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Everyday memory and cognitive styles in adults with autism spectrum disorder: the relationship between the Rivermead Behavioral Memory Test performance and Empathizing-Systemizing models

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Objective: To examine everyday memory functioning using the Rivermead Behavioral Memory Test (RBMT) in adults with autism spectrum disorder (ASD) compared to healthy controls.
Methods: The present study was conducted with 22 ASD patients and 20 healthy adults. Welch's test was conducted to compare the ASD group and the healthy controls group on the basis of their RBMT scores, and a generalized linear model was conducted to better understand the relationships between RBMT performance and the explanatory variables.
Results: Welch's tests showed significant differences between the groups in "Total profile scores" (t = 2.982, degrees of freedom (df) = 40, P = 0.005) and "Prospective memory (PM)" (t = 2.781, df = 40, P = 0.008) for the RBMT. A general linear model revealed that an ASD diagnosis was not associated with total scores on the RBMT (partial regression coefficient [B] = 1.179, confidence interval (CI): 95% CI [-0.273, 2.632], P = 0.112). In contrast, empathy quotient (EQ) showed significant associations with total RBMT scores (B = 0.066, CI: 95% CI [0.012, 0.121], P = 0.017).
Conclusion: The results indicated that everyday memory and PM functioning were impaired in adults with ASD. EQ was consistently associated with total RBMT scores in all models as the sole factor, suggesting the involvement of theory of mind and empathy in everyday memory.

Key words: everyday memory, cognitive styles, autism spectrum disorder, Rivermead Behavioral Memory Test, Empathizing-Systemizing models

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by deficits in social interaction, social communication, and restricted, repetitive patterns of behavior.[1] In the area of cognitive neuroscience research, social problems in ASD have been found to be associated with impaired executive functions, working memory, and long-term memory.[2] Current understandings of memory profiles in ASD suggest difficulties with some aspects, including free verbal recall of words, sentences, and stories,[3,4] but also in the areas of preserved skills, including recognition memory[4] and cued or supported recall.[5] Although much memory research on ASD is based on laboratory studies, the ecological validity of this research has been considered low.[6,7]

One neuropsychological test that compensates for ecological validity is the Rivermead Behavioral Memory Test (RBMT), which consists of tasks that assume the fluid memory required in everyday life (everyday memory). Everyday memory is described as "memory for action" and is seen as memory functioning for performing complex tasks in daily situations.[2,8] Everyday memory is also seen as the ability to function in situations that require social and communication skills and cognitive

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processing.[7] Impairments to everyday memory have been reported in neurodevelopmental groups, especially in patients with mild intellectual disability and in children with developmental coordination disorder.[9,10] However, little attention has been paid to everyday memory functioning in people with ASD. To the best of our knowledge, the only exception is the study by Jones et al.[7] examining everyday memory in individuals with ASD.

Jones et al.[7] used the RBMT to examine everyday memory functioning in adolescents with ASD. The results showed that, compared with healthy controls, the adolescents with ASD did not show differences in performance on the "Names" task, in which participants must remember the name of a portrait, or on the "Messages" task, in which participants are required to follow directions in an experimental room, but they showed poor performance on the delayed tasks "Appointments" and "Belongings." These tasks required participants to spontaneously recall what they were asked to remember during the task, following cues given in the task situation. Based on these results, Jones et al.[7] argued that individuals with ASD have problems with prospective memory (PM), such as difficulties "remembering what you remember" (e.g., "If you see a mailbox, don't forget to put the mail out") at some point in the future. They suggested that prospective memory might be associated with social and communication problems, which are closely related to a weak theory of mind (ToM), meaning difficulties imagining the mental states of others based on their own mental states, findings, and intentions.[11]

In recent works, cognitive styles of identifying the feelings and thoughts of others, responding to them with appropriate emotions, and predicting the behavior of others have collectively been called "Empathizing," and this concept includes understanding the mental representations of self and others, such as ToM or mentalizing.[12-14] Empathizing is an ability related to emotional cognition and the detection of nonverbal communication cues.[12,13] On the other hand, cognitive styles of analyzing system factors and eliciting rules that govern the workings of systems are, "Systemizing."[12,13,15] Systemizing is thought to be related to mathematical fields and spatial cognitive abilities.[12,13] Baron-Cohen proposed the E-S model (Empathizing-Systemizing model), which explains cognitive styles by the functioning of these two cognitive tendencies.[12] Previous studies have commonly shown that ASD individuals have lower empathy quotient (EQ) and higher systemizing quotient (SQ) compared to healthy individuals.[13-16]

However, to our knowledge, there have been no studies published using the RBMT in adults with ASD to assess relationships between everyday memory functioning and empathizing. Given that social and communication problems in ASD originate from early-onset neurodevelopmental disorders and these characteristics may persist into adulthood,[1,17] we predicted that adults with ASD would have impaired everyday memory function due to a weakness in their ability to empathize. The present study used the RBMT to examine the everyday memory profiles of adults with ASD and compared their performance to that of healthy controls. We also examined relationships between everyday memory functioning and the measures of the E-S model, which are the EQ and the SQ. We hypothesized that an ASD group would show impaired everyday memory, indicated by poor performance in PM tasks, compared to a healthy control group. We also predicted that poor performance in the RBMT would be associated with EQ and SQ.

Participants and Methods

Participants

The present study was conducted with 30 patients aged 20－39 years with a primary diagnosis of ASD or pervasive developmental disorder and attending medical institutions, along with 22 healthy adults as a control group. Undergraduate and postgraduate students were excluded from the study. The research was conducted from September 2020 to February 2022. Both offline and online recruitment methods were adopted in the recruitment process. The offline recruitment was conducted at the Research Center for Child Mental Development, Chiba University, Chiba University Hospital Cognitive Behavior Therapy Center, Chiba Autism Support Center, Mamenoki Clinic, and Shintsudanuma Mental Clinic. The online recruitment was conducted on the website of the Newing NPO Corporation.[18] The ASD patients were diagnosed based on the ICD-10 (International Classification of Diseases-10)[19] or the DSM-V (Diagnostic and Statistical Manual of Mental Disorders, fifth edition)[1] and were currently being treated as an outpatient or inpatient at a hospital. Exclusion criteria for the ASD patients included: 1. a history of head trauma, 2. co-occurring neurological disorders, 3. a diagnosis of psychosis (schizophrenia or bipolar disorder), or 4. full-scale IQ <80. Exclusion criteria for the control participants were: 1. a history of psychiatric treatment, 2. the Japanese version of the PHQ-9 score >19, 3. the Japanese version of GAD-7 >14, or 4. the Japanese version of an Autism Spectrum Quotient (AQ) >32. Consequently, 22 ASD patients (mean age =

29.2, SD = 5.4, 13 males/9 females) and 20 healthy adults (mean age = 32.1, SD = 4.6, 9 males/11 females) were included in the present study. All the participants provided written informed consent to participate in the study, which was approved by the Research Ethics Committee of the School of Allied Health Sciences, Kitasato University, and by the Graduate School of Medicine, Chiba University.

Measures

Everyday memory: The RBMT detects impairments in everyday memory.[20-22] We used the Japanese version of the RBMT,[23] including 12 subtests: Names (remembering the first and second names of a person shown in a portrait photo), Belongings (remembering to ask for personal belongings at the end of the test session), Appointments (remembering to ask questions when an alarm rings 20 minutes after the questions are given), Picture Recognition (delayed recognition of line drawings), Story Recall (immediate and delayed recall of a short story), Face Recognition (delayed recognition of photographs of faces), Route Recall (immediate and delayed recall of a short route in the examination room), Messages (immediate and delayed remembering to pick up an envelope), and Orientation and Date (remembering to answer questions relating to person, time, and place). We calculated a standard profile score for each subtest excluding Orientation and Date scores, because some participants came from far away and had no familiarity with the place of research, and it was considered that they would be disadvantaged by the task to answer the municipality of the current location. The standard profile score was converted to a 3-point scale from 0 to 2. The Japanese version of the RBMT has been confirmed to have the high reliability and validity of the original version.[21] According to previous studies, prospective memory (PM) was calculated by summing the standard profile scores for "Belongings," "Appointments," and "Messages (immediate and delayed)."[7,9]

Intellectual abilities: Intellectual abilities were assessed with the Wechsler Adult Intelligence Scale-III (WAIS-III).[24] We used the Japanese version of the WAIS-III,[25] including the verbal (information, similarities, arithmetic, vocabulary, comprehension) and the performance (picture completion, coding, picture arrangement, block design, object assembly) subtests. For the present study, we calculated full-scale IQ (FSIQ), verbal IQ (VIQ), and performance IQ (PIQ).

Questionnaires

The Patient Health Questionnare-9 (PHQ-9): PHQ-9 is a self-administered questionnaire measuring symptom levels of depressive disorders and consists of 9 items.[26] The total score (0－27) was calculated from symptom ratings ranging from "not at all = 0" to "a few days = 1," "more than half of the time = 2," and "almost every day = 3." The Japanese version of the PHQ-9 was used in this study to assess depression.[27]

The Geralized Anxiety Disorder-7 (GAD-7): GAD-7 is a self-administered questionnaire measuring the symptom level of generalized anxiety disorder and consists of 7 items.[28] The total score (0－21) was calculated from symptom ratings ranging from "not at all = 0" to "a few days = 1," "more than half of the time = 2," and "almost every day = 3." The Japanese version of the GAD-7 was used in this study to assess anxiety.[29]

The Everyday Memory Checklist (EMC): The Japanese version of the EMC consists of 13 items and was used to assess the state of everyday memory.[30] The ratings were made on a 4-point scale from 0 (not at all) to 3 (always so). The scores ranged from 0 to 39, with higher scores suggesting stronger impairments in everyday memory.

EQ: EQ consists of 40 questions and 20 filter items to examine empathy.[14] The Japanese version of the EQ was used in this study.[13] The total score was used as an indicator of Empathizing according to a 4-point scale ranging from "1: applies" to "4: does not apply," with scores ranging from 0 to 80. The response format and scoring method were carried out in the same way as in the original version.[14,15] The Japanese version of the EQ developed by Wakabayashi was found to have sufficient internal consistency and construct validity as a psychological measurement scale, with results similar to the original version.[13]

SQ: SQ was proposed as an indicator of autistic tendencies based on the E-S theory, which indicates that individuals with high autistic tendencies have reduced empathy but excel at systemizing.[12] The Japanese version of the SQ consists of 40 questions and 20 filter items.[13] The total score was used as an index of Systemizing according to a 4-point scale ranging from "1: applies" to "4: does not apply." The response format and scoring method were carried out in the same way as in the original version.[13,15]

AQ: The Japanese version of the AQ is a 50-item self-reported measure of autistic traits.[31] The AQ was rated on a 4-point scale ranging from "1: applies" to "4: does not apply." The total score was used for the analysis.

Procedure

In this study, the research procedures varied according to the demographics of the participants. We conducted 2 research sessions with the ASD patients. In the first session, we explained the overview of the present study and the WAIS-III and administered the WAIS-III, which lasted approximately 60 minutes. We arranged the second session via email for the participants with FSIQ >79. In the second session, we explained the RBMT and administered it, which took approximately 25 minutes. After a 10-minute break, we administered the questionnaires. The second session took approximately 1 hour. On the other hand, we had informed the participants with FSIQ <80 that they could not participate in the second session and that we could discuss the results of the WAIS-III if they wished. We also informed them that if they experienced any burdens or concerns during the examination, they could consult a licensed psychiatrist, the principal investigator of the study, use the university's counseling room, and/or be referred to health care providers if necessary. We explained the overview of the study to the healthy participants. First, we administered the WAIS-III. We then gave the participants a 15-minute break. After the break, we administered the RBMT, and after a 10-minute break, we administered the questionnaires. The study survey took a total of approximately 120 minutes.

Statistical analyses

Welch's test was conducted to compare the ASD groups and the healthy controls groups (CON) on the basis of RBMT scores. The *t*-test was used to compare scores on the intellectual abilities and psychological measures between the groups, and Fisher's exact test was used for the categorical variables. Because there were missing values in the EQ and SQ questionnaires, multiple imputation methods were carried out to assign the missing values, and the *t*-values and P-values were calculated. A general linear model (GLM) was conducted to better understand the relationships between RBMT performance and the explanatory variables, with the total profiles scores of the RBMT as the dependent variable and ASD/CON and cognitive styles (EQ and SQ) as the explanatory variables. As the moderator variables, multiple models were created with age, gender, FSIQ, PHQ-9, and GAD-7 as the explanatory variables. Statistical analyses were carried out with IBM SPSS Statistics for Windows version 28. The statistical significance level was set to $P < 0.05$.

Table 1. Demographic variables for the ASD group and the healthy controls

	ASD (n = 22)	CON (n = 20)	t/χ^2	P value
Gender ratio (Male/Female)	13/9	9/11	0.834	0.537
Mean age	29.2 (5.4)	32.1 (4.6)	1.892	0.066
FSIQ	105.6 (11.0)	107.0 (12.7)	0.386	0.702
VIQ	111.1 (12.5)	110.4 (13.4)	0.184	0.855
PIQ	97.2 (15.0)	101.2 (14.0)	0.884	0.382

Table 2. Mean scores on the psychological measures for the ASD group and the healthy controls

Questionnaire	ASD			CON			*t*	P value
	Mean	SD	Range	Mean	SD	Range		
AQ	34.2	7.8	12－46	17.0	7.7	5－28	6.776	0.000*
PHQ-9	11.3	6.8	0－23	2.6	2.5	0－9	5.150	0.000*
GAD-7	7.4	6.7	0－20	2.0	2.7	0－8	3.150	0.002*
EMC	14.7	8,2	2－34	8.2	8.2	1－20	2.833	0.005*
EQ[a]	23.0	11.9	9－50	36.0	13.9	15－64	3.320	0.001*
SQ[b]	23.7	15.6	6－66	22.9	9.4	2－38	0.239	0.811

[a]ASD group n = 21
[b]ASD group n = 20
*P < 0.01

Results

Demographics (Table 1)

The gender ratio of the participants was 13 males and 9 females in the ASD group (n = 22); and 9 males and 11 females in the CON group (n = 20). Fisher's exact test showed no significant association between the groups on "Gender ratio" ($\chi^2 = 0.834$, degrees of freedom [df] = 1, P = 0.537). The *t*-test showed no significant associations between the groups on: "Mean age" ($t = 1.892$, df = 40, P = 0.066), "FSIQ" ($t = 0.386$, df = 40, P = 0.702), "VIQ" ($t = 0.184$, df = 40, P = 0.855), and "PIQ" ($t = 0.884$, df = 40, P = 0.382). Thus, there were no significant differences in gender ratio, age, FSIQ, VIQ, or PIQ between the groups.

Group differences in psychological measures (Table 2)

The *t*-test showed significant differences between the groups for AQ ($t = 6.776$, df = 40, P < 0.01), PHQ-9 ($t = 5.150$, df = 40, P < 0.01), GAD-7 ($t = 3.150$, df = 40, P = 0.002), EMC ($t = 2.833$, df = 40, P = 0.005), and EQ ($t = 3.261$, df = 40, P = 0.001). As the EQ and SQ values were missing, multiple imputation methods were carried out to assign the missing values, and the *t*-values and P-values were calculated. The results showed that the ASD group had higher scores for AQ, PHQ-9, GAD-7, and EMC, and lower scores for EQ compared with the CON

Tabel 3. Mean scores on the RBMT subyests for the ASD group and the healthy controls

RBMT subtest	ASD		CON		*t*	P value
	Mean	SD	Mean	SD		
Names	1.5	0.8	1.9	0.4	2.020	0.051
Story Recall-immediate	1.9	0.3	1.9	0.5	0.468	0.643
Story Recall-delayed	1.9	0.3	1.9	0.4	0.077	0.939
Belongings	1.1	0.7	1.6	0.6	2.038	0.048*
Appointments	1.5	0.6	1.8	0.4	1.911	0.064
Messages	1.7	0.6	1.8	0.6	0.607	0.547
Picture	1.6	0.7	1.9	0.4	1.901	0.066
Face Recognition	1.8	0.4	1.9	0.4	0.271	0.788
Route Recall-immediate	1.4	0.7	1.7	0.6	1.440	0.158
Route Recall-delayed	1.4	0.7	1.7	0.6	1.440	0.158
Prospective memory (6)[a]	4.3	1.0	5.2	1.0	2.781	0.008**
Total profile scores (20)[a]	15.8	2.5	18.0	2.1	2.982	0.005**

[a]Numbers in parentheses are maximum scores.
*P < 0.05; **P < 0.01

Table 4. Relationships between the total profile scores on the RBMT and the explanatory variables

Explanatory variable		Model 3		Model 2		Model 1	
		B	[95% CI]	B	[95% CI]	B	[95% CI]
ASD/CON		1.179	[-0.273, 2.632]	1.445	[-0.003, 2.893]	1.187	[-0.630, 3.003]
Cognitive style	EQ	0.066*	[0.012, 0.121]	0.073**	[0.018, 0.128]	0.066*	[0.010, 0.121]
	SQ	-0.016	[-0.075, 0.044]	-0.004	[-0.068, 0.061]	-0.012	[-0.081, 0.056]
Age		-0.110	[-0.243, 0.023]	-0.108	[-0.238, 0.021]		
Gender (M/F)		0.243	[-1.158, 1.645]	-0.349	[-1.937, 1.238]		
FSIQ		0.042	[-0.016, 0.100]	0.051	[-0.006, 0.109]		
Depression	PHQ-9	-0.168	[-0.438, 0.103]				
Anxiety	GAD-7	0.225	[-0.062, 0.511]				
AIC		179.465		180.927		181.653	

*P < 0.05; **P < 0.01

group. In addition, 15 (68.2%) of the participants in the ASD group exceeded the cutoff score for AQ (AQ ≥33). However, no significant differences were found between the groups in SQ (t = 0.368, df = 40, P = 0.811).

Group differences in RBMT performance (Table 3)
Because unequal variances were found for the comparisons between the groups, we carried out Welch's tests. The results showed significant differences between the groups in "Total profile scores" (t = 2.982, df = 40, P = 0.005) and "Prospective memory" (t = 2.781, df = 40, P = 0.008). "Belongings" showed a significant difference between the groups (t = 2.038, df = 40, P = 0.048). Thus, the ASD group had lower total scores and PM scores on the RBMT compared to the CON group. The subtests on the RBMT showed lower in "Belongings."

Relationships between the total scores on the RBMT and the explanatory variables (Table 4)
A GLM was carried out to examine the associations between the RBMT total profile scores and the explanatory variables. The analysis included 42 participants (the ASD group and the CON group). The dependent variable was the "Total profile score" on the RBMT, and the explanatory variables were "ASD/CON," "EQ," and "SQ." The results showed that the diagnosis of ASD was not associated with the total profile scores of the RBMT (partial regression coefficient (B) = 1.179, CI: 95% CI [-0.273, 2.632], P = 0.112). On the other hand, EQ was significantly associated with the total profile score (B = 0.066, CI: 95% CI [0.012, 0.121], P = 0.017). EQ was also significantly associated with the total profile score on the RBMT in Models 2 and 3, which were created by adding age, gender, and the multiple psychological measures scores as moderator variables (Model 2: B = 0.073, CI: 95% CI [0.018, 0.128], P = 0.009; Model 3: B = 0.066, CI: 95% CI [0.010, 0.121], P = 0.021).

Discussion

The present study found that adults with ASD had lower total RBMT scores than did the healthy controls, indicating everyday memory impairments with ASD. This result is consistent with the results of a previous study of adolescent with ASD,[7] suggesting that everyday memory difficulties with ASD can be a common feature from adolescence into adulthood. As we hypothesized, PM was shown to be weak in ASD. Participants with ASD scored especially low in "Belongings" among the PM tasks. This task involves hiding one of the participant's belongings at the initiation of the test, asking the participant to remember the belonging and the location where they last saw it, before it was hidden, and finding out whether the participant can, at the end of the test, spontaneously recall the belonging and the last location the participant remembered it to be in. As the participant was required to "remember" the hidden belonging while performing a variety of tasks, poor performance in this task suggested that adults with ASD would have difficulty retaining multiple pieces of information for longer periods of time while processing tasks. In a study by Jones et al.,[7] 18.1% of the participants in an ASD group had an FSIQ <70, indicating a correlation between the FSIQ and PM scores. However, because both the ASD and CON groups in the present study had an FSIQ >79, there may be a common abnormality in the PM of individuals with ASD regardless of their intellectual abilities.

Compared with the CON group, the ASD group showed higher mean scores on the AQ, EMC, PHQ, and GAD among psychological measures and a lower mean score on the EQ. It is likely that the high-functioning ASD individuals were aware of their weak memory functioning, which was reflected in their higher EMC scores. Regarding the depression and anxiety indices, it has been reported that individuals with ASD have an increased risk of mood and anxiety symptoms compared to those without ASD,[32-34] as well as their having increased risks of multiple psychiatric diagnoses, such as depression, anxiety disorder, and bipolar disorder.[35] The findings of these previous studies are replicated in the present study. Moreover, the present study supports the previous findings about higher AQ and lower EQ in individuals with ASD compared to healthy individuals.[16] EQ was designed to measure empathic abilities, which refer to how easily a person perceives the feelings of others and is affected by their emotions.[36] Some argue that low empathic abilities are particularly important in understanding a person's social adjustment challenges and are important factors in psychiatric diagnoses of adults.[37]

Therefore, GLM was then carried out to examine the factors that influence the RBMT total profile scores, and the results showed that it was difficult to predict the total outcomes of the RBMT based on a diagnosis of ASD alone. As a single factor, EQ was consistently associated with the total scores on the RBMT in all models, suggesting the involvement of ToM and empathy in everyday memory functioning. These results predicted that the low RBMT scores would not merely represent weakness in real-life memory functioning but would also be associated with social and communication problems.

However, the ASD diagnosis and the SQ scores were not associated with the total RBMT scores. This result was inconsistent with our hypothesis. This might be due to the variation in the attributes of participants in the ASD group. Because 7 participants (31.8%) in the ASD group did not meet the cutoff scores for AQ, more than a few of them did not have significant ASD symptoms. There is also a possibility that more than a few adults with ASD may also have ADHD (attention deficit hyperactivity disorder).[36] Future surveys would need to be grouped and analyzed based on mental disorders or symptoms. This would require a larger sample population with ASD.

The present study compared adults with ASD and healthy controls, and examined everyday memory using the RBMT. In addition, the associations between everyday memory functions and cognitive styles were examined. The results showed that the individuals with ASD had impaired everyday memory and PM functioning. As executive functions and attentional processes are thought to be related to PM, future studies are warranted to investigate relationships between neuropsychological features of ASD and PM tasks to examine memory functions more thoroughly in individuals with ASD. We believe that verifications using physiological indicators such as frontal lobe and autonomic nerve activities, as well as eye movements during tasks, would help to clarify the memory processing process. Moreover, we carried out a GLM with the RBMT total profile score as the dependent variable and ASD/CON, EQ, and SQ as the explanatory variables. Multiple models were created with age, gender, and psychological measure scores as the moderator variables. The results showed that EQ, as a single factor, was consistently related to the total profile scores on the RBMT in all models, suggesting the involvement of ToM and empathy in everyday memory.

A limitation of the present study is that the results were susceptible to intraindividual factors because of the small sample population. In this respect, it was understandable that there were no significant differences in SQ between the groups. Another consideration is that the developmental level of language norms in adults with ASD may lead to improvements in interpersonal relationships, and ASD symptoms may likely decrease in adulthood.[38] In the future, we will need to take into account the variability of attributes in the ASD group. This will require a larger number of ASD participants and an analysis of their data based on their symptomatology.

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Conflicts of Interest: None

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