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Clinical correlates of mind wandering in adults with ADHD

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ABSTRACT

The objective of this study was to investigate the prevalence and clinical correlates of ADHD patients with mind wandering. 255 consecutively referred 18- to 55-year-old adults of both sexes with ADHD were assessed. Subjects completed a demographic interview, the Mind Wandering Questionnaire (MWQ), the ADHD Rating Scale (ADHD RS), the Behavior Rating Inventory of Executive Function – Adult Version (BRIEF-A), the Social Responsiveness Scale – Second Edition (SRS-2) Adult Self-Report Form, the Adult Self-Report (ASR), the Barkley Emotional Dysregulation Scale, and the Quality of Life Enjoyment & Satisfaction Questionnaire (Q-LES-Q). We used receiver operator characteristic (ROC) curves to identify the optimal cut-off on the MWQ to categorize patients as having high-versus low-level mind wandering and compared demographic and clinical characteristics between the two groups. Participants were categorized by ROC analysis as having high- (N = 127) and low-level (N = 128) mind wandering based on an MWQ total score ≥ or < than 24, respectively. Compared with low-level mind wandering participants, those with high-level mind wandering had significantly more Inattentive and Hyperactive symptoms (all $p < 0001$), worse executive functioning as measured by the BRIEF-A, more impaired mean (all $p \leq 0.001$) and dichotomized scores (t-score ≥65) (all $p < 0.005$) on subscales and composite ASR scales, more impaired scores on the Barkley Emotional Dysregulation Scale ($p < 0.001$), and more impaired quality of life scores. High-level mind wandering is prevalent in adults with ADHD and is associated with more severe ADHD symptoms, more executive function deficits, more emotional dysregulation, higher levels of associated psychopathology, and more impaired quality of life.

1. Introduction

Mind wandering refers to the shifting of attention toward internal thoughts (Seli et al., 2015b; Smallwood et al., 2007; Smallwood and Schooler, 2006). While mind wandering can be deliberate or spontaneous (Carriere et al., 2013; Giambra, 1989; Seli et al., 2015a, 2015b; Shaw and Giambra, 1993), as shown by Shaw and Giambra (1993) and Seli et al. (2015b), it is the spontaneous, unintentional shifting of attention that seems most relevant to ADHD (Carriere et al., 2013; Seli et al., 2015a). Moreover, this latter type of mind wandering has been shown to be associated with impulsivity (Cheyne et al., 2009), poor sustained attention (Seli et al., 2013a, 2013b), and fidgeting (Seli et al., 2014), all of which are mental functions associated with ADHD.

However, the spontaneous and unconscious nature of mind wandering associated with ADHD is distinct from other mental processes that typify ADHD such as inattention and distractibility. It can be viewed as "Internal Distractibility" to contrast it with the traditional type of distractibility seen with ADHD that refers to external stimuli. In contrast to external distractibility, internal distractibility is spontaneous, and subjects are often unaware of its presence.

An emerging literature has begun to examine the association between ADHD and mind wandering. Helfer et al. (2019) found that mind wandering predicted ADHD symptom severity in adults with ADHD. Soffer-Dudek (2019) showed that items from the ADHD Self-Report Scale (ASRS) and Mind Wandering Questionnaire loaded onto a similar factor which they called "Mind Wandering/Distraction", suggesting that ADHD symptoms and mind wandering are related.

We previously used the Mind Wandering Questionnaire (MWQ) (Mrazek et al., 2013) in a clinical sample of adults with ADHD to investigate whether mind wandering was associated with specific symptoms of ADHD (Biederman et al., 2017). We found that inattentive ADHD scores had the strongest association with the MWQ. However,

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uncertainties remain as to whether mind wandering is associated with other correlates of ADHD beyond symptom domains.

Further insights into the prevalence and correlates of mind wandering in adults with ADHD have important implications. Clinically, patients with high levels of mind wandering may have unique challenges and outcomes and may respond differently to treatments for ADHD. Considering the heterogeneity of ADHD, the presence of mind wandering may help identify a more homogeneous subgroup of ADHD patients with unique clinical, therapeutic and neurobiological underpinnings.

The main aim of this study was to investigate the prevalence and clinical correlates of mind wandering in adults with ADHD. To this end, we assessed the association between the MWQ scores and ADHD symptom dimensions and other clinical correlates in a large sample of referred adults with ADHD.

2. Material and methods

2.1. Sample

Our sample consisted of 255 consecutively referred 18- to 55-year-old adults of both sexes who were clinically referred for the evaluation and treatment of ADHD to the Clinical and Research Program in Adult ADHD at the Massachusetts General Hospital. A Statement of Research was presented to potential patients before their clinical appointment detailing the purpose of the study, what data were being collected, and the confidentiality and security of the data. Patients presenting to the clinic had the choice to opt into or out of participating in research and their decision did not impact their clinical care. There was no selection bias based on social class or insurance restrictions. We received institutional review board approval to review, analyze, and report anonymously on these subjects.

2.2. Assessment procedures

All new clinic patients completed a battery of rating scales before their initial evaluation. This battery included a demographic interview, the Mind Wandering Questionnaire (MWQ), the ADHD Rating Scale (ADHD RS), the Behavior Rating Inventory of Executive Function – Adult Version (BRIEF-A), the Social Responsiveness Scale – Second Edition (SRS-2) Adult Self-Report Form, the Adult Self-Report (ASR), the Barkley Emotional Dysregulation Scale, and the Quality of Life Enjoyment & Satisfaction Questionnaire (Q-LES-Q).

The demographic interview collected information on age, race, sex, socioeconomic status, history of head injury or trauma, and mother's pregnancy and delivery characteristics. The MWQ is a 5-item scale that assesses mind wandering traits with each item rated on a Likert scale of 1 (almost never) to 6 (almost always) (Mrazek et al., 2013). The ADHD RS is an 18-item patient-rated questionnaire to determine how often ADHD symptoms occur with each question rated on a scale of 0 (Never) to 4 (Very Often) (DuPaul et al., 1998). Nine questions assess inattentive symptoms and nine questions assess hyperactive symptoms. The BRIEF-A is a 75-item patient-rated questionnaire to assess an adult's cognitive, emotional, and behavioral functions within the past month with each question rated on a scale of 1 (Never) to 3 (Often) (Roth et al., 2005). Raw scores are calculated and used to generate T-scores for 9 scales (Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials), 2 summary index scales (Behavioral Regulation Index and Metacognition Index), and one scale reflecting overall functioning (Global Executive Composite). The SRS-2 Adult Form is a 65-item self-rated assessment used to measure the severity of autism spectrum symptoms as they occur in natural settings with each item rated on a scale of 1 (Not True) to 4 (Almost Always True) (Constantino and Gruber, 2012). Raw scores are calculated and used to generate T-scores for 5 subscales (Awareness, Cognition, Communication, Motivation, RRB) and one total scale. The ASR is a 126-item self-rated assessment of adult behavior, social competence, and substance use with each question rated on a scale of 0 (Not True) to 2 (Very True or Often True) (Achenbach and Rescorla, 2003). Raw scores are calculated and used to generate T-scores for 8 scales (Aggressive Behavior, Anxious/Depressed, Attention Problems, Intrusive, Rule-Breaking Behavior, Somatic Complaints, Thought Problems, and Withdrawn), 2 composite scales (Externalizing Problems, Internalizing Problems), and one Total Problems scale. The Barkley Emotional Dysregulation Scale is subset of 8 questions from the Current Behavior Scale (CBS) designated by Barkley as measuring deficient emotional self-regulation (Barkley, 1997a, b). It asks subjects to describe their behavior in the past 6 months with responses rated on a scale of 0 (Never or Rarely) to 3 (Very Often). The Q-LES-Q is a self-rated 16-item rating scale to assess enjoyment and satisfaction levels in various areas of daily functioning with each question rated on a scale of 1 (Very Poor) to 5 (Very Good) (Endicott et al., 1993).

2.3. Statistical analysis

First, we used receiver operator characteristic (ROC) curves to examine the ability of the MWQ to identify those with and without clinical impairment on the BRIEF, ADHD RS, SRS, and ASR. ROC curve analysis uses each value across the entire range of the MWQ as the cut-off for defining clinical impairment and compares this classification to the "true" classification, as defined by the rating scale. ROC analysis summarizes diagnostic efficiency with the area under the curve (AUC) statistic. An AUC of 0.5 means the scale does not predict clinical impairment in any way and an AUC of 1.0 means the scale predicts clinical impairment perfectly. Based on the information from the ROC curve analysis, we used the Liu approach to calculate the optimal MWQ cut-point to identify those with and without clinical impairment on each rating scale and used conditional probabilities to examine the diagnostic utility of those optimal MWQ cut-points (Liu, 2012); the Liu approach defines the optimal cut-point as the point where the product of the sensitivity and specificity is maximized. We then identified the average optimal MWQ cut-point among the rating scales and used it to categorize patients in our sample as having high-versus low-level mind wandering.

After categorizing subjects into high-versus low-level mind wanderers, we compared demographic and clinical characteristics between the two groups. We used Student's t-tests, Kruskal-Wallis ranksum tests, and Pearson's chi-square tests to analyze demographic characteristics. We analyzed clinical characteristics using linear, logistic, ordered logistic, truncated Poisson, or negative binomial regression models, depending on the outcome.

We then performed stepwise logistic regression using backwards selection ($p \geq 0.05$ for removal) to see what subscales on the BRIEF and ASR (excluding composite scales) were significantly associated with high-level mind wandering. After identifying the significant subscales, we performed ROC curve analyses to identify the optimal cut-points on the BRIEF and ASR to identify high-vs. low-level mind wandering. All tests were two-tailed and performed at the 0.05 alpha level using Stata (Version 15.1) (StataCorp, 2017).

For the last part of our analysis, we computed inter-item correlations for all five items of the MWQ as well as Cronbach's alpha for the entire MWQ to determine the internal consistency of the scale. Cronbach's alpha can range from 0 to 1, with lower scores indicating poor internal consistency and higher scores indicating excellent internal consistency.

3. Results

3.1. Receiver Operator Characteristic (ROC) Curve analysis

The ROC and conditional probability analyses for each rating scale are in Table 1. Of all the scales, the MWQ best identified clinical

Table 1
ROC curve analysis and conditional probability analysis to see how well the Mind Wandering Questionnaire (MWQ) identifies subjects with scores in the clinical range on scales measuring attention-deficit/hyperactivity (ADHD) symptomatology, executive function deficits, autism spectrum disorder (ASD) symptomatology, and psychopathology.

Rating Scale	RS Clinical Scores	AUC Statistic	MWQ Optimal Cutpoint	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Correctly Classified
ADHD Symptomatology								
ADHD RS – Total	≥24 in either subdomain	0.85	24	80%	80%	80%	80%	80%
ADHD RS – Inattention	≥24	0.87	24	82%	80%	80%	83%	81%
ADHD RS – Hyperactivity	≥24	0.78	25	83%	66%	36%	95%	69%
Executive Function Deficits								
BRIEF-GEC	≥65	0.81	25	67%	82%	80%	70%	74%
ASD Symptomatology								
SRS Total	≥60	0.68	25	64%	65%	42%	82%	65%
SRS Total	≥66	0.62	24	72%	54%	21%	92%	57%
Psychopathology								
ASR Total	≥64	0.69	24	68%	61%	50%	76%	63%
ASR Externalizing	≥64	0.65	25	63%	62%	33%	85%	63%
ASR Internalizing	≥64	0.57	24	58%	55%	44%	68%	56%
ASR Attention	≥70	0.72	25	69%	69%	52%	82%	69%

Average Optimal MWQ Cut-point = 24.

impairment on the ADHD RS-Inattentive scale (AUC = 0.87) and the BRIEF-GEC (AUC = 0.81). Clinical impairment was defined as a score ≥24 on the ADHD RS-Inattentive scale and a t-score ≥65 on the BRIEF-GEC. Of the 9 subscales analyzed, 4 had an optimal MWQ cut-point of 24 and 5 had an optimal MWQ cut-point of 25 (Table 1). Sensitivity and specificity ranged from 58% to 55%, respectively, on the ASR Internalizing scale, to 82% and 80%, respectively, on the ADHD RS-Inattentive scale. Using the optimal cutpoints from the ROC curve analyses, we categorized subjects as having high-level mind wandering (N = 127) and low-level mind wandering (N = 128), as defined by having a MWQ total score of ≥24 or < 24, respectively. Subsequent comparisons were made between ADHD subjects with low versus high MWQ scores.

3.2. Demographic Characteristics

As shown in Table 2, there were no significant differences in age, socioeconomic status, sex, or race between those with high- and low-level mind wandering (Table 2).

Table 2
Demographic and medication characteristics of subjects with high-level mind wandering (total MWQ score ≥24) and low-level mind wandering (total MWQ score < 24).

	Low-Level Mind Wanderers N = 128	High-Level Mind Wanderers N = 127	Test Statistic	P-Value
	Mean ± SD	Mean ± SD		
Age	32.8 ± 14.1	34.7 ± 12.5	$t_{253} = 1.13$	0.26
Socioeconomic Status[a]	1.8 ± 0.8	1.8 ± 0.9	$z = -0.26$	0.79
	N (%)	N (%)		
Male	77 (60)	67 (53)	$\chi^2 = 1.42$	0.23
Caucasian[a]	99 (80)	99 (79)	$\chi^2 = 0.06$	0.80
Current Psychiatric Medications[a]				
Stimulants	47 (39)	29 (24)	$\chi^2 = 6.52$	0.01
Other Psychiatric Medications	33 (27)	37 (30)	$\chi^2 = 0.24$	0.63

[a] Smaller sample sizes. Socioeconomic status: Low-level: N = 89, High-level: N = 94; Caucasian: Low-level: N = 123, High-level: N = 125; Current psychiatric medications: Low-level: N = 121, High-level: N = 123.

3.3. Mind wandering and ADHD symptoms

As shown in Fig. 1A, subjects with high-level mind wandering had significantly more impaired scores on both the Inattentive and Hyperactive domains as well as the total scale score (all $p < 0.001$). We found the same results for the inattentive and hyperactive-impulsive subscales and each individual symptom (all $p \leq 0.009$) (Fig. 1A, B & 1C). Subjects with high-level mind wandering experienced both inattentive and hyperactive-impulsive symptoms more often than subjects with low-level mind wandering. When we ran correlation analyses of the MWQ total score with the two ADHD RS domain scores and the ADHD RS total score, we found that the MWQ had a strong positive correlation with the Inattentive domain ($r = 0.78$, $p < 0.001$) and the total score ($r = 0.72$, $p < 0.001$), and a moderate positive correlation with the Hyperactive-Impulsive domain ($r = 0.52$, $p < 0.001$). We found a significant difference between the Inattentive and the Hyperactive-Impulsive correlations ($z = 5.27$, $p < 0.001$).

3.4. Mind wandering and executive functioning

Subjects with high-level mind wandering demonstrated worse executive functioning compared with subjects with low-level mind wandering as measured by the BRIEF-A (Fig. 2A). High-level mind wanderers had significantly more impaired mean scores (all $p \leq 0.001$; Fig. 2A) and higher rates of subjects with scores in the clinical range (t-score ≥65) (all $p < 0.005$) (Fig. 2B), on all 9 subscales and all 3 composite scales. High-level mind wanderers were also more socially impaired, with significantly higher scores on all five SRS subdomains and the SRS total score (all $p \leq 0.005$) (Fig. 2C). As with the BRIEF-A, those with high-level mind wandering had significantly higher rates of subjects with scores in the clinical range of the SRS (t-score ≥65; all $p < 0.01$) (Fig. 2D).

3.5. Mind wandering and psychopathology

ompared to low-level mind wanderers, high-level mind wanderers had significantly more impaired scores on seven out of eight ASR Clinical scales and all three ASR Composite scales (all $p \leq 0.001$ except for the Withdrawn subscale with $p = 0.09$) (Fig. 3A). When we dichotomized the ASR Clinical and Composite scales into clinical range (Clinical: t-score ≥70; Composite: t-score ≥64) versus non-clinical range (Clinical: t-score < 70; Composite: t-score < 64), those with high-level mind wandering only had a significantly higher rates of

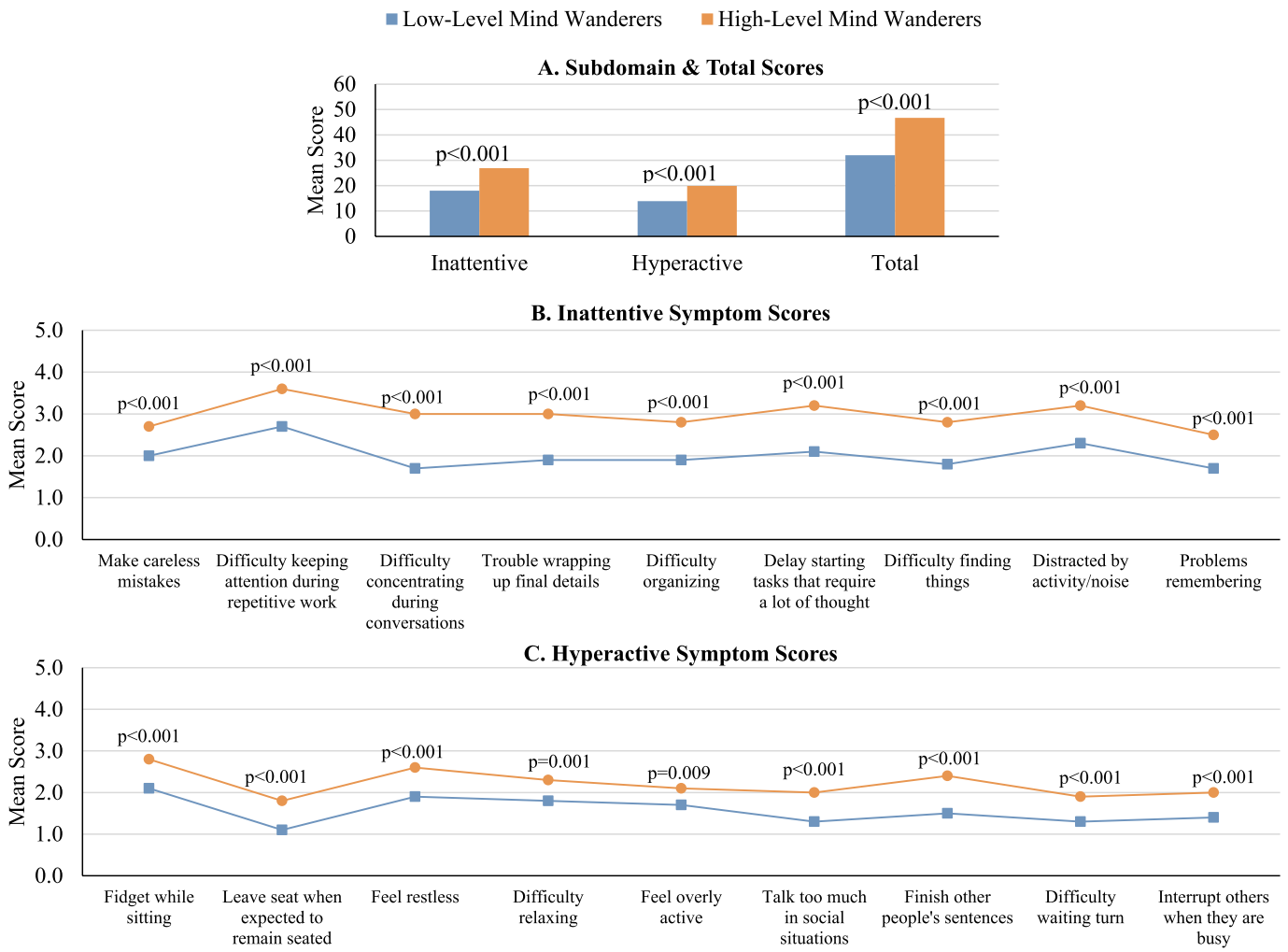

Fig. 1. ADHD Rating Scale scores for subjects with high-level mind wandering (total MWQ score ≥ 24) and low-level mind wandering (total MWQ score < 24).

scores in the clinical range for the Attention Problems ($p < 0.001$), Externalizing Problems ($p = 0.005$), and Total Problems ($p < 0.001$) scales (Fig. 3B). Those with high-level mind wandering also had more impaired scores on the Job ($p = 0.001$), Education ($p = 0.02$), and Mean Adaptive ($p = 0.002$) ASR Adaptive Functioning scales (Fig. 3C). There were no significant differences between the two groups on the Friends, Spouse/Partner, or Family ASR Adaptive Functioning scales (all $p > 0.05$). When we dichotomized the ASR Adaptive Functioning scales into clinical range (t-score ≤30) versus non-clinical range (t-score > 30), those with high-level mind wandering only had significantly higher rates of subjects with scores in the clinical range on the Family ($p = 0.01$) and Job ($p = 0.004$) scales (Fig. 3D). There were no significant differences between high- and low-level mind wanderers when examining tobacco (High-level: 50.3 ± 2.0 [mean t-score ± standard deviation] vs. Low-level: 50.2 ± 0.9; $z = 1.27$, $p = 0.20$), alcohol (High-level: 55.6 ± 7.0 vs. Low-level: 54.8 ± 6.2; $z = 1.38$, $p = 0.17$), and drug use (High-level: 52.6 ± 6.3 vs. Low-level: 52.1 ± 5.3; $z = 1.66$, $p = 0.10$) using the ASR Substance Use scales.

3.6. Mind wandering and emotional dysregulation

Participants with high-level mind wandering had significantly more impaired scores on the Barkley Emotional Dysregulation (ED) Scale compared to those with low-level mind wandering ($p < 0.001$) (Fig. 4A). When we dichotomized Barkley ED Scale scores into high- (score ≥8) versus low-level (score < 8) ED, we found that those with high-level mind wandering had significantly higher rates of high-level ED compared to those with low-level mind wandering ($p < 0.001$) (Fig. 4B).

3.7. Mind wandering and quality of life

Overall quality of life as measured by the Q-LES-Q was significantly more impaired for participants with high-level mind wandering compared to those with low-level mind wandering (Fig. 4C).

3.8. Mind wandering and occupation and education

There were no significant differences between those with high- and low-level mind wandering in rates of learning disabilities (High-level: 29% [N = 36/125] vs. Low-level: 33% [N = 41/124]; $\chi^2 = 0.53$, $p = 0.47$), completion of at least 4 years of college (High-level: 73% [N = 90/123] vs. Low-level: 71% [N = 86/121]; $\chi^2 = 0.13$, $p = 0.72$), or current employment (High-level: 78% [N = 98/125] vs. Low-level: 77% [N = 95/123]; $\chi^2 = 0.11$, $p = 0.74$).

3.9. Mind wandering and environmental risk factors

Upon examination of pregnancy and delivery characteristics, we found no significant differences between those with high- and low-level mind wandering in the rates of having mothers with problems during pregnancy (High-level: 6%, N = 7/125 vs. Low-level: 6%, N = 8/124; $\chi^2 = 0.08$, $p = 0.78$), problems during delivery (High-level: 12%, N = 15/127 vs. Low-level: 15%, N = 18/128; $\chi^2 = 0.34$, $p = 0.56$),

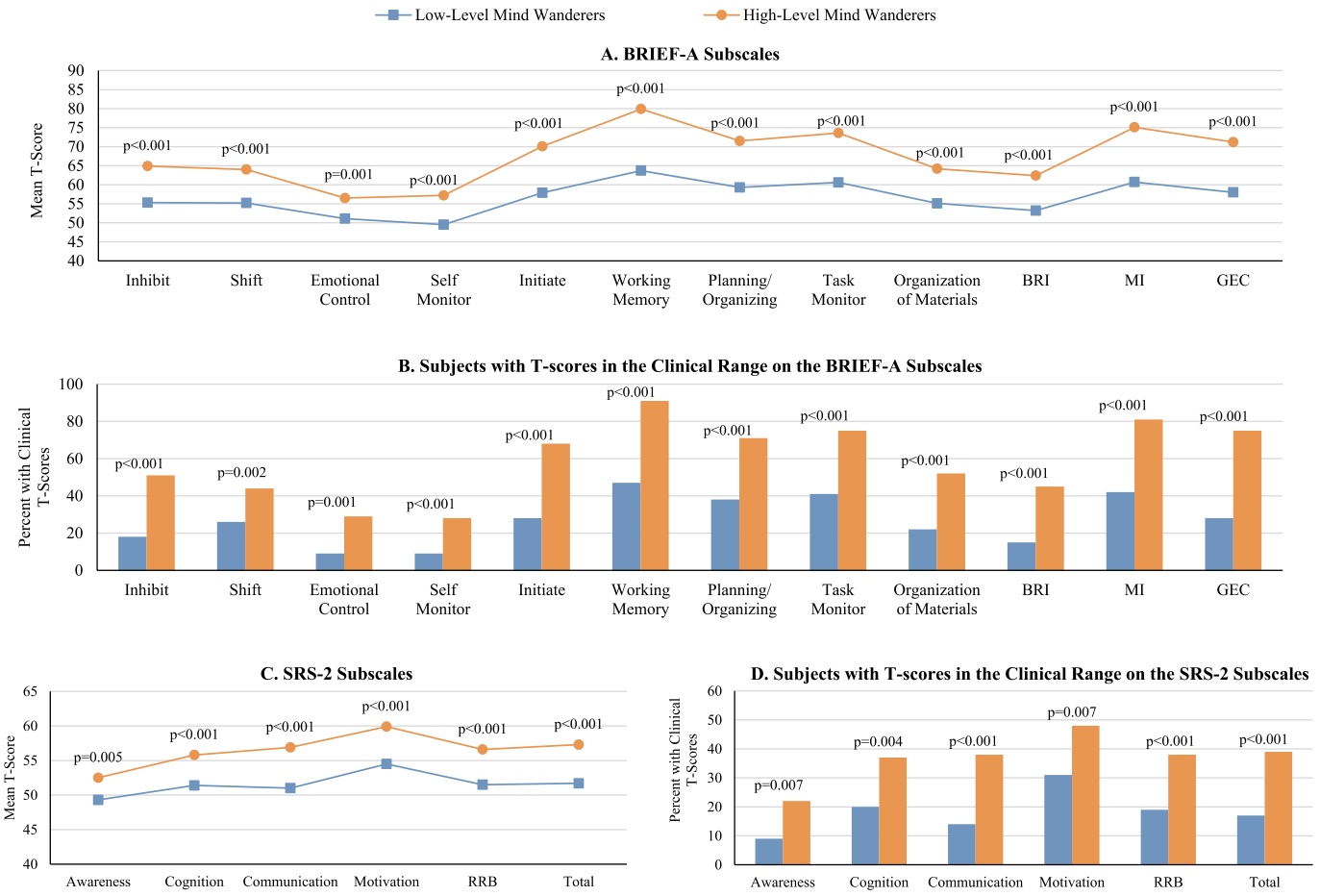

Fig. 2. Behavior Rating Inventory of Executive Function – Adult Version (BRIEF-A) and Social Responsiveness Scale – Second Edition (SRS-2) Adult Self-Report scores for subjects with high-level mind wandering (total MWQ score ≥ 24) and low-level mind wandering (total MWQ score < 24).

alcohol use during pregnancy (High-level: 9%, N = 11/127 vs. Low-level: 3%, N = 4/128; $\chi^2 = 3.25$, p = 0.07), drug use during pregnancy (High-level: < 1%, N = 1/127 vs. Low-level: 0%, N = 0/128; Fisher's exact, p = 1.00), or cigarette smoking during pregnancy (High-level: 11%, N = 14/127 vs. Low-level: 8%, N = 10/128; $\chi^2 = 0.76$, p = 0.38).

There were no significant differences in the rate of head injuries between those with high- and low-level mind wandering (High-level: 11%, N = 14/127 vs. Low-level: 9%, N = 11/128; $\chi^2 = 0.42$, p = 0.52).

3.10. ROC analyses of mind wandering and executive functioning

Using backwards selection, we started with a stepwise logistic regression model predicting high-level mind wandering from all 9 subscales of the BRIEF; we removed insignificant subscales one by one based on the largest p-value ≥0.05. The final model included the Initiate, Working Memory, and Planning/Organizing subscales (all p < 0.05). We created an aggregate score of the three subscales and found that the optimal cut-point for identifying subjects with high-level mind wandering was 209 (sensitivity = 70%, specificity = 85%, positive predictive value = 82%, negative predictive value = 74%, percent correctly classified = 78%). The aggregate scores on the Initiate, Working Memory, and Planning/Organizing subscales yielded and ROC curve with an AUC = 0.83 (Fig. 5A).

Using the same process for the ASR, we started with a stepwise logistic regression model predicting high-level mind wandering from all 8 clinical subscales of the ASR; we removed insignificant subscales one by one based on the largest p-value ≥0.05. We arrived at a final model that included only the Attention Problems subscale (p < 0.001). After performing ROC curve analysis, we identified a t-score of 65 as the optimal cut-point for identifying subjects with high-level mind wandering (sensitivity = 75%, specificity = 65%, positive predictive value = 68%, negative predictive value = 72%, percent correctly classified = 70%). The Attention Problems subscale yielded and ROC curve with an AUC = 0.76 (Fig. 5B).

3.11. Psychometric analyses of the Mind Wandering Questionnaire

We calculated Cronbach's alpha to determine the internal consistency of the MWQ and got an alpha of 0.91 for the entire scale. This indicates a high level of internal consistency. The item-rest correlations ranged from 0.69 for question #1 to 0.83 for question #4 and are reported in Table 3.

Two of five MWQ questions that overlap with inattention items on the ADHD RS (#1. “I have difficulty maintaining focus on simple or repetitive work” and #3. “I do things without paying full attention”). Therefore, we re-ran our analyses excluding these two questions. Using a cut-point of 15 on the MWQ to categorize high-versus low-level mind wandering based on ROC curve analyses, the new set of analyses yielded the same results as those using the 5-question MWQ reported above. We also calculated Cronbach's alpha to determine the internal consistency of the 3-question MWQ and got an alpha equal to 0.88 for the entire scale. The item-rest correlations were 0.73, 0.79, and 0.77 for questions #2, #4, and #5, respectively.

Fig. 3. Adult Self-Report (ASR) scores for subjects with high-level mind wandering (total MWQ score ≥ 24) and low-level mind wandering (total MWQ score < 24).

4. Discussion

This study investigated the prevalence and associated correlates of mind wandering in adults with ADHD. High levels of mind wandering were highly prevalent in adults with ADHD and their presence was associated with more severe symptoms of ADHD, more impaired executive function deficits, higher levels of associated psychopathology, more emotional dysregulation and more impaired quality of life. To the best of our knowledge, this study represents the most comprehensive evaluation of the prevalence and morbidity associated with mind wandering in a clinical sample of adults with ADHD.

Strengths of this study include its large sample size of participants of both sexes, the comprehensive assessment battery, and the ecological validity of the sample as it was drawn from undiagnosed and untreated adults referred to a specialized adult ADHD program by community and primary care physicians for clinical assessment and management of ADHD symptoms. The concept of mind wandering as internal distractibility is a novel concept in the field of ADHD given that diagnostic criteria and assessment instruments only use external distractibility as a defining feature of the disorder. In contrast to external distractibility, internal distractibility is spontaneous, and subjects are often unaware of its presence.

The finding that many adults with ADHD are afflicted with mind wandering is consistent with findings reported by Shaw and Giambra (1993) and Seli et al. (2015b) indicating that mind wandering is an important component of the clinical picture of ADHD. Although prevalent, mind wandering only affects some, but not all, patients with ADHD suggesting that it represents a type of cognitive comorbidity.

Our finding that mind wandering is associated not only with inattention symptoms but also with hyperactivity and impulsivity is consistent with other studies that found mind wandering to be associated with impulsivity (Cheyne et al., 2009) and fidgeting (Seli et al., 2014).

On the other hand, the findings that high levels of mind wandering were associated with executive dysfunction, high levels of comorbid psychopathology, impaired scores on the Social Responsiveness Scale (SRS), high levels of emotional dysregulation, and more impaired quality of life are novel and indicate that mind wandering represents an important source of morbidity and disability in adults with ADHD worthy of clinical and scientific attention.

On the other hand, the finding that mind wandering was not associated with TBI, substance use disorders, educational deficits or perinatal complications indicate that the outcomes associated with mind wandering are selective and not global.

Our findings documenting similar outcomes when the data were reanalyzed excluding two of the five MWQ items overlapping with ADHD's inattention diagnostic criteria support the idea that mind wandering represents a different and separate cognitive domain from core inattention symptoms of ADHD.

Our findings provide new insights into the relevance of mind wandering in adults with ADHD. Results suggest that ADHD adult patients with high levels of mind wandering face unique challenges and that their outcomes may be more compromised than those of other adults with ADHD with low levels of mind wandering. More work is needed to

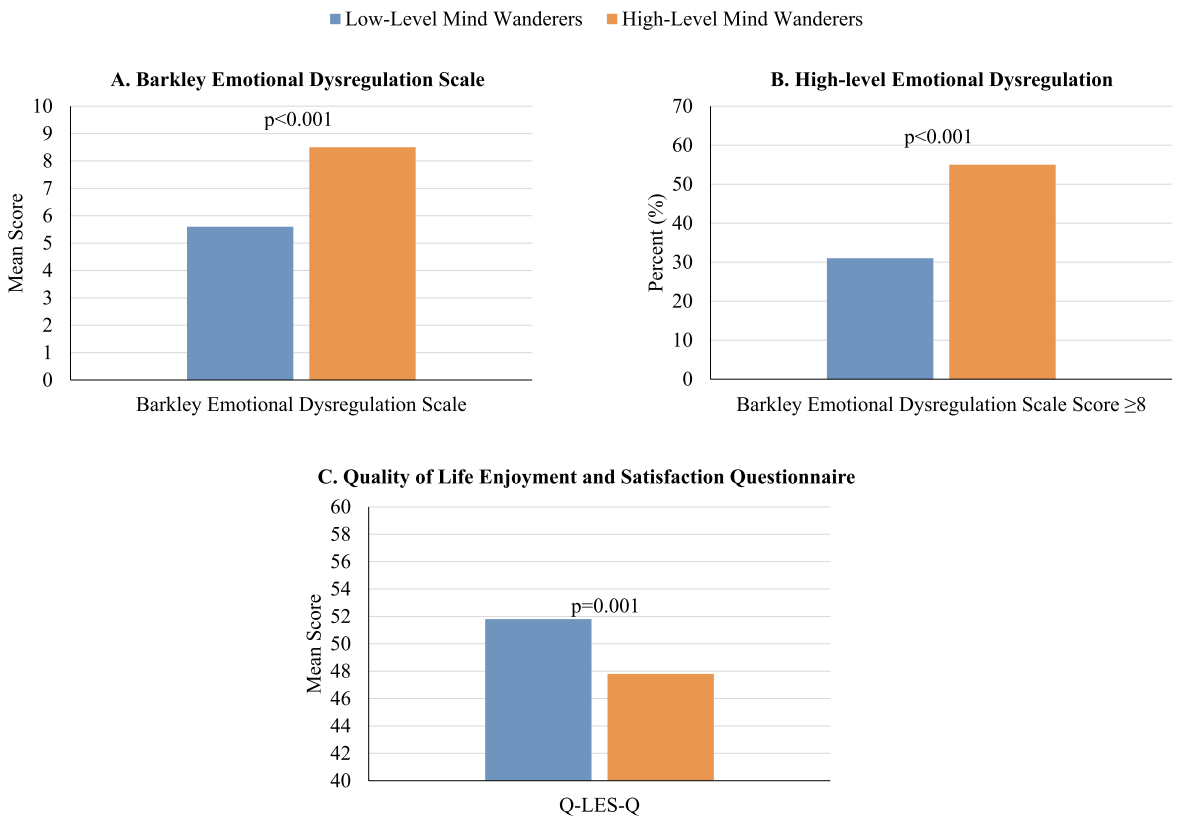

Fig. 4. Barkley Emotional Dysregulation Scale and the Quality of Life Enjoyment & Satisfaction Questionnaire (Q-LES-Q) scores for subjects with high-level mind wandering (total MWQ score ≥ 24) and low-level mind wandering (total MWQ score < 24).

examine whether the presence of mind wandering may help identify a more homogeneous subgroup of ADHD patients with unique clinical, therapeutic and neurobiological underpinnings.

Our findings need to be viewed in light of some methodological limitations. In the absence of adequate guidance on how to best define mind wandering, we used an empirical approach with ROC curve analysis. Thus, we cannot rule out the possibility that other approaches could have been equally informative. Our assessment of mind wandering relied exclusively on self-report. Future studies may benefit from an objective performance-based measure of mind wandering. Although we lacked healthy controls, we were interested in quantifying the prevalence of mind wandering and its clinical correlates. Future population-based studies will be useful for establishing norms for the MWQ and for assessing generalizability to non-referred samples. While our study focused on ADHD, more work is needed to investigate mind wandering in other clinical states.

Despite these considerations, our results indicate that high levels of mind wandering are very prevalent in adults with ADHD and that its presence is associated with more severe symptoms of ADHD, more impaired executive function deficits, higher levels of associated psychopathology, and a more impaired quality of life. To the best of our knowledge, this study is the most comprehensive evaluation of the prevalence and morbidity associated with mind wandering in a clinical sample of adults with ADHD. More research is needed to explore the

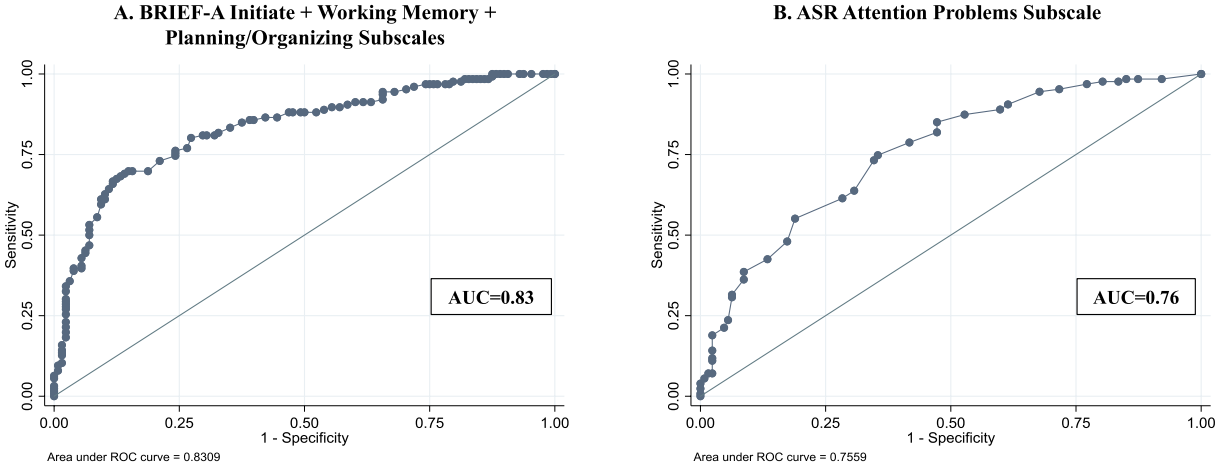

Fig. 5. We performed stepwise logistic regression models using backwards selection (p ≥ 0.05 for removal) to identify the subscales on the (A) BRIEF and (B) ASR that were significantly associated with high-level mind wandering (total MWQ score ≥24). We then used ROC curve analyses to see how well these subscales identified subjects with high-vs. low-level mind wandering.

Table 3
Cronbach's alpha for the Mind Wandering Questionnaire.

Item	Observations	Sign	Item-test correlation	Item-rest correlation	Average interitem covariance	alpha
1. I have difficulty maintaining focus on simple or repetitive work.	254	+	0.80	0.69	1.15	0.90
2. While reading, I find I haven't been thinking about the text and must therefore read it again.	254	+	0.83	0.73	1.10	0.90
3. I do things without paying full attention.	254	+	0.88	0.80	1.05	0.88
4. I find myself listening with one ear, thinking about something else at the same time.	254	+	0.89	0.83	1.04	0.87
5. I mind-wander during lectures or presentations.	254	+	0.87	0.79	1.05	0.88
Test Scale					1.08	0.91

underlying neurobiology, neurophysiology and therapeutics of mind wandering for ADHD.

Contributors

Dr. Joseph Biederman substantially contributed to the concept and design, acquisition of the data, drafting of the manuscript, critical revision of the manuscript for important intellectual content. In addition, he provided administrative, technical, or material support, and supervision.

Dr. Jane Lanier substantially contributed to the concept and design, acquisition and interpretation of the data, and drafted and critically revised the manuscript for important intellectual content.

Ms. Maura DiSalvo performed all statistical analyses. She substantially contributed to the interpretation of the data. She also drafted and critically revised the manuscript for important intellectual content.

Ms. Elizabeth Noyes substantially contributed to the acquisition and interpretation of the data, and drafted substantially contributed to the acquisition, analysis, and interpretation of the data, and drafted and critically revised the manuscript for important intellectual content.

Dr. Ronna Fried contributed substantially to the concept and design, analysis and interpretation of data, and critical revision of the manuscript for important intellectual content. She also provided supervision.

Ms. K. Yvonne Woodworth contributed substantially to the drafting of the manuscript, and critical revision of the manuscript for important intellectual content. In addition, she provided administrative, technical, or material support.

Mr. Itai Biederman contributed substantially to the critical revision of the manuscript for important intellectual content, and he provided administrative, technical, or material support.

Dr. Stephen V. Faraone substantially contributed to the concept and design, analysis and interpretation of the data and drafting of the manuscript. In addition, he provided administrative, technical, or material support, and supervision of the statistical analyses.

All authors gave their final approval for this article.

Role of the fundinding source

The MGH Pediatric Psychopharmacology Council Fund had no involvement in study design, collection, analysis, and interpretation of data, the writing of the report, or the decision to submit the manuscript for publication.

Conflicts of interest

Dr. Joseph Biederman is currently receiving research support from the following sources: AACAP, Feinstein Institute for Medical Research, Food & Drug Administration, Genentech, Headspace Inc., Lundbeck AS, Neurocentria Inc., NIDA, Pfizer Pharmaceuticals, Roche TCRC Inc., Shire Pharmaceuticals Inc., Sunovion Pharmaceuticals Inc., and NIH. Dr. Biederman has a financial interest in Avekshan LLC, a company that develops treatments for attention deficit hyperactivity disorder (ADHD). His interests were reviewed and are managed by Massachusetts General Hospital and Partners HealthCare in accordance with their conflict of interest policies. Dr. Biederman's program has received departmental royalties from a copyrighted rating scale used for ADHD diagnoses, paid by Bracket Global, Ingenix, Prophase, Shire, Sunovion, and Theravance; these royalties were paid to the Department of Psychiatry at MGH. In 2019, Dr. Biederman is a consultant for Akili, Jazz Pharma, and Shire. Through MGH corporate licensing, he has a US Patent (#14/027,676) for a non-stimulant treatment for ADHD, and a patent pending (#61/233,686) on a method to prevent stimulant abuse. In 2018, Dr. Biederman was a consultant for Akili and Shire. In 2017, Dr. Biederman received research support from the Department of Defense and PamLab. He was a consultant for Aevi Genomics, Akili, Guidepoint, Ironshore, Medgenics, and Piper Jaffray. He was on the scientific advisory board for Alcobra and Shire. He received honoraria from the MGH Psychiatry Academy for tuition-funded CME courses. In 2016, Dr. Biederman received honoraria from the MGH Psychiatry Academy for tuition-funded CME courses, and from Alcobra and APSARD. He was on the scientific advisory board for Arbor Pharmaceuticals. He was a consultant for Akili and Medgenics. He received research support from Merck and SPRITES.

In the past 36 months, Dr. Ronna Fried received grant research support from Shire Pharmaceuticals and Roche Pharmaceuticals.

In the past year, Dr. Faraone received income, potential income, travel expenses continuing education support and/or research support from Vallon, Tris, Otsuka, Arbor, Ironshore, Shire, Akili, Enzymotec, Sunovion, Supernus and Genomind. With his institution, he has US patent US20130217707 A1 for the use of sodium-hydrogen exchange inhibitors in the treatment of ADHD. In previous years, he received support from: Shire, Ironshore, Neurovance, Alcobra, CogCubed, Rhodes, KemPharm, Enzymotec, Akili, Neurolifesciences, Lundbeck/Takeda, Otsuka, McNeil, Janssen, Novartis, Pfizer and Eli Lilly. Dr. Faraone receives royalties from books published by Guilford Press: Straight Talk about Your Child's Mental Health, Oxford University Press: Schizophrenia: The Facts and Elsevier: ADHD: Non-Pharmacologic Interventions. He is principal investigator of www.adhdinadults.com.

Dr. Lanier, Ms. DiSalvo, Ms. Noyes, Ms. Woodworth, and Mr. I. Biederman declare no interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2019.06.012.

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