Title: Wandering Minds in Attention-Deficit/Hyperactivity Disorder and Borderline Personality Disorder

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Abstract

Attention-deficit/hyperactivity Disorder (ADHD) and borderline personality disorder (BPD) have overlapping symptoms. We proposed that excessive spontaneous mind wandering (MW-S) might reflect a component of psychopathology that distinguishes ADHD from BPD. Using a questionnaire measure of MW-S and an experience sampling method, we investigated MW-S in daily life, in 28 ADHD, 19 BPD, 22 comorbid ADHD+BPD, and 29 control females. The clinical groups reported heightened frequency and intensity of MW-S compared to controls, but no differences from each other. When controlling for depression and anxiety, significant differences only persisted between controls and ADHD, who also showed elevated intensity of MW-S compared to BPD and comorbid ADHD+BPD. We found no MW-S instability differences among clinical cases as well as cases versus controls. Negative content of MW-S was higher in BPD and comorbid ADHD+BPD compared to controls, with no differences between ADHD and controls. When controlling for depression/anxiety, the differences between BPD and comorbid ADHD+BPD and controls dissipated. MW-S is a trans-diagnostic process present in both ADHD and BPD. Yet, the underlying mechanisms of this experience may be driven by anxiety/depression in BPD but reflect a core process in ADHD.

Keywords: Mind wandering; Attention-deficit/hyperactivity disorder; Borderline personality disorder; Experience sampling method.

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1. Introduction

Disentangling a diagnosis of attention-deficit/hyperactivity disorder (ADHD) from that of borderline personality disorder (BPD) is a frequent conundrum in clinical practice

(Moukhtarian et al., 2018; Xenaki and Pehlivanidis, 2015). The disorders display high co-occurrence and share many clinical features (Matthies and Philipsen, 2014; Philipsen, 2006). A large population survey reported a lifetime co-occurrence of ADHD in BPD of 33% compared to 5% in the general population (Bernardi et al., 2012). In clinical samples the reported prevalence of comorbid ADHD in BPD patients ranges from 16 to 38% (Calvo et al., 2020; Ferrer at al. 2010; Moukhtarian et al., 2018; Philipsen et al., 2008).

Although ADHD is primarily defined by impairing levels of inattention and/or hyperactivity/impulsivity, associated features of ADHD show considerable overlap with the symptoms used to define BPD (Philipsen, 2006; Philipsen et al., 2009). Emotional dysregulation, poor impulse control, impulsive risk-taking behaviour and unstable interpersonal relationships are all core features of BPD which are also commonly observed in ADHD (Asherson et al., 2014; Moukhtarian et al., 2018; Philipsen, 2006). Core symptoms that delineate the disorder from ADHD include frantic efforts to avoid real or imagined abandonment, identity disturbance, recurrent suicidal behaviour, gestures, or threats, or self-mutilating behaviour, chronic feelings of emptiness, transient, and stress-related paranoid ideation or severe dissociative symptoms (American Psychiatric Association, 2013). Nevertheless, the presence of overlapping symptoms can lead to misdiagnosis, resulting in individuals not receiving optimal treatment for their clinical condition (Asherson et al., 2014).

One approach to this problem is to focus in detail on aspects of psychopathology that might distinguish ADHD from BPD. Here we focus on the association of excessive spontaneous mind wandering (MW-S) which we and others have found to be strongly associated with ADHD (Biederman et al., 2019; Bozhilova et al., 2018; Helfer et al., 2019; Mowlem et al., 2016; Seli et al., 2015b; Shaw and Giambra, 1993; Van den Driessche et al., 2017), but has yet to be fully investigated in BPD.

Mind wandering is a universal phenomenon that takes up around 50% of daily thinking time (Smallwood and Schooler, 2015) and occurs when one's mind drifts away from the primary task on-hand and focuses on internal, task-unrelated thoughts and images (Smallwood et al., 2007a). However, mind wandering is a heterogeneous construct with several different subtypes described in the literature (Bozhilova et al., 2018; Christoff et al., 2016; Seli et al., 2015a; Vatansever et al., 2019). In relation to ADHD, Seli and colleagues (Seli et al., 2015b) made the important distinction between deliberate mind wandering (MW-D) and spontaneous mind wandering (MW-S), with only MW-S found to be associated with ADHD. Further work by Mowlem and colleagues from our group (Mowlem et al., 2019), using the mind excessively wandering scale (MEWS), which captures reports of mind wandering by adult patents with ADHD, found this was associated strongly with MW-S (r=.76, *p*<0.0001), but not with MW-D (r=0.05, *p*=0.06). Here, MW-S refers to the unintentional drifting of one's thoughts from a focal task toward inner, task-unrelated thoughts, in contrast to intentional, deliberate or strategic shifts in attention toward internal thought (Seli et al., 2015a). Excessive or poorly controlled levels of MW-S are thought to be detrimental to performance (Seli et al., 2015a; Carrier et al., 2013), and has been proposed as a possible mechanism underlying both the symptoms and impairments of ADHD (Bozhilova et al., 2018).

Another important distinction is between MW-S with normal or unconstrained content of thought, from depressive ruminations reflecting MW-S resulting from negative mood that is often linked to psychological distress and unhappiness (Smallwood, 2013; Smallwood and Schooler, 2006; Smallwood and Andrews-Hannah, 2013). Christoff in her theoretical account of spontaneous thought described this as a dimension of automatic constraints on the content of thought (Christoff et al., 2016), reflecting negative repetitive (ruminative) thoughts about oneself or the past. This type of MW-S is associated with several mental health disorders including depression and anxiety (Watkins, 2008), BPD (Baer and Sauer, 2011), and suicidality (Raes et al., 2005).

To date, we identified two previous investigations of mind wandering in BPD. Using experience sampling (thought probes) of mind wandering during a reaction time task no differences were found in the frequency of reported mind wandering compared to controls; although BPD cases reported more negative thoughts and greater instability of mind wandering (Kanske et al., 2016). It should be noted that, Kanske and colleagues did not however distinguish between MW-D and MW-S. A second study reported higher frequency and duration of reported mind wandering in BPD cases compared to controls, using an experimenter-prompted mindfulness task (Scheibner et al., 2016). Based on these two studies, it is unclear whether there is greater intensity, frequency or instability of mind wandering in BPD compared to controls. We are not aware of studies of BPD which make the distinction of MW-S from MW-D.

In contrast, there have been several studies of mind wandering in ADHD using rating scales, and experience sampling during attention tasks and in daily life. The first study in ADHD found more frequent task-unrelated thoughts in college students with a childhood history of ADHD compared to controls, using momentary assessments during a sustained-attention task (Shaw and Giambra, 1993). Higher frequency of reported MW-S rather than deliberate was found to be associated with ADHD symptoms and strongly correlated with ADHD symptom severity in students, using a rating scale measure (Seli et al., 2015b). In an adult community sample, ADHD symptoms were positively correlated with frequency of, and lack of awareness of mind wandering, using both lab-based and daily-life experience sampling method (ESM) measures (Franklin et al., 2014). Recently, our group also found elevated ratings of MW-S in ADHD participants compared to controls, in three independent clinical samples (Mowlem et al., 2016) and a large population survey (Mowlem et al., 2019) using the MEWS (Mowlem et al., 2016).

In a more recent study using experience sampling (thought probes) of mind wandering during a standard go/no-go task, similar frequencies of "mind blanking" (mind wandering without awareness of the content) were seen in 6-12- year-old children and young adults with ADHD. In this study the use of medication by individuals with ADHD led to a shift from mind blanking to mind wandering with awareness, more than focused attention (Van den Driessche et al., 2017). In another study, ADHD symptomatology was found to be positively correlated with mind wandering without awareness (Franklin et al., 2014). Furthermore, lacking awareness of mind wandering mediated between ADHD symptoms and impairment, suggesting that increasing awareness of mind wandering in ADHD might lead to functional improvements (Franklin et al., 2014). Related to these findings, Christoff et al. (2009) had earlier found in an ESM study of mind wandering in healthy control subjects, using functional magnetic resonance imaging (fMRI) during a sustained attention task, that mind wandering without awareness shows greater neural deficits. During periods of mind wandering with awareness there was less deactivation of the default mode network (DMN) than during periods of mind wandering with awareness, suggesting that the neural processes associated with mind wandering may be most pronounced and cause greater disruption to task performance when it goes unnoticed.

Although these findings confirm sensitivity of MW-S measures to ADHD, they do not investigate specificity compared to other psychiatric disorders. As discussed above, MW-S is also associated with other disorders such as anxiety and depression and may therefore reflect a heterogenous transdiagnostic mental phenomena (Christoff et al., 2016; Hoffmann et al., 2016; Ottaviani and Couyoumdjian, 2013; Xu et al., 2017). However, because depressive rumination is not considered a core symptom of BPD, and the association of MW-S with BPD remains unclear, we hypothesised that MW-S would be more frequent in ADHD than BPD. We further hypothesized that in ADHD MW-S would not be driven by depressive ruminations, but reflect unconstrained (normal) thought content, whereas this might not be the case in BPD.

To address these questions, we set out to investigate MW-S in ADHD and BPD using two measurement approaches. First using the MEWS self-report scale of MW-S, and secondly using ESM of mind wandering in everyday life. The use of ESM is important because excessive MW-S is a highly dynamic and non-deliberate phenomenon, and the repeated assessment of MW-S in daily life using e-diaries can track how MW-S unfolds in time and in context throughout the day. Different parameters of MW-S can be investigated including intensity, instability and frequency (operationalised as the amount of time engaged in mind wandering), as well as content valence and awareness of MW-S. We hypothesized that MW-S would be more frequently reported and more intense (higher ratings of MW-S items reflecting greater severity) in ADHD than BPD. Based on Christoff et al.'s model (2016), which suggests ADHD would be reflected by a problem with excessive variability in thought movement (i.e. thoughts that flit from one topic to another), we also hypothesized that greater instability of MW-S will be experienced in ADHD than in BPD. Finally, based on previous findings, we predicted that in ADHD there would be more periods of mind wandering without awareness compared to BPD and controls, and the content of MW-S would reflect higher negative valence thoughts in BPD than in the other groups.

2. Methods

2.1 Participants

98 females aged 18–65 years were recruited. Controls, not meeting criteria for ADHD or BPD, were recruited through advertisements and volunteer databases. Clinical cases were recruited from ADHD and borderline personality outpatient clinics in the South and Midland regions of England. Based on presence or absence of an ADHD and/or BPD diagnosis, each of the 98 participants were assigned to the ADHD, BPD, comorbid ADHD+BPD or control groups. Clinical diagnoses followed DSM criteria (Xu et al., 2013), validated by the research team using the Diagnostic Interview for ADHD in Adults (DIVA) (Kooij, 2013) and the Zanarini rating scale for Borderline Personality Disorder (ZAN-BPD) (Zanarini, 2003) (see supplementary materials for further details). Co-morbidities were excluded using a checklist of common mental health disorders by screening clinical case records. Exclusion criteria included: male sex; history of bipolar I or II, recurrent depressive episodes and schizophrenia; current Axis I disorders; drug or alcohol dependency; head injury or neurological conditions; IQ<70; current treatment with mood stabilisers and/or anti-psychotics. Participants taking stimulants for ADHD were asked to stop this medication for 48 h before baseline assessment and the following five days during ESM.

2.2 Materials and Procedure

2.2.1 Symptom measures

Self-reported MW-S was assessed using the MEWS The MEWS is a 15-item scale (now reduced to 12-items) that captures subjective accounts of MW-S by individuals with ADHD: multiple thoughts, constantly on the go, that jump and flit from one topic to another. MEWS scores showed high sensitivity (~0.9) and specificity (~0.9) for discriminating ADHD cases and controls, accounted for unique variance in self-reported functional impairments, and were related to a specific measure of MW-S (Mowlem et al., 2016).

Comorbid depression and anxiety was measured by the Brief Symptom Inventory (BSI) (Derogatis, 1993); a 53-item self-rated scale using a 4-point Likert-scale (0=not at all to 3=extremely).

Intellectual function (IQ) was assessed using two subtests (vocabulary and matrix reasoning) of the Wechsler Abbreviated Scale of Intelligence-Second edition (WASI-II) (Wechsler, 2011).

2.2.2 Experience sampling of mind wandering

Experience sampling of MW-S was carried out eight times daily, across five consecutive days starting the day after their research appointment We used an iOS app called MoodMapper, designed for the investigation of emotional dysregulation and MW-S by co-authors CR and PA. MoodMapper was uploaded onto Apple iPods with other functions disabled. Signals for the onset of each monitoring period were provided by Vibralite 12 wristwatches that were synchronised with the iPods, giving silent vibration signals eight times a day, at the onset of each rating period. Participants were instructed to complete ESM ratings basing their responses on the time-period just before the signal. Signals followed a pseudorandomised schedule, with a minimum inter-rating interval of 65 min and a maximum interval of 135 min (around 10 h of data collection each day). Start and end times were the same each day, starting at 9:30 in the morning, and finishing at about 7:30 in the evening, with each monitoring instance lasting no more than two minutes. MoodMapper employed continuous analogue scale questions or multiple-choice questions on negative and positive mood and frequency of reported mind wandering (e.g. “How frustrated do you feel NOW?”, “How much is your mind on what you are doing or elsewhere NOW?"). Additionally, content and awareness of mind wandering, as well as good or bad experiences that had occurred to participants during the hour preceding each monitoring period (e.g. "Did any good things happen to you in the PAST HOUR?"), were assessed by multiple-choice questions. Details of each item used in the ESM analyses pertaining only to mind wandering are presented in this chapter (see Table 1). Several steps were implemented to promote compliance including written instructions, telephone calls to prompt initiation of the monitoring period, a follow-up call during the monitoring week, and providing telephone and email contact with the research team.

ESM focused on three parameters of daily subjective MW-S: intensity, instability, and content (something pleasant/unpleasant). The use of 40 ratings spread over five days enabled evaluation of changes in MW-S over time. MoodMapper included 7 questions (Table 1): five items used a continuous visual analogue scale ranging from 0 (not at all) to 100 (extremely), and two categorical items.

---*Insert Table 1 here*---

2.2.3 Study procedure

The study consisted of one 3- hour research assessment session, followed by 5-day experience sampling assessment. At the start of the research appointment, all participants gave full informed consent. The National Research Ethics Service Committee (London Bridge) granted approval for this study (15/LO/1280). Participants first underwent IQ testing, then clinical interviews, followed by the completion of several self-report questionnaire (we only report relevant ones in this paper) including the MEWS. At the end of the testing session, participants were provided with the ESM equipment, and were given full instructions and training for use. A postage paid envelope was provided for participants to return the equipment after completing their monitoring period.

All participants were compensated for their travel expenses. In addition, all were given a monetary incentive (£50) upon completion of the study.

2.3 Data processing

2.3.1 Pre-processing of ESM data

All reports not completed within 16 min after the vibration signal were excluded from analyses. Compliance rates were evaluated as the proportion of monitoring events completed within the 16-minute window. In line with previous studies (Simons et al., 2009; Skirrow et al., 2014), participants with compliance rates less than 40% were excluded from analyses (n=7).

To evaluate MW-S instability of the continuous items, we calculated squared successive differences (SSD): the squared value of the difference between successive responses, $(t_i - t_{i-1})^2$ (Ebner-Priemer et al., 2007). SSD is a robust measure evaluating change from one rating to the next (Trull et al., 2008), incorporating amplitude and frequency of change, and temporal dependency of ratings (Jahng et al., 2008). See supplementary materials for further details.

2.3.2 Statistical Analyses

Mean ratings were computed for questionnaire based self-report measures and compared between groups. Normality of data was assessed by examining histograms and QQ plots and the Shapiro-Wilk statistic. Parametric and non-parametric tests were used, as appropriate. For ESM data, multilevel models were used that take into account correlated observations nested within individuals, and perform well with missing data (Jahng et al., 2008). Analyses were carried out in SAS (University Edition). Adjustments per item for multiple testing contrast tests were made by applying Bonferroni and Bonferroni-Holm corrections. No adjustment was made for multiple measures of MW-S as these were highly correlated (see supplementary materials for details).

Instead of the conventional predefined diagnostic group comparisons, we used binary categorical grouping variables indicating the presence or absence of ADHD and BPD diagnoses separately (using dummy variables). These variables were used as predictors in the analyses of a 2 x 2-model with two main effects of ADHD and BPD and the interaction ADHD*BPD (assuming non-additivity of the ADHD and BPD effects). We then investigated differences across diagnoses by contrasts, evaluating intensity of MW-S using raw data, and instability of MW-S using SSDs. Normally distributed data were analysed with a linear multilevel model; a linear mixed model with a random intercept (SAS procedure MIXED). As an example, we present the below model single equation representation we used to calculate MW intensity with two main effects of ADHD and BPD and the interaction of ADHD*BPD.

$$Y_{ij} = \beta_{00} + \beta_{10} * \mathrm{ADHD(yes/no)}_j + \beta_{20} * \mathrm{BPD(yes/no)}_j + \beta_{30} * \mathrm{ADHD(yes/no)}_j * \mathrm{BPD(yes/no)}_j + u_{0j} + \varepsilon_{ij}$$

Here, Y_{ij} represents the level of MW intensity at time i for person j. The β coefficients represent the intercept and the fixed main and interaction effects, while the u_{0j} denote random intercepts for person j and the ε_{ij} the residuals at level 1.

SSDs follow a χ^2 distribution which is a special case of the gamma distribution and were analysed with generalised multilevel models with gamma distributions and log links (SAS procedure GLIMMIX), which relies on linearization and Taylor series techniques, to construct Wald-type test statistics and confidence intervals to estimate these models (Santangelo et al., 2017). For further details on the equations we used for the gamma model, please refer to Santangelo et al., 2017, online supplement appendix S3.

Categorical data exploring reported frequency of MW-S occurrence, MW-S awareness and content of MW-S were analysed using multilevel logistic regression models with a binary distribution in the SAS procedure GLIMMIX. As above, please refer to Santangelo et al., 2017, online supplement appendix S3 for the PAC (Probability of Acute Change) logistic regression equation used.

As MW-S has been previously associated with depression, anxiety (Christoff et al., 2016; Hoffmann et al., 2016; Xu et al., 2017) and unhappiness (Killingsworth and Gilbert, 2010), and given the significant co-occurrence of comorbid mood problems in ADHD and BPD populations (Cumyn et al., 2009; Zanarini et al., 1998), we explored potential confounding effects of depressive and anxious symptoms on MW-S.

3. Results

3.1 Sample Characteristics and Compliance

There were 98 participants: 28 with ADHD (M_{age}=38.2, SD=11.7; M_{IQ}=106.5, SD=14.2), 19 with BPD (M_{age}=35.4, SD=11.4; M_{IQ}=97, SD=13.8), 22 with comorbid ADHD+BPD (M_{age}=33.8, SD=13.8; M_{IQ}=97.7, SD=12.40), and 29 controls (M_{age}=27.1, SD=5.2; M_{IQ}=107.2, SD=9.2). There were significant group differences on age ($X^2(3)$ =14.18, p=.003) and IQ (F (3,93) = 4.6. p=.005). Both age and IQ were initially controlled for but did not have a significant effect in the models. Therefore, we report models excluding these covariates. There were no group differences ($X^2(3)$ =.12, p=.989) in compliance rates for ESM ratings ($M_{compliance}$=74.8%, SD=14.9 across the sample).

The non-parametric Kruskal-Wallis test showed a significant effect of group on the MEWS ($X^2(3) = 58.06$, $p<.001$). Bonferroni adjusted post-hoc tests revealed that controls (mean rank=16.2) reported significantly ($p<.001$) less MW-S than ADHD (mean rank=66.7), BPD (mean rank=56.4) and comorbid ADHD+BPD (mean rank=65.4). There were no significant differences between clinical groups ($p=1$). When adjusting for anxiety and depression scores, differences only between ADHD and comorbid ADHD+BPD remained non-significant ($p=.558$).

3.2 Group Differences on ESM Ratings

3.2.1 Intensity

For the continuous measures of MW-S, multilevel models revealed significant interaction effects of ADHD*BPD ($p< .01$) for all five items, with significantly elevated intensity of MW-S for all clinical diagnoses compared to controls (model 1, Table 2). When adjustments were made for anxiety and depression scores, models also revealed significant interaction effects of ADHD*BPD ($p< .01$) for all five items, but there only remained significant differences between controls and ADHD for all the items except item-5 (model 2, Table 2; see supplementary Tables 2 and 3 for interactions per item).

---*Insert Table 2 here*---

Multilevel models revealed no significant differences between clinical diagnoses on intensity of MW-S (model 1, Table 3). When adjustments were made for the anxiety and depression scores, where only anxiety had a significant main effect in the model, significant differences between ADHD and BPD, plus ADHD and comorbid ADHD+BPD diagnosis were revealed on items 3 and 4, as well as between ADHD and BPD on item-2. The ADHD group had heightened reports of MW-S intensity compared to BPD and comorbid ADHD+BPD (see model 2, Table 3). There were no significant differences between BPD and comorbid ADHD+BPD diagnoses in any of the models.

---*Insert Table 3 here*---

3.2.2 Instability

Multilevel models revealed a significant interaction effect of ADHD*BPD (*p*=<.01) only for item-5 (F (1, 92.82) = 4.96, *p*=.028). Contrasts showed no significant differences between clinical diagnoses and controls on items 1, 2, 3, and 4 (Table 4). Controls reported significantly less instability of MW-S rated on item-5 compared to all clinical diagnoses (*p*<.05), despite item-5 being highly correlated with all other ESM items. There were no between-diagnoses differences found on all items (Table 4, supplementary materials). Anxiety and depression scores had no effect on the instability models.

---*Insert Table 4 here*---

3.2.3 Frequency of occurrence, awareness and content of MW

For the categorical measure of reported MW-S frequency (Table 1, item 6), multilevel logistic regression models revealed a significant interaction effect of ADHD*BPD (F (1, 80.66)= 6.49, *p*=.013) with all clinical diagnoses reporting greater frequency of MW-S compared to controls (*p*<.001; for BPD (OR=3.9, CI:1.7- 9.3), ADHD (OR=3.9, CI:1.8- 8.3) and ADHD+BPD (OR=5.2, CI:2.3- 11.6). When adjusted for anxiety and depression there was still a significant interaction effect of ADHD*BPD (F (1, 79.73)= 5.08, *p*=.027), but significant differences between controls and BPD diagnosis (*p*=.142) as well as controls and comorbid ADHD+BPD diagnosis dissipated (*p*=.142), and only the ADHD diagnosis still reported greater MW-S frequency than controls (*p*=.005, OR=2.9, CI:1.2- 6.7). However, there were no differences in the frequency of MW-S among clinical diagnoses, even after controlling for the covariates (*p*=1).

We further investigated whether participants were aware or unaware of MW-S (Table 1, item 6). There was no significant interaction effect of ADHD*BPD with (*p*=.387) and without (*p*=.466) adjusting for anxiety and depression. Contrasts showed significantly elevated rates of MW-S without awareness only in the comorbid ADHD+BPD diagnosis compared to controls with (*p*=.009; OR=.1; CI: .01- .7) and without (*p*=.002; OR=.2; CI: .01- .7) controlling for anxious and depressive symptomatology. However, there were no differences in MW-S awareness among clinical diagnoses, even after controlling for the covariates (*p*>.05).

Regarding the content of MW-S (Table 1, item 7), our models revealed non-significant interaction effects of ADHD*BPD with (*p*=.760) and without (*p*=.497) adjusting for anxiety and depression. Contrasts revealed significantly elevated rates of MW-S about 'something unpleasant' in the BPD (*p*=.017; OR=.3; CI: .1- .9) and comorbid ADHD+BPD (*p*=.017; OR=.3; CI: .1- .9) diagnosis compared to controls, whereas no differences were seen between ADHD and controls (*p*=.806). When the multilevel logistic models were adjusted for anxiety and depression, these differences between controls and BPD diagnosis (*p*=1), as well as controls and comorbid ADHD+BPD diagnosis (*p*=1) disappeared. However, no differences were found in the proportion of MW-S about "something unpleasant" between clinical diagnoses (*p*>.05), even after accounting for anxiety and depression (*p*=1).

4. Discussion

This study conducted a comparative analysis of MW-S in ADHD, BPD, comorbid ADHD+BPD and controls, using firstly a self-report questionnaire and then ESM of mind wandering in daily life. We set out to examine different parameters of excessive MW-S, including intensity, instability, reported frequency, content valence and awareness. While excessive MW-S is an established feature of ADHD (Biederman et al., 2019; Bozhilova et al., 2018; Helfer et al., 2019; Mowlem et al., 2016; Shaw and Giambra, 1993; Seli et al., 2015a; Van den Driessche et al., 2017), this is not the case for BPD and we had therefore hypothesised that MW-S would be more frequent, in ADHD than BPD, with higher intensity and instability. However, our findings did not support this hypothesis. We found similarly high levels of MW-S for both the ADHD and BPD diagnoses compared to controls using the MEWS rating scale, and ESM measures of MW-S in daily life. These findings suggest that excessive MW-S in daily life may be as much a part of BPD as ADHD and may be a greater problem in the daily lives of people with BPD than generally recognised.

Nevertheless, the cause of excessive MW-S might be very different in the two disorders, since the effect of increased MW-S dissipated for the BPD diagnosis, but not for ADHD, when controlling for symptoms of anxiety and depression. This suggests that in BPD excessive MW-S may be driven by anxiety and depression, reflecting anxious or depressive rumination, whereas in ADHD this may reflect core psychopathology of the disorder (Bozhilova et al., 2018; Mowlem et al., 2016). This view was further supported by our analysis of the valence of content of thought during periods of mind wandering. For ADHD there was a similar proportion of pleasant to unpleasant thoughts compared to controls, whereas for BPD and the comorbid ADHD+BPD groups, there was a greater reported frequency of thinking about something unpleasant compared to both ADHD and controls.

Furthermore, as for the frequency of MW-S, this effect on the content of thought in BPD disappeared when controlling for anxious and depressive symptoms. Overall these findings support the view that in BPD, measures of MW-S likely reflect anxious and depressive ruminations, whereas in ADHD, MW-S reflects a core difficulty with sustaining attention, independent of a mood state.

The finding of excessive MW-S in BPD compared to controls differed from a previous report which found no increase in the reported frequency of MW-S during a choice reaction time task (Kanske et al., 2016), whereas in ADHD excessive MW-S was reported during a similar attention task (Shaw and Giambra, 1993). However, this is perhaps not unexpected since we used ESM in daily life rather than during a laboratory computer task probing sustained attention and is consistent with the view that in BPD MW-S reflects rumination, rather than the core sustained attention deficit seen in ADHD.

The stability of MW-S in ADHD and BPD daily life has to be investigated further, but is of interest since it has been proposed that in ADHD, greater variability in task performance might be due to greater frequency of shifting (fluctuating) attention from on task to off-task (Adamo et al., 2019), and this might also be true in daily life. However, the absence of MW-S instability differences between the clinical and control groups in our study suggests that while MW-S in daily life is more frequent in both ADHD and BPD, this is not related to greater fluctuations throughout the day when measured at approximately hourly intervals. This contrasts with the regulation of emotions that show heightened instability, as well as greater intensity, in both disorders (Skirrow et al., 2014; Trull et al., 2008), suggesting a different mechanism involved in the regulation of MW-S compared to emotional symptoms. While the relatively low sampling rate in the ESM cannot exclude greater rapid-fluctuations of MW-S in the clinical disorders, these findings suggest that MW-S is a relatively stable trait across the day, with key differences reflected only in the frequency and intensity of MW-S.

Finally, we used ESM to investigate the frequency of periods of mind wandering with and without awareness. Previous research using this method in children and young adults with ADHD had found greater periods of 'mind-blanking', reflecting MW-S without awareness during a sustained attention/inhibitory control go/no-go task (Van den Driessche et al., 2017) and we had therefore hypothesised that this could also be the case for mind wandering in daily life. We did not however replicate this finding using ESM in the current study, although there was greater MW-S without awareness for the comorbid ADHD+BPD diagnosis, perhaps reflecting co-occurrence of two independent disorders leading to a cumulative greater severity of MW-S without awareness.

Overall our results show that although excessive MW-S is a characteristic of both ADHD and BPD, the source of MW-S may be very different. The findings for BPD are supported by literature on the relationship of negative/unhappy moods and mind wandering (Smallwood et al., 2007b; Smallwood and O'Connor, 2011). Current evidence shows depressive symptoms can enhance mind wandering during attention and memory tasks (Smallwood et al., 2007b), and laboratory induced sadness has been shown to exacerbate task-irrelevant thoughts with detrimental effects on cognitive performance in healthy, non-depressed, young adults (Jonkman et al., 2017; Smallwood and O'Connor, 2011). The type of MW-S found in ADHD could therefore be different from that found in other conditions as some studies report that mind wandering in daily life is in fact not associated with the sustained physiological reactivity that has been shown during rumination (Ottaviani and Couyoumdjian, 2013), and others point to the negative consequences of rumination such as the maintenance of anxiety and negative mood, and the negative impact that pathological rumination might have on individuals (Baer and Sauer, 2011; Robinson and Alloy, 2003). Although depressive ruminations do not form part of the BPD diagnostic criteria, BPD symptoms have been shown to be strongly associated with depressive rumination even after controlling for current depressive symptoms (Selby et al., 2009).

These findings point towards the importance of further investigating the role of depression and anxiety in mind wandering in patients with BPD. One hypothesis is that social threat hypersensitivity is a core characteristic of BPD patients, who show heightened attention to perceived threats (Bertsch et al., 2013). Therefore, we can speculate that the combination of a higher tendency to overestimate social threat from ambiguous cues, together with difficulties in relational functioning (Kaiser et al., 2017), increases feelings of resentment and anxiety leading to alternative forms of MW-S such as anxious worrying and depressive ruminations. Overall, this is consistent with our finding of higher levels of negative valence thoughts during periods of MW-S in BPD, and the high levels of anxiety and depressive symptoms seen in people with BPD (Stepp et al., 2016).

In contrast, our recent review of MW-S in ADHD hypothesises that excessive MW-S reflects a core problem related to a failure of DMN deactivation during task conditions, reflecting dysfunctional interactions between DMN and salience and cortical control networks (Bozhilova et al., 2018). Such heightened DMN activity may lead to periods of spontaneous MW-S that interfere with attention to external tasks, underlying the symptoms and impairments of ADHD. In fact, the first investigations of mind wandering associated neural activity by fMRI studies found strong correlation between reduced deactivation of the DMN and frequency of reported mind wandering (Mason et al., 2007; McKiernan et al., 2006). Here, our findings drawn attention to differences in the characteristics of MW-S in ADHD and BPD with the overall conclusion that excessive MW-S in daily life is seen equally in both disorders but potentially for very different reasons. However, high levels of MW-S in both disorders might be reflected in neuroimaging studies that have reported similar brain structural and functional commonalities between ADHD and BPD in the salience and executive control networks (Xenaki and Pehlivanidis, 2015), and altered functioning of the DMN (Fassbender et al., 2009; Sidlauskaite et al., 2015; Wolf et al., 2011; Yang et al., 2016). This might therefore potentially be related to excessive MW-S in both disorders since the degree of DMN deactivation has been proportionately linked to the frequency of self-generated task-unrelated thoughts (Mason et al., 2007; McKiernan et al., 2006; Christoff et al., 2016; Smallwood et al., 2012).

An important direction for future research will be investigating the different mechanisms by which DMN activity and related to this frequency of MW-S are regulated. In our view, these findings fit well with theoretical conceptualisation of different types of MW-S seen in disorders such as ADHD and BPD. In the seminal review from Christoff et al., (2016) they describe two core-dimensions of spontaneous internally generated thought. First, a dimension of ‘deliberate constraints’ from strong goal-directed thoughts to weak control of internally generated (unfocused) thoughts. Secondly, a dimension of ‘automatic constraints’ from narrow repetitive thought content such as rumination, to unconstrained content of thought, as in ADHD. Further they outline the neural processes that regulate these two dimensions independently. In line with our findings and this model, MW-S in ADHD reflects weak deliberate constraints and weak automatic constraints, while MW-S in BPD reflects weak deliberate constraints but strong automatic constraints.

Although we used multiple measures of MW-S and carefully diagnosed clinical groups, there are several limitations to consider. First, the sample consisted of females only. This has the advantage of eliminating any confounding by sex but means the findings cannot be generalised to males. Depression and anxiety symptoms were measured by the BSI, a self-report scale, which has varied evaluations about its validity. Previous confirmatory factor analyses have shown high intercorrelations among the BSI subscales, suggesting that the BSI could be a better general indicator of psychopathology rather than a screening tool for each of the subscales separately (Boulet and Boss, 1991; Wang et al., 2010). We should therefore consider this limitation before drawing strong conclusions about the relationship of MW-S specifically to anxiety and depression in BPD, rather than an index of psychopathology more generally (Caspi and Moffitt, 2018). Finally, despite having an acceptable compliance rate for the ESM ratings, further studies exploring the specificity of MW-S in ADHD and BPD using an experience sampling approach could benefit from larger sample sizes, to also specifically enable in-depth analyses on contextual and situational factors which are important to understand daily life symptomatology in clinical patients.

CONCLUSIONS AND CLINICAL IMPLICATIONS

In conclusion, regardless of these limitations, our findings suggest that excessive MW-S is a trans-diagnostic process present in both ADHD and BPD. Yet, different processes may drive the underlying mechanisms of this subjective experience. Further research on the content of thought may better differentiate ADHD from BPD, but this requires further evaluation. Research on the specific cognitive and neurobiological mechanisms associated with MW-S should be investigated both in ADHD and BPD, to explain the underlying causes of the different clinical conditions. The strong association of anxiety and depression with MW-S in BPD only should be further explored in the context delineating different aetiological subtypes of MW-S. An analogy is fever, which like MW-S is a symptom seen across conditions but reflecting different underlying specific causes. This analogy could be further extended to treatment of MW-S and related impairments. It has been suggested that treatment of ADHD with methylphenidate might be mediated by reductions in MW-S (Mowlem et al., 2016). Moreover, it is assumed that methylphenidate improves focus and enhances executive resources, as well as enhances task-related DMN deactivation (Van den Driessche et al., 2017), which in turn could reduce MW-S. Whether methylphenidate would reduce excessive MW-S in other conditions such as BPD is however entirely unknown, requiring further studies. Thus, further critical work is required to disentangle the relationship between ADHD and BPD, leading to more accurate diagnoses and, targeting of treatments.

The high rate of overlap in diagnosis and clinical features makes differential diagnosis difficult for clinicians, requiring further detailed studies for clinical markers of the two conditions. This is clinically important as ADHD and BPD require different treatment. Whilst pharmacotherapy in the form of stimulants or atomoxetine is the mainstay of treatment for ADHD (Castells et al., 2011; Cunill et al., 2013), psychological treatment is the primary treatment for BPD (Cristea et al., 2017).

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