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RESEARCH

Recurrent involuntary memories and mind wandering are related but distinct

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Abstract

Spontaneous thought is common in daily life, and includes recurrent involuntary autobiographical memories (IAMs; memories retrieved unintentionally and repetitively) and mind wandering (MW). Both recurrent IAMs and MW are often unintentional or unconstrained, and both predict symptoms of mental health disorders. However, not all MW is unintentional, and not all IAMs are unconstrained. To what extent do recurrent IAMs and MW converge versus diverge? Undergraduates ($N = 2{,}701$) completed self-report measures of recurrent IAMs, trait MW, and psychopathology (i.e., PTSD, depression, anxiety). Regressions indicated that recurrent IAMs were significantly associated with spontaneous MW, but not deliberate MW. Further, both spontaneous MW and recurrent IAMs had unique relationships with disorder symptoms. Results suggest that recurrent IAMs are related to MW to the extent that recurrent IAMs are spontaneous. Conversely, recurrent IAMs are distinct from MW to the extent that recurrent IAMs' associations with disorder symptoms could not be solely explained by trait MW (and vice versa). This work highlights related, but distinguishable, forms of spontaneous thought and their transdiagnostic links with psychopathology.

Spontaneous thought is ubiquitous in daily life. Defined as a mental state that occurs relatively freely due to low constraints on the contents of one's thoughts (Christoff et al., 2016; Mildner & Tamir, 2019), spontaneous thought has been estimated to occupy surprising percentages of peoples' everyday lives (~20–50%; Kane et al., 2007; Killingsworth & Gilbert, 2010; Klinger & Cox, 1987; Seli et al., 2018; Song & Wang, 2012). Given how often people experience spontaneous thought, a growing literature has sought to better define the constructs that compose it (Mildner & Tamir, 2019; Wang et al., 2018), as well as the consequences of experiencing this phenomenon on daily functioning (Christoff et al., 2011; Smallwood & Andrews-Hanna, 2013). An important hypothesis here is that though different forms of spontaneous thought might be united by their unintentional or undirected nature, they may still have differential impacts on peoples' everyday lives (Wang et al., 2018).

Two such forms of spontaneous thought include involuntary autobiographical memories (IAMs; Berntsen, 1996, 2010) and mind wandering (MW; Smallwood & Schooler, 2006). IAMs have been defined as memories of one's personal past that are retrieved unintentionally (i.e., "without preceding attempts at retrieving it"; Berntsen, 1996, p. 435). In a similar fashion, MW has been defined by "a shift of attention away from a primary task toward internal information, such as memories" (Smallwood & Schooler, 2006, p. 946), which often occurs unintentionally or even without awareness. One interpretation of these definitions is that IAMs and MW are disparate mental states that typically share a common origin: arising without deliberate intent. On the other hand, another potential reading of these definitions is that IAMs can be thought of as a subset of MW – after all,

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if IAMs are unintentional cognitions and MW consists of unintentionally retrieved memories, then it could be parsimonious to say that IAMs simply represent a form of MW.

However, defining (and delineating) the constructs related to spontaneous thought has been an important point of debate in recent years. A whole host of properties have been proposed as key to MW, including being stimulus-independent (Smallwood & Schooler, 2006), task-unrelated or unintentional (Seli et al., 2018b; Smallwood & Schooler, 2015), perceptually decoupled (i.e., attention drawn inward rather than towards the perceived environment; Schooler et al., 2011), and/or freely moving (Christoff et al., 2016; Mills et al., 2018). Researchers have recently noted that not all of these definitions of MW apply to IAMs (e.g., IAMs are not necessarily stimulus-independent; Berntsen, 2021). Likewise, we note that not all of the definitions of IAMs apply to MW. For instance, while IAMs are fundamentally defined by their spontaneous nature (Berntsen, 1996), MW can occur spontaneously or deliberately (Seli et al., 2016). Given these conceptual distinctions, in what ways do IAMs and MW converge versus diverge empirically? To address this question, we investigated the degree to which IAMs, MW, and their links to psychopathology overlap in a large sample of undergraduate students. Specifically, we examined recurrent IAMs, or IAMs of the same episode experienced repetitively (Berntsen & Rubin, 2008), due to their previously reported associations with symptoms of mental health disorders (Brewin et al., 2010; Bryant et al., 2011; Mihailova & Jobson, 2018; Yeung & Fernandes, 2020, 2021). Here, we first outline the major commonalities versus differences between IAMs and MW at both conceptual and empirical levels.

Similarities between IAMs and MW

When people mind wander, they regularly report experiencing IAMs (e.g., "offline memory replay" or "spontaneous memory replay"; Mildner & Tamir, 2019). In one study, approximately 60% of participants' MW instances were situated in a specific place and time (i.e., were episodic), 20% of which were based in the past (Song & Wang, 2012). Comparable estimates come from Andrews-Hanna et al., (2013): 77% of participants' MW instances were episodic, 40% of which were past-oriented. As such, IAMs appear to constitute MW for a large subset of MW episodes. Similar support comes from prior research showing strong relationships between IAMs and MW-related cognitive phenomena. For instance, across multiple samples, self-reported frequency of IAMs in daily life was strongly and positively correlated with self-reported daydreaming frequency ($rs = .54–.62$; Berntsen et al., 2015). In a similar vein, the number of IAMs experienced during a memory walk paradigm (i.e., walking along a route in a familiar environment; Berntsen & Hall, 2004; Galton, 1883) was positively correlated with one's tendency to experience cognitive failures ($r = .60$; Kamiya, 2014) as measured by the Cognitive Failures Questionnaire (CFQ; Broadbent et al., 1982). Critically, the CFQ includes MW-related items (e.g., "Do you daydream when you ought to be listening to something?"; Broadbent et al., 1982, p. 15) and has been associated with MW rates during a Sustained Attention to Response Task (SART; Smallwood et al., 2004). These remarkably high correlations seem to imply that IAMs and MW have considerable overlap.

Another noteworthy domain where recurrent IAMs and MW might overlap is their association with symptoms of mental health disorders. In one theoretical framework, spontaneous thought is proposed to be a vulnerability factor leading to the development of psychopathology (Marchetti et al., 2016): spontaneous thoughts such as IAMs and MW could worsen symptoms by promoting unpleasant, maladaptive cognitions (i.e., rumination, hopelessness, low self-esteem, and cognitive reactivity) in individuals predisposed towards negative thought patterns. Empirical studies seem to confirm these purported associations between spontaneous thought and psychopathology. Higher self-reported levels of trait MW, especially spontaneous MW, have been linked to greater symptoms of posttraumatic stress disorder (PTSD; Brosowsky et al., 2022), depression (Greenberg et al., 2018; Seli et al., 2019), and generalized anxiety disorder (GAD; Marcusson-Clavertz & Kjell, 2018; Sekiguchi, 2023; Seli et al., 2019). Behavioural evidence further corroborates this relationship: a greater number of MW instances during laboratory tasks (e.g., the SART) has been significantly correlated with greater symptoms of depression (Deng et al., 2014; Hoffmann et al., 2016; Nayda & Takarangi, 2021; Smallwood et al., 2007) and PTSD (Nayda & Takarangi, 2021).

Likewise, IAMs have shown similar relationships with symptoms of mental health disorders: greater self-reported frequency of experiencing IAMs in daily life has been significantly and positively correlated with symptoms of PTSD, depression, and generalized anxiety disorder (GAD; Berntsen et al., 2015). More recent work has focused on recurrent IAMs—IAMs of the same episodes experienced repetitively (Berntsen & Rubin, 2008)—because of their theoretical role in transdiagnostic models of mental health disorders (Brewin et al., 2010; Bryant et al., 2011; Harvey et al., 2004). Aligning with these models, evidence suggests that recurrent IAMs, especially negatively valenced ones, are associated with significantly elevated symptoms of PTSD, depression, GAD, and social anxiety disorder (Yeung & Fernandes, 2020, 2021). Finally, work has also shown that properties (e.g., emotional qualities) of involuntary

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cognitions (e.g., memories, daydreams, future thoughts, etc., collapsed together) were related to general levels of psychopathology (Krans et al., 2015). Taken together, current evidence suggests reliable links between not only MW and psychopathology, but also IAMs and psychopathology.

Differences between IAMs and MW

Berntsen (2021) has argued that though IAMs and MW are related (e.g., both being spontaneous), they remain fundamentally distinct from each other in a number of ways. For instance, IAMs are not always stimulus-independent or unconstrained. IAMs are typically evoked by contextual cues, which can be external (e.g., sights, smells, etc.) or internal (e.g., abstract thoughts, emotional states; Mace, 2004). Because people can often identify these cues as the antecedents to their IAMs, IAMs could thus be classified as stimulus-dependent, or constrained to the presentation of a specific cue. Others have proposed that these cues are what provides access to the episodic memory system during spontaneous thought (Jordão & St. Jacques, 2022), because cues serve to isolate specific memories (cue-item discriminability). This notion is echoed by Christoff et al. (2016), who state that "mind-wandering can be clearly distinguished from rumination and other types of thought that are marked by a high degree of automatic constraints" (p. 719), which seems to be the case for IAMs. Furthermore, IAMs can also often be thought of as task-related, since an individual's ongoing task can cue IAMs related to said task. Past samples have, on average, rated their IAMs as at least "slightly" or "somewhat" relevant to their current situation, and as having served problem-solving functions (Rasmussen et al., 2015). Because these core definitions of MW (e.g., being stimulus-independent, unconstrained, task-unrelated) seem to not fully encompass IAMs, it may be warranted to keep these constructs separate.

Finally, a potentially important distinction between recurrent IAMs and MW is that recurrent IAMs are defined as being repetitive (Rubin & Berntsen, 2008). For instance, these memories can involve unintentionally reexperiencing the same event several times per week, month, or year, and are quite prevalent even in nonclinical samples (e.g., ~ 50–55% of participants; Yeung & Fernandes, 2020, 2021). If these recurrent memories are unpleasant or unwanted, this persistence can have "profound consequences for psychological health", leaving some individuals "haunted to death" (Schacter, 2021); accordingly, persistent memories have been identified as an important target for intervention (Iyadurai et al., 2019; Joensen et al., 2022). Although MW can (and often does) involve repetitive thoughts (e.g., "perseverative cognition"; Ottaviani & Couyoumdjian, 2013; Ottaviani et al., 2013), MW is not *defined* by repetition in the same way that recurrent IAMs are. As such, recurrent IAMs may be especially correlated with symptoms of mental health disorders, relative to trait MW.

Current study

Despite researchers having drawn some conceptual distinctions between IAMs and MW (Berntsen, 2021; Christoff et al., 2016), there remains little in the way of empirical evidence to separate the two. Strong overlap between IAMs and MW has been demonstrated based on prior self-report (Berntsen et al., 2015), behavioural (Kamiya, 2014), and neuroimaging data (Christoff et al., 2004). As such, our goal was to identify specific dimensions along which recurrent IAMs and MW converge or diverge, and examine the degree to which they do so. Here, we hypothesized that recurrent IAMs and MW would converge to the extent that recurrent IAMs are, by definition, unintentional. If so, the properties of recurrent IAMs (e.g., their presence and frequency) ought to track with spontaneous MW, but not deliberate MW (effortful, intentional initiation of unguided thoughts). We also hypothesized that the valence of recurrent IAMs might be associated with spontaneous MW, given previous associations between unintentional MW and negative affect (Thiemann et al., 2022).

We further predicted that the properties of recurrent IAMs (presence, frequency, and valence) would explain unique variance in symptoms of psychopathology, above and beyond trait MW. We expected to replicate past findings that spontaneous MW would be positively correlated with symptoms of PTSD (Brosowsky et al., 2022), depression (Greenberg et al., 2018; Seli et al., 2019), and general anxiety (Marcusson-Clavertz & Kjell, 2018; Sekiguchi, 2023; Seli et al., 2019). Importantly, we tested the novel hypothesis that recurrent IAMs could explain unique variance in psychopathology symptoms, beyond that of trait MW. Others have argued that MW is not wholly detrimental, but rather that MW about *persistent or perseverative* content (Ottaviani et al., 2013) is maladaptive. Recurrent IAMs may reflect this persistence more so than trait MW, and as such, may account for unique variance in disorder symptoms.

Methods

Participants

A convenience sample of undergraduate students was recruited at the University of Waterloo, who participated in the current study in return for course credit. Data were

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collected in two waves, with each wave occurring at the start of an academic term (i.e., Winter/January 2020 and Spring/May 2020). In total, 2,701 unique individuals participated, 73% of whom were women; 25% were men; 1% were nonbinary, genderqueer, gender nonconforming, or two-spirit; and 1% declined to respond[1]. Mean age was 20.2 ($SD = 3.0$, range = 17–48). The most common self-reported ethnicities among our participants were Canadian (43%), Indian (10%), and Chinese (9%). We had no further inclusion criteria (beyond being an undergraduate student at the institution), and no exclusion criteria.

Materials

Recurrent Memory Scale. The Recurrent Memory Scale (Yeung & Fernandes, 2020) assessed participants' recurrent IAMs. Participants indicated if they had experienced at least one recurrent IAM within the past year, not within the past year, or never (Berntsen & Rubin, 2008). If they had experienced at least one within the past year, they wrote a brief description of their one most frequently recurring IAM and rated its phenomenological properties on a series of 5-point Likert scales. For example, participants were asked how frequently the memory recurred (1 = *once/year*, 5 = *several/day*) and its valence (-2 = *very negative*, 2 = *very positive*; see Yeung & Fernandes, 2020 for details).

Deliberate and Spontaneous Mind Wandering Scales. The Deliberate (MW-D) and Spontaneous (MW-S) Mind Wandering Scales consist of 4 items each, which index the tendency to experience intentional and unintentional mind wandering, respectively (Carriere et al., 2013). Internal consistency was high in the current sample for both MW-S ($\alpha = .88$) and MW-D ($\alpha = .89$).

PTSD Checklist for DSM-5. The PCL-5 (Weathers et al., 2013) consists of 20 items assessing symptoms of posttraumatic stress disorder. Participants indicated the degree to which they experienced symptoms in the past month in response to any very stressful event. Internal consistency was high in the current sample ($\alpha = .96$).

Depression, Anxiety, & Stress Scales. The DASS-21 (Lovibond & Lovibond, 1995) consists of 21 items, including a 7-item subscale assessing symptoms of depression (DASS-D). Internal consistency was high in the current sample for the full scale ($\alpha = .95$) and the depression subscale ($\alpha = .92$).

State-Trait Inventory of Cognitive and Somatic Anxiety – Trait Version. The STICSA-T (Grös et al., 2007) consists of 21 items assessing cognitive and somatic aspects of trait anxiety. Internal consistency was high in the current sample ($\alpha = .94$).

Procedure

Undergraduate students at the University of Waterloo were eligible to self-register for the current 60-minute online study if they were enrolled in at least one psychology course. After providing informed consent, participants completed a battery of measures in a randomized order, including the Recurrent Memory Scale, Deliberate and Spontaneous Mind Wandering Scales (MW-S, MW-D), and mental health indices (PCL-5, DASS-21, STICSA-T). All other measures were unrelated to the current study. All procedures were approved by the University of Waterloo's Office of Research Ethics (Protocol #40049).

Results

Data were excluded pairwise (analysis-by-analysis) for participants who provided no response to a given scale/item included in an analysis. To examine evidence for null hypotheses, we conducted equivalence tests (Harms & Lakens, 2018; Kruschke, 2011, 2018) on nonsignificant predictors ($ps \geq .05$). Regions of practical equivalence (ROPEs) were set at the recommended values for each model (i.e., [-0.18, 0.18] for logistic models and [$-0.1 \times SD_y$, $0.1 \times SD_y$] for linear models; Kruschke, 2018; Makowski et al., 2019). We calculated 95% highest density intervals (HDIs) for nonsignificant predictors and adopted the HDI + ROPE decision rule (Harms & Lakens, 2018; Kruschke, 2018), such that if 100% of the 95% HDI was within the ROPE, we accepted that a difference was equivalent to zero for practical purposes.

Estimating properties of recurrent IAMs

Presence of recurrent IAMs

We conducted a logistic regression to estimate the presence of recurrent IAMs (0 = absent, 1 = present[2]) using trait MW scores ($n = 1{,}656$; Table 1; Fig. 1). VIFs were less than 1.3, indicating no multicollinearity issues. No overly influential outliers were detected based on Cook's distance, and predictors were linearly related to the logit of the outcome.

MW-S was significantly associated with the presence of recurrent IAMs ($\beta = 1.51$, $p < .001$), such that higher MW-S scores were related to greater probability of recurrent IAMs

[1] We did not conduct sex/gender-based analyses in the current study because we did not have a priori hypotheses regarding sex or gender. To facilitate reanalyses, we have provided disaggregated data on gender in the openly available data.

[2] Responses of "*no, never*" or "*yes, but not within the past year*" were coded as absent (0), whereas responses of "*yes, within the past year*" were coded as present (1).

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Table 1 Regressions estimating properties of recurrent IAMs using spontaneous & deliberate MW

Outcome	Predictor	Odds ratio / B	SE B	β	R^2
Recurrent IAM presence	MW-S	1.35	0.06	1.51***	.04***
	MW-D	1.01	0.04	1.02	
Recurrent IAM frequency	MW-S	0.17	0.03	0.21***	.04***
	MW-D	-0.02	0.03	-0.03	
Recurrent IAM valence	MW-S	-0.04	0.04	-0.04	.003
	MW-D	0.04	0.03	0.05	

Notes Odds ratios are presented for the logistic model (Presence); unstandardized B values are presented for the linear models (Frequency, Valence). MW-S = Spontaneous Mind Wandering, MW-D = Deliberate Mind Wandering, IAM = involuntary autobiographical memory. ***$p < .001$

being present. The odds ratio for MW-S indicated that, holding MW-D at a fixed value, we would expect a 35% increase in the odds of experiencing recurrent IAMs for each one-unit increase in MW-S score. In contrast, MW-D was not a significant predictor of recurrent IAM presence (β = 1.02, $p = .8$), with an equivalence test indicating that 100% of its 95% HDI ([-0.07, 0.09]) fell within the ROPE.

Frequency of recurrent IAMs

We conducted a linear regression to estimate the frequency of recurrent IAMs (1 = *once/year*, 5 = *several/day*) using trait MW scores ($n = 775$; Table 1; Fig. 1). VIFs were less than 1.2, indicating no multicollinearity issues. No overly influential outliers were detected based on Cook's distance, predictors were linearly related to the outcome, and residuals were normally distributed.

MW-S was significantly associated with frequency of recurrent IAMs (β = 0.21, $p < .001$), such that higher MW-S scores were related to more frequently recurring IAMs. In contrast, MW-D was not a significant predictor of recurrent

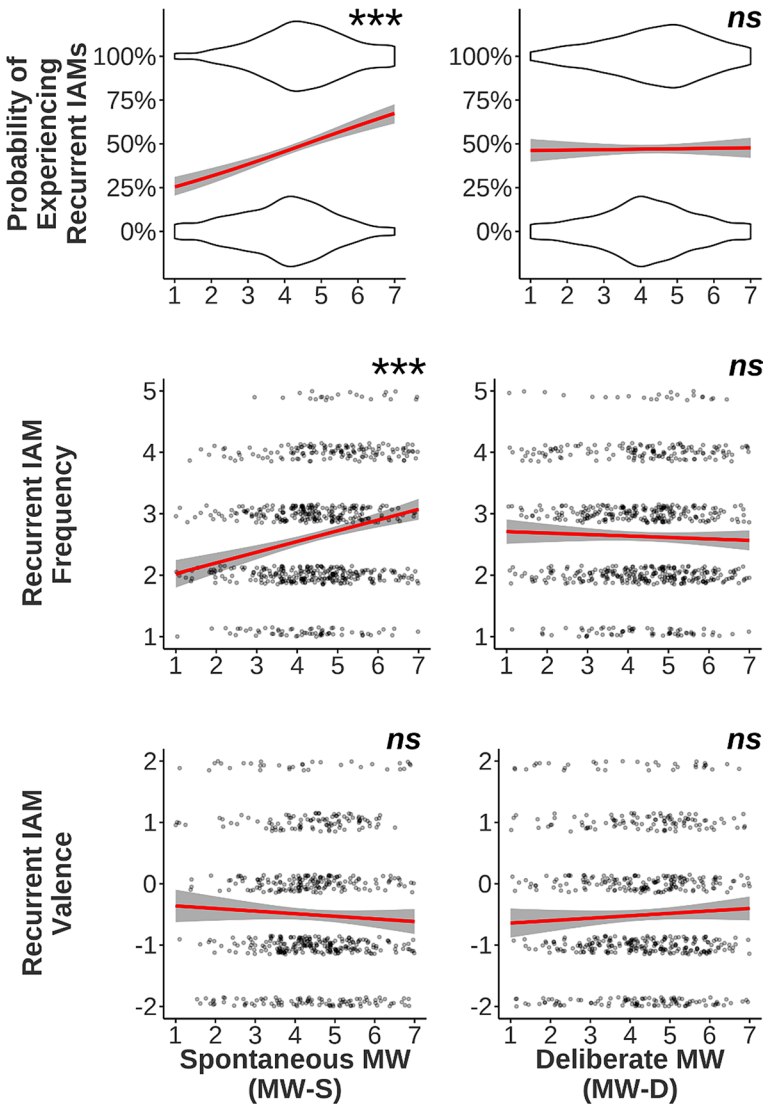


Fig. 1 Partial effects of spontaneous & deliberate MW on properties of recurrent IAMs. *Note* IAM = involuntary autobiographical memory. Ribbons represent 95% confidence intervals. ***$p < .001$

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IAM frequency (β = -0.03, $p = .4$), with an equivalence test indicating that 100% of its 95% HDI ([-0.08, 0.03]) fell within the ROPE.

Valence of recurrent IAMs

We conducted a linear regression to estimate the valence of recurrent IAMs (-2 = *very negative*, 2 = *very positive*) using trait MW scores ($n = 772$; Table 1; Fig. 1). VIFs were less than 1.2, indicating no multicollinearity issues. No overly influential outliers were detected based on Cook's distance, predictors were linearly related to the outcome, and residuals were normally distributed.

Neither MW-S (β = -0.04, $p = .2$) nor MW-D (β = -0.05, $p = .2$) were significant predictors of recurrent IAM valence (overall model $p = .4$). An equivalence test indicated that 100% of the 95% HDIs for both MW-S ([-0.11, 0.03]) and MW-D ([-0.03, 0.10]) fell within the ROPE.

Estimating symptoms of mental health disorders

For each of recurrent IAM presence ($ns = 1{,}634$–$1{,}648$), frequency ($ns = 763$–775), and valence ($ns = 760$–772), we conducted hierarchical linear regressions to investigate whether the properties of recurrent IAMs accounted for significant variance in symptoms of mental health disorders (PTSD, depression, general anxiety), unique from the variance explained by trait MW. VIFs were less than 1.3, indicating no multicollinearity issues. No overly influential outliers were detected based on Cook's distance, predictors were linearly related to the outcome, and residuals were normally distributed.

Presence of recurrent IAMs

Model 1 indicated that MW-S was a significant positive predictor of symptoms of each mental health disorder (βs > 0.39, $ps < .001$), whereas MW-D was not a significant predictor of symptoms of any disorder (βs > -0.04, $ps > .1$). Adding recurrent IAM presence in Model 2 was a significant improvement for estimating PTSD and general anxiety symptoms (ΔR^2s > .005, $ps < .001$), but not depression symptoms ($\Delta R^2 < .001$, $p = .1$) with 64% of the 95% HDI ([-0.08, 0.86]) falling within the ROPE. While MW-S remained as a significant predictor for PTSD and general anxiety symptoms (βs > 0.36, $ps < .001$) in Model 2, recurrent IAM presence also accounted for unique variance as a significant positive predictor of PTSD symptoms (β = 0.28, $p < .001$) and general anxiety symptoms (β = 0.15, $p < .001$). MW-D remained as a nonsignificant predictor of all symptoms in Model 2 (βs > -0.04, $ps > .1$), with 100% of the 95% HDIs ([-0.84, 0.34] for PTSD, [-0.31, 0.05] for depression, and [-0.42, 0.36] for general anxiety) falling within the ROPEs ([-1.75, 1.75], [-0.52, 0.52], and [-1.19, 1.19], respectively; Table 2; Fig. 2).

Frequency of recurrent IAMs

Model 1 indicated that MW-S was a significant positive predictor of symptoms of each mental health disorder (βs > 0.37, $ps < .001$). In contrast, MW-D was a significant negative predictor for depression symptoms (β = -0.08, $p = .03$), but not PTSD or general anxiety symptoms (βs = -0.01, $ps > .7$). Adding recurrent IAM frequency in Model 2 led to a significant improvement in estimating symptoms of each mental health disorder (ΔR^2s > .01, $ps < .01$). While MW-S remained as a significant predictor for symptoms of each mental health disorder (βs > 0.32, $ps < .001$) in Model 2, recurrent IAM frequency also accounted for unique variance as a significant positive predictor of all symptoms (βs > 0.11, $ps < .01$). MW-D remained as a significant negative predictor of depression symptoms in Model 2 (β = -0.07, $p = .04$). Conversely, MW-D was a nonsignificant predictor for PTSD and general anxiety symptoms (βs = -0.01, $ps > .8$), with 100% of the 95% HDIs ([-0.89, 0.74] for PTSD and [-0.59, 0.46] for general anxiety) falling

Table 2 Linear regressions estimating symptoms of mental health disorders using spontaneous & deliberate MW and recurrent IAM presence

	PCL-5			DASS-D			STICSA-T		
Variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Model 1									
MW-S	5.04	0.32	0.39***	1.50	0.10	0.40***	4.00	0.21	0.46***
MW-D	-0.23	0.31	-0.02	-0.13	0.09	-0.04	-0.03	0.20	>-0.001
Model 2									
MW-S	4.70	0.33	0.37***	1.47	0.10	0.39***	3.88	0.22	0.44***
MW-D	-0.25	0.30	-0.02	-0.13	0.09	-0.04	-0.03	0.20	>-0.001
Recurrent IAM presence	4.84	0.81	0.28***	0.39	0.24	0.08	1.78	0.53	0.15***
Model 1 R^2		.15***			.15***			.21***	
Model 2 ΔR^2		.02***			< .001			.005***	

Notes MW-S = Spontaneous Mind Wandering, MW-D = Deliberate Mind Wandering, IAM = involuntary autobiographical memory, PCL-5 = PTSD Checklist for DSM-5, DASS-D = Depression, Anxiety, and Stress Scales – Depression Subscale, STICSA-T = State-Trait Inventory of Cognitive and Somatic Anxiety – Trait Version. **$p < .01$; ***$p < .001$

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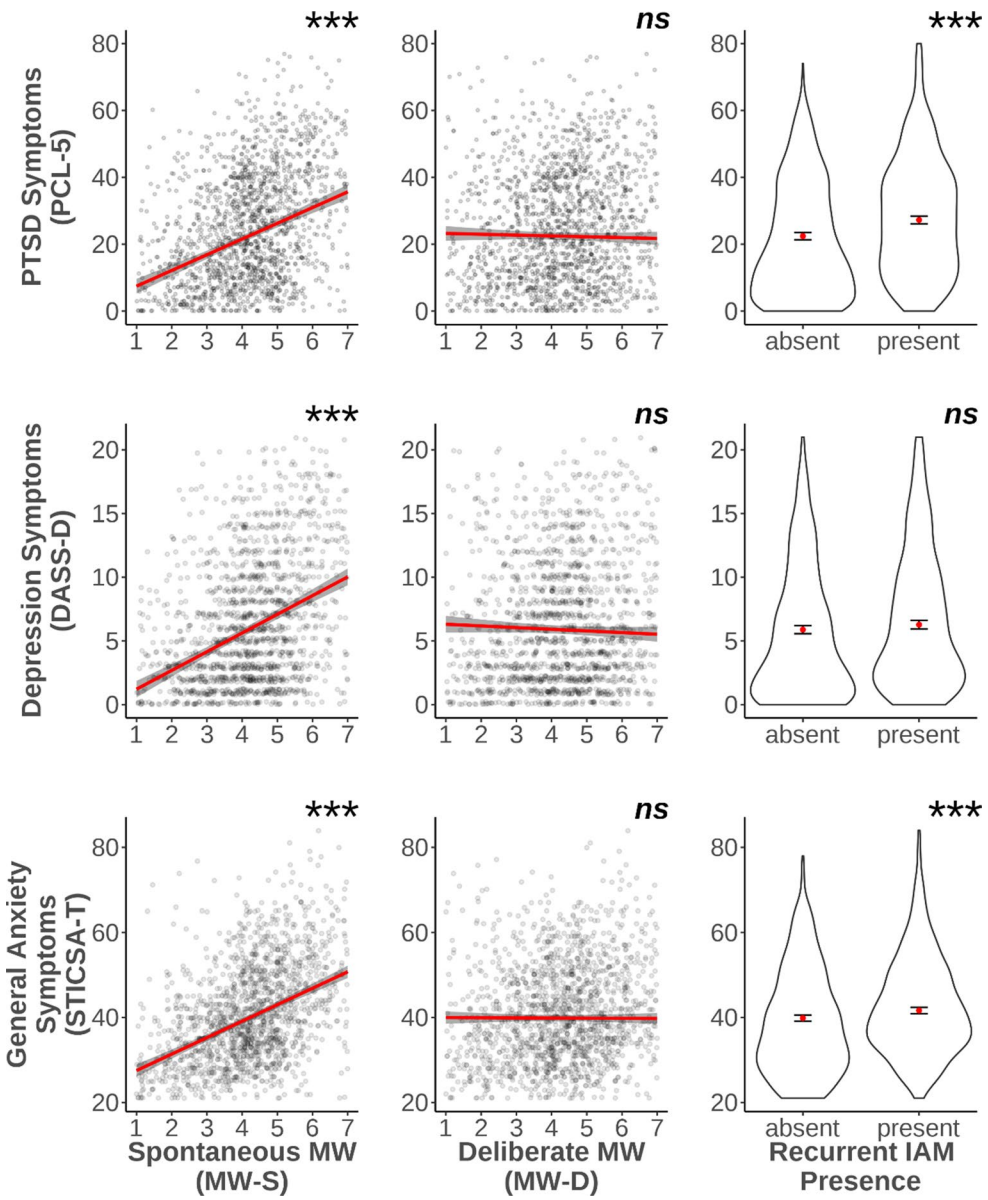


Fig. 2 Partial effects of spontaneous & deliberate MW and recurrent IAM presence on symptoms of mental health disorders. *Note* This figure represents Model 2 in Table 2. IAM = involuntary autobiographical memory, PCL-5 = PTSD Checklist for DSM-5, DASS-D = Depression, Anxiety, and Stress Scales – Depression Subscale, STICSA-T = State-Trait Inventory of Cognitive and Somatic Anxiety – Trait Version. Ribbons/error bars represent 95% confidence intervals. $^{***}p < .001$

within the ROPEs ([-1.75, 1.75] and [-1.14, 1.14], respectively; Table 3; Fig. 3).

Valence of recurrent IAMs

Model 1 indicated that MW-S was a significant positive predictor of symptoms of each mental health disorder (βs > 0.37, *p*s < .001). In contrast, MW-D was a significant negative predictor for depression symptoms (β = -0.07, *p* = .04), but not PTSD or general anxiety symptoms (βs > -0.01, *p*s > .7). Adding recurrent IAM valence in Model 2 led to a significant improvement in predicting symptoms of each mental health disorder (ΔR^2s > .02, *p*s < .001). While MW-S remained as a significant predictor for symptoms of each mental health disorder (βs > 0.36, *p*s < .001) in Model 2, recurrent IAM valence also accounted for unique variance as a significant negative predictor of all symptoms (i.e., more positive valence was associated with fewer symptoms; βs < -0.16, *p*s < .001). MW-D was a nonsignificant predictor of all symptoms in Model 2 (βs > -0.07, *p*s > .06), with 100% of the 95% HDIs ([-0.80, 0.84] for PTSD, [-0.49, 0.01] for depression, and [-0.57, 0.48] for general anxiety) falling within the ROPEs ([-1.75, 1.75], [-0.53, 0.53], and [-1.14, 1.14], respectively; Table 4; Fig. 4).

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Table 3 Linear regressions estimating symptoms of mental health disorders using spontaneous & deliberate MW and recurrent IAM frequency

	PCL-5			DASS-D			STICSA-T		
Variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Model 1									
MW-S	4.95	0.48	0.37^{***}	1.61	0.14	0.40^{***}	3.79	0.30	0.44^{***}
MW-D	-0.14	0.43	-0.01	-0.28	0.13	-0.08^{*}	-0.10	0.27	-0.01
Model 2									
MW-S	4.24	0.47	0.32^{***}	1.52	0.14	0.38^{***}	3.53	0.30	0.41^{***}
MW-D	-0.08	0.42	-0.01	-0.27	0.13	-0.07^{*}	-0.06	0.27	-0.01
Recurrent IAM frequency	4.18	0.54	0.26^{***}	0.52	0.16	0.11^{**}	1.44	0.35	0.14^{***}
Model 1 R^2		$.13^{***}$			$.15^{***}$			$.18^{***}$	
Model 2 ΔR^2		$.06^{***}$			$.01^{**}$			$.02^{***}$	

Notes MW-S = Spontaneous Mind Wandering, MW-D = Deliberate Mind Wandering, IAM = involuntary autobiographical memory, PCL-5 = PTSD Checklist for DSM-5, DASS-D = Depression, Anxiety, and Stress Scales – Depression Subscale, STICSA-T = State-Trait Inventory of Cognitive and Somatic Anxiety – Trait Version. $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

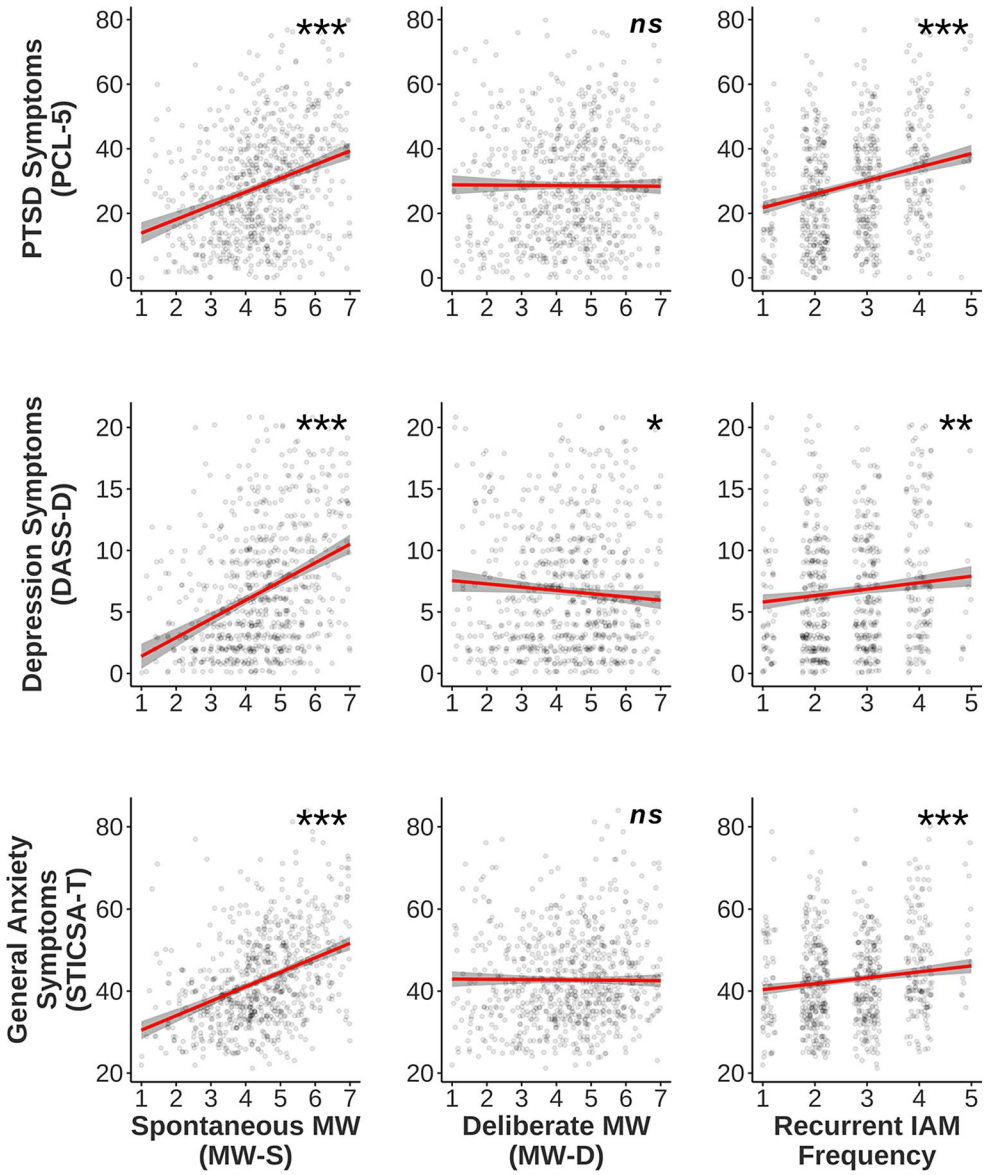


Fig. 3 Partial effects of spontaneous & deliberate MW and recurrent IAM frequency on symptoms of mental health disorders. *Note* This figure represents Model 2 in Table 3. IAM = involuntary autobiographical memory, PCL-5 = PTSD Checklist for DSM-5, DASS-D = Depression, Anxiety, and Stress Scales – Depression Subscale, STICSA-T = State-Trait Inventory of Cognitive and Somatic Anxiety – Trait Version. Ribbons represent 95% confidence intervals. $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

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Table 4 Linear regressions estimating symptoms of mental health disorders using spontaneous & deliberate MW and recurrent IAM valence

	PCL-5			DASS-D			STICSA-T		
Variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Model 1									
MW-S	4.95	0.48	0.37^{***}	1.59	0.14	0.40^{***}	3.79	0.30	0.43^{***}
MW-D	-0.10	0.43	-0.01	-0.26	0.13	-0.07^{*}	-0.11	0.27	-0.01
Model 2									
MW-S	4.86	0.46	0.36^{***}	1.56	0.14	0.39^{***}	3.74	0.30	0.43^{***}
MW-D	0.02	0.42	< 0.001	-0.24	0.13	-0.07	-0.04	0.27	-0.01
Recurrent IAM valence	-3.44	0.45	-0.25^{***}	-0.67	0.14	-0.16^{***}	-1.54	0.29	-0.17^{***}
Model 1 R^2		$.13^{***}$			$.14^{***}$			$.18^{***}$	
Model 2 ΔR^2		$.06^{***}$			$.02^{***}$			$.03^{***}$	

Notes MW-S = Spontaneous Mind Wandering, MW-D = Deliberate Mind Wandering, IAM = involuntary autobiographical memory, PCL-5 = PTSD Checklist for DSM-5, DASS-D = Depression, Anxiety, and Stress Scales – Depression Subscale, STICSA-T = State-Trait Inventory of Cognitive and Somatic Anxiety – Trait Version. $^{*}p < .05$; $^{***}p < .001$

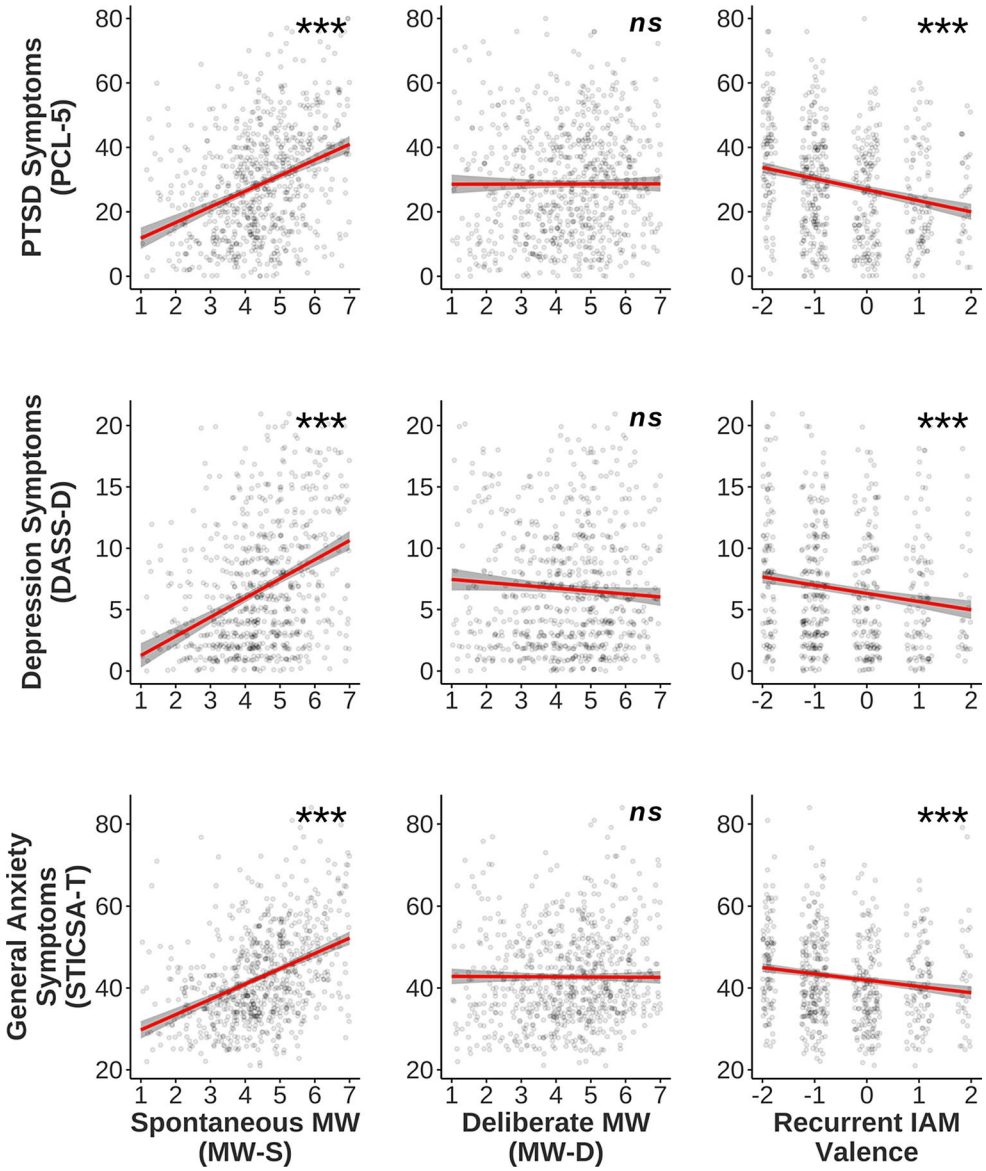


Fig. 4 Partial effects of spontaneous & deliberate MW and recurrent IAM valence on symptoms of mental health disorders. *Note* This figure represents Model 2 in Table 4. IAM = involuntary autobiographical memory, PCL-5 = PTSD Checklist for DSM-5, DASS-D = Depression, Anxiety, and Stress Scales – Depression Subscale, STICSA-T = State-Trait Inventory of Cognitive and Somatic Anxiety – Trait Version. $^{***}p < .001$. Ribbons represent 95% confidence intervals

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Discussion

In current literature, there exists a growing discourse around the constructs that make up spontaneous thought. Of recent interest have been the similarities and differences between two such constructs: IAMs and MW (Berntsen, 2021). Prior work suggests that there is substantial overlap between IAMs and MW (Berntsen et al., 2015; Christoff et al., 2004; Kamiya, 2014), especially in terms of their relationship to psychopathology (Marchetti et al., 2016). However, taxonomies of spontaneous thought have still taken the position that IAMs and MW are differentiable constructs (Christoff et al., 2016; Meyer et al., 2015), though these models have not yet reached consensus as to what specifically separates them (e.g., automatic constraints, meta-awareness). To what extent do recurrent IAMs and MW converge or diverge? The current study addressed this question by examining associations between recurrent IAMs, trait MW, and symptoms of mental health disorders in a large, nonclinical sample.

MW and properties of recurrent IAMs

Here, we found that the presence and frequency of recurrent IAMs were significantly associated with spontaneous MW, and not deliberate MW. We can draw two main conclusions based on this finding. First, this result underscores the validity and value of distinguishing between spontaneous and deliberate forms of MW (Seli et al., 2016). For example, we can interpret this finding as convergent validity for the MW-S scale and divergent validity for the MW-D scale, since recurrent IAMs are, by definition, unintentional. Second, this finding provides evidence for the involuntary nature of recurrent IAMs, even when participants are asked to voluntarily retrieve the memory during a study. In the current study (along with many previous ones; Berntsen & Rubin, 2008; Yeung & Fernandes, 2020, 2021; Yeung et al., 2022), the response format was retrospective self-report: participants were asked to intentionally recall the memory that spontaneously sprang to mind most frequently in their daily lives. As such, participants could potentially misjudge or misclassify whether a memory had originally been involuntary or voluntary (Barzykowski et al., 2021; Barzykowski & Mazzoni, 2022), since this is a decision that requires accurate metacognition (e.g., reflecting on the memory's phenomenology and how effortful it was to retrieve; Moulin et al., 2022). For example, if one voluntarily/deliberately retrieves an AM that involves negative content or evokes unpleasant feelings, one might mistakenly label it as involuntary/spontaneous since one didn't enjoy experiencing the AM. Thankfully, this validity concern is lessened based on the current data since the presence and frequency of recurrent IAMs—which are, theoretically, spontaneous—were exclusively associated with spontaneous MW, not deliberate MW. Participants seem to be able (and willing) to make retrospective self-reports of recurrent IAMs in their daily lives that are either accurate, or at least internally consistent with their self-reports of trait MW.

Another interesting finding was that the valence of recurrent IAMs was not significantly related to either spontaneous or deliberate MW, with equivalence tests indicating strong evidence for the null. A body of work argues that MW leads to negative affect and vice versa (Killingsworth & Gilbert, 2010; Marchetti et al., 2012; Smallwood & O'Connor, 2011; Stawarczyk et al., 2012). In particular, unintentional MW has been associated with more negative momentary affect relative to intentional MW (Thiemann et al., 2022). More spontaneous MW could thus lead to more negative moods, which could in turn lead to more negative recurrent IAMs (Berntsen et al., 1996; Bywaters et al., 2004; Kvavilashvili & Schlagman, 2011; Schlagman et al., 2006). However, such a pattern was not observed here. Rather, we found support for a null effect in the association between trait MW and recurrent IAM valence. Participants with high spontaneous MW scores did not necessarily wander into more negative recurrent IAMs; participants with high deliberate MW scores did not necessarily choose more positive recurrent IAMs. This finding supports at least one area where recurrent IAMs and MW may be relatively distinct from one another. Our results also align with work presenting more nuanced views of emotion and MW, such that MW is not necessarily detrimental and can sometimes have affective or functional benefits (Mason et al., 2013; Mills et al., 2021; Ottaviani et al., 2015; Poerio et al., 2013; Smallwood & Andrews-Hanna, 2013; Welz et al., 2018), even if repetitive or intrusive (Baars, 2010). An important caveat here is that we only measured participants' one most frequently recurring IAM. It remains possible that the valence of other, less frequently recurring, IAMs could ultimately correlate with trait MW (e.g., whether one experiences many versus few negative recurrent IAMs).

Estimating symptoms of mental health disorders

In the current study, we replicated findings that greater spontaneous MW significantly correlates with more symptoms of PTSD (Brosowsky et al., 2022), depression (Deng et al., 2014; Nayda & Takarangi, 2021; Seli et al., 2019; Smallwood et al., 2007), and GAD (Marcusson-Clavertz & Kjell, 2018; Seli et al., 2019). We also found that deliberate MW had either no significant relationship with psychopathology, or the opposite pattern (more deliberate MW correlated with fewer depression symptoms; Table 3; Fig. 3), which further replicates past work (Brosowsky et al., 2022; Seli et al., 2019). In other words, higher spontaneous MW was related

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to more symptoms of all disorders, whereas little to no relationship was found with deliberate MW after accounting for spontaneous MW. Our results confirm previous conclusions that spontaneous MW has closer ties to psychopathology than deliberate MW.

A critical novel finding was that the properties of recurrent IAMs accounted for significant variance in psychopathology, above and beyond that of trait MW. This was true for almost all properties of recurrent IAMs (presence, frequency, and valence) and symptom types (PTSD, depression, general anxiety) included in this study. First, this finding supports theoretical accounts that claim that spontaneous thought is an important mechanism through which psychopathology develops (Marchetti et al., 2016). The observed relationships also highlight ideas that spontaneous thoughts (especially recurrent IAMs) serve as transdiagnostic components of mental health disorders (Brewin et al., 2010; Harvey et al., 2004). Second, this result indicates that spontaneous MW and recurrent IAMs are distinct sources of information when estimating symptoms of mental health disorders. Recurrent IAMs appear to have unique associations with psychopathology that cannot be explained by general tendencies to spontaneously mind wander.

The one exception was that recurrent IAM presence did not improve the model estimating depression symptoms. This null effect could potentially be explained by past results indicating similar prevalence of recurrent IAMs between those with low versus high depressive symptoms (Brewin et al., 1996; Bywaters et al., 2004; Newby & Moulds, 2010, 2011). Alternatively, spontaneous MW and recurrent IAM presence may be more overlapping in depression versus other disorders or properties of IAMs: MW has been found to be more past-oriented in participants with major depressive disorder versus without (Hoffmann et al., 2016). Spontaneous MW in those with high depression symptoms may already reflect the presence of recurrent IAMs, thus minimizing the impact of adding presence as a predictor.

Differences between spontaneous MW and recurrent IAMs

We demonstrated here that recurrent IAMs significantly accounted for unique variance above and beyond trait MW when estimating symptoms of mental health disorders. But what about recurrent IAMs is unique (or at least distinct) from trait MW? Though the present data cannot pinpoint a specific mechanism, we can put forth a few candidates for future exploration.

First, it is possible that the properties of recurrent IAMs reflected some degree of state MW as opposed to trait MW. Knowing information about *specific* episodes of spontaneous thought (e.g., valence ratings of recurrent IAMs) could have accounted for unique variance above *general* patterns of spontaneous thought (i.e., trait MW). As such, individuals' ratings of their recurrent IAMs could have provided better insight into the contents of their spontaneous thought compared to trait MW scales. However, it remains worth noting that phenomenological properties of single AMs are quite consistent with individuals' trait-like experiences of their AMs in general (Gehrt et al., 2022; Rubin, 2021). In other words, since state-like ratings of specific AMs are generally stable within individuals, this potential difference between state and trait measures appears to be relatively unlikely. To address this point directly, future work could administer trait measures of recurrent IAMs or state measures of MW.

Second, another possible difference is the perseverative nature of recurrent IAMs as opposed to MW (Ottaviani & Couyoumdjian, 2013; Ottaviani et al., 2013). Repetitive reexperiencing of past events is a notable clinical feature across many disorders (Brewin et al., 2010; Bryant et al., 2011; Harvey et al., 2004), leading to the idea that persistence has greater consequences on mental health relative to one-off spontaneous thoughts. Some researchers have proposed that it is this repetitiveness or inflexibility in thought that makes some types of MW maladaptive versus adaptive (Ottaviani & Couyoumdjian, 2013; Ottaviani et al., 2013). Hence, the properties of recurrent IAMs could have added unique value when estimating psychopathology symptoms because of its persistent nature. Future studies could investigate persistence in MW and contrast recurrent nonmemories (e.g., repetitive negative thinking; Ehring & Watkins, 2008) against recurrent IAMs.

Third, recurrent IAMs and MW could have differed in terms of temporal direction or orientation. MW can be focused on the past, present, or future (or even no specific time, i.e., atemporal MW; Jackson et al., 2013), though a bias toward the future has typically been observed ("prospective bias"; D'Argembeau et al., 2011; Smallwood et al., 2009; Song & Wang, 2012; Stawarczyk et al., 2011). In contrast, recurrent IAMs in the current study were defined as past-focused (or at least, involving past lived events). This past focus in recurrent IAMs could have led the memories to be more negative in valence than (typically) future-focused MW episodes (Smallwood & O'Connor, 2011). Evidence also suggests that future-focused spontaneous thoughts are more effortful and require more cognitive resources (e.g., metacognition, executive functions) compared to IAMs (Mazzoni, 2019). Future work could assess the temporal focus and valence of MW episodes to directly investigate their potential roles in distinguishing IAMs from MW. Alternatively, researchers could examine involuntary future thoughts (IFTs) as a future-focused analogue to IAMs

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(Barzykowski et al., 2019; Berntsen & Jacobsen, 2008; Cole & Kvavilashvili, 2021).

Limitations and future directions

A limitation of the current study is that we relied on retrospective, scale-based, self-report measures. For example, responding to one scale (e.g., MW-S or MW-D) could have potentially biased participants to respond similarly to the other (e.g., Recurrent Memory Scale). Though possible, this was mitigated by the scales being presented at randomized points during an hour-long battery of questionnaires. It seems unlikely that responding to one scale would artificially impact responses on the other, since participants would have no reason to associate the scales together, beyond the constructs they tap into. Nevertheless, the use of self-report scales as measures opens the possibility that our observed patterns could have been driven by content overlap across items on different scales. Although we could not qualitatively identify any redundant items on our measures of interest, additional studies could be conducted to rule out this possibility. Future work could consider using measures of MW that are more behavioural (e.g., responses during a SART; Robertson et al., 1997), measures of recurrent IAMs that are less retrospective (e.g., diary studies; Berntsen, 1996), or experience sampling methods (Chaieb et al., 2022). Though these methods still have elements of self-report (e.g., self-reporting whether one was mind wandering or not during a SART), replicating the current findings using alternate methods would be an important next step.

Here we only examined symptoms of mental health disorders as continuous, dimensional constructs and in a nonclinical sample. It is not certain whether these patterns might change when contrasting nonclinical to clinical populations (e.g., those currently diagnosed with mental health disorders). Given that recurrent or intrusive memories are clinical features in many models of psychopathology (Brewin et al., 2010; Bryant et al., 2011; Harvey et al., 2004), it is possible that recurrent IAMs may be even *more* strongly associated with disorders rather than the (largely subclinical) symptoms measured in the current study. Future studies could extend the current work to clinical populations and/or compare across individuals with different diagnoses (e.g., those diagnosed with PTSD versus major depressive disorder) to further explore relationships between spontaneous thought and psychopathology.

Another potential avenue for future research involves nonrecurrent IAMs. While in the current study we focused on recurrent IAMs due to their prominence in theoretical models of transdiagnostic mental health (e.g., Brewin et al., 2010; Harvey et al., 2004), it remains worth noting that even nonrecurrent IAMs might share similar relationships to psychopathology or MW. For instance, the way in which one emotionally responds to IAMs in general (e.g., less happiness, more rumination) has been found to be related to depression (Isham et al., 2020; Shan et al., 2023). Further work could examine whether the current study's patterns extend to other forms of IAMs (e.g., nonrecurrent ones). In particular, directly comparing recurrent to nonrecurrent IAMs could shed light on the role of persistence or perseveration in the observed relationships between recurrent IAMs and transdiagnostic mental health.

Conclusions

Spontaneous thought encompasses a variety of constructs, including recurrent IAMs and MW. Though existing data suggest strong overlap between IAMs and MW (e.g., both being associated with psychopathology), conceptual distinctions have been drawn between them (Berntsen, 2021; Christoff et al., 2016). Here, we provided empirical evidence of how recurrent IAMs and MW converge versus diverge. First, recurrent IAMs and MW converged to the extent that recurrent IAMs are spontaneous. Second, recurrent IAMs and MW diverged to the extent that both phenomena explained unique variance in symptoms of psychopathology (i.e., PTSD, depression, general anxiety). In other words, relationships between recurrent IAMs and symptoms of mental health disorders could not be solely explained by general MW tendencies, and vice versa. Recurrent IAMs and MW appear to be related—but distinct—forms of spontaneous thought, each with unique associations to symptoms of multiple mental health disorders.

Author contributions Ryan C. Yeung: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing - original draft, and Writing - review & editing. Myra A. Fernandes: Funding acquisition, Project administration, Resources, Supervision, and Writing - review & editing.

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Data availability Data and code supporting the findings of this study are openly available on the Open Science Framework at: https://doi.org/10.17605/OSF.IO/8AQMV

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Declarations

Research involving human participants and/or animals This study was approved by the University of Waterloo's Office of Research Ethics (Protocol #40049) and performed in line with the principles of the Declaration of Helsinki.

Ethical approval All procedures were approved by the University of Waterloo's Office of Research Ethics (Protocol #40049).

Consent to participate Informed consent to participate was obtained from all participants.

Consent for publication Informed consent to publish was obtained from all participants.

Competing interests The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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