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Psychometric properties of the Repetitive Behavior Scale-Revised for individuals with autism spectrum disorder in Japan

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ABSTRACT

Restricted and repetitive behaviors (RRBs) constitute a core symptom of autism spectrum disorder (ASD). The Repetitive Behavior Scale-Revised (RBS-R) is a widely used questionnaire administered by parents or caregivers to assess RRBs in individuals with ASD. This study evaluated the psychometric properties of the RBS-R Japanese Version (RBS-R-J). The ASD and non-ASD groups comprised 274 and 36 participants, respectively. We examined corrected item-total correlation, Cronbach's alpha, and RBS-R-J scores of different diagnostic groups, as well as correlations between RBS-R-J scores and intelligence quotient (IQ), autistic symptoms, adaptive/maladaptive functioning, aberrant

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behaviors, and sensory processing. All items showed moderate corrected item-total correlations. Cronbach's alpha coefficient was .93. We found significant differences in the mean RBS-R-J scores of the low-functioning ASD group and the intellectual disabilities group, and of low-functioning and high-functioning ASD groups. RBS-R-J scores negatively correlated with IQ and scores on the Sensory Profile (Japanese version) and Adaptive Behavior Composite of the Maladaptive Behavior Index of the Vineland Adaptive Behavior Scales-Second Edition (VABS-II; Japanese version), but positively correlated with scores on the peak and current symptoms subscales of the Pervasive Developmental Disorders Autism Society Japan Rating Scale, the VABS-II, and the Aberrant Behavior Checklist-Community (Japanese version). From these results, we conclude that RBS-R-J showed good reliability, diagnostic validity, and convergent validity, indicating that it is a reliable, valid instrument for use among ASD individuals in clinical and research settings.

1. Introduction

Autism spectrum disorder (ASD) is defined by two core symptom areas: (1) deficits in social communication and social interaction and (2) restricted, repetitive patterns of behavior, interests, or activities (RRBs) such as restricted interests, compulsive behaviors, stereotyped movements, and/or unusual responses to sensory stimuli (American Psychiatric Association, 2013). Over the years, much of the research on the features of ASD has focused on core social and communication deficits, rather than on RRBs, which are another core feature. RRBs are often among the most striking signs of ASD as they involve the presence of atypical behaviors, rather than the absence of typical behaviors. Yet despite this, the body of systematic studies of RRBs has grown only recently.

The existing literature clearly indicates that RRBs are not unique to ASD; they are also characteristic of other developmental disorders (e.g. intellectual disabilities [ID]), psychiatric disorders (e.g. schizophrenia, obsessive compulsive disorder), and neurological conditions (e.g. Tourette's syndrome, Parkinson's disease) (Lewis & Bodfish, 1998). Several instruments have presently been developed to measure RRBs (Campbell et al., 1990; Goodman et al., 1989; McDougle et al., 1995; Prior & MacMillan, 1973; Scahill et al., 1997), but these instruments were not developed specifically for assessing RRBs in ASD, or can evaluate only a part of RRBs. Therefore, a comprehensive assessment instrument is required to assess the wide range of RRBs in individuals with ASD. Recently, Bodfish, Symons, Parker, and Lewis (2000) developed an informant-based questionnaire, the Repetitive Behavior Scale-Revised (RBS-R), intended to comprehensively assess the variety and severity of RRBs in individuals with ASD. Dimensional evaluation can be a more successful approach to encompass the features of RRBs than using diagnostic categories in research and clinical settings. In fact, various studies have used the RBS-R as a simple, useful instrument for evaluating RRBs in clinical trials on ASD treatment efficacy (Anagnostou et al., 2012; Dawson et al., 2010; Hardan et al., 2012), examinations of RRB subcategories (Bishop et al., 2012; Lam & Aman, 2007; Lam, Bodfish, & Piven, 2008), and research on the relationship between RRBs and associated ASD clinical features (Gabriels, Cuccaro, Hill, & Ivers, 2005).

The RBS-R-Japanese version (RBS-R-J) has already been translated, back-translated, and authorized. In a preliminary study with a small sample size, we examined reliability and validity of clinician ratings for RBS-R-J based on parental interview. Although we found the clinician-rated measure to be an effective and valid instrument (Inada et al., 2012, in Japanese), the RBS-R is originally a parent/caregiver- or teacher-administered questionnaire. Therefore, this study aimed to examine the psychometric properties of the RBS-R-J as rated by parent/caregivers in Japan.

2. Methods

2.1. Participants

The main sample comprised 310 participants from an ASD group ($n = 274$; high-functioning ASD [HFASD] = 96, low-functioning ASD [LFASD] = 80, intelligence quotient [IQ]-unknown ASD = 98) and a non-ASD group ($n = 36$; ID = 28, attention deficit hyperactivity disorder = 5, learning disabilities = 2, epilepsy = 1) (Table 1). Participants were referred to medical and educational facilities due to developmental concerns and were randomly recruited to this study by examiners belonging to these facilities, located in 28 prefectures across Japan. Experienced child psychiatrists or psychiatrists diagnosed participants with ASD or non-ASD based on the DSM-IV-TR (American Psychiatric Association, 2000). Best-estimate clinical diagnoses were made by integrating information from parental interviews, developmental and medical information, records provided by parents/caregivers and teachers, and direct observations of and interactions with the participants. To assess the IQ of participants, we used the Japanese version of the Wechsler Intelligence Scale for Children, Third Edition (Japanese WISC-III Publication Committee, 1998), Japanese version of the Wechsler Adult Intelligence Scale,

Table 1
Characteristics of participants.

	Gender	Age (years)	IQ
	Male:female	Mean (*SD*) range	Mean (*SD*) range
ASD ($n = 274$)	219:55	15.0 (6.3) 3–33	80.3 (30.0) 18–140[a]
Without ID (IQ = >70)	83:13	12.8 (4.6) 3–29	101.7 (14.6) 70–140[b]
With ID (IQ < 70)	60:20	13.4 (5.6) 3–27	48.1 (14.1) 18–84[c]
IQ unknown	76:22	18.5 (6.9) 4–33	–
Non-ASD ($n = 36$)	24:12	13.1 (7.3) 4–40	66.0 (31.7) 25–135[d]
Without ID (IQ = >70)	6:1	9.7 (4.4) 6–18	111.6 (15.0) 97–135[e]
With ID (IQ < 70)	17:11	14.1 (7.8) 4–40	49.7 (15.3) 25–67[f]
IQ unknown	1:0	9.0 (–) 9	–

Note: IQ, intelligence quotient; ASD, autism spectrum disorder; ID, intellectual disabilities.
[a] IQ was identified in 140 participants.
[b] IQ was identified in 84 participants; the remaining 12 were clinically judged as having no ID.
[c] IQ was identified in 56 participants; the remaining 24 were clinically judged as having ID.
[d] IQ was identified in 19 participants.
[e] IQ was identified in five participants; the remaining two were clinically judged as having no ID.
[f] IQ was identified in 14 participants; the remaining 14 were clinically judged as having ID.

Third Edition (Japanese WAIS-III Publication Committee, 2006), or the Tanaka-Binet Intelligence Scale, Fifth Edition (Tanaka Institute for Educational Research, 2003).

2.2. Measures

2.2.1. Repetitive Behavior Scale-Revised

The RBS-R (Bodfish et al., 2000) is an informant-based questionnaire for measuring the presence and severity of a variety of RRBs. The scale was designed to provide a quantitative, continuous measure of the full spectrum of various repetitive behaviors in individuals with ASD. The RBS-R requires 10–15 min to complete. The 43 items of the RBS-R are grouped conceptually (i.e. based on clinical experience) into six subscales: stereotyped behavior (six items), self-injurious behavior (eight items), compulsive behavior (eight items), ritualistic behavior (six items), sameness behavior (11 items), and restricted behavior (four items). RBS-R items are rated on a 4-point Likert scale for severity (0 = behavior does not occur, 1 = behavior occurs and is a mild problem, 2 = behavior occurs and is a moderate problem, 3 = behavior occurs and is a severe problem). Higher RBS-R scores indicate more severe behaviors. For the Japanese adaptation, the RBS-R was translated, back-translated, and authorized. In this study, the RBS-R-J was completed by the parents/caregivers of the participants.

2.2.2. Autistic symptoms: The Pervasive Developmental Disorders Autism Society Japan Rating Scale

The Pervasive Developmental Disorders Autism Society Japan Rating Scale (PARS; PARS Committee, 2008) is a semi-structured interview of parents/caregivers for assessing autistic symptoms, and was developed in Japan to provide a valid and simple instrument. The PARS comprises two subscales: the peak symptoms subscale evaluates symptoms during the preschool years when they are most pronounced and the current symptoms subscale evaluates current symptoms. The former is used mainly to aid in ASD diagnosis, whereas the latter is used mainly to assess current ASD symptoms and support needs. The 34-item peak symptoms scale has one version common to all age groups, whereas the 57-item current symptoms scale has three versions for different age groups: early childhood (preschool age, 34 items), late childhood (elementary school age, 33 items), and adolescence/adulthood (junior high school age and older, 33 items). Current symptom subscale items partially overlap among these three age groups. The PARS peak symptom subscale contains four factors: social communication (SC), sensitivity/difficulty (S/D; e.g. sensory interests, sensory sensitivity, and difficulty in daily life), stereotyped behavior (SB; e.g. stereotypic body/hand movement), and restricted interests (RI; e.g. restricted interests, sameness, and compulsion) (Ito et al., 2012). PARS items are rated on a 3-point Likert scale for frequency (0 = rarely, 1 = sometimes or partially, 2 = always). Higher PARS scores indicate more severe autistic symptoms.

2.2.3. Sensory processing: sensory profile

The sensory profile (SP) is an informant-based questionnaire for assessing levels of sensory processing in everyday life. Based on Dunn's (1997) model of sensory processing, the SP contains 125 items with four subscales in each quadrant of the model: low registration, sensation seeking, sensory sensitivity, and sensation avoiding. The SP requires 10–15 min to complete. Each item is scored on a 5-point Likert scale for frequency (1 = always [95%], 2 = often [75%], 3 = sometimes [50%], 4 = rarely [25%], 5 = never [5%]). Answers within each quadrant are summed, with lower SP scores indicating more sensory processing behaviors. Although the original version of the SP (Dunn, 1999) was developed for children aged 3–10 years, the Japanese version of the SP (SP-J) was adopted for individuals aged 3–82 years and was standardized for the Japanese general population for each age group (i.e. 3, 4, 5–10, 11–17, 18–34, 35–64, 65–82 years) (Ito et al., 2013). In this study, the SP-J was completed by each participant's parent/caregiver, and we used SP-J raw scores of four quadrants.

2.2.4. Adaptive and maladaptive functioning: Vineland Adaptive Behavior Scales, Second Edition-Interview Form

The Vineland Adaptive Behavior Scales-Second Edition (VABS-II; Sparrow, Balla, & Cicchetti, 2005) is a semi-structured interview of the parent/caregiver to assess adaptive and maladaptive behaviors in individuals from birth to age 90 years. The VABS-II contains five main domains each with two to three subdomains. The main domains are: communication, daily living skills, socialization, motor skills (in children aged <7 years), and maladaptive behavior (optional). Open-ended questions gather in depth information and promote rapport between the interviewer and respondent. Items on the VABS-II are rated on a 3-point Likert scale for adaptive/maladaptive functioning (0 = never, 1 = sometimes or partially, 2 = usually). The first four domain scores (communication, daily living skills, socialization, motor skills) yield an adaptive behavior composite and a norm-referenced standardized score with a mean of 100 and standard deviation (SD) of 15, which were calculated for each domain, including the adaptive behavior composite. Higher scores indicate better adaptive functioning. The maladaptive domain yields a maladaptive behavior index (MBI) and V-scale scores with a mean of 15 and a SD of 3, which were calculated. Higher MBI scores indicate more maladaptive behaviors. In this study, we used the Japanese version of the VABS-II standardized for the Japanese general population (Ito et al., 2012a, 2012b; Yukihiro et al., 2013).

2.2.5. Behavior problems: Aberrant Behavior Checklist-Community (Parent Form)

The Aberrant Behavior Checklist-Community (ABC-C; Aman & Singh, 1986, 1994) is an informant-based questionnaire to assess maladaptive or problem behaviors known to occur in individuals with moderate to profound ID. The ABC-C consists of 58 items and five subscales: irritability, lethargy, stereotypy, hyperactivity, and inappropriate speech. Each item is scored on a 4-point Likert scale for severity (0 = not a problem at all, 1 = the behavior is a problem but slight in degree, 2 = the problem is moderately serious, and 3 = the problem is severe in degree). Higher ABC-C scores indicate more severe behaviors. In this study, we used the Japanese version of the ABC-C (ABC-J) (Ono, 2006). The ABC-J was completed by each participant's parent/caregiver.

2.3. Ethical issues

The study was prospectively approved by the Institutional Review Board of Hamamatsu University School of Medicine, Japan. For participants who were minors, we obtained written informed consent from the participants' parents/caregivers and, if possible, oral assent from the participants. For participants who were adults, we obtained written informed consent from the participants if possible, or from their parents/caregivers if not.

2.4. Data analysis

Psychometric properties of the RBS-R-J were evaluated by six steps in terms of reliability (including item-total correlation and internal consistency), diagnostic validity, and convergent/discriminant validity. First, to examine the function of each item, we calculated the corrected item-total correlations between each item and the corresponding subscale score (excluding the item score) and total score (excluding the item score). Second, to examine internal consistency, we calculated Cronbach's alpha coefficient for six subscales and overall items. Third, to examine diagnostic validity, we conducted one-way analysis of variance to compare RBS-R-J total scores among the LFASD, ID, and HFASD groups. We could not include the non-ASD without-ID group for this analysis because of the insufficient number of cases in this group. Also, we estimated effect sizes by computing mean differences of the RBS-R-J total score between two groups divided by the overall standard deviation of all three groups combined. Fourth, we calculated Pearson's correlation coefficients and 95% confidence intervals (CIs) to examine the relationship between RBS-R-J total scores and IQ. Fifth, to examine convergent validity, we calculated Pearson's coefficients and 95% CIs between RBS-R-J total scores and PARS scores. Sixth, we calculated Pearson's coefficients and 95% CIs between RBS-R total scores and other associated symptoms, evaluated by scale scores of the SP-J, VABS-II-J, and ABC-J.

Statistical analysis was performed using SPSS Version 18.0J (SPSS Inc.) and we used R-version 2.9.2 to calculate 95% CIs.

3. Results

3.1. Item analysis

Table 2 shows the mean, standard deviation, and corrected item-total correlation for each item of the RBS-R-J. This index evaluates whether or not each item matches the concept of the scale, with a higher score signifying higher fitness. Although corrected item-total correlation values for total scores were below .20 for some items (i.e. items 2, 10, and 11), most items showed positive and substantial values. In addition, corrected item-total correlations for the corresponding subscale were close to .30 or more for all items, indicating generally effective functioning as an index of each subscale concept.

3.2. Internal consistency

Alpha coefficients for six subscale items and total items of the RBS-R-J were as follows: stereotypy = .749, self-injurious = .743, compulsive = .771, ritualistic = .793, sameness = .877, restricted = .693, and overall = .928. Except for the

Table 2
Mean, standard deviation, and corrected item-total correlation of the RBS-R-J.

RBS-R-J	Mean	SD	Corrected item-total correlation	
			Subscale	Total items
Stereotypy subscale				
1. Body movement	0.30	0.59	.413	.284
2. Head movements	0.20	0.45	.296	.068
3. Finger movement	0.42	0.76	.616	.397
4. Locomotion	0.44	0.72	.603	.390
5. Object Usage	0.45	0.76	.515	.401
6. Sensory	0.46	0.71	.475	.465
Self-injurious subscale				
7. Hits w/body	0.30	0.62	.538	.436
8. Hits against surface	0.17	0.50	.584	.400
9. Hits w/object	0.07	0.33	.507	.289
10. Bites self	0.25	0.61	.254	.173
11. Pulls hair/skin	0.16	0.48	.335	.155
12. Rubs/scratches	0.17	0.54	.469	.296
13. Insert finger/object	0.05	0.34	.573	.327
14. Picks skin	0.07	0.29	.460	.224
Compulsive subscale				
15. Ordering	0.47	0.70	.641	.591
16. Completeness	0.39	0.66	.640	.527
17. Washing	0.22	0.55	.420	.313
18. Checking	0.17	0.45	.540	.447
19. Counting	0.11	0.36	.349	.259
20. Hoarding	0.43	0.74	.372	.391
21. Repeating	0.15	0.44	.471	.428
22. Needs to touch/tap	0.36	0.65	.428	.552
Ritualistic subscale				
23. Eating/mealtime	0.45	0.79	.558	.652
24. Sleeping/bedtime	0.48	0.80	.529	.586
25. Self-care routine	0.20	0.51	.503	.507
26. Transportation routine	0.32	0.65	.628	.598
27. Play/leisure routine	0.38	0.69	.686	.632
28. Communication	0.61	0.87	.449	.536
Sameness subscale				
29. Placement of objects	0.35	0.63	.630	.666
30. No new places	0.59	0.85	.624	.601
31. No interruption	0.72	0.78	.678	.680
32. Walks certain way	0.14	0.40	.497	.485
33. Sits certain place	0.22	0.51	.567	.531
34. Appearance/behavior of others	0.25	0.60	.710	.617
35. Uses certain door	0.05	0.26	.427	.405
36. Videotapes	0.74	0.88	.494	.559
37. Difficult transitions	0.72	0.81	.662	.624
38. Insists on routine	0.35	0.61	.694	.666
39. Insists on time	0.27	0.63	.631	.638
Restricted subscale				
40. Preoccupation with subject	0.96	0.90	.559	.421
41. Attached to object	0.76	0.89	.593	.613
42. Preoccupied with part of object	0.24	0.54	.511	.558
43. Preoccupation with movement	0.17	0.45	.353	.423

restricted subscale, the remaining subscales and total scale had values of .70 or more, which indicate generally sufficient internal consistency.

3.3. Diagnostic comparison

Fig. 1 shows descriptive statistics of RBS-R-J total scores among the three diagnostic groups. The main effect of diagnostic group was significant ($F = 17.41$, $p < .001$), and Tukey's post hoc test demonstrated significantly higher RBS-R total scores in the LFASD group than in the ID and HFASD groups ($p < .001$, respectively). We found large effect sizes between the LFASD and ID groups (.87) and between the LFASD and HFASD groups (.79).

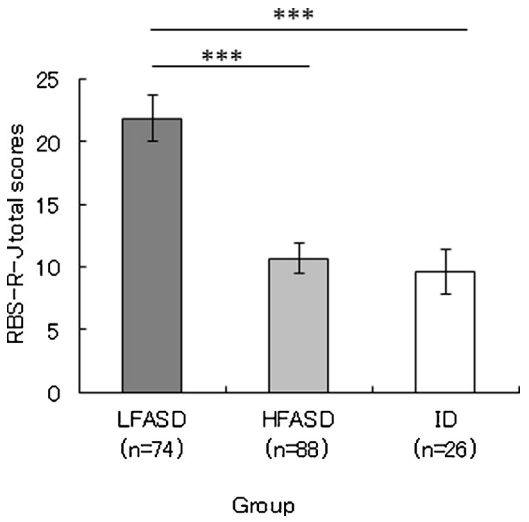

Fig. 1. RBS-R-J total scores among three groups. Note: HFASD = high functioning autism spectrum disorders, LFASD = low functioning autism spectrum disorders, ID = intellectual disabilities. Error bars represent standard error of the mean. *** $p < .001$

3.4. Correlation with IQ

RBS-R-J and IQ data were available for 128 individuals with ASDs. The correlation coefficient between RBS-R-J total scores and IQ showed a significant negative correlation ($r = -.468$) (Table 3), indicating that lower IQ level is moderately associated with the presence of more RRBs.

3.5. Correlation with autistic symptoms

RBS-R-J and PARS data were available for 95 individuals with ASDs. RBS-R-J total scores showed a significant positive correlation among SC, S/D, SB, RI, and total scores on the peak symptom scale ($r = .428, .381, .450, .429, .545$, respectively), and childhood and adolescence/adulthood scores on the current symptom scale ($r = .493, .492$, respectively) (Table 3). These results indicate that more overall ASD symptoms are moderately associated with the presence of more RRBs, which suggests convergent validity.

3.6. Correlation with other associated symptoms: sensory processing problems, adaptive functioning, and behavior problems

SP and RBS-R-J data were collected for 235 individuals with ASD. RBS-R-J total scores showed significant negative correlations with low registration, sensation seeking, sensory sensitivity, and sensation avoiding ($r = -.387, -.627, -.567$, and $.617$), indicating that a higher sensory processing problem is moderately to strongly associated with the presence of more RRBs. VABS-II and RBS-R-J data were collected in 178 individuals with ASD. RBS-R-J total scores showed significant negative correlations with communication, daily living, socialization, motor skills, and adaptive behavior composite scores ($r = -.431, -.458, -.498, -.754$, and $-.453$, respectively), indicating that lower adaptive ability is moderately associated with the presence of more RRBs. RBS-R-J total scores showed significant positive correlations with VABS-MBI scores ($r = .493$). RBS-R-J and ABC-J data were available for 235 individuals with ASD, and RBS-R-J total scores showed significant positive correlations with five subscales (irritability, lethargy, stereotypy, hyperactivity, and inappropriate speech) and total scores ($r = .655, .573, .545, .609, .527$, and $.699$, respectively). These results indicate that having more behavior problems is strongly associated with the presence of more RRBs.

4. Discussion

This is the first study to examine the psychometric properties of the RBS-R as rated by parents/caregivers in Asia. The reliability of the RBS-R-J was supported by moderate item-total correlations and sufficient internal consistency values. As for its validity, the RBS-R-J total score could distinguish between LFASD and ID individuals and between LFASD and HFASD individuals. Although RRBs occur in individuals with developmental disorders such as ID, the variety and severity of RRBs differ between individuals with LFASD and those with ID (Bodfish et al., 2000). The difference in RBS-R-J scores between these two groups suggests diagnostic validity. In addition, individuals with LFASD showed higher RBS-R-J scores than those with HFASD. This can be concluded from the relationship between RRBs and IQ in individuals with ASD, as is seen in the results of the present study, as well as those of previous studies (Bishop, Richler, & Lord, 2006; Gabriels et al., 2005).

Table 3
Correlation of the RBS-R total score with other scale scores.

Scale	*n*	Mean (*SD*)	*r*	95% CI
IQ	128	80.37 (30.06)	−.468***	−.593 to −.321
PARS				
Peak symptom scale score (during preschool days)				
Social communication	93	8.97 (5.08)	.428***	.246–.581
Sensitivity/difficulty	95	7.20 (4.49)	.381***	.194–.541
Stereotyped behavior	95	5.83 (3.79)	.450***	.273–.597
Restricted interest	94	7.65 (4.12)	.429***	.248–.581
Total	91	29.47 (13.69)	.545***	.382–.675
Current symptom scale score				
Late childhood (age 6–11)	51	24.84 (11.51)	.493***	.252–.677
Adolescence/adulthood (age 12∼)	88	21.68 (11.58)	.492***	.315–.636
VABS-II-J				
Communication	178	55.29 (26.55)	−.431***	−.544 to −.303
Daily living skills	177	61.28 (24.72)	−.458***	−.567 to −.333
Socialization	178	52.66 (22.47)	−.498***	−.601 to −.379
Motor Skills (age < 7)	14	68.36 (17.83)	−.754***	−.918 to −.372
Adaptive behavior composite	177	51.51 (23.65)	−.453***	−.563 to −.327
MBI	178	19.34 (2.51)	.493***	.373–.597
ABC-J				
Irritability	228	5.88 (7.67)	.655***	.574–.723
Lethargy	224	6.73 (7.22)	.573***	.478–.655
Stereotypy	232	1.79 (3.36)	.545***	.448–.630
Hyperactivity	225	6.93 (8.07)	.609***	.520–.685
Inappropriate Speech	235	2.43 (2.88)	.527***	.428–.614
Total	208	22.55 (23.69)	.699***	.622–.763
SP-J				
Low registration	223	61.20 (11.10)	−.387***	−.493 to −.269
Sensation seeking	212	118.49 (13.21)	−.627***	−.702 to −.538
Sensory sensitivity	221	89.10 (9.26)	−.567***	−.650 to −.470
Sensation avoiding	204	116.17 (17.22)	−.617***	−.695 to −.524
Total	184	312.33 (41.24)	−.617***	−.699 to −.519

Note: CI, confidence interval; PARS, Pervasive Developmental Disorders Autism Society Japan Rating Scale; VABS-II-J, The Vineland Adaptive Behavior Scales-Second Edition Japanese Version; MBI, Maladaptive Behavior Index; ABC-J, Aberrant Behavior Checklist-Community Japanese version; SP-J, Sensory Profile Japanese Version.
*** $p < .001$.

RBS-R-J scores were moderately correlated with both peak overall ASD symptoms during early childhood and current overall ASD symptoms evaluated by the PARS. RRBs are one of two core ASD symptoms; therefore, the relationship between RRBs and overall ASD symptoms may be considered normal. In line with previous studies on the relationship between RRBs and sensory processing problems, adaptive functioning, and behavior problems in autism or ASD (Baghdadli, Pascal, Grisi, & Aussilloux, 2003; Boyd, McBee, Holtzclaw, Baranek, & Bodfish, 2000; Gabriels et al., 2005; Liss et al., 2001; Rojahn et al., 2013), we expected a negative correlation between RBS-R scores and the four subscale scores (low registration, sensation seeking, sensory sensitivity, sensation avoiding) on the SP, four domain (communication, daily living, socialization, motor skill) and adaptive behavior composite scores on the VABS-II, and a positive correlation between the RBS-R scores and VABS-II MBI scores, and five subscale scores (irritability, lethargy, stereotypy, hyperactivity, and inappropriate speech) and total scores on the ABC-J. These results were consistent with our expectations. Sensory processing problems constitute a portion of RRBs in the DSM-5 ASD criteria (American Psychiatric Association, 2013). Thus, it is natural for higher sensory processing problems and more behavior problems to be associated with the presence of more RRBs. Although the reason for the relationship between adaptive behaviors and RRBs is unclear, this relationship might parallel that between RRBs and cognitive abilities (Gabriels et al., 2005).

This study had some limitations. First, the inadequate sample size of non-ASD without ID in this study prevented us from examining RBS-R-J total scores between ASD and non-ASD samples without ID. RRBs are not unique to ASD, and are present in individuals with various psychiatric disorders (e.g. schizophrenia, obsessive compulsive disorder), and neurological conditions (e.g. Tourette's syndrome, Parkinson's disease) (Lewis & Bodfish, 1998). Future studies are needed to compare RBS-R-J profiles among various clinical samples without ID. Second, the sample might not be completely representative of the ASD population because the intellectual level in one third of the participants was unspecified. However, among the 164 participants whose intellectual level was known, 80 (48.8%) had ID. This percentage was similar to proposed estimates of associated cognitive impairments in ASD populations, which currently range from 40% to 70% (Baird et al., 2006; Fombonne, 2005; Kim et al., 2011). Furthermore, this nationwide survey included individuals from various centers that reflected differing residential options available in Japan. Further studies need to include a more diverse ASD sample. Finally, in this

study, we focused on the RBS-R-J total score to examine validity but did not consider factor structuring. To date, although several researchers have suggested multidimensional structuring models of the RBS-R (Bishop et al., 2012; Lam & Aman, 2007; Mirenda et al., 2010; Szatmari et al., 2006), the structuring models were inconsistent. One explanation appears to be that principal component analysis has difficulty with localized solutions. In fact, Bishop et al. (2012) and Lam and Aman (2007) proposed a five-factor model of the RBS-R items, but each model had different items. Studies using a more appropriate analysis technique are needed to examine multidimensional structuring of RRBs for ASD.

This study demonstrated that the psychometric properties of the RBS-R-J are sufficient for assessing RRBs in individuals with ASD, similarly to the original U.S. version. However, the RBS-R is a comprehensive assessment instrument specific to RRBs, and cannot evaluate the other main symptoms of ASD, namely, impairments in social interaction and communication. The RBS-R alone cannot be expected to adequately diagnose the individuals in our clinical sample, and diagnostic processes should be included in combination with several test batteries, such as cognitive tests and semi-structured diagnostic assessment instruments. However, the RBS-R-J is a reliable and validated measure that is useful for assessing the variety and severity of RRBs for individuals with ASD in Japan. Furthermore, identifying the subtypes of RRBs might be helpful for detecting specific genetic or neurobiological components of ASD. The RBS-R might also be a useful tool for assessing treatment efficacy. Lastly, its use can promote various national and cross-cultural studies on RRBs in ASD.

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