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Review article

Mind wandering and depression: A status report

Leila Chaieb *, Christian Hoppe, Juergen Fell

Department of Epileptology, University Hospital Bonn, Venusberg-Campus 1, 53127 Bonn, Germany

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ABSTRACT

While many clinical studies and overviews on the contribution of rumination to depression exist, relatively little information regarding the role of mind wandering (MW) in general is available. Therefore, it remains an open question whether patterns of MW are altered in depression and, if so, how these alterations are related to rumination. Here, we review and discuss studies investigating MW in cohorts, showing either a clinically significant depression or with clinically significant disorders accompanied by depressive symptoms. These studies yield first tentative insights into major issues. However, further investigations are required, specifically studies which: i) compare patients with a primary diagnosis of major depression with healthy and appropriately matched controls, ii) implement measures of both MW and rumination, iii) are based on experience sampling (in combination with other key approaches), iv) compare experience sampling during daily life, resting state and attentional tasks, v) explore possible biases in the assessment of MW, vi) acquire data not only related to the propensity and contents of MW, but also regarding meta-awareness and intentionality.

1. Introduction

The term "mind wandering" (MW) refers to the production of thoughts or images which are unrelated to our external surroundings and the task at hand, and therefore usually distract attention to some degree (e.g. Schooler et al., 2011). The person may be aware of having these thoughts or images (meta-awareness) or only becomes aware of them if prompted. Within the remit of this review, rumination will be regarded as a special subtype of MW (e.g. van Vugt et al., 2018), which is mainly characterized by its perseverative (if not pressing) nature and negative contents (e.g. negatively biased memories and thoughts about one's future) (Smith and Alloy, 2009). Alternatively, rumination has been seen as a phenomenon distinct from MW (e.g. Christoff et al., 2016; Fox et al., 2018) or overlapping with MW (e.g. Linz et al., 2021). Rumination is commonly seen as the cognitive key symptom of depression (e.g. Spinhoven et al., 2018), and as such became one major target of cognitive psychotherapy for depression (e.g. Kovács et al., 2020) including newer mindfulness-based approaches (e.g van der Velden et al., 2015). However, it remains unclear whether the emergence of rumination rather is an isolated symptom or whether broader distortions in the amount and characteristics of MW occur in depression. While many clinical studies and overviews on the contribution of rumination to depression have been published, relatively few data on the role of MW in general are available. With the present status report, we try to contribute knowledge to fill this gap and to evaluate a possible role of MW in clinical contexts.

1.1. Mind wandering

The investigation of MW is based on different methodological approaches, which aided to the organization of the present report. A commonly used approach is to collect data based on subjective self-rating scales (e.g. Mowlem et al., 2019; Mrazek et al., 2013a, b). These scales require participants to score different aspects of their MW and allow researchers to harvest relatively large amounts of data, but may depend on the subjects' sincerity, reflective capability and self-image. It is fair to state that the majority of clinical studies on rumination are based on a retrospective and introspective questionnaire/interview approach. An alternative, temporally more specific approach is to assess resting state or everyday MW based on so-called experience sampling, i.e. in real time (e.g. Killingsworth and Gilbert, 2010). Hereby, visual or auditory prompts require participants to describe or rate their MW (or its absence) experienced just prior to the appearance of the prompt. Finally, a third mostly laboratory-based approach is to apply experience sampling during simple well-defined attentional paradigms, which also allows quantifying the objective effects of MW on performance (e.g. Weinstein, 2018). Often vigilance tasks are used, since these are known to stimulate MW due to their

* Corresponding author.
E-mail address: leila.chaieb@ukbonn.de (L. Chaieb).

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monotonous flow and the low density of events requiring subjects to adapt their reaction. In such paradigms, experience sampling probes may inquire, for instance, whether participants were focused on task performance or not, and if not, what their thought contents were. Importantly, task performance measures such as reaction times or error rates can reveal the objective attentional effects of MW, in addition to the introspective data.

The phenomenology of MW is complex and multifaceted. It can, for instance, consist of inner speech or imagery, be self-related or not, be oriented towards the past, present or future, have a positive, neutral, or negative valence, be intentional or unintentional, and be accompanied by meta-awareness or not (for reviews see Schooler et al., 2011; Smallwood and Schooler, 2015). All these characteristics are dependent on the individual, as well as on the situation and environmental context. MW can exert positive and/or negative effects (Mooneyham and Schooler, 2013). Amongst the positive effects are enhanced creativity (Leszczynski et al., 2017; Yamaoka and Yukawa, 2020), improved problem solving (Ruby et al., 2013b) and better future planning (Oettingen and Schwörer, 2013). The negative effects range from increased reaction times and errors in ongoing perceptual and cognitive tasks (Leszczynski et al., 2017; McVay and Kane, 2009) to increased stress levels (Engert et al., 2014) and a decline in mood (Yamaoka and Yukawa, 2020). This decline in mood has not only be observed during unpleasant, but also during neutral MW (Killingsworth and Gilbert, 2010). Reduced mood conversely causes more frequent episodes of MW (Smallwood et al., 2009), resulting in a vicious circle.

Two important frameworks addressing the role of attention in MW are the attentional resource and the executive failure theory (Smallwood and Schooler, 2006; McVay and Kane, 2010). According to the first theory, MW consumes attentional resources causing perceptual decoupling and attentional withdrawal from task execution (Smallwood and Schooler, 2006). In this construct, MW utilises the same resources and mechanisms as executive control. According to the second framework MW reflects failures of the executive control system and is not, per se, resource dependent (McVay and Kane, 2010). More recently, a theory has been proposed which integrates aspects of both frameworks. According to the resource-control theory (Thomson et al., 2015), self-generated thought is the default state of the individual and attention is continuously biased towards this state. Therefore, executive control is required to prevent MW from consuming attentional resources needed for task performance. With regard to phenomenology, MW has been suggested to be a member of a family of spontaneous thought processes including, for instance, creative thought and dreaming (Christoff et al., 2016). Furthermore, spontaneous thought including MW has been conceptualized as an unconstrained memory process with the stream of thoughts flowing through the landscape of memories (Mildner and Tamir, 2019).

While the neurobiological underpinnings of MW are not fully understood, mainly activity in the default mode network (DMN) and in fronto-parietal control regions, such as dorso-, rostro- and ventrolateral prefrontal cortex and inferior parietal lobule, has been shown to play a major role (e.g. Christoff et al., 2009; Mason et al., 2007; for a meta-analysis, see Fox et al., 2015). Several neuroimaging studies have particularly pointed to the relevance of the medial temporal lobe (MTL), which is part of the DMN. Two recent studies, for instance, investigating MW in patients with hippocampal damage and in MTL epilepsy patients, indicated that past-oriented MW depends on hippocampal activity (Krakau et al., 2020; McCormick et al., 2018).

1.2. Rumination

Rumination (zoological meaning: regurgitation of food) refers to "obsessional thinking involving excessive, repetitive thoughts or themes that interfere with other forms of mental activity" (Rumination - APA Dictionary of Psychology, 2021). While this term can also be used in a non-pathological sense (e.g. to ruminate on a mathematical conundrum), it more specifically indicates automatic and persistent dwelling on negative thoughts with depressing, disgusting or threatening content in the context of affective, obsessive-compulsive or generalized anxiety disorders, respectively (for a thorough review of the rumination concept see Smith and Alloy, 2009). Rumination is also associated with post-traumatic stress disorder symptoms (Arditte Hall et al., 2019) and suicidality (Morrison and O'Connor, 2008). Thus, rumination is a transdiagnostic psychopathological symptom and therapy target (Drost et al., 2014; Hejazi and McCallum, 2014).

A series of measures for rumination have been developed (e.g. the 10-item Self-Critical Rumination Scale (Smart et al., 2016); for a critical overview see Samtani and Moulds, 2017). In models of depression, depressive rumination is considered as a (i) predisposing cognitive vulnerability factor (i.e. a trait) which also contributes to explaining the increased prevalence of depression amongst women (Kertz et al., 2019; Papadakis et al., 2006; more controversially, Shors et al., 2017); (ii) a maladaptive strategy for emotion regulation which mediates the development of depression after stressful life events (Demeyer et al., 2012; LeMoult and Gotlib, 2019); (iii) one cognitive key symptom of acute depression (i.e. a [pathological] state) which improves together with mood during therapy (Spinhoven et al., 2018); and, as such, (iv) an important leverage point for the causal treatment of unipolar and bipolar depression within the framework of cognitive-behavior therapy (CBT) (Kovács et al., 2020) or mindfulness-based stress reduction-based treatments (van der Velden et al., 2015). From the early behavioristic stopping-technique approaches (Stern et al., 1973; Wolpe and Lazarus, 1966), which conceptualized rumination as covered ("private") verbal behavior, to rumination-focused CBT for residual depression (e.g. Cook and Watkins, 2016; Hvenegaard et al., 2020; Moeller et al., 2020; Roberts et al., 2021), psychotherapists have for decades attempted to reduce rumination, and thereby to improve the patient's condition (for a review on techniques for improving rumination (see Querstret and Cropley, 2013). Several psychological models of rumination have been introduced. For example, the 'impaired disengagement hypothesis' suggests that attentional disengagement from negative self-referent information is impaired, resulting in prolonged processing of this kind of information (Koster et al., 2011), while the 'mood-as-input' hypothesis considers negative mood to affect the individual's stop-rules for a given task resulting in perseveration of this task (Meeten and Davey, 2011). In contrast, other accounts underline the adaptive function of rumination for complex problem solving (e.g. due to reduced distraction) (Andrews and Thomson, 2009; Whitmer and Gotlib, 2013).

On the basis of a comprehensive literature review, Rayner et al. (2016) demonstrated that two neurocognitive networks, namely the autobiographic memory network and the cognitive control network, which are correlated and anti-correlated with rumination, respectively, are central to several cognitive depressive symptoms (e.g. self-blame or indecisiveness); downstream effects of this imbalance on other networks provide the link to affective and vegetative symptoms of depression (Rayner et al., 2016). Several neuroimaging studies showed a strong link between rumination and the DMN (Zhou et al., 2020). More specifically, while perseverative cognition generally involves brain structures like the medial frontal gyrus, cingulate gyrus, insula, and posterior cingulate cortex, the involvement of the anterior cingulate cortex distinguished patients with mental disorders from healthy controls (Makovac et al., 2020). Other authors reported no role of the DMN as such, but found increased connectivity of the subgenual prefrontal cortex with the DMN (Hamilton et al., 2015).

1.3. Scope of this review

In contrast to the vast amount of studies which have investigated rumination in depression, only a few clinical studies, up to now, have addressed MW in general. Therefore, it is yet an open question whether patterns of MW are altered in depression and, if so, how these alterations are related to rumination. In particular, it is unclear whether the

propensity to mind wander overall is greater in depression or whether only rumination is increased. Moreover, it is still unknown if rumination emerges as an isolated phenomenon or from a general shift of MW patterns towards a ruminative nature. Furthermore, it is not yet understood, what the emotional and physiological impact of rumination is compared to that of commonplace MW. Here, we aim to contribute to answering these and other questions by summarizing and discussing available clinical studies on MW in depression, as well as on MW in clinically significant disorders accompanied by depressive symptoms.

2. Literature search strategy

Literature research for this review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria. Searches were conducted using the electronic databases PubMed and MEDLINE. The search terms and search logic used were: ("mind wandering" OR mind-wandering OR mind-wandering) AND (depression OR depressive OR dysphoria OR dysphoric OR melancholia OR melancholy OR melancholic). In addition to the electronic search strategy, the reference lists of the manuscripts that were reviewed were examined to identify any additional articles not captured by the main search strategy. Analysis of the papers followed the inclusion and exclusion criteria recommended by the PRISMA Guidelines. Manuscripts in English in the form of original articles, and clinical and experimental studies were considered. Exclusion criteria were case studies (case reports and case series) and non-original studies such as reviews, commentaries, letters to the editor etc. This initial search step yielded 39 articles. In a second search step, we identified the articles describing cohorts showing either a clinically significant depression or with clinically significant disorders accompanied by depressive symptoms. Full texts of all 39 articles were assessed against these inclusion criteria. This second search step yielded the 13 articles, which are discussed in this review. Basic information on these studies is listed chronologically in Table 1. Study summaries are grouped according to the implemented methodological approach.

3. MW assessed by task-related experience sampling

3.1. *Watts and Sharrock (1985): description and measurement of concentration problems in depressed patients*

In a very early pioneering study, Watts and Sharrock (1985) sought to characterise lapses in concentration during the performance of routine activities in depression patients recruited from across three hospitals. Such lapses in concentration are a frequent complaint in depression patients and can negatively impact upon cognitive performance (Cheyne et al., 2006). Interestingly through clinical patient contact, Watts and Sharrock (1985) had previously noted that depression patients often reported that a loss of concentration was preceded by 'mind blanking', i.e. the absence of thoughts, rather than MW. Therefore, the authors hypothesised that depressed patients may be more prone to lapses in concentration that are unassociated with MW, but are rather due to mind blanking. In addition, they aimed to examine memory performance and its interrelation with deficits in concentration.

Patients considered for the study completed the Levine-Pilowsky questionnaire, which derives two depression scores for severity and endogeneity (Pilowsky and Boulton, 1970), to ascertain eligibility. 31 subjects were included and their mean severity of depression score was 12.4, indicating moderate to severe depression (Pilowsky and Spalding, 1972). The State form of the Spielberger Anxiety Questionnaire was also administered to the patients, as well as the synonyms section of the Mill Hill vocabulary test. Moreover, a structured interview was conducted with each patient detailing their inability to concentrate, the extent to which their concentration was affected during different activities, and the contributions of MW, mind blanking and external distraction. In a reading task, patients were instructed to read an excerpt from a book in silence for 10 min, and to indicate to the experimenter if and when they lost concentration. The experimenter then asked whether their mind had wandered onto something else, with the answer 'yes' indicating MW and 'no', indicating mind blanking. Finally, in a memory task, patients had to listen to a passage from an audio book recording, and were then asked to freely recall the content, as well as to answer 14 specific questions (cued recall).

As major findings, concentration problems during reading and watching television, as reported in the interview, were significantly correlated with depression severity, endogeneity and with state anxiety. This was the same in the case of the number of lapses in concentration experimentally assessed during reading. However, partial correlations showed that neither depression nor anxiety was significantly correlated with concentration lapses, when the other was partialled out. The concentration lapses were also positively correlated with interview-based reading and television concentration problems, as well as negatively correlated with free and cued recall of details about the audio book passage. The percentage of MW-related lapses was significantly correlated only with depression endogeneity. On the other hand, depression severity had its highest correlation with interview-based mind blanking, while state anxiety had its highest correlation with interview-based MW. Moreover, free recall was negatively correlated with depression severity and state anxiety. Regarding the distribution of MW versus blanking, the interview revealed a significantly higher amount of MW, and the experimental assessment during the reading task yielded 81 % of 'yes' lapses (MW) versus 19 % of 'no' lapses (mind blanking).

In summary, the authors were unable to find evidence for the supposition that depressed patients are more likely to experience mind blanking, rather than MW during lapses in concentration. Instead, their findings from the interview data and reading task point towards a major role for MW in concentration deficits in depression. Watts and Sharrock acknowledge that the associations between MW/blanking and depression versus anxiety cannot be unambiguously disentangled based on their data. Another obvious limitation is the absence of a healthy control group. Thus, it remains unclear whether the number of concentration lapses and the amounts of MW/blanking are indeed larger in depression. Nevertheless, to our knowledge, Watts and Sharrock were the first to define mind blanking as an off-task state without thoughts. In spite of their efforts, research on mind blanking was only revived much later by other groups (e.g. Kawagoe et al., 2019; Ward and Wegner, 2013).

3.2. *Watts et al. (1988): associations between phenomenal and objective aspects of concentration problems in depressed patients*

In a follow-up study to Watts and Sharrock (1985); Watts et al. (1988) further investigated the distinction between "mind-wandering" and "blanking" lapses of concentration, again in a group of depression patients. In this later study, the authors hypothesise that these types of lapses in concentration have differential impacts on cognitive tasks. More specifically, they supposed that MW would impair memory for prose, while mind blanking would hinder complex planning, as required in the 'Tower of London' task. Thirty-six patients diagnosed with unipolar depression were recruited mostly from an acute in-patient unit. Mean depression severity score, obtained by applying the Levine-Pilowsky depression questionnaire, was 12.7. Moreover, 24 control subjects matched for age, gender and education level were recruited. Based on a self-report scale, lapses in concentration during different activities were quantified in the patients for the following categories: a) external distraction, b) MW, c) mind blanking (i.e. absence of thoughts), d) mind becomes "confused and jumbled". Three different experimental tasks were performed by the patients. In one, they silently read an excerpt from a text and indicated when they lost concentration and whether they were mind wandering or had experienced mind blanking, similar to the method described in Watts and Sharrock (1985). Moreover, memory for prose (an excerpt about a shopping centre) was probed using ten questions in an ordinary condition (plain reading) and

Table 1
A summary of the studies included in this status report.

Authors	Year	Title	Primary diagnosis	Comorbidities	Intervention	Control group	MW assessed by self-report scales (SRS) and/or experience sampling (ES)	ES task	Functional measure-ments	Key finding(s)
Watts and Sharrock	1985	Description and measurement of concentration problems in depressed patients	Major depression			None	SRS + ES	Reading task		Concentration lapses in depression mainly related to MW, lesser to mind blanking
Watts et al.	1988	Associations between phenomenal and objective aspects of concentration problems in depressed patients	Major depression			Healthy	SRS + ES	Reading task		MW and mind blanking differently affect cognitive tasks
Ottaviani et al.	2015	Cognitive, behavioral, and autonomic correlates of mind wandering and perseverative cognition in major depression	Major depression			Healthy	SRS + ES	None	Heart rate, heart rate variability	Perseverative thoughts: more common in MDD (not off-task thoughts in general); negative influence on mood
Hoffmann et al.	2016	Where the depressed mind wanders: self-generated thought patterns as assessed through experience sampling as a state marker of depression	Major depression			Healthy	ES	Choice reaction time task		MDD vs. controls: more MW; thoughts less positive, more negative, more self-related, more past-related
Rosenbaum et al.	2017	Aberrant functional connectivity in depression as an index of state and trait rumination	Major depression			Healthy	SRS + ES	None	Resting state fNIRS, functional connectivity	Disrupted network organisation in MDD; correlated with state and trait rumination
Greenberg et al.	2018	Compassionate hearts protect against wandering minds: self-compassion moderates the effect of mind wandering on depression	Mild to severe depression		Mindfulness-based cognitive therapy	Conventional treatment	SRS			Complex interplay between feelings of self-compassion, MW and depression
Hoffmann et al.	2018	Evidence for depressogenic spontaneous thoughts and altered resting-state connectivity in adolescents with a maltreatment history	Maltreatment history	Depressive symptoms		Healthy adolescents	ES	Choice reaction time task	Resting state fMRI, functional connectivity	Reduced positive thoughts in subjects with maltreatment history; reduced functional connectivity between sgACC and fronto-parietal regions
Soffer-Dudek and Somer	2018	Trapped in a daydream: daily elevations in maladaptive daydreaming are associated with daily psychopathological symptoms	Maladaptive daydreaming	Anxious, depressive and obsessive compulsive symptoms		None	SRS			Maladaptive daydreaming increases negative emotions and depression symptoms
El Haj et al.	2019	Off-track thoughts: Intentional and unintentional mind wandering in Alzheimer's disease	Alzheimer's disease	Depressive symptoms		Healthy	SRS			More intentional and unintentional MW in AD patients; both correlated with depression scores
Takahashi et al.	2019	Changes in depression and anxiety through mindfulness group therapy in Japan: the role of mindfulness and self-compassion as possible mediators	Major depression, dysthymia, panic disorder, agoraphobia, obsessive compulsive disorder	Depressive and anxiety symptoms	Mindfulness-based therapy program	None	SRS			Reduced depression and anxiety symptoms after mindfulness program; mindfulness and self-compassion were mediators

(*continued on next page*)

Table 1 (*continued*)

Authors	Year	Title	Primary diagnosis	Comorbidities	Intervention	Control group	MW assessed by self-report scales (SRS) and/or experience sampling (ES)	ES task	Functional measure-ments	Key finding(s)
Figueiredo et al.	2020	Mind-wandering, depression, anxiety and ADHD: disentangling the relationship	ADHD	Learning disabilities, depressive and/or anxious symptoms		Learning disabilities, depressive and/or anxious symptoms without ADHD	SRS			Anxiety, depression and inattention symptoms related to increased MW; MW more closely related to anxiety than depression symptoms
Moukhtarian et al.	2020	Wandering minds in attention-deficit/ hyperactivity disorder and borderline personality disorder	ADHD and borderline personality disorder	Depressive and anxious symptoms		Healthy	SRS + ES	None		More MW in both ADHD and BDP vs. controls; related to anxiety and depression symptoms only in BDP (not in ADHD)
El Haj and Nandrino	2021	Intentional and unintentional mind-wandering in Korsakoff syndrome	Korsakoff syndrome	Depressive symptoms		Healthy	SRS			More intentional and unintentional MW in Korsakoff patients; both correlated with depression scores in patients (not in controls)

also in an effortful condition, in which subjects had to form visual images relating to the text during reading. Finally, patients were asked to perform the 'Tower of London' task, which requires one to move three beads arranged on sticks of unequal length into a target position. The control group only performed the 'Tower of London' task and did not participate in the text-based tasks.

As for major findings, the questionnaire data revealed that MW was a more common concentration problem in the patient group than mind blanking or confusion (distraction data were excluded because of low internal homogeneity). Correlations of the three types of concentration lapses with depression scores were not significant. The MW score was positively, and the mind blanking score negatively, correlated with the proportion of MW-related lapses during silent reading. For the "Tower of London" task, depressive subjects solved fewer problems during the 60 s test time and needed more time to arrive at a solution than controls. MW-related lapses during silent reading were not correlated with performance in the 'Tower of London' task, but were negatively correlated with memory for prose in the ordinary condition. On the contrary, mind blanking-related lapses were positively correlated with the planning time taken in the 'Tower of London' task, but were not correlated with the memory for prose.

To summarize, Watts et al. (1988) found evidence for their hypothesis that MW and mind blanking differently affect cognitive tasks. While subjects more prone to MW seem to perform worse in memorizing prose, subjects more prone to mind blanking appear to perform worse in a complex planning task. A shortcoming is that the authors did not assess MW and blanking in control subjects, and thus could not compare their occurrence in patients versus controls. Moreover, the authors neglected to correlate experimentally measured MW and blanking frequencies during silent reading with depression scores.

3.3. Hoffmann et al. (2016): where the depressed mind wanders: self-generated thought patterns as assessed through experience sampling as a state marker of depression

In this study self-generated thoughts (SGTs) during a simple attentional task were investigated in patients with depressive disorder and healthy controls. The authors recruited twenty-five patients (8 males) with a diagnosis of acute major depression (average BDI: 32.0, HAMD-21: 20.4), as well as twenty-six (10 males) age, education and gender-matched healthy subjects (average BDI: 2.5, HAMD-21: 0.77). The aims of the study were to monitor the amount, content and variability of SGTs. Based on cognitive models of depression and findings related to rumination and worry, the authors hypothesised that MDD patients would show a greater tendency to mind wander, i.e. to be less 'present' during the task, and that their SGTs would be more negative, as well as oriented toward the self and the past, compared to those of healthy controls. Furthermore, MDD patients would think more often about future events and show less variability and more rigid thought patterns compared to the control group (Hoffmann et al., 2016).

To investigate their hypotheses, Hoffmann et al. (2016), implemented a non-demanding choice reaction time task (CRT) which has been shown to allow for spontaneous SGTs. Frequent black and rare red digits were presented and subjects had to respond to the red digits by indicating whether they were even or odd. At random time points, participants were asked what the content of their thoughts prior to the probe was (number of thought probes were between 4 and 9). The authors assessed SGTs over seven different dimensions: 1) past-oriented, 2) future-oriented, 3) self-related, 4) other-related, 5) negatively valenced, 6) positively valenced, and 7) how much off-task their thoughts were at the time (i.e. MW), using a nine-point Likert scale. Variability of the answers given was quantified by calculating fluctuations (squared successive differences) and extremity of the ratings (squared differences from the total sample mean). These data were then analysed mainly based on linear mixed models.

Key findings of the study were that when compared to the healthy participants, MDD patients did indeed engage in more "off-task" thoughts (i.e. MW). They also observed more negative, less positive, as well as more past-oriented and self-related thoughts when compared to the control group. The strongest predictor of depressive SGTs was decreased positive valence. Moreover, past- and future-related thoughts of MDD patients were more negatively valenced compared to controls.

With regard to variability, MDD patients showed no significant differences from controls for extremity and only a trend for less fluctuating past-related SGTs. Moreover, there were no differences in task performance of the CRT with regard to accuracy and reaction times.

In summary, the data reported by Hoffmann et al. (2016) indicate that MDD patients compared to controls engage in more MW during task performance. Most importantly, their SGTs exhibited patterns, which point to a ruminative nature, i.e. their SGTs were less positive and more negative, as well as more self- and past-related. Limitations of the study were the low number of thought probes and that no measures of rumination were acquired, which could corroborate the suggested link between SGT patterns and rumination. A minor methodological shortcoming of the study is that the experience sampling procedure did not comprise a "no-thought" option. Whenever subjects indicate that their thoughts are on-task, this makes it difficult to disentangle, whether subjects are thinking about the task (i.e. MW) or whether they are actually focused on performing the task (i.e. absent MW).

3.4. *Hoffmann et al. (2018): evidence of depressogenic spontaneous thoughts and altered resting-state connectivity in adolescents with a maltreatment history*

The authors investigated spontaneous thoughts during an attentional task in 29 adolescents (age: 12–16 years) with a maltreatment history (MT) and 39 healthy controls (Hoffmann et al., 2018). Subjects in the MT group were recruited through a London Social Services Department and adoption agencies. Control subjects were matched for age, IQ, verbal fluency, pubertal status, level of education of parents, gender and ethnicity. A choice reaction time task (CRT) with embedded thought probes was used, similar to Hoffmann et al. (2016). Subjects were asked to rate how much 1) off-task, 2) other-related, 3) self-related, 4) negatively valenced, 5) positively valenced, 6) past-related, and 7) future-related their thoughts were on a nine-point Likert scale. Additionally, they rated their current mood on two dimensions (positive, negative). Moreover, all participants completed the Childhood Trauma Questionnaire (CTQ; average values, MT: 31.6; controls: 27.9), the Child and Adolescent Symptom Inventory (CASI-4R; average depressive symptoms, MT: 59.8; controls: 53.1; according to Gadow et al. (2013), impairment cut-off for depressive disorders is 62) and the Wechsler Abbreviated Scales of Intelligence (WASI). Furthermore, functional magnetic resonance imaging (fMRI) scans were acquired during resting state (490 s duration) using a 1.5 T scanner and functional connectivity, in terms of Pearson's correlations, was analyzed. The authors hypothesized an altered functional connectivity of the subgenual anterior cingulated cortex (sgACC) with other brain regions in the MT subjects, since the sgACC has been implicated in behavioral withdrawal and negative self-reflective processes.

The authors found that subjects with a maltreatment history showed increased levels of negative and decreased levels of positive mood. They had fewer positive thoughts and larger deviations of ratings for positively valenced thoughts from the norm (i.e. less positive rating values). There were no group differences for the amount of off-task thoughts and the other thought dimensions. Moreover, task performance measures (accuracy, reaction time) did not differ between groups. Regarding resting state fMRI, the control group exhibited greater connectivity between the right superior sgACC and the right supramarginal gyrus, the right dorsolateral prefrontal cortex and the cuneus. Overall, depressive symptoms (CASI-4R) were negatively correlated with ratings for positively valenced thoughts, as well as with connectivity between and sgACC and cuneus. Moreover, group differences in depressive symptoms were mediated by differences in sgACC-cuneus connectivity.

To sum up, the authors report reduced positive thoughts in subjects with a maltreatment history, as well as reduced functional connectivity between the sgACC and regions of a fronto-parietal network involved in cognitive and attentional control. They interpret their findings as indicating that childhood abuse and neglect may lead to an internalization of negative self-referential schemas that bias information processing away from positive content. The authors speculate that a stronger connection between sgACC and the fronto-parietal regions could facilitate processes making rumination less likely, such as attentional shifts from internal default mode network processes to the outside environment. A limitation of the study is the relatively small differences between the MT and control group regarding Childhood Trauma Questionnaire and depressive symptoms (CASI-4R) ratings.

4. MW assessed by resting state or everyday experience sampling

4.1. *Ottaviani et al. (2015): cognitive, behavioural, and autonomic correlates of MW and perseverative cognition in major depression*

In this study the impact of different types of thoughts on mood and cardiac measures (heart rate and heart rate variability) was investigated using an ecological experience sampling approach in depression patients (Ottaviani et al., 2015). Decline in heart rate variability is a trait-marker for MDD (Brunoni et al., 2013; Udupa et al., 2007), and is associated with an increased risk of developing cardiovascular disease (Thayer et al., 2010). The authors differentiated between the following states: a) being on task, b) MW, c) perseverative thoughts (rumination or worry). Ottaviani and colleagues hypothesized that perseverative thoughts have a negative influence on mood and autonomic function, but not (non--perseverative) MW. According to this idea, MW turns into a risk factor for health whenever it becomes rigid and inflexible.

Ottaviani et al. (2015) recruited a group of 18 MDD patients (12 female; average BDI: 31.1) and compared them with a group of 18 gender and education- matched healthy controls (11 female; average BDI: 6.7). Age, however, was not properly matched between both groups (average age: MDD 38.4, controls 30.1 years). The design and implementation of this current study was based on earlier findings regarding repetitive and non-repetitive thoughts during an attentional task in healthy subjects (Ottaviani et al., 2013), suggesting that perseverative cognition is associated with increased cognitive inflexibility, lower heart rate variability and decline in mood.

Patients attended a clinical evaluation with a health care professional who administered either the Structured Clinical Interview for DSM-IV (SCID) or the Mini International Neuropsychiatric Interview (MINI) to confirm a current MDD diagnosis. Eligible MDD patients and controls were then instructed on how to use a smart phone as an electronic thought diary and were given an ambulatory heart rate device. Over the course of the next 24 h, all study participants had to respond to thought prompts approximately every 30 min. on the smart phone, to complete the diary. They were asked to report 1) contents of their current thought, including specifics (e.g. a problem, a past experience etc.); 2) the duration of the thought; 3) if the thought was positive, negative or neutral; 4) whether the thought was repetitive; 5) temporal dimension (past, present, future); 6) whether it was interfering with their current task; 7) how much they were trying to supress the thought; 8) annoying or disturbing events before; 9) factors that may affect heart rate (e.g. caffeine, alcohol etc.); 10) current mood (tired, anxious, sad, happy, angry, bored) using a 5-point scale. Afterwards, for analysis purposes thoughts were re-coded as: being on task, MW, or perseverative thoughts (rumination or worry). In addition, raw heart rate was recorded as beat-to-beat intervals.

As major findings, the authors reported that MDD patients indeed had more episodes of perseverative cognition and worse mood compared to controls. On the other hand, they found a trend for decreased non-perseverative MW in the patient group. Thus, the overall amount of off-task thoughts did not differ between MDD patients and controls. Perseverative thoughts were always characterized by worse mood (i.e. less happy and more tired, anxious, sad, angry, bored) compared to MW and being on task. Interestingly, mood during MW did not differ from mood during on-task thoughts. Perseverative thoughts

required more effort to be inhibited or supressed and interfered more with ongoing activities than MW. Moreover, they were associated with lower heart rate variability compared to MW in both groups. However, there were no statistically significant differences to on-task thoughts.

To summarize, Ottaviani et al. (2015) reported that perseverative thoughts, but not off-task thoughts in general, are more common in MDD patients than in healthy controls. In both groups, perseverative thoughts, but not non-perseverative MW had a negative influence on mood. A methodological shortcoming of the study, similar Hoffmann et al. (2016), is the absence of a no-thought category, and that thoughts about the task at hand were interpreted as being focused on task performance, which is not necessarily the case.

4.2. Rosenbaum et al. (2017): aberrant functional connectivity in depression as an index of state and trait rumination

This study investigated functional connectivity based on functional near-infrared spectroscopy (fNIRS) in depression patients and healthy controls. Near infrared spectroscopy is an optical imaging method which uses light in the near-infrared spectrum to measure changes in de-/oxygenated haemoglobin concentration. 60 patients with a current major depression diagnosis and twenty-four healthy controls were recruited into the study (Rosenbaum et al., 2017). Age between the two groups was not properly matched (average age: MDD 40, controls 33 years). Diagnosis and assessment of symptom severity was based on the SCID, the Patient Health Questionnaire (PHQ-9) and the Montgomery-Åsberg Depression Rating Scale (MADRS; average value patients: 21.1, controls: 1.4). Trait rumination was quantified using the Rumination Response Scale (Nolen-Hoeksema and Morrow, 1991). FNIRS measurements (52 channels) were undertaken during a 7-minutes resting period, in which participants were asked to sit still with eyes closed and simply let their thoughts flow. Afterwards subjects documented their mental experiences in addition to indicating the amount of time they spent with different mental processes, on visual analogue scales. Four main categories were analyzed (based on 10 items): state rumination, MW, fight against fatigue and focus on sensation. Functional connectivity was analysed with network-based statistics comprising univariate testing and subsequent cluster-based permutation tests. The authors hypothesized that depression patients would report more trait and state rumination and less MW than healthy controls, and that rumination would be anti-correlated with network connectivity strengths in parietal regions.

As major findings the authors report that both state and trait rumination scores were negatively correlated with MW. Patients reported significantly more rumination and less MW than controls (average rumination: 40.0 % vs. 8.3 %; average MW: 48.3 % vs. 87.5 %). Functional connectivity analyses revealed a significant network disconnection in patients versus controls involving bilateral regions of the default mode network and mainly interhemispheric links. However interestingly, when controlling for state rumination, these network differences were reduced, and when controlling for trait rumination, they disappeared. Both trait and state rumination scores were negatively correlated with functional connectivity values, with trait rumination showing stronger and more widespread correlations. Moreover, a median-split analysis dividing patients into high versus low ruminators, again, showed decreased functional connectivities in the depression-related network for high ruminators, with stronger effects for trait versus state rumination. On the contrary, a similar analysis revealed increased functional connectivities in the depression-related network for high versus low mind-wanderers (see Rosenbaum et al., 2017, Supplementary material).

The authors suggest that their findings support the idea of a disrupted network organisation in major depression, which is closely correlated with state and trait rumination. Times spent in the states of MW versus rumination were found to be anti-correlated. Moreover, effects of MW versus rumination on connectivity within the depression-related network appeared to be opposite, although this question has not been investigated systematically. A limitation of the study is that thought processes were only assessed after the resting period, and not by using a real-time experience sampling approach.

4.3. Moukhtarian et al. (2020): wandering minds in attention-deficit/hyperactivity disorder and borderline personality disorder

In this study, patients with attention-deficit/hyperactivity disorder (ADHD) and borderline personality disorder (BPD) were investigated (Moukhtarian et al., 2020). Both disorders exhibit overlapping symptoms and are therefore difficult to disentangle in clinical practice. The authors hypothesized that ADHD could possibly be distinguished from BPD based on the observation of excessive spontaneous MW. 28 ADHD patients, 19 BPD patients and 22 comorbid ADHD + BPD patients were recruited from outpatient clinics in England, and 29 healthy controls were recruited from the general public (all participants were female). Age and intelligence quotient were not exactly matched, but, according to the authors, did not have a significant effect in the analysis models. Comorbid depression and anxiety was measured using the Brief Symptom Inventory (BSI: Derogatis, 1993). Self-reported spontaneous MW was quantified using the Mind Excessively Wandering Scale (MEWS, Mowlem et al., 2019). To experimentally assess MW, experience sampling was carried out eight times daily with a smartphone application (MoodMapper), across five consecutive days. Frequency of occurrence, intensity and content of MW was assessed by seven questions, and experience sampling data were analysed using multilevel models.

Based on the self-report questionnaire, control subjects reported significantly less MW than subjects in the clinical groups, which had similarly high levels of spontaneous MW. Based on experience sampling, a higher frequency of occurrence and intensity of MW was reported by all clinical groups compared to controls, with no differences amongst clinical diagnoses. However, when adjustments were made for anxiety and depression scores, significant differences of MW frequency and intensity versus controls remained only for ADHD group. Moreover, MW intensity was increased in the ADHD group compared to the other clinical groups after controlling for the covariates. Regarding content of MW, BPD and comorbid ADHD + BDP groups reported a greater frequency of 'thinking about something unpleasant' than ADHD patients and controls. Again, this effect disappeared when controlling for anxiety and depression.

The authors interpret their data as indicating that excessive MW is as much a part of BPD as ADHD. Thus, they reject their initial hypothesis that both disorders can be disentangled by measuring the propensity to mind wander. However, the adjustments for anxiety and depression suggest that MW in BDP probably reflects anxious and depressive ruminations, whereas in ADHD, it reflects a core difficulty with sustaining attention. A limitation of this study is that anxiety and depression were quantified only with the brief symptom inventory, which is a rather general indicator of psychopathology, and not with more specialised screening tools.

5. MW evaluated by self-report scales

5.1. Greenberg et al. (2018): compassionate hearts protect against wandering minds: self-compassion moderates the effect of mind-wandering on depression

While MW is often linked to decreases in mood (Killingsworth and Gilbert, 2010; Stawarczyk et al., 2013; Yamaoka and Yukawa, 2020), self-compassion has been shown to decrease depressive symptoms and increase levels of resilience (Krieger et al., 2013; MacBeth and Gumley, 2012; Van Dam et al., 2011). Self-compassion has been described as „being open to and moved by one's own suffering, experiencing feelings of caring and kindness toward oneself and taking an understanding, nonjudgmental attitude toward one's inadequacies and failures" (Neff, 2003). Despite the association between MW and self-compassion being

plausible, there is sparse evidence to suggest that these factors interact on any level to mediate depression and/ or depressive symptoms.

Greenberg et al. (2018), aimed to explore this putative interaction, by recruiting patients undergoing treatment for depression, into a study implementing Mindfulness Based Cognitive Therapy (MBCT). The authors hypothesised that expressing self-compassion would prevent and protect depressed individuals against the detrimental effects of MW on depressive symptoms. A final sample of forty patients screened for mild to severe depressive symptoms, designated by a score of ≥11 (indicating at least a mild depression), on the 28-item Hamilton Scale (HAMD-28) were recruited into the study. The patients were randomly assigned to one of two groups: the first which will undergo MBCT, as well as continuing to adhere to a treatment plan, or the second- a group termed the 'treatment-as-usual' (TAU) group, whereby patients would continue regular treatment, and who would later be offered MBCT after the study was completed. Prior to the start of the study, participants underwent clinical evaluation using the Mini International Neuropsychiatric Interview (MINI) and HAMD-28, for eligibility as previously mentioned. In addition, subjects were asked to complete the Self-Compassion Scale (SCS; Neff, 2003), which is a 26-item self-report scale. The SCS comprised of six subscales specifying self-kindness, self-judgement, common humanity, isolation, mindfulness and over-identification. MW was assessed using the Mind-Wandering Questionnaire (MWQ; Mrazek et al., 2013a, b) and depression scores were recorded using the Beck Depression Inventory-II (BDI-II; Beck et al., 1996), which was administered 0–2 weeks prior to the start of the study and then every 2–3 weeks during the program. HAMD-28, SCS and MWQ were assessed before and after the MBCT program. This comprised of eight weekly 2-h therapy sessions lead by trained MBCT teachers, and which combined elements of cognitive therapy, mindfulness training and experiential meditation exercises (Segal et al., 2012). The program required patients to practice and implement their newly-learned skills between sessions and record their progress in a daily log.

At baseline the authors found that BDI-II scores were significantly correlated with those from the HAMD-28, SCS and MWQ. This suggests that patients exhibiting more severe depressive symptoms had more MW, and also scored lower on the self-compassion scale. In accordance with this, higher levels of baseline self-compassion correlated significantly with lower MW scores and predicted longitudinal improvement in depression symptoms. A moderation analysis on these baseline measures showed that self-compassion scores did indeed influence the interplay between MW and depressive symptoms. In patients exhibiting low levels of self-compassion, MW differentially related to depressive symptoms scores, but not in patients with high levels of self-compassion. Following MBCT training, patients assigned to the MBCT group scored significantly lower on the BDI-II (average score, pre: 23.6, post: 12.2), HAMD-28 (average score, pre: 22.8, post: 12.7) and the MWQ, and higher on the SCS than those undergoing regular treatment. Furthermore, moderation analysis revealed that changes in MW differentially related to changes in depressive symptoms only in patients decreasing in self-compassion, but not in patients increasing in self-compassion, similar to the baseline finding.

In summary, the findings by Greenberg et al. (2018) suggest that there is indeed a complex interplay between feelings of self-compassion, MW and depression, and that training of self-compassion may help to protect from the detrimental effects of MW in individuals exhibiting depressive symptoms. Limitations of the study are the large number of drop-outs (12 from 40 subjects withdrew prior to conclusion) resulting in small group sizes, and the lack of an active intervention for the control group.

5.2. *Soffer-Dudek and Somer (2018): trapped in a daydream: daily elevations in maladaptive daydreaming are associated with daily psychopathological symptoms*

Daydreaming is a kind of intense MW with fantastical dream-like qualities. Daydreaming disorder, more commonly referred to as maladaptive daydreaming, characterises a mental condition in which individuals frequently engage in episodes of excessive and absorbing daydreaming. This often leads to functional impairment, goal-neglect and in particular, heightened levels of negative emotion (Somer, 2002). Maladaptive daydreaming, however, despite having a significant impact on the functioning of a subject's daily life, is a unique construct that has yet to be included in standard mental health diagnostic manuals (Somer et al., 2017).

In a longitudinal daily diary-based study, Soffer-Dudek and Somer (2018) aimed to examine the preceding, co-occurring and subsequent symptoms that accompany maladaptive daydreaming. These included, for instance, changes in mood, dissociation, obsessive-compulsive symptoms, and anxiety, so that the etiology of this complex disorder may be better understood. The authors formulated a three-pronged hypothesis: (i) that individuals reporting an increase in maladaptive daydreaming would also report an increase in other psychopathological symptoms associated with this condition, such as dissociation (Somer, 2002); (ii) that days where episodes of maladaptive daydreaming were most frequent, would be characterised by a higher likelihood of individuals reporting associated symptoms the following day; (iii) that maladaptive daydreaming would be closely related to increased reports of both positive and negative affect, due to the rewarding-addictive aspect of this condition on the one hand (which reinforces the behaviour and explains its chronic development), and the later feelings of disappointment and guilt, on the other (Soffer-Dudek and Somer, 2018). A group of seventy-seven individuals (82 % female), who were self-identified maladaptive daydreamers, were asked to complete a battery of daily questionnaires which comprised of the Maladaptive Daydreaming Scale (MDS), the Clinician Administered Dissociative States Scale (CADSS), the Obsessive-Compulsive Inventory- Revised (OCI-R), the Beck's Cognitive Triad (BCT) for depression, a shortened version of the State-Trait Anxiety Inventory (STAI), the Mini- Social Phobia Inventory (Mini-SPIN) and the Positive and Negative Affect Schedule (PANAS). The diary-based data collection period lasted for 14 days, where participants recorded the daily levels of depression, general anxiety, social anxiety, obsessive compulsive disorder (OCD) symptoms, dissociation, as well as positive and negative emotions using these scales. MW in the form of day dreaming was indirectly assessed using the MDS.

Soffer-Dudek and Somer (2018) observed that participants spent on average around 4.5 h a day daydreaming (range not reported). They found that daydreaming intensity and frequency (quantity of episodes) were strongly correlated to each other, as well as to other variables. The strongest correlations were found between daydreaming intensity and obsessive-compulsive symptoms, depression, negative emotion and anxiety. Although participants were initially recruited based on self-identification, analysis of MDS scores showed that 87 % of the sample tested above the clinical cut-off for a suspected diagnosis of maladaptive daydreaming. Of note is that on days where maladaptive daydreaming was reported to be most intense and time-consuming, participants reported significantly higher levels of dissociation, depression, negative emotion, obsessive-compulsive symptoms and anxiety and lower levels of positive emotion. Moreover, a time-lag analysis revealed that elevated levels of maladaptive daydreaming on a particular day were associated with increased negative emotions on the following day, as well as increased dissociation and obsessive-compulsive symptoms on the preceding and following day. What is especially intriguing is that the authors found no evidence of an increase in positive emotion associated with the rewarding-additive aspect of maladaptive daydreaming, possibly because these effects are rather short-lived (Somer et al., 2016).

Overall, this study shows that maladaptive daydreaming increases negative emotions and depression. However, this finding is somewhat circular, since the authors investigated daydreaming in a cohort with mostly above-threshold maladaptive traits. Thus, a correlation with

negative symptoms is to be expected. Nevertheless, this study addressed how a unique kind of excessive and absorbing MW is closely related to depression.

5.3. El Haj et al. (2019): off-track thoughts: intentional and unintentional MW in Alzheimer's disease

El Haj and colleagues investigated MW and other cognitive characteristics in patients with Alzheimer's disease (AD) and healthy controls (El Haj et al., 2019). Since AD is characterized by high rates of depression, the authors hypothesized that AD patients may exhibit increased levels of MW. 30 participants with a clinical diagnosis of probable mild AD and 33 controls matched for age, gender and educational level were recruited. MW was assessed using the 8-item scale developed by Seli et al. (2017a, b, c), which differentiates between intentional and unintentional MW. In addition, three cognitive variables were measured: general cognitive functioning (Mini-Mental State Examination), episodic memory (word list learning, Grober and Buschke, 1987), and working memory (forward and backward digit span). As expected, AD patients showed significantly reduced scores for all three cognitive measures compared to controls. Furthermore, depression was quantified using the Hospital Anxiety and Depression Scale. Depression scores were significantly increased in patients (average: 8.1) compared to controls (average: 5.7) (according to Olssøn et al., 2005, cut-off for MDD is 8).

Altogether, the authors observed that AD patients reported significantly higher intentional and unintentional MW than controls. Both intentional and unintentional MW were significantly correlated with depression scores in AD patients ($r = 0.50$ and $r = 0.51$, respectively), as well as in controls ($r = 0.48$ and $r = 0.41$, respectively). There was no correlation between MW with working memory scores. Moreover, a regression analysis yielded no significant contribution of MW to episodic memory scores. A major limitation of this study is that only a self-report scale was used to measure MW, and that the contents of MW were not further explored.

5.4. Takahashi et al. (2019): changes in depression and anxiety through mindfulness group therapy in Japan: the role of mindfulness and self-compassion as possible mediators

Takahashi et al. (2019) investigated the effect of an 8-week mindfulness program in 16 subjects with depression and/or anxiety symptoms. Participants were recruited using a website of the clinic at which the study was based, and were evaluated based on the Mini-International Neuropsychiatric Interview (MINI). The participants had various diagnoses: in two participants a major depression, in one a dysthymia and in two others moderate suicidal tendencies. Moreover, panic disorder, agoraphobia and obsessive compulsive disorder were diagnosed in four other subjects. The mindfulness program was comprised of eight sessions of 2 h each, addressing mindfulness-meditation practice and related issues. Participants were asked to engage in a meditation practice each day for 45−60 min and to be mindful of daily experiences. The following self-report scales were used: BDI-II (average score: 14.3 ± 8.3), trait anxiety scale (State-Trait Anxiety Inventory: STAI), Five Facet Mindfulness Questionnaire (FFMQ), Mindful Attention Awareness Scale (MAAS), Mind Wandering Questionnaire (MWQ), Self-Compassion Scale (SCS), and the Behavioral Inhibition/Activation Scales (BIS/BAS). These scales were completed at the beginning and end of the mindfulness program, as well as 8 weeks later which served as a follow-up.

As for statistically significant findings, the authors reported that depression (BDI-II) and trait-anxiety scores were lower and mindfulness (FFMQ) scores were higher immediately after the program and at the follow-up compared to baseline (Hedge's g effect sizes: BDI-II: 1.18, 1.21; trait-anxiety: 0.53, 0.92; FFMQ: −0.61, −0.79). Moreover, self-compassion scores were also increased at the follow-up (Hedge's g: −0.69). No significant effects were observed for the other scales (MAAS, MWQ, BIS/BAS). Changes in depression and trait anxiety were inversely correlated with self-compassion (both), mindfulness (FFQM, trait anxiety) and behavioral inhibition (i.e. motivation to avoid aversive outcomes). The authors suggest that the absence of effects for MW may be due to the fact that rumination and worry were not specifically measured in this study. Results are interpreted as indicating that the 8-week program is efficient in ameliorating depression and anxiety, and that mindfulness and self-compassion are important mediators in this process. Limitations of the study are the small sample size, the wide-ranging diagnoses and symptom levels, the sole reliance on self-report measures, and most importantly, the lack of a control condition, which logically excludes any causal attribution of the obtained changes to the intervention.

5.5. Figueiredo et al. (2020): mind-wandering, depression, anxiety and ADHD: disentangling the relationship

In a recent study, Figueiredo et al. (2020) examined the contributing role of anxiety and depression to rates of MW in adolescents diagnosed with attention-deficit hyperactivity disorder (ADHD) and clinical controls. Other studies have shown a high co-occurrence between the ADHD symptoms of inattention and hyperactivity with MW (for reviews, see Bozhilova et al., 2018; Lanier et al., 2019) and maladaptive daydreaming (Somer et al., 2017). However, Figueiredo et al. (2020) suspected that rather than MW being associated with ADHD, it is more likely correlated with anxiety and/or depressive symptoms, which frequently co-occur with ADHD. In order to investigate their hypothesis, Figueiredo et al. (2020), administered a language adapted version of the Mind Excessively Wandering Scale (MEWS; Mowlem et al., 2019) to measure levels of MW. Anxiety symptoms were assessed using the Screen for Child Anxiety Related Emotion Disorders (SCARED) questionnaire (Birmaher et al., 1999) and depressive symptoms were recorded using the Child Depression Inventory (CDI, Kovacs, 1992). Seventy-eight participants were recruited into the study through a referral by a health care professional and according to their diagnoses, were sorted into one of two groups. One group consisted of patients with learning disabilities, depressive and/or anxiety symptoms, but without ADHD - which was termed the clinical control group ($N = 40$). The second group of patients primarily consisted of subjects with an ADHD diagnosis, both with and without comorbidities ($N = 38$).

First, the authors performed a correlational analysis of MEWS scores, anxiety, depression, inattention scores (indicating ADHD), and demographic factors across all subjects. They reported significant positive correlations of MEWS scores with anxiety, depression and inattention scores. Second, the authors performed a multiple linear regression analysis showing that anxiety and inattention scores are the best predictors of MW. Depression scores only slightly improved the prediction, most likely due to their strong correlation with anxiety scores, and were alone not predictive for MW. Moreover, the authors found no differences in MW levels between ADHD and non-ADHD groups – in spite of the significant correlation of MW scores with inattention. The authors concluded that MW is more likely associated with anxiety and inattention symptoms than with clinically diagnosed ADHD.

To summarize, this study shows that anxiety, depression and inattention symptoms are related to increased levels of MW. Moreover, these findings suggest that MW is more closely related to anxiety than to depression symptoms. However, it remains unclear why a strong correlation of MW with inattention symptoms, but no association with clinically diagnosed ADHD was found, and the authors chose not to elaborate further on this conundrum.

5.6. El Haj and Nandrino (2021): intentional and unintentional mind-wandering in Korsakoff syndrome

Korsakoff syndrome is characterised by a decline in episodic memory, general cognitive functioning and executive capabilities. Its main

causes are thiamine deficiency, malnutrition and prolonged alcoholism (Arts et al., 2017). In this study, the authors recruited 31 patients diagnosed with Korsakoff syndrome and 33 healthy controls matched for gender, age and educational level (El Haj and Nandrino, 2021). Similar to a previous study by El Haj et al. (2019), MW was quantified using the scale developed by Seli et al. (2017a, b, c), which differentiates between intentional and unintentional MW. Again, the following three cognitive variables were evaluated: general cognitive functioning (Montreal Cognitive Assessment, MOCA), working memory (forward and backward digit span), and response conflict processing (Stroop task). Scores for all three cognitive measures were significantly reduced in Korsakoff patients compared to controls. Moreover, depression was quantified using the Hospital Anxiety and Depression Scale, similar to El Haj et al. (2019). Depression scores were significantly higher in patients (average: 6.90) compared to controls (average: 3.64) (according to Olssøn et al., 2005, cut-off for MDD is 8).

As for major findings, Korsakoff patients reported significantly higher intentional and unintentional MW than controls. Both intentional and unintentional MW was strongly correlated with depression scores in these patients ($r = 0.52$ and $r = 0.51$, respectively). In contrast to El Haj et al. (2019) however, MW was not significantly correlated with depression in the control group. Possible reasons for this discrepancy were not discussed further by the authors. Moreover, there were no significant correlations of MW scores with any of the cognitive measures. Similar to the earlier study by El Haj et al. (2019), the sole reliance on a self-report scale to measure MW without further exploration its contents, is a weakness of this study.

6. Discussion

In this status report, we have described currently available studies on MW in clinical depression and disorders accompanied by depressive symptoms. Interestingly, the topic of MW in clinical depression has been addressed by the older investigations (1985–2018), while MW in disorders accompanied by depressive symptoms has been targeted in the more recent studies (2018–2021). Overall, the methodological approaches underlying these studies are very heterogeneous. Eleven of the 13 studies that we have selected have used self-rating scales to measure MW, but only seven implemented experience sampling, and only four of those used an attentional task. In three investigations additional functional measures were acquired.

Here, our main aim has been to clearly and thoroughly describe the few available studies, and thereby to provide researchers in the field with a comprehensive overview of the status quo. Due to the heterogeneity of the methods used and specific research questions, it is difficult to synthesize across these studies. In the following subsections, we will discuss several points for which, from our view, at least a partial synthesis has been feasible. The impossibility to extract more common insights based on these studies constitutes part of the problem we intended to point to. Importantly, we will highlight several conceptual, methodological and interpretational difficulties below. Although further research efforts are needed to solve all of these issues, to this aim, we have listed some suggestions for future approaches in the summary. We hope that these suggestions, as well as awareness of the difficulties highlighted, may contribute to enabling faster and steadier progress in the field.

6.1. Looking at the available studies, is there evidence to indicate that depression is characterized by a larger overall amount of MW (including rumination)?

Most of the investigations regarding clinical disorders accompanied by depressive symptoms point to this direction (Soffer-Dudek and Somer, 2018; El Haj et al., 2019; Figueiredo et al., 2020; Moukhtarian et al., 2020; El Haj and Nandrino, 2021). However, for the studies targeting clinical depression, the picture is more divergent. The classic works by Watts and Sharrock (1985) and Watts et al. (1988) did not address this issue. Based on experience sampling during an attentional task, Hoffmann et al. (2016) reported that depression patients do indeed have more MW than controls, and that their thought patterns are more inclined towards a ruminative nature. Based on self-report scales, Greenberg et al. (2018) described that the interrelation between MW propensity and depression scores holds true only for patients with low self-compassion, but not for those exhibiting high self-compassion. On the other hand, based on intraday experience sampling, Ottaviani et al. (2015) found significantly more perseverative thoughts (rumination plus worry), but a trend for less non-perseverative thoughts in patients compared to controls. In this study, the amount of overall MW (including perseverative thoughts) was numerically even larger in the control group. Similarly, based on experience sampling during resting state, Rosenbaum et al. (2017) reported more rumination, but less MW (excluding rumination) for patients compared to control subjects. Again, the amount of overall MW (including rumination) was numerically larger in the controls. Thus, the question whether the amount of overall MW (including rumination) is related to depression remains an open one. A possible reason for the divergent outcomes of the experience-sampling based studies is that Hoffmann et al. (2016) measured MW during an attentional task, while Ottaviani et al. (2015) and Rosenbaum et al. (2017) applied the method in daily life and resting state, respectively. Speculatively speaking, depressive patients may find it more difficult to withdraw attention from task-unrelated (perseverative) thoughts and attend to task performance than healthy controls. This idea is generally in line with findings by Smallwood et al. (2007) indicating that links between dysphoria (i.e. subclinical depressive symptoms) and off-task thoughts tighten with task effort.

6.2. Does rumination in depression emerge rather as an isolated phenomenon or is there a gradual transition from non-ruminative MW to rumination?

The data reported by Hoffmann et al. (2016) point towards the latter idea. With regard to average characteristics, they found MW to be more negative, past-oriented, self-related and less positive in MDD patients compared to controls. Importantly, in the case of isolated ruminative thoughts larger fluctuations and extremity of these characteristics would be expected in patients than controls. However, no significant differences were observed regarding fluctuations and extremity of the ratings, and even a trend for less fluctuating past-oriented MW in the patients was found. With the limitation of a quite low number of thought probes, these data tentatively suggest that the patterns of MW overall shift towards a ruminative nature in depression.

Please note, that we have regarded rumination as a subtype of MW within the remit of this review, deriving from a very broad definition of MW (i.e. “production of thoughts or images which are unrelated to our external surroundings and the task at hand”, see Introduction). Several other equally valid categorizations of MW have been proposed, which were suggested to contribute to a family-resemblance view (Seli et al., 2018). Depending on the specific definition of MW, rumination may alternatively be seen as overlapping with or distinct from MW. For instance, MW has been categorized as a spontaneous thought process according to an influential framework (Christoff et al., 2016; Fox et al., 2018). This view is based on the notion that both deliberate and automatic constraints on the contents of commonplace MW are relatively low. In contrast, automatic constraints appear to be high in case of rumination resulting in an excessive stability in thought content. Consequently, rumination has to be considered as a phenomenon distinct from MW based on this categorization. Importantly, we do not intend to pick sides regarding the conceptual framing of MW and rumination, which from our view does not affect the conclusions of this status report. From a pragmatic perspective, it is important that investigators clearly state how MW and rumination have been assessed and what the reported measures comprise of (for instance, overall MW

including rumination or commonplace MW excluding rumination).

6.3. What is the emotional and physiological impact of rumination compared to commonplace MW?

The studies by Ottaviani et al. (2015) and Rosenbaum et al. (2017) shed some light on this question. Ottaviani et al. (2015) reported that perseverative thoughts (rumination plus worry) were characterized by worse mood (less happy; more tired, anxious, sad, angry, bored) than MW. They required more effort to be inhibited or suppressed, interfered more with ongoing activities and were associated with lower heart rate variability. Moreover, based on fNIRS measurements, Rosenbaum et al. (2017) reported opposite effects of rumination versus MW on functional connectivity within a depression-related network, with decreased connectivities for high versus low ruminators, but increased connectivities for high versus low MW. As to be expected, these data indicate multiple negative consequences of rumination versus commonplace MW. However, further investigations differentially assessing both rumination and MW are needed to reveal a more detailed picture and to corroborate these initial findings.

A related, more general issue is the temporal and causal relation between MW and negative mood: does negative mood follow MW or vice versa? Evidence for temporal dependencies in both directions has been reported. Based on daily-life experience sampling in a large population, Killingsworth and Gilbert (2010) observed that decreases in mood followed increased MW. Poerio et al. (2013) reported also based on daily-life experience sampling in a smaller population, that MW only predicted feeling worse if its content was negative. Moreover, Ruby et al. (2013a, b) found that not only negative thoughts were associated with subsequent negative mood, but also past- and other-related thoughts, even when thought content was positive. On the other hand, based on experimental induction of negative moods increased MW propensities (Smallwood et al., 2009) have been observed. Moreover, after negative mood induction increases of past-oriented MW were detected and decreases of present-oriented MW were correlated with depression scores (Smallwood and O'Connor, 2011). Hence, there is evidence for temporal dependencies between MW and negative mood in both directions. This bi-directionality may constitute a vicious circle, which may contribute to the development of depressive disorder. Regarding rumination, it has been suggested that a ruminative processing style interacts with dysphoric mood (Smallwood et al., 2003). In the absence of dysphoria, rumination was found to be associated with high levels of task focus. However, while in the presence of dysphoria, it was associated with a pre-occupation with one's own task performance. In short, the causal interaction and temporal relation between MW/rumination and negative mood/depression is still under exploration.

6.4. Methodological considerations

The studies described in this review used a wide variety of different approaches to measure MW. The methodologies ranged from self-rating scales to experience sampling during daily life and in laboratory settings with or without attentional tasks. Other investigations found only modest correspondence between these different methodologies. The MW questionnaire (Mrazek et al., 2013a, b), for instance, yielded moderate intra-subject correlations in the range between 0.23 and 0.42 with experience sampling during daily life (Ostojic-Aitkens et al., 2019), during reading (Mrazek et al., 2013a, b) and during the SART (Kawagoe et al., 2020; Krakau et al., 2020). A recent study compared both experience sampling during daily life and during attentional/cognitive laboratory tasks (Linz et al., 2021). Moderate to strong intra-subject correlations in the range between 0.25 and 0.53 were observed for different aspects of thought content (emotional valence, self-relatedness, temporal orientation). However, for MW propensity a complete absence of a correlation was reported ($r = -0.02$) and other studies found only weak associations (e.g. Kane et al., 2017). Comparing off-task thoughts in laboratory and daily life contexts, Ho et al. (2020) found broad similarities of thought patterns, but also apparent differences. For instance, off-task laboratory thoughts were more social and occurred more spontaneously. This shows that MW assessments using different methodologies do not necessarily have to converge towards the same conclusion. Importantly, differences in MW between patients and control subjects may depend considerably on the situation or setting. For instance, a laboratory setting may induce more stress, and consequently more MW, in depression patients than in healthy subjects. Moreover, patients may be more inclined to provide the responses they interpret to be desired by the experimenter than controls (Weinstein, 2018). Furthermore, levels and contents of MW may be differentially modulated by attentional tasks in patients versus control participants. Therefore, much more work is needed to understand these potential biases and moderators of clinical MW data.

Closely related to these considerations are the issues of task complexity and task context, such as place and situation (Smallwood et al., 2021). For instance, while patterns of thought content have been found to vary depending on task and context, unpleasant intrusive thoughts were correlated with depression scores across tasks and contexts (e.g. Konu et al., 2021). Regarding MW propensity, often increased MW has been reported during performance of easier compared to more difficult tasks (Forster and Lavie, 2009; McKiernan et al., 2006; Turnbull et al., 2019). However, opposite effects have also been observed, such as reduced MW being reported during the reading of easy, versus difficult texts (e.g. Feng et al., 2013). Regarding task context, it has been found, for instance, that mind wandering increased during the course of a pre-recorded lecture in video-format, but did not during a live performance of the same lecture (Wammes and Smilek, 2017). Another study reported that when listening to an audiobook in a controlled laboratory compared to a natural setting, distraction rates were higher than MW rates outside the lab, but not inside (Varao-Sousa et al., 2018). In short, there is still an ongoing discussion as to which tasks and task contexts are most suitable to understand the relation between MW and depression. Ideally, studies may choose to implement more than a single task, task condition or task context, and/or complementary methodologies (questionnaire, daily-life experience sampling, task-based experience sampling).

6.5. Meta-awareness and intentionality

Important and yet underinvestigated aspects of MW are whether it is intentional or unintentional (Giambra, 1995), and whether it is accompanied by meta-awareness or not (Schooler, 2002). Both aspects are interrelated (Seli et al., 2017c): at least at the onset, intentional MW is supposed to more often be paralleled with meta-awareness than unintentional MW (Smallwood, 2013). Since the validity of MW reports depends on meta-awareness (Zedelius et al., 2015), it is important to monitor meta-awareness in order to exclude a potential bias in MW propensities. Hereby, the sampled meta-awareness during MW is thought to correlate with the level of meta-awareness after appearance of the MW prompt. However, none of the studies described here measured meta-awareness. The studies by Greenberg et al. (2018) and Takahashi et al. (2019) indirectly addressed this issue by investigating the impact of mindfulness-based training in depression patients. The central tenet of mindfulness is to focus one's full attention on what is experienced in the present moment. Since the present experience includes the contents of MW, meta-awareness of MW is essential for mindfulness practice (Dunne et al., 2019). The findings by Greenberg et al. (2018) and Takahashi et al. (2019) suggest that mindfulness-based training is able to alleviate depressive symptoms. However, a concomitant reduction of MW scores was only observed by Greenberg et al. (2018). Such a decrease of MW due to mindfulness training is in line with findings in healthy subjects (e.g. Mrazek et al., 2012, 2013a; Rahl et al., 2017). Since meta-awareness is most likely a key mediator of the impact of mindfulness on MW and rumination, it would be important to

measure this aspect in future studies.

The content of MW episodes has been shown to differ depending on whether MW is intentional or unintentional. Intentional MW was found to be rated as more future-oriented and as less vague than unintentional MW (Seli et al., 2017b). Since depression patients are often overwhelmed by past-oriented ruminations (Hamlat et al., 2015), one may naively expect depressive symptoms to be specifically associated with unintentional MW. However, findings up to now do not support this hypothesis. In healthy subjects, correlations of intentional, but not unintentional MW with negative mood (Robison et al., 2020), and of both, intentional and unintentional MW with BDI scores (Nayda and Takarangi, 2021) have been reported. The studies by El Haj et al. (2019) and El Haj and Nandrino (2021), measured intentional versus unintentional MW based on self-report questionnaires in Alzheimer's and Korsakoff patients. In line with Nayda and Takarangi (2021), both studies found similar correlations of intentional and unintentional MW with depression scores. However, data on intentional versus unintentional MW in depression patients are needed, before any firm conclusions can be drawn.

7. Summary

To summarize, the clinical studies described in this review represent a first step in the investigation of MW in depression. Given the dominance of cognitive approaches in psychological research and psychotherapeutic treatment of depression it is surprising how little research has been done on mind wandering in relation to this disorder. The studies yield tentative insights into major issues, for instance, whether the propensity to MW overall is increased in depression or not, and whether rumination emerges as an isolated phenomenon or from a general shift of MW patterns towards a ruminative nature. Much more work is required to provide robust answers to these and other open questions. In particular, further studies are necessary, which: i) compare patients with a primary diagnosis of major depression with healthy and appropriately matched controls, ii) implement measures of both MW and rumination, iii) are based on experience sampling (in combination with other key approaches), iv) compare experience sampling during daily life, resting state and attentional tasks, v) explore possible biases in the assessment of MW, vi) acquire data not only related to the propensity and contents of MW, but also regarding meta-awareness and intentionality.

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Appendix A

Abbreviations

AD: Alzheimer's disease
ADHD: attention-deficit/hyperactivity disorder
BCT: Beck's Cognitive Triad
BDI: Beck Depression Inventory
BIS/BAS: behavioral inhibition/activation scales
BPD: borderline personality disorder
BSI: Brief Symptom Inventory
CADSS: Administered Dissociative States Scale
CASI-4R: Child and Adolescent Symptom Inventory
CBT: cognitive behaviour therapy
CDI: Childhood Depression Inventory
CRT: choice reaction time task
CTQ: Childhood Trauma Questionnaire
DMN: default mode network
FFMQ: Five Facet Mindfulness Questionnaire
fMRI: functional magnetic resonance imaging
fNIRS: functional near-infrared spectroscopy
HAMD: Hamilton Depression Scale
MAAS: Mindful Attention Awareness Scale
MADRS: Montgomery-Asberg Depression Rating Scale
MBCT: Mindfulness Based Cognitive Therapy
MDD: major depressive disorder
MDS: Maladaptive Daydreaming Scale
MEWS: mind excessively wandering scale
MINI: Mini International Neuropsychiatric Interview
MOCA: Montreal Cognitive Assessment
MT: maltreatment history
MTL: medial temporal lobe
MW: mind wandering
MWQ: Mind-Wandering Questionnaire
Mini-SPIN: Mini- Social Phobia Inventory
OCD: obsessive compulsive disorder
OCI-R: Obsessive-Compulsive Inventory- Revised
PANAS: Positive and Negative Affect Schedule
PHQ-9: Patient Health Questionnaire
SCARED: Screen for Child Anxiety Related Emotion Disorders
SCID: Structured Clinical Interview (DSM-IV)
SCS: self-compassion scale
sgACC: subgenual anterior cingulated cortex
SGTs: self-generated thoughts
STAI: State-Trait Anxiety Inventory
TAU: treatment-as-usual group
WASI: Wechsler Abbreviated Scales of Intelligence

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