

## ORIGINAL ARTICLE

# Mind wandering in adults with attention deficit hyperactivity disorder: Preliminary evaluation using the Mind Excessively Wandering Scale in a Japanese clinical population

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## Abstract

**Aim:** Mind wandering (MW) has been closely associated with attention deficit hyperactivity disorder (ADHD); however, the field remains understudied in Japan. The present study examined MW in adults with ADHD using the Mind Excessively Wandering Scale (MEWS) in a Japanese clinical population.

**Methods:** Fifty-two adults with ADHD (mean age, 33.0 years; 33 men), diagnosed per the *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition (DSM-5) criteria, completed the MEWS, Mind Wandering Questionnaire, Conners' Adult ADHD Rating Scale (CAARS), Autism Spectrum Quotient (AQ), and Japanese Adult Reading Test-25.

**Results:** The mean MEWS score was 18.8 (standard deviation, 7.6). MEWS scores showed significant correlations with the CAARS Inattention/Memory Problems, Problems with Self-Concept, DSM-IV ADHD Symptoms Total, ADHD Index, and AQ scores. Higher MEWS scores were associated with greater ADHD and autism spectrum disorder symptoms in patients with ADHD.

**Conclusion:** Our results not only provide supporting evidence of the presence of excessive MW in adults with ADHD, but also indicate the heterogeneous nature of MW in ADHD.

## KEYWORDS

adult, attention-deficit/hyperactivity disorder, Mind Excessively Wandering Scale, mind-wandering, Mind Wandering Questionnaire

## INTRODUCTION

Ubiquitously found in our daily lives, mind wandering (MW) is the experience or state in which attention and thoughts do not remain on an original or ongoing task and drift away to unrelated internal thoughts, feelings, or images.<sup>1</sup> MW is experienced by all individual and is estimated to account for 25%–50% of our waking hours.<sup>2,3</sup> While MW may be involved in promoting creativity, effective problem-solving, and future planning,<sup>4–9</sup> it is closely related to

several unfavorable outcomes, such as poor academic performance,<sup>10–12</sup> increased risk of motor accidents,<sup>13–15</sup> and the production of negative feelings and unhappiness.<sup>3</sup> Spontaneous MW, as opposed to deliberate MW, lacks conscious initiation and control,<sup>16–18</sup> and is suggested to be more involved in task interference, negative consequences, and maladaptive psychological processes.<sup>19–23</sup>

As adults with ADHD have thought processes with characteristics that are similar to those of MW, such as constantly ongoing mental activity, thoughts jumping from one subject to another, and

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multiple short-lived thoughts,<sup>24–27</sup> researchers now postulate that excessive spontaneous MW may be the core mental phenomenon of ADHD that underlies the symptoms and multiple impairments.<sup>26,28</sup> In support, numerous studies have found frequent MW in individuals with ADHD.<sup>20,26,29</sup> Franklin et al.<sup>29</sup> studied an adult community sample population and showed that ADHD symptomatology was positively correlated with both the frequency of MW and the lack of metacognition of MW. Similarly, Seli et al.<sup>20</sup> found increased spontaneous MW and its independent relationship with ADHD symptomatology in clinical and non-clinical populations with ADHD. While ADHD is characterized by inattention, hyperactivity, and impulsivity,<sup>30</sup> behavioral symptoms that are often used for diagnosis may be masked in well-adapted adults in whom symptoms remain and manifest as internal thought processes as excessive MW.<sup>26,28</sup> Therefore, Mowlem et al.<sup>26</sup> developed the Mind Excessively Wandering Scale (MEWS) to evaluate excessive MW in ADHD to help diagnose and examine the impairments in adults with ADHD. The 12-item scale (initially developed with 15 items but reduced to 12 after psychometric analysis) showed good psychometric properties (internal consistency,  $\alpha > 0.9$ ; sensitivity and specificity, both 0.9), and an elevated level of MW was found in adults with ADHD.<sup>26</sup> In accordance with previous studies, MW was positively correlated with all domains of ADHD symptoms (inattention, hyperactivity/impulsivity, emotional lability) and functional impairments, which were assessed using self-report rating scales.<sup>26</sup>

Despite the importance of assessing MW in ADHD, particularly in high-functioning adults, the field remains understudied in Japan. Thus, the present study used the MEWS to examine MW and its relationship with ADHD symptoms in a clinical adult population in Japan for the first time. In addition to the MEWS, the Mind Wandering Questionnaire (MWQ), which measures the frequency of MW, irrespective of whether it is deliberate or spontaneous,<sup>31</sup> was administered for further MW evaluation. Moreover, due to the common presence of autism spectrum disorder (ASD) symptoms in adults with ADHD (even though they may not be clinically diagnosed with ASD),<sup>32,33</sup> the Autism Spectrum Quotient (AQ)<sup>34,35</sup> was used to study the relationship between ASD symptoms in ADHD and MW.

## METHODS

### Participants

Participants were recruited from outpatients who visited the specialty clinic for adult neurodevelopmental disorders at the Showa University Karasuyama Hospital, in central Tokyo, Japan, between October 2020 and May 2021. Only those fulfilling the *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition (DSM-5) criteria for ADHD<sup>29</sup> and with an estimated intelligence quotient (IQ) of over 85 per the Japanese Adult Reading Test (JART)-25<sup>36</sup> were included. The exclusion criteria were age <18 years and presence of comorbid psychiatric disorders (including ASD) according to the DSM-5 criteria.<sup>30</sup>

### Procedure

Each candidate participant underwent a comprehensive diagnostic assessment, which included: (1) two sets of interviews, by expert psychiatrists, on developmental and medical history; (2) the Japanese version of Conners' Adult ADHD Diagnostic Interview for DSM-IV (CAADID)<sup>37,38</sup>; (3) reviews of maternity record books and elementary school (6–12 years old) reports; and (4) the JART-25.<sup>36</sup> The final diagnosis of ADHD and comorbid psychiatric disorders, including ASD, was determined by consensus between psychiatrists and psychologists who were involved in administering assessments (1)–(4). The final study population consisted of 52 adults with ADHD (mean age 33.0 years; standard deviation [SD] 11.4; 33 men). This diagnostic selection step was followed by the administration of the following assessments to all participants: the Japanese versions of (1) the Conners' Adult ADHD Rating Scale-Self-Report: Long Version (CAARS-S:L-J),<sup>39,40</sup> (2) the AQ,<sup>34,35</sup> (3) the MEWS,<sup>26,41</sup> and (4) the MWQ.<sup>31,42</sup> In addition, the social functioning level of the participants was estimated by calculating the percentage of months with full attendance (including housework for a housewife) at work or school in the past year (social functioning estimate).

### Assessment tools

#### Conners' Adult ADHD Rating Scale self-report

Developed by Keith Conners<sup>39</sup> (Japanese version by Nakamura<sup>40</sup>), the CAARS measures the presence and severity of subjective ADHD symptoms. The long version consists of 66 items, which are rated on a four-point Likert scale to produce seven domain scores: Inattention/Memory Problems, Hyperactivity/Restlessness, Impulsivity/Emotional Lability, Problems with Self-Concept, DSM-IV Inattentive Symptoms, DSM-IV Hyperactive-Impulsive Symptoms, DSM-IV ADHD Symptoms Total, and ADHD Index.

#### AQ

The AQ, developed by Baron-Cohen et al.,<sup>34</sup> is a 50-item self-report measure for adults with normal intelligence that assesses the presence of autistic traits. Each item is answered on a four-point Likert scale, with higher scores indicating greater ASD traits. The Japanese version has been standardized, and 33 is considered a suitable cut-off.<sup>35</sup>

#### MEWS

The MEWS consists of 12 items and measures the level of MW in persons with ADHD; items are scored on a four-point Likert scale, and 15 is suggested to be a suitable cut-off.<sup>26</sup> The mean MEWS

scores were 25.0 (SD 10.1) and 27.7 (SD 9.3) in the validation study of two adult populations with ADHD.<sup>26</sup> A large online general population survey found no sex differences in the MEWS score; the mean was 26.3 (SD 6.6) for men and 25.4 (SD 7.8) for women with ADHD.<sup>28</sup> Further, Bozhilova et al.<sup>43</sup> showed in their ADHD participants that MEWS scores significantly and strongly correlated with task-unrelated thoughts during MW and sustained attention tasks ( $\beta$  scores of 0.67 and 0.66, respectively). The Japanese version was developed by Saito<sup>41</sup> (back-translation performed) and is used in this study.

## MWQ

Mrazek et al.<sup>31</sup> developed the MWQ—a five-item assessment—to evaluate the propensity and frequency of MW in the general population. The score is known to correlate positively with task-unrelated thoughts during cognitive tasks and is associated with worsened mood, lowered life satisfaction, and lowered self-esteem.<sup>31,42</sup> The Japanese version was developed and validated by Kajimura and Nomura.<sup>42</sup>

## Statistical analyses

All statistical analyses were performed using SPSS version 25.0 (IBM Corp.). First, to characterize the study sample, descriptive analyses by sex were performed for demographic (age, years of education, estimated IQ, and social functioning estimate) and clinical (MEWS, MWQ, CAARS, and AQ) measures. Independent samples *t*-tests and  $\chi^2$  tests were used to examine any sex differences in the continuous and categorical variables, respectively. Second, to determine the relationships between MW and other clinical symptoms, Pearson product-moment correlation coefficients were calculated between the MEWS, MWQ, CAARS, AQ, and JART-25 (estimated IQ) scores for the total, male, and female participants, respectively. Third, to determine the clinical characteristics of those with high levels of MW (high-level mind wanderers), the study population was divided into two groups (high- and low-level MW) according to the mean MEWS score, and the between-group comparisons were made using independent samples *t*-tests and  $\chi^2$  tests. The significance level was set at 0.05, except that 0.01 was set for correlations to account for the possibility of type I error. All tests were two-sided.

## Ethics

This study was approved by the Medical Ethics Committee of Showa University School of Medicine, and protocols were carried out in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants after information was provided about the study.

## RESULTS

### Demographic and clinical characteristics

A total of 52 participants (33 men, 19 women) were included in the analyses. All participants visited our clinic for specialist attention and treatment for ADHD. Thirty-three percent were on psychotropic medication, of which 7.7% were on ADHD medication. Patient demographic and clinical characteristics are presented in Table 1. The participants had a relatively high average for years of education (mean 15.2, SD 1.9) and estimated IQs (mean 107.1, SD 10.3). Their level of social functioning was high with an average social functioning estimate of 86.0% (SD 28.2) and the majority of them (88.5%) had an estimate of 60% or higher. The mean MEWS score was 18.8 (SD 7.6), and 35 (67.3%) of the total participants scored higher than 15 (the recommended cut-off score for MEWS). No sex differences were found for any demographic and clinical measures, including the MEWS, MWQ, CAARS, and AQ scores.

### Relationship between MW, ADHD, and ASD symptoms

Tables 2–4 show the correlations between the MEWS, MWQ, CAARS, AQ, and estimated IQ for the total, male, and female participants respectively. While the MEWS score was positively and mild to moderately correlated with the CAARS Inattention/Memory Problems, CAARS Problems with Self-Concept, CAARS DSM-IV ADHD Symptoms Total, and CAARS ADHD Index scores for the total participants, it only correlated moderately with CAARS DSM-IV ADHD Symptoms Total and CAARS ADHD Index scores for men and CAARS ADHD Index scores for women. The AQ score was positively and mildly correlated with the MEWS score in the total and male participants, but not in the female participants. The MEWS score did not correlate with the MWQ or estimated IQ for the total, male, or female participants. The MWQ score positively and mild to moderately correlated with CAARS Inattention/Memory Problems, CAARS Hyperactivity/Restlessness, CAARS DSM-IV Inattentive Symptoms, CAARS DSM-IV ADHD Symptoms Total, and CAARS ADHD Index scores in the total participants. In male participants, MWQ did not correlate with any of the CAARS scores, but for female participants, MWQ positively and moderately correlated with CAARS Inattention/Memory Problems, CAARS Hyperactivity/Restlessness, CAARS Impulsivity/Emotional Lability, CAARS DSM-IV Inattentive Symptoms, and CAARS DSM-IV ADHD Symptoms Total scores. The MWQ did not correlate with the AQ score or estimated IQ in any of the three groups.

### Characteristics of adults with ADHD by MW level (high versus low)

Table 5 compares the demographic and clinical characteristics of those who scored higher than the mean MEWS score of 18 (high

**TABLE 1** Demographic and clinical characteristics of the participants by sex

	Men (n = 33)		Women (n = 19)		Total (n = 52)	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Age	33.0 (10.7)	19–56	33.1 (12.8)	19–57	33.0 (11.4)	19–57
Years of education	15.2 (1.9)	12–18	15.0 (2.0)	11–18	15.2 (1.9)	11–18
Estimated IQ <sup>a</sup>	107.8 (9.7)	85.4–119.8	105.9 (11.4)	85.4–119.8	107.1 (10.3)	85.4–119.8
Social functioning estimate (%)	86.1 (29.8)	0–100	85.8 (26.0)	0–100	86.0 (28.2)	0–100
AQ: Total	30.6 (7.4)	13–46	31.5 (7.4)	15–44	30.9 (7.3)	13–46
CAARS: Inattention/Memory Problems	75.9 (12.8)	50–90	75.7 (10.9)	52–90	75.8 (12.0)	50–90
CAARS: Hyperactivity/Restlessness	67.6 (12.9)	39–90	62.7 (17.5)	41–90	65.9 (14.8)	39–90
CAARS: Impulsivity/Emotional Lability	68.0 (12.6)	36–90	64.0 (14.0)	38–90	66.5 (13.1)	36–90
CAARS: Problems with Self-Concept	69.1 (9.9)	45–87	66.4 (9.0)	49–78	68.1 (9.6)	45–87
CAARS: DSM-IV Inattentive Symptoms	79.5 (11.0)	51–90	76.7 (14.2)	42–90	78.5 (12.2)	42–90
CAARS: DSM-IV Hyperactive-Impulsive Symptoms	68.1 (16.7)	21–90	66.7 (17.8)	39–90	67.6 (17.0)	21–90
CAARS: DSM-IV ADHD Symptoms Total	77.5 (11.0)	45–90	74.6 (15.4)	40–90	76.5 (12.7)	40–90
CAARS: ADHD index	75.3 (10.1)	58–90	71.0 (11.7)	52–89	73.7 (10.8)	52–90
MEWS	19.2 (7.0)	6–33	18.0 (8.7)	0–32	18.8 (7.6)	0–33
MWQ	23.8 (4.4)	14–30	22.3 (5.3)	9–30	23.3 (4.8)	9–30

Abbreviations: AQ, Autism Spectrum Quotient; CAARS, Conners' Adult ADHD Rating Scale; DSM-IV, *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition; IQ, intelligence quotient; MEWS, Mind Excessively Wandering Scale; MWQ, Mind Wandering Questionnaire; SD, standard deviation.

<sup>a</sup>Estimated IQ indicated by the Japanese Adult Reading Test-25.

An independent samples *t*-test revealed no significant sex differences at  $p < 0.05$ .

MW) and those who scored 18 or lower on MEWS (low MW). Individuals with high MW had significantly more years of education and scored higher than those with low MW in the CAARS Inattention/Memory Problems, CAARS Hyperactivity/Restlessness, CAARS Impulsivity/Emotional Lability, CAARS DSM-IV Inattentive Symptoms, CAARS DSM-IV Hyperactive-Impulsive Symptoms, CAARS DSM-IV ADHD Symptoms Total, CAARS ADHD Index, and AQ scores.

## DISCUSSION

To the best of our knowledge, this is the first study to evaluate MW in a clinical population of adults with ADHD in Japan using the MEWS. As in previous studies, we found an elevated level of MW in adults with ADHD. MW was significantly related not only to ADHD symptoms but also to ASD symptoms in adults with ADHD.

Consistent with the original work by Mowlem et al.,<sup>26,28</sup> adults with ADHD had high MEWS scores, which indicated an elevated level of MW. Although our mean score of 18.8 (SD 7.6) was higher than that of their control groups (4.8 [SD 7.0] and 7.2 [SD 6.3]), it was lower than the means of their ADHD population, which were 25.0 (SD 10.1) and 27.7 (SD 9.3).<sup>26</sup> Further, while the absence of sex differences in MEWS scores was also similar with their results, our

mean MEWS scores for men and women (19.2 [SD 7.0] and 18.0 [SD 8.7], respectively), were lower than those in their study (26.3 [SD 6.6] and 25.4 [SD 7.8], respectively<sup>28</sup>). Moreover, 32.7% of our participants did not score above the suggested cut-off of 15 for the MEWS. Similarly, our mean MWQ score of 23 was smaller than 24, which was calculated to be an optimal cut-off for defining high- and low-level mind wanderers in a clinically referred population with ADHD.<sup>44</sup> Since the average MWQ score was 20.3 (SD 2.7) in Japanese university students,<sup>42</sup> our mean score, though not high, may be viewed as a slight elevation of MW. Several reasons can be postulated for our relatively low MW scores. One is regarding the characteristics of our participants, which only consisted of individuals who visited the doctor and received their diagnoses for the first time in adulthood. Due to the late consultations and the average to high IQs, they may have better adaptive and coping skills to compensate for their problems. As excessive MW is a strong predictor of ADHD-related functional impairments—which are independent of core ADHD symptoms,<sup>26</sup> the level of impairments and associated MW may have been relatively less severe in our participants. Moreover, our participants included those who were taking psychotropics, including ADHD medications, which could have lowered their scores. Methylphenidate may reduce excessive MW,<sup>26</sup> possibly by normalizing default mode network (DMN) activity, a neural basis implicated in MW and ADHD.<sup>45</sup> Another possibility is that excessive MW is just a common cognitive comorbidity and does not underlie all ADHD

**TABLE 2** Correlations among the MEWS, MWQ, CAARS, AQ, and IQ in the total participants (n = 52)

	MEWS	MWQ	CAARS: IM	CAARS: HR	CAARS: IE	CAARS: SC	CAARS: IA	CAARS: HI	CAARS: Total	CAARS: Index	AQ: Total	Estimated IQ
MEWS		0.34	0.36*	0.28	0.34	0.38*	0.30	0.32	0.44*	0.66*	0.39*	0.17
MWQ			0.43*	0.49*	0.34	0.18	0.61*	0.25	0.55*	0.42*	0.04	0.19
CAARS: IM				0.51*	0.62*	0.38*	0.82*	0.48*	0.81*	0.66*	0.13	-0.01
CAARS: HR					0.53*	0.03	0.52*	0.68*	0.72*	0.62*	-0.06	-0.09
CAARS: IE						0.31	0.61*	0.53*	0.67*	0.68*	0.28	0.11
CAARS: SC							0.36*	0.11	0.30	0.51*	0.35	0.18
CAARS: IA								0.52*	0.88*	0.57*	0.14	0.04
CAARS: HI									0.74*	0.59*	0.14	0.10
CAARS: Total										0.75*	0.14	0.03
CAARS: Index											0.35	0.13
AQ: Total												0.27
Estimate-d IQ												

Note: Estimated intelligence quotient (IQ) as indicated by the Japanese Adult Reading Test-25.

Abbreviations: AQ, Autism Spectrum Quotient; CAARS, Conners' Adult ADHD Rating Scale; HI, DSM-IV Hyperactive-Impulsive Symptoms; HR, Hyperactivity/Restlessness; IA, DSM-IV Inattentive Symptoms; IE, Impulsivity/Emotional Lability; IM, Inattention/Memory Problems; Index, ADHD Index; MEWS, Mind Excessively Wandering Scale; MWQ, Mind Wandering Questionnaire; SC, Problems with Self-Concept; Total, DSM-IV ADHD Symptoms Total.

\*Correlation is significant at the 0.01 level (two-tailed).

**TABLE 3** Correlations among the MEWS, MWQ, CAARS, AQ, and IQ in the male participants (n = 33)

	MEWS	MWQ	CAARS: IM	CAARS: HR	CAARS: IE	CAARS: SC	CAARS: IA	CAARS: HI	CAARS: Total	CAARS: Index	AQ: Total	Estimated IQ
MEWS		0.35	0.31	0.42	0.23	0.33	0.20	0.30	0.50*	0.67*	0.44*	0.13
MWQ			0.34	0.30	0.12	0.28	0.40	0.02	0.35	0.29	0.13	0.38
CAARS: IM				0.63*	0.55*	0.39	0.83*	0.38	0.83*	0.64*	0.17	0.09
CAARS: HR					0.46*	0.16	0.45*	0.58*	0.73*	0.69*	-0.09	-0.09
CAARS: IE						0.25	0.50*	0.34	0.53*	0.61*	0.32	0.08
CAARS: SC							0.49*	0.17	0.46*	0.48*	0.29	0.21
CAARS: IA								0.36	0.82*	0.44	0.23	0.26
CAARS: HI									0.63*	0.51*	0.16	0.15
CAARS: Total										0.75*	0.21	0.16
CAARS: Index											0.31	0.13
AQ: Total												0.29
Estimated IQ												

Note: Estimated intelligence quotient (IQ) as indicated by the Japanese Adult Reading Test-25.

Abbreviations: AQ, Autism Spectrum Quotient; CAARS, Conners' Adult ADHD Rating Scale; HI, DSM-IV Hyperactive-Impulsive Symptoms; HR, Hyperactivity/Restlessness; IA, DSM-IV Inattentive Symptoms; IE, Impulsivity/Emotional Lability; IM, Inattention/Memory Problems; Index, ADHD Index; MEWS, Mind Excessively Wandering Scale; MWQ, Mind Wandering Questionnaire; SC, Problems with Self-Concept; Total, DSM-IV ADHD Symptoms Total.

\*Correlation is significant at the 0.01 level (2-tailed).

**TABLE 4** Correlations among the MEWS, MWQ, CAARS, AQ, and IQ in the female participants (n = 19)

	MEWS	MWQ	CAARS: IM	CAARS: HR	CAARS: IE	CAARS: SC	CAARS: IA	CAARS: HI	CAARS: Total	CAARS: Index	AQ: Total	Estimated IQ
MEWS		0.31	0.46	0.13	0.46	0.46	0.41	0.34	0.38	<b>0.66*</b>	0.34	0.22
MWQ			<b>0.61*</b>	<b>0.67*</b>	<b>0.60*</b>	-0.01	<b>0.83*</b>	0.56	<b>0.75*</b>	0.54	-0.07	-0.06
CAARS: IM				0.39	<b>0.77*</b>	0.38	<b>0.88*</b>	<b>0.68*</b>	<b>0.84*</b>	<b>0.74*</b>	0.05	-0.17
CAARS: HR					<b>0.58*</b>	-0.21	0.57	<b>0.82*</b>	<b>0.70*</b>	0.52	0.00	-0.14
CAARS: IE						0.37	<b>0.74*</b>	<b>0.81*</b>	<b>0.82*</b>	<b>0.76*</b>	0.25	0.12
CAARS: SC							0.15	-0.02	0.07	0.53	0.51	0.11
CAARS: IA								<b>0.73*</b>	<b>0.95*</b>	<b>0.71*</b>	0.05	-0.23
CAARS: HI									<b>0.90*</b>	<b>0.71*</b>	0.11	0.01
CAARS: Total										<b>0.74*</b>	0.08	-0.13
CAARS: Index											0.47	0.11
AQ: Total												0.25
Estimated IQ												

Note: Estimated intelligence quotient (IQ) as indicated by the Japanese Adult Reading Test-25.

Abbreviations: AQ, Autism Spectrum Quotient; CAARS, Conners' Adult ADHD Rating Scale; HI, DSM-IV Hyperactive-Impulsive Symptoms; HR, Hyperactivity/Restlessness; IA, DSM-IV Inattentive Symptoms; IE, Impulsivity/Emotional Lability; IM, Inattention/Memory Problems; Index, ADHD Index; MEWS, Mind Excessively Wandering Scale; MWQ, Mind Wandering Questionnaire; SC, Problems with Self-Concept; Total, DSM-IV ADHD Symptoms Total.

\*Correlation is significant at the 0.01 level (two-tailed).

**TABLE 5** Characteristics of ADHD adults with high and low levels of mind wandering by MEWS

Mean (SD)	High MW (n = 28)	Low MW (n = 24)	p
Age	33.5 (11.8)	32.5 (11.1)	0.736
Years of education	15.6 (1.7)	14.6 (2.0)	0.046
Sex (male) n (%)	20 (71.4)	13 (54.2)	0.198
Estimated IQ <sup>a</sup>	108.8 (10.5)	105.1 (9.9)	0.189
MWQ	24.5 (4.2)	21.9 (5.2)	0.056
CAARS: Inattention/Memory Problems	79.1 (11.6)	72.0 (11.6)	0.033
CAARS: Hyperactivity/Restlessness	70.6 (14.1)	60.3 (13.8)	0.011
CAARS: Impulsivity/Emotional Lability	71.1 (14.0)	61.2 (9.8)	0.004
CAARS: Problems with Self-Concept	70.3 (8.6)	65.5 (10.3)	0.082
CAARS: DSM-IV Inattentive Symptoms	82.0 (9.1)	74.4 (14.2)	0.030
CAARS: DSM-IV Hyperactive-Impulsive Symptoms	74.7 (16.8)	59.3 (13.3)	0.001
CAARS: DSM-IV ADHD Symptoms Total	82.1 (8.9)	69.8 (13.4)	<0.001
CAARS: ADHD Index	80.0 (7.8)	66.4 (9.2)	<0.001
AQ: Total	33.3 (6.1)	28.2 (7.8)	0.013

Note: Items that showed significant group difference at  $p < 0.05$  by independent samples  $t$ -test ( $\chi^2$  test for sex) are in bold.

Abbreviations: ADHD, attention deficit hyperactivity disorder; AQ, Autism Spectrum Quotient; CAARS, Conners' Adult ADHD Rating Scale; DSM-IV, *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition; MEWS, Mind Excessively Wandering Scale; MWQ, Mind Wandering Questionnaire; SD, standard deviation.

<sup>a</sup>Estimated IQ indicated by the Japanese Adult Reading Test-25.

cases, as suggested by Biederman et al.<sup>44</sup> Some of our participants scored very low on both the MEWS and MWQ, including a score of 0. Further studies with controls and differing clinical populations together with the assessment of functional impairments are certainly required.

Excessive MW was strongly associated with ADHD symptoms, further supporting the existing literature that MW and ADHD symptomatology are closely linked.<sup>26,28,29</sup> Although the correlation analysis revealed that only inattention and general ADHD symptoms positively correlated with MEWS score, the group analysis of high- and low-level mind wanderers yielded significant increases in the scores for all ADHD symptom domains (inattention, hyperactivity, and impulsivity) in the high-level mind wanderers. The MWQ also correlated with inattention and hyperactivity but not impulsivity, which is partially congruent with the study by Biederman et al.,<sup>44</sup> wherein all three symptom domains correlated. Interestingly, when analyses by sex were performed, only the MEWS correlated with ADHD symptoms in the male participants, but MWQ correlated with many more domains of ADHD symptoms than MEWS for female participants. More importantly and unexpectedly, MEWS and MWQ scores did not correlate with each other. While the MEWS is designed to assess MW more specific to ADHD, such as constantly ongoing mental activity, thoughts jumping from one topic to another, and multiple thoughts at the same time,<sup>25</sup> the MWQ evaluates MW more generally, especially while performing specific tasks, such as reading.<sup>31,46</sup> It can also be interpreted that the MEWS captures the

quality and the MWQ the frequency of MW, which may have resulted in the non-correlation. Since this is the first study to evaluate MEWS and MWQ simultaneously in individuals with ADHD, further examinations are required, as both scales have been shown to reflect ADHD symptomatology separately.<sup>26,28,44</sup> Although we cannot rule out the problem of underpowered statistics, especially for analysis based on sex, our mixed results may suggest the heterogeneous nature of MW present in clinical adults with ADHD.

MW was also associated with ASD symptoms in adults with ADHD, as indicated by positive correlations between AQ and MEWS scores, and an elevated AQ score in the high-level mind wanderers. This is, in fact, congruent with Biederman et al.,<sup>44</sup> who found that high-level mind wanderers, based on MWQ, had significantly higher Social Responsiveness Scale scores than those with low-level mind wanderers in ADHD. Although only the MEWS (and not the MWQ) score correlated with AQ score in our study, this result suggests a possible link between ASD symptoms and MW. There have been very few studies on MW in ASD, and the results are mixed and partial. In the study by Helfer et al.,<sup>47</sup> MEWS scores did not differ between adults with ADHD and ASD, both of which were higher than those of the controls. Similar neural abnormalities associated with DMN and MW have been reported in ADHD and ASD<sup>45,48-50</sup>; however, the mechanisms or content of MW may differ.<sup>47,51</sup> Given that individuals with both ADHD and ASD exhibit greater impairments in various domains than those with only ADHD,<sup>52</sup> elevated MW with an association with AQ scores may reflect the social



impairments experienced by the participants. Further studies are warranted for those with ASD and ADHD comorbid with ASD.

The current study has several limitations. First, the absence of a control group poses a major constraint to our result interpretation. Moreover, a validation study of the Japanese version of the MEWS has not yet been performed. These significantly limit the precise evaluation of the level of MW in ADHD in our study. The reliability and validity assessment with ADHD and non-ADHD participants in Japan is essential for further discussion. Second, given that negative mood, including sadness, depression, and anxiety, have been strongly associated with MW,<sup>53-57</sup> our results may have been influenced by these factors. Although we thoroughly assessed and excluded those with depression and anxiety disorders, subclinical symptoms may have been present and had an effect. Future studies should simultaneously evaluate mood, depressive symptoms, and anxiety levels. Third, since the exclusion of ASD was based on a clinical diagnosis without the use of the *Autism Diagnostic Observation Schedule*, Second Edition (ADOS-2<sup>58</sup>) and the *Autism Diagnostic Interview, Revised* (ADI-R<sup>59</sup>), adults with ASD may have been included. However, this effect should be minimal, as thorough examinations of developmental history from multiple resources were conducted. A future study using the ADOS-2 and ADI-R may be ideal for a detailed examination of the relationship between ASD, ADHD, and MW. Finally, we did not use medication-naïve individuals, and psychotropic medications could have altered the level of MW and ADHD symptoms. A further study with a larger non-medicated ADHD population against a neurotypical control is in progress.

## CONCLUSIONS

Literally translated as *Kokorokokoni arazu* (absent mind) in Japanese, MW may play an important role in the psychopathology of ADHD. Using the MEWS, the present study demonstrated a high level of spontaneous MW in clinical adults with ADHD. MW also correlated significantly with ADHD symptoms, as reported previously. ASD symptoms in ADHD may also be associated with MW.

## AUTHOR CONTRIBUTIONS

Wakaho Hayashi performed the data analysis and wrote the first draft of the manuscript. Akira Iwanami contributed to the data interpretation and writing of the manuscript. Akisa Tomita was involved in the study design, data analysis, subject recruitment, and clinical diagnostic assessments. All authors contributed to and approved the final manuscript.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

Research data will not be shared, as the participants did not consent to open data sharing.

## ETHICS APPROVAL STATEMENT

This study was approved by the Medical Ethics Committee of Showa University School of Medicine, and protocols were carried out in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants after information was provided about the study.

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