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Research paper

Where the depressed mind wanders: Self-generated thought patterns as assessed through experience sampling as a state marker of depression

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ABSTRACT

Background: Self-generated thoughts (SGTs), such as during mind wandering, occupy much of our waking life. Individuals with Major Depressive Disorder (MDD) are less in the "here and now" and prone to rumination. Few studies have looked at SGTs in depression using experience sampling methods and no study has so far investigated the specific contents of depressive SGTs and how they vary from one time point to another.

Methods: MDD patients (n=25) and matched healthy controls (n=26) performed an established mind wandering task, involving non-demanding number discriminations. Intermittent probe questions ask for participants' current SGTs, that is, how off-task the thoughts are, how positive or negative, self- or other-related, and past- or future-oriented.

Results: Multi-level modelling revealed that MDD patients engaged in more mind wandering than healthy controls. Their SGTs were predominantly negative and less positive, more self-related and past-oriented. Strongest predictor of depressive SGT was the decreased positive valence of thoughts. MDD patients' future and past-oriented thoughts were particularly more negative compared to healthy controls. Within MDD patients, the less positively valenced thoughts they had and the less variable these thoughts were, the more depressive symptoms they showed.

Limitation: No other measures of rumination and worry were used.

Conclusion: MDD patients show a very specific SGT pattern, possibly reflecting ruminative and anxious thoughts. This SGT pattern in depression might represent a useful state marker and even constitute an etiological factor of this debilitating disease, considering the importance of current SGT on and individual's cognitive processes and affective states.

1. Introduction

Self-generated thoughts (SGTs) arise independently of external stimulation through the environment, and comprise experiences such as mind wandering, day-dreaming, rumination and planning (Smallwood, 2013). It is known that SGT forms a crucial part of human mental activity, occupying up to 50% of our waking mind (Kane et al., 2007; Killingsworth and Gilbert, 2010). Mind wandering occurs particularly when attentional and cognitive demands in relation to the external environment are low (e.g. Smallwood et al., 2004). Some studies have linked SGT such as mind wandering to negative mood and unhappiness (Killingsworth and Gilbert, 2010; Stawarczyk et al., 2013), recent findings, however, suggest that it is crucial to consider 'where the mind wanders' and to look more specifically at the content of SGTs. For example, in healthy individuals, past-focused thoughts seem to be related to a reduction in positive mood, more depressive symptoms and increased cortisol levels after stress, while future-focused thoughts lead to an increase in positive mood and an attenuated stress response (Baird et al., 2011; Engert et al., 2014; Ruby et al., 2013a; Smallwood and O'Connor, 2011; Smallwood et al., 2007). Thus, SGT seems to represent a heterogeneous mental phenomenon with variable effects on human cognition, affect and behaviour (Andrews-Hanna et al., 2014).

Patients with depression are known to show considerable difficulties with staying in the "here and now". Investigations have demonstrated that MDD patients tend to engage in maladaptive

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SGTs in the form of excessive rumination and worry (Nolen-Hoeksema, 1991, 2000; Watkins, 2008). Depressive rumination has been characterized as a mode of responding to distress which involves repetitively and passively focusing on symptoms of distress and on the possible causes and consequences of these symptoms (Nolen-Hoeksema, 2000). Worry, in contrast, has been described as a chain of negative uncontrollable thoughts and images, constituting an attempt to engage in problem-solving on issues with an uncertain outcome (Borkovec et al., 1983). While rumination and worry tend to correlate and share some similar features such as their repetitive nature, they have also been found to be statistically distinguishable (Nolen-Hoeksema et al., 2008). It has thus been proposed that rumination is more past and present oriented, focused on issues of self-worth, meaning and loss, whereas worry seems to be future-oriented, focused on anticipating threats (Nolen-Hoeksema et al., 2008; Watkins, 2008). While both rumination and worry have been associated with depressive symptoms, rumination seems to be more strongly related to depression (Hendriks et al., 2014; Hong, 2007). In MDD, rumination seems to represent a vulnerability marker for developing the disorder, and also shows a relation to the duration of MDD episodes and relapse probability (Nolen-Hoeksema et al., 2008). According to the cognitive model of depression, adverse early life events lead to internalization of negative self-referential schemas that subsequently bias information processing, in how stimuli are encoded, organized and retrieved (Disner et al., 2011). Therefore, these negative self-referential schemas might bias thoughts towards rumination of negative past experiences in depressive patients.

Previous research on rumination and worry in depression has been largely based on questionnaire and induction methods, which both have considerable limitations and lack ecological validity. Questionnaire methods rely heavily on retrospection which is often impaired in psychiatric populations. Most induction methods prompt participants towards rumination about certain subjects (thinking e.g. about the long-term goals you have set), which then is compared to distraction inductions, asking the participants to focus on non-self-relevant images (Nolen-Hoeksema and Morrow, 1993). However without no-intervention control conditions, the effects between the two different conditions are difficult to disentangle. More critically these induction methods do not capture momentary online thoughts. In contrast growing research on SGTs in healthy individuals suggests that if one wants to make more objective claims about the wandering mind in health or in depression one ought to investigate SGTs using online experience sampling measures. Such online-measures of SGTs would allow picking up disease specific SGT patterns in the moment when they actually occur, and are particularly useful in depression research as ecological momentary assessment avoids the recall bias toward negative memories and also allows for better generalization to real life. To our knowledge only one study looked at online SGTs in clinically depressed participants (Ottaviani et al., 2014). Using an experience sampling method this study categorized SGTs in depression as either normal mind wandering, on task thoughts or perseverative cognition, linking the latter to autonomic inflexibility in lower heart-rate variability. No study however has so far tried to objectively decompose the specific SGT contents in clinical depression, regarding the previously established temporal (past or future oriented), social (self or other related), and emotional (negative or positive) dimensions of SGT (Engert et al., 2014; Ruby et al., 2013a, 2013b). From a clinical perspective identifying the specific SGT pattern in depression seems of great interest, as such SGT pattern could function as a state marker of depression, which could potentially then be utilized as a measure of disease progression and therapeutic change, as well as helping better differentiation of mental disorders. In addition it is unknown how these SGT contents in MDD patients relative to healthy controls vary over time, which could function as a good indicator of the repetitiveness of thoughts, inherent in rumination and also worry. This study thus aimed to comprehensively investigate the space of SGTs in depression in terms of amount, content and variability.

Based of clinical observation and description disordered thoughts in depression have been commonly conceptualized as rumination and worry. Such disordered thoughts in depression can however, considering the recent findings in mind wandering research possibly more accurately be described by pathological SGTs in depression. In this study we thus aimed to specifically investigate the online SGT contents and their variability in a sample of clinically depressed patients. We used an established non-demanding choice reaction time task (CRT) that allows spontaneous SGTs in participants. During this task participants are asked at random time points, first, how much they were on task, and, secondly, about the specific content of their thoughts (Engert et al., 2014; Ruby et al., 2013a, 2013b), such as questions asking if their thoughts were focused on certain temporal epochs (future or past), involved different referents (self or other) and varied in valence (negative or positive). This task is particularly useful as an objective online measure of the amount and specific content of SGTs, but also of their variability over time, as participants are asked about the SGTs repeatedly throughout the task. One index of thought variability is the fluctuation of thought ratings from one thought probe to the next, computed as the squared successive difference in ratings, which has been an established method in experience sampling studies (Ebner-Priemer et al., 2007; Jahng et al., 2008; Skirrow et al., 2014; Trull et al., 2008). Another index of variability represents the extremity of the thought ratings, calculated as the squared difference of each rating from the mean for that variable.

We first hypothesized that MDD patients relative to healthy controls would generally show more mind wandering, that is engage in more SGTs, being less in the ‘here and now’, and that these stimulus independent thoughts would be more negative, self, and past related in accordance with the cognitive model of depression and findings on increased rumination in depression. Secondly, we also hypothesized that MDD patients would think more about negative future events, possibly pointing to their tendency to engage in stronger worrying compared to healthy controls. Thirdly we expected that MDD patients would also show less variability and more rigid thought patterns compared to healthy controls, capturing the repetitive nature of their thoughts. Lastly we expected a relation between symptom severity and specific patterns in SGTs and their variability in depression.

2. Methods

2.1. Participants

25 patients with depression were recruited through the inpatient clinic of the Charité-Universitätsmedizin Berlin, or were referred to us by specialized clinicians (see Table 1). 26 healthy control (HC) participants matched to the patients in terms of years of education, age, and gender with no history of psychiatric or neurological disorders were recruited by public notices and from project databases of the Charité-Universitätsmedizin Berlin. Participants were assessed for mental disorders using the Structured Clinical Interview for the DSM-IV (American Psychiatric Association, 2000) and a diagnosis of acute state of depression was confirmed with no other primary diagnoses. All participants completed the Beck Depression Inventory (BDI, Hautzinger et al., 1995), and were also assessed with the Hamilton Depression Rating Sale (HAMD-17, Hamilton, 1960). Additionally, participants completed a measure of

Table 1
Demographic and clinical characteristics of the participants.

	Healthy controls	MDD patients	Significant effects ($p < 0.05$)
Sample size	26	25	
Gender	10 males	8 males	
Age	41.9 (13.6)	41.1 (12.6)	
Education (years)	16.9 (2.9)	15.2 (3.2)	
Verbal IQ (WST)	105.4 (7.5)	100.7 (11.4)	
BDI	2.5 (3.8)	32.0 (9.6)	*
HAMD-21	0.77 (1.6)	20.4 (3.6)	*

Table 2
Medication of MDD patients.

Medication	Number of participants
SSRI	6
NaSSA	2
SNRI	3
NDRI	2
TCA	1
AAP	1
SSRI+Lithium	1
TCA+Lithium	1
NaSSA+Lithium	1
SSRI+AAP	1
SNRI+AAP	1
SSRI+TCA	1
SSRI+Agomelatine	1
AAP+Lithium	1
SSRI+NaSSA	1

crystallized intelligence (Wortschatztest, WST, a vocabulary test part of the HAWIE-R, the German adaptation of the Wechsler Adult Intelligence Scale, Schmidt and Metzler, 1992). All MDD patients except one were on medication (see Table 2). No patient was medicated with benzodiazepines for at least 48 h. Exclusion criteria included any comorbid axis I disorder, current neurological disorder, substance abuse within 6 months before study participation, diagnosis of antisocial personality disorder or borderline personality disorder. None of the patients had a history of electroconvulsive therapy (ECT). The study was approved by the local research ethics committee (Charité-Universitätsmedizin Berlin) and written informed consent was obtained from all participants.

2.2. CRT task

We used an established mind wandering paradigm that probes off-task thoughts during a choice reaction time task (Baird et al., 2012; Ruby et al., 2013a; Smallwood et al., 2013) and assessed the content of the participants' thoughts on six different dimensions 1) past, 2) future, 3) self, 4) other, 5) negative valence and 6) positive valence (e.g. Engert et al., 2014; Ruby et al., 2013a). A series of black digits between 1 and 8 was presented. One sixth of the digits was presented in red color signaling participants that they should indicate via button press if this number was odd or even. Black digits were presented for 1000 ms and red digits for 2000 ms. Responses had to be made while the colored digits were still present on the screen. Stimuli were separated by a fixation cross of variable duration (2200–4400 ms).

The number of thought probes and their presentation were randomly determined (Ruby et al., 2013a), to avoid any expectancy biases, and thus sampling SGTs in the most unconstrained way (number of probes between four and nine). Participants were asked to rate their current thoughts using a nine-point Likert scale on several dimensions including how much their thoughts were 1) past-oriented, 2) future-oriented, 3) self-related, 4) other-related, 5) negatively valenced and 6) positively valenced and 7) how much off task their thoughts were at that point in time. Additionally, they rated their current mood (i.e. how positive and how negative they felt). Importantly healthy controls and MDD patients did not differ in terms of accuracy (healthy controls: 87.2%, MDD patients: 86.4%) and reaction time (healthy controls: 882.29 ms, MDD patients: 923.62 ms) on the CRT task (more detail reported in Section 3). The entire task lasted approximately 14 min. Stimuli were presented using E-prime 2.0 (Psychology Software Tools, Inc., Sharpsburg, PA, USA).

2.3. Data analysis

For the main analyses, we used multi-level models because they take correlated observations within individuals into account and perform well with missing data or unequal numbers of data points within individuals (Jahng et al., 2008). Linear mixed models were calculated in SPSS version 22 with the number of the particular sampling point within the session (e.g., sample 5) as covariate and with a random intercept. Sampling point was used as a covariate within the models to account for different numbers of sampling points between the participants. In addition to the rating level (e.g. to what extent was a certain thought negative or self-related), we investigated two indices of variability, i.e., fluctuations and extremity in ratings. To obtain a measure of how much individuals fluctuate in their single SGT ratings from one thought probe to the next, we calculated squared successive differences, which has been established in experience sampling studies (Ebner-Priemer et al., 2007; Jahng et al., 2008; Skirrow et al., 2014; Trull et al., 2008). Fluctuation scores were calculated for each SGT dimension separately. To obtain a measure of how extreme the individual ratings were, we calculated the squared difference of each rating from the total sample mean (including healthy controls and MDD patients) for that variable. In contrast to the fluctuations, this does not take into account how big successive changes are, but rather indicates how much a certain rating differs from the "norm". As a measure of effect size for the central main effects and interaction effects Omega-squared (ω^2) was calculated by taking the difference from 1 and the variance of the residuals of the full model divided by the variance of the residuals of the model without the respective fixed factor of interest (Xu, 2003). A value of $\omega^2 = .010$ represents a small effect size, a value of $\omega^2 = .059$ indicates a medium effect size and a value of $\omega^2 = .138$ represents a large effect size (Kirk, 1996). In a first step, differences between MDD patients and HCs in ratings levels, fluctuations in ratings, and extremity in ratings (see below for details) were subjected to multi-level models as described above. In a second step we tested for group differences and in particular interrelations of the different content dimensions of SGT, on which healthy controls and MDD patients were found to differ. This allowed us to investigate whether certain SGTs were more strongly correlated with one another in MDD patients compared to healthy controls. Finally in a third step, we investigated how symptom severity in healthy controls and MDD patients related to the different SGT measures (rating, fluctuation, extremity). Symptom severity in healthy controls and MDD patients might relate to very specific SGTs. In the case of healthy controls such SGTs might represent a vulnerability factor towards the development of depression.

3. Results

3.1. Performance

Independent samples *t*-tests showed no significant differences between healthy controls and MDD patients in accuracy ($t(49) = -$

Table 3
Differences between MDD patients and HCs in rating levels, fluctuations in ratings and extremity in ratings as estimated with multi-level modelling.

	Model parameters											
	Predictors	Rating levels				Fluctuations in ratings				Extremity of ratings			
		b	S.E.	p-value	ω^2	b	S.E.	p-value	ω^2	b	S.E.	p-value	ω^2
Off task	Intercept	−6.634	4.363	0.140		359.591	203.236	0.078		846.379	147.244	< 0.001	
	Group	−24.736	5.432	0.001	0.108	277.831	180.207	0.124	0.009	−75.813	184.016	0.682	0.002
	Sample	2.571	0.734	0.001	0.050	43.210	45.631	0.345	0.004	−60.207	17.665	0.001	0.033
Other	Intercept	25.859	4.221	< 0.001		933.098	206.792	< 0.001		680.979	104.074	< 0.001	
	Group	−2.930	5.403	0.593	0.004	43.052	268.797	0.874	< 0.001	120.726	113.300	0.287	0.006
	Sample	1.268	0.622	0.042	0.012	2.681	49.229	0.957	0.004	11.640	21.552	0.590	0.003
Self	Intercept	45.729	3.634	< 0.001		857.550	246.294	0.001		990.713	125.197	< 0.001	
	Group	−21.686	4.446	< 0.001	0.070	300.419	218.004	0.169	0.008	108.317	143.679	0.451	0.004
	Sample	2.879	0.869	0.007	0.052	−21.361	55.763	0.702	0.001	−10.471	19.568	0.593	< 0.001
Negative	Intercept	45.036	5.374	< 0.001		268.231	117.744	0.024		1032.565	133.213	< 0.001	
	Group	−26.220	7.024	0.001	0.191	122.903	104.220	0.239	0.006	−115.103	170.661	0.503	0.011
	Sample	3.109	0.660	< 0.001	0.053	6.681	26.658	0.802	< 0.001	−7.895	17.227	0.647	< 0.001
Positive	Intercept	40.583	4.665	< 0.001		524.571	108.168	< 0.001		845.119	132.122	< 0.001	
	Group	28.135	5.724	< 0.001	0.226	−2.515	105.093	0.981	< 0.001	−62.209	166.982	0.711	0.003
	Sample	−1.449	0.492	0.006	0.013	−45.744	21.686	0.036	0.018	−5.986	16.267	0.713	< 0.001
Past	Intercept	28.7787	3.417	< 0.001		352.832	219.309	0.108		852.037	215.769	< 0.001	
	Group	−16.268	4.344	0.001	0.129	461.218	244.840	0.062	0.020	−304.787	215.674	0.166	0.016
	Sample	1.661	0.672	0.014	0.050	54.674	43.935	0.214	0.018	45.124	20.314	0.029	0.017
Future	Intercept	24.160	5.001	< 0.001		954.850	235.007	< 0.001		787.485	125.673	< 0.001	
	Group	−10.964	6.068	0.077	0.021	−40.411	208.597	0.847	< 0.001	105.544	145.361	0.470	0.014
	Sample	3.680	0.725	< 0.001	0.087	−48.768	52.983	0.358	0.003	47.501	29.654	0.112	0.020
Negative mood	Intercept	49.204	3.943	< 0.001		688.076	194.558	0.001		662.681	124.650	< 0.001	
	Group	−19.361	5.877	0.002	0.134	−199.076	181.977	0.279	0.009	22.053	162.188	0.892	0.001
	Sample	1.820	0.594	0.003	0.030	−55.060	32.040	0.087	0.009	44.862	13.689	0.001	0.003
Positive mood	Intercept	37.993	3.667	< 0.001		257.217	73.350	0.001		607.443	118.0167	< 0.001	
	Group	25.131	5.048	< 0.001	0.240	−23.414	65.278	0.720	< 0.001	32.923	152.701	0.830	0.001
	Sample	−1.357	0.491	0.006	0.010	2.991	16.133	0.853	0.032	20.523	12.877	0.112	0.002

Note: sample represents the covariate of the number of sampling points of the thought probes.

0.13, p=.894; healthy controls: 87.2% ± 17.3, MDD patients: 86.4% ± 24.7) or reaction times (t(49)=1.26, p=.212; healthy controls: 882.29 ms ± 106.24, MDD patients: 923.62 ms ± 126.74) in the CRT.

3.2. Mood probes

Multilevel models revealed that MDD patients showed elevated levels of negative and decreased levels of positive mood (see Table 3 and Fig. 1 Supplemental material). The fluctuations and extremity of the mood ratings were not significantly different between groups.

3.3. Thought probes

3.3.1. Rating levels

Multilevel models revealed that MDD patients show significantly increased off-task thoughts, relative to the healthy controls (see Fig. 1 and Table 3). Regarding the particular SGT contents, MDD patients reported more negative and less positive, as well as more past- and self-related thoughts compared to healthy controls. MDD patients also engaged in marginally more future-oriented SGTs. Number of sampling points ("Sample"), was included as a covariate in all analyses. Non-significant results of the number of sampling points particularly for fluctuation and extremity suggest that variability measures were not as strongly influenced by the number of sampling points, thus did not change as much over the course of the experiment, as the ratings themselves. Including current mood as a covariate showed significant relations between mood and thought valence, but did not change the group differences in positive (b=7.800, S.E.=2.940, p=.010) and negative thoughts (b=−15.4435, S.E.=4.124, p=.001). There were no group differences in the amount of other-related thoughts. While healthy controls had more positive thoughts than negative thoughts (t(25)=−4.022, p<.001), MDD patients had marginally more negative thoughts than positive thoughts (t(24)=1.981, p=.059).

3.3.2. Variability

There were no significant differences between the groups in extremity of SGTs (see Table 3). There was however a marginally significant group difference in fluctuations of past-related thoughts, with MDD patients showing less fluctuating past-related SGTs (see Table 3).

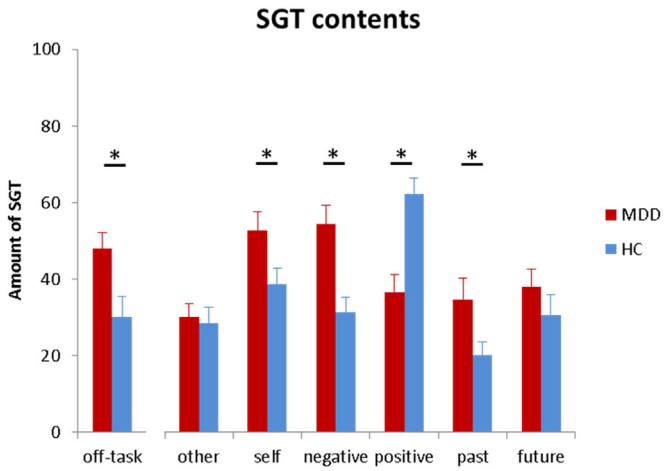

Fig. 1. Amount of SGT and SGT contents for healthy controls and MDD patients. Depressed patients showed increased negative and decreased positive as well as increased self- and past-related thoughts, relative to healthy controls (error bars represent standard errors).

3.3.3. SGT contents as predictors of MDD

Looking at what SGT content was the most accurate in distinguishing between MDD patients and healthy controls a stepwise logistic regression was performed on the two groups, with the six SGT contents as predictors (past, future, other, self, negative, positive). The results showed that the amount of positive thoughts was most discriminative between the two groups (B = −0.45, Wald = 59. 05, p < .001, Nagelkerke R square = .323).

3.3.4. Interrelations between SGT contents in MDD patients and healthy controls

Looking specifically at interrelations of the different content dimensions of SGT, multi-level models were used on the SGT contents in which MDD patients and healthy controls were found to differ (self, past, negative, positive, see Section 3.3.1). These analyses were run to investigate whether certain SGTs tended to interrelate more strongly in MDD patients relative to healthy controls. Each SGT content was used as a covariate to investigate interrelation with another SGT (as dependent variable), while group was used as an independent factor (healthy controls vs MDD patients). This resulted in twelve separate models, with only the significant models reported in Table 4. In particular, it was found that MDD patients' temporal thoughts of past and future were significantly more negatively valenced in comparison to the healthy controls (see Fig. 2 and Table 4), suggesting a stronger preoccupation with negative past and negative future events. In contrast positive thoughts in healthy controls were more past-related compared to MDD patients. In addition past-oriented thoughts were more self-related in MDD patients compared to healthy controls.

3.4. Relation of SGT variables to symptom severity

3.4.1. MDD patients

To test for a relation of the observed effects with symptom severity in the MDD group, we ran two separate liner-mixed models with BDI and Hamilton scores as covariates. Both symptom severity measures, BDI and Hamilton scores showed a significant positive correlation (healthy controls: r = 0.68, p < 0.01; MDD patients: r = 0.43, p = 0.03). BDI was a marginal predictor for the amount of mind wandering in general (b = 0.942, S.E. = 0.500, p = 0.071). Looking specifically at SGT contents, BDI was a predictor of increased levels of past-related thoughts (b = 1.109, S.E. = 0.497, p = 0.045), and a marginally significant predictor of decreased positive valence (b = −0.863, S.E. = 0.420, p = 0.050). Hamilton scores were a significant predictor of future-related thoughts (b = 4.271, S.E. = 0.623, p < 0.001) and negative valence (b = 2.369, S.E. = 1.293, p = 0.080). These findings suggest that more severe symptoms are associated with an increase in specific SGT contents.

Relating symptom severity to SGT fluctuations, BDI scores were found to be a predictor of the fluctuations in self-related thoughts (b = −39,527, S.E. = 14.031, p = 0.006) and fluctuations in negative (b = −18,634, S.E. = 8.369, p = 0.027) and positive valence (b = −20,029, S.E. = 7.460, p = 0.008). Hamilton scores were found to be a predictor of the fluctuations in self-related thoughts (b = −74,202, S.E. = 34.163, p = 0.032) and fluctuations positive valence (b = −54,834, S.E. = 18.460, p = 0.004). These findings suggest that, the more severe the depressive symptoms in MDD patients were the less variable the reported experience of specific SGTs in the course of the experiment was.

Relating symptom severity to SGT extremity, BDI was found to be a predictor of extremity in past-related thoughts (b = 34,396, S.E. = 713.425, p = 0.015). Hamilton was a predictor of extremity in future-related thoughts (b = 91,014, S.E. = 27.059, p = 0.001).

3.4.2. Healthy controls

Another interesting question was how depressive symptomatology in healthy controls related to SGTs, possibly indicating that certain SGTs can indicate a vulnerability to developing depression. BDI was found to be a marginal predictor of the amount of past-related thoughts (b = 1.492, S.E. = 0.775, p = 0.067). Hamilton scores were also found to be a significant predictor of the amount of past-related thoughts (b = 4.025, S.E. = 1.718, p = 0.023.

Symptom severity was found to be unrelated to fluctuations in SGTs in healthy controls. BDI (b = −54.687, S.E. = 16.886, p = 0.001), as well as Hamilton (b = −70.058, S.E. = 41.067, p = 0.090) were found to be a predictor of extremity in the amount of general mind wandering.

Table 4
Significant differences in interrelations between SGT contents in MDD patients and healthy controls as estimated with multi-level modelling.

	Model parameters				
	Predictors	Rating levels			
		b	S.E.	p-value	ω^2
Negative	Intercept	38.418	5.543	< 0.001	
	Group	−20.527	6.406	0.002	0.074
	Sample	2.803	0.760	0.001	0.017
	Past*Group	−0.217	0.092	0.019	0.032
Negative	Intercept	41.157	5.746	< 0.001	
	Group	−22.254	6.901	0.002	0.106
	Sample	3.025	0.794	< 0.001	0.043
	Future*Group	−0.173	0.083	0.038	0.014
Positive	Intercept	46.546	4.896	< 0.001	
	Group	20.628	6.156	0.001	0.107
	Sample	−1.419	0.516	0.009	< 0.001
	Past*Group	0.245	0.085	0.004	0.041
Past	Intercept	13.961	5.927	0.022	
	Group	−4.647	6.337	0.466	< 0.001
	Sample	1.299	0.543	0.017	0.032
	Self*Group	−0.179	0.085	0.036	0.019

Note: sample represents the covariate of the number of sampling points of the thought probes.

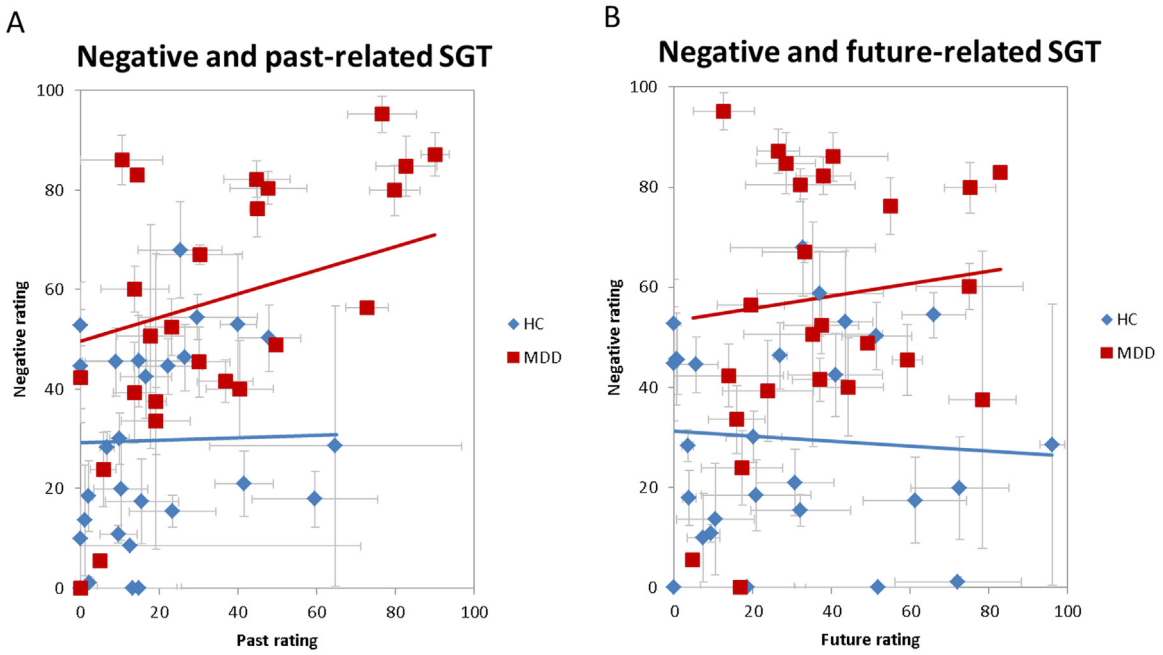

Fig. 2. (A) In contrast to healthy controls, MDD patients show a significant positive relation between the negative valence and past-relatedness of SGTs. (B) In contrast to healthy controls, MDD patients show a significant positive relation between the negative valence and future-relatedeness of SGTs.

4. Discussion

In this study we aimed to investigate thinking patterns related to mind wandering in clinical depression relative to healthy controls using an objective online-measure, a mind wandering laboratory task that probes the amount and specific content of task-unrelated thoughts in the moment in which they occur. More specifically the content of thoughts was assessed on following six dimensions: 1) past, 2) future, 3) self, 4) other, 5) negative valence and 6) positive valence (Engert et al., 2014; Ruby et al., 2013a, 2013b). In addition to typically used average scores of STG frequencies, we also looked here at fluctuation and extremity of SGTs as a measure of variability over time. We hypothesized that MDD patients relative to healthy controls would engage in more mind wandering, showing a specific SGT pattern possibly related to rumination and worry. In addition we expected that the amount and also the variability of depression specific SGTs would relate to symptom severity.

As hypothesized MDD patients engaged in a greater amount of SGTs compared to healthy controls, showing more off-task mind wandering, being less in the “here and now”. The SGT pattern in MDD patients relative to healthy controls was characterized by significantly more self- and past-related thoughts that were more negative and less positive in valence. In particular, MDD patients' past-related thoughts were strongly coupled to negatively valenced SGTs. These findings suggest that distorted thought processes in depression can be very well captured and described in online depressive mind wandering. This specific depressive SGT pattern might in part relate to pathological rumination about negative past events, which is commonly found to be increased in depression (Nolen-Hoeksema, 1991, 2000). Supporting this suggestion, the “feelings of guilt” item of the Hamilton scale including questions about rumination was particularly associated with past-related thoughts in MDD patients (see Supplemental Information). This SGT pattern is also in accordance with the three proposed elements of rumination (Disner et al., 2011): altered emotion and memory processing, increased self-referential processing, and decreased top-down inhibition of these processes.

Interestingly, the strongest predictor of depressive SGT was the positive valence of the thoughts. This is in accordance with some findings showing that the absence of positive affect might be actually more indicative of the depressive state, as increased negative affect is shared by most mood and anxiety disorders (Watson et al., 1988). Further, symptom severity also related with the amount of positive thoughts within the group of the MDD patients, as well as their variance. This suggests that the low and flat positive valence of thoughts plays a crucial functional role in depression and its severity. Findings of decreased positive affect in response to rewards and abnormal functioning of reward sensitive brain areas such as the nucleus accumbens in depression (Heller et al., 2009), might be seen as further support. In the case of the healthy controls depressive symptoms were related to increased amount of past-related thoughts as previously reported (Ruby et al., 2013a; Smallwood and O'Connor, 2011; Smallwood et al., 2007). Past-related thoughts might therefore represent a vulnerability factor for depression, possibly related to a ruminative response style, which has been shown to be associated with onset, maintenance and reoccurrence of depressive episodes (Nolen-Hoeksema, 2000; Nolen-Hoeksema et al., 2008).

While MDD patients only marginally engaged in more future-related thoughts, their future-oriented thoughts were significantly more negative than in healthy controls. This could be interpreted as a SGT pattern of worry, and indeed the somatic anxiety scale of the Hamilton scale was positively related to future thoughts in MDD patients, lending support for this suggestion (see Supplemental information). Interestingly future-related thoughts in healthy controls have mostly been associated with adaptive and beneficial effects such as increasing subsequent positive mood and attenuated cortisol levels at baseline and after a stressor (Engert et al., 2014; Ruby et al., 2013a). It has also been suggested that future-oriented SGT is instrumental in autobiographical planning and consolidation (Baird et al., 2011; Smallwood et al., 2011). Our results do show however that in the case of clinical depression future thoughts are negative and potentially maladaptive being related to worry that exacerbates the depressive state.

In this study we also looked at SGT variability over time given the multiple sampling points of the thought probes. We used two indices of SGT variability, namely the fluctuation of the SGT

ratings, and the extremity of the SGT ratings, which both can be seen as a good indicator of the repetitiveness or perseverance of thoughts, such as present in depressive rumination and worry. Significant group differences were only found for the fluctuation of past-related thoughts, with MDD patients showing less variability in past-related thoughts compared to healthy controls. In addition, symptom severity in MDD patients related to fluctuations in SGTs. Particularly, the stronger the symptoms that the MDD patients portrayed, the less self-related, positive and negative thoughts fluctuated. Similarly symptom severity in MDD patients was associated with the extremity of future-related SGTs. In general these findings suggest that the stronger the depressive symptoms portrayed by MDD patients, the more rigid certain SGTs are over time. In particular the less variable the positive valence of such SGTs is, the more repetitive and perseverative certain thoughts and the corresponding affect are. Increasing inflexibility in SGTs in depression might be associated with reported cognitive inflexibility in depression (Altamirano et al., 2010; Joormann et al., 2011; Whitmer and Gotlib, 2013), due to serotonergic dysregulation within prefrontal cortex (Clarke et al., 2004).

From a clinical point of view, identifying SGT patterns of MDD and other mental disorders seems to be of relevance. Disease specific SGT patterns can function as state markers, which can be utilized to monitor disease progression and more importantly therapeutic changes and shifts towards more adaptive SGTs. Mapping disease specific SGT patterns, could be also further helpful for diagnostic purposes. As decreased positive valence of SGT was most representative of the depressive mind, one could envision how therapies fostering self-compassion and positive affect might be particularly useful for clinical interventions (Van Dam et al., 2011). In addition mindfulness-based therapies have been shown to be very effective in treating depression, by increasing momentary positive emotions and reward experience (e.g. Geschwind et al., 2011) and decreasing negative mind wandering in terms of ruminative thinking (e.g. Ramel et al., 2004). For future studies it would be interesting to compare SGT patterns between different mental disorders. Naturally, investigating SGT patterns in anxiety disorders relative to depression would be very interesting, particularly as there exists a high comorbidity between these two disorders. It could be assumed that the SGT pattern of anxiety disorders relative to MDD shifts more strongly in the temporal domain towards future, representing pathological worry, while being possibly equally negative and self focused. Additionally it would be interesting to explore how SGT patterns change in remission from depression. Investigating SGT “online” with tasks such as the CRT combined with assessment of the different thought content dimensions, as used in this study could represent a more objective measure than clinical interviews and self-reports. Particularly self-reports demand a certain amount of retrospection and introspection, which are often deficient in many mental disorders.

4.1. Limitations

One limitation of the present study is that no other measures of rumination and worry were available to relate these to the SGT pattern in depression, and strongly validate the interpretation of rumination and worry. In addition the study was based on a relatively small sample size.

5. Conclusion

In conclusion this study aimed to investigate the specific contents of online SGTs and their variability in depression. The findings show that MDD patients engaged in more SGTs than healthy controls that were seemingly ruminative in nature, being more negative and less positive in valence as well as more self- and past related. Particularly in the temporal domain, MDD patients' thoughts about the past and the future were more negatively valenced. The decreased positive valence of SGTs was the best predictor for depression. Additionally the variability in SGTs related negatively to symptom severity in depression. Investigating different SGT patterns of mental disorders such as depression using event-sampling online measures can be useful for deriving state markers that may help diagnosis and intervention.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.jad.2016.03.005.

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