11.5
\$20,000–\$29,999	10.5	10.9
\$30,000–\$39,999	13.1	10.0
\$40,000–\$49,999	9.3	8.9
\$50,000–\$59,999	8.5	7.6
\$60,000–\$69,999	5.5	6.8
\$70,000–\$79,999	5.5	5.9
\$80,000–\$89,999	2.8	4.9
\$90,000–\$99,999	3.2	4.0
\$100,000–\$149,999	4.9	12.4
≥\$150,000	2.1	9.5

general population, the cohort included families with a lifetime presence of NDD and NPD in 35.8% of adult respondents and 25.6% of children, which is consistent with previous epidemiologic reports on the frequency of NDDs and NPDs in the United States^{24,25} (Supplement 1, Table S1, available online).

Measurements

The CRI-R is a 62-item parent-report measurement rated on a 5-point Likert scale. The original CRI⁷ consisted of 19 items assessing routines, habits, and “compulsive-like” RRBs consistent with symptoms associated with ASD and OCD. However, the original CRI did not encompass certain RRBs that are associated with ASD (e.g., stereotypies) and other NDDs and NPDs. As was the case with the original CRI, items constituting the CRI-R were first derived conceptually by the 2 lead authors after a systematic literature search on RRBs because they present in a range of NDDs and NPDs and of *DSM* criteria for specific disorders while also considering their manifestations in the context of typical development. The final items were retained based on consensus decision and after independent confirmation by a neurodevelopmental pediatrician. Items were chosen to reflect the full range of RRBs seen in normative development and across NDDs and NPDs such as ASD, OCD, tic disorders, schizophrenia, and intellectual disability and included compulsions, motor stereotypies, tics, sensory sensitivities, difficulties with and resistance to minor changes in routine or personal environment, and rituals. When possible, items were cast in a developmentally appropriate context and worded to avoid technical and stigmatizing terms associated with clinical pathology. The same procedure was followed for developing the ARI, an adult self-report measurement that serves as a companion measurement to the CRI-R

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