

# Novel Approach to Mind Wandering in Major Depressive Disorder and Bipolar Disorder Patients: Does the Direction of Thoughts Matter?

Samira Rostami<sup>1</sup> (MSc), Ahamad Borjali<sup>1</sup> (PhD), Hossein Eskandari<sup>1</sup> (PhD), Reza Rostami<sup>2</sup> (PhD), Georg Northoff<sup>3</sup> (PhD)

1. Department of Psychology, Allameh Tabataba'i University, Tehran, Iran
2. Department of Psychology, University of Tehran, Tehran, Iran
3. Mind, Brain Imaging and Neuroethics, Institute of Mental Health Research, The Royal Mental Health Centre, University of Ottawa, Ottawa, Canada

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## Corresponding Author:

Samira Rostami,  
Department of Psychology,  
Allameh Tabataba'i University,  
Tehran, Iran  
E-mail: samira.rostami@theroyal.ca

## Abstract

**Introduction:** This study investigated the features of mind wandering in patients with major depressive disorder and bipolar disorder in comparison with the healthy control group.

**Method:** The number and duration of internally- and externally-oriented thoughts during MW in 90 healthy control, major depressive disorder, and depressed bipolar disorder subjects were measured by a novel method of experience sampling experiment in the laboratory at the Royal Mental Health Centre of the University of Ottawa, Canada using the MATLAB software. Subjects also filled out BDI-II to evaluate current depressive symptoms. The methods used to analyze data included Chi-square, ANOVA, LSD Post Hoc Test, Pearson and Spearman correlation.

**Results:** 1) an increased number of internally-oriented thought contents in MDD and BD; 2) the duration of time MDD and BD groups engage with the internal thoughts is almost twice the time the HC spend on it; 3) the relationship between the direction of thoughts during MW and depressive symptoms.

**Conclusion:** Our results show depressed patients with MDD and BD spend a longer time on internal thoughts during MW which is related to the severity of their depressive symptoms, which carries clinical implications for both diagnosis and therapy.

**Keywords:** Mind Wandering, Direction of Thoughts, Major Depressive Disorder, Bipolar Disorder, Internal Thoughts

## Introduction

Major Depressive Disorder (MDD) is a common illness, affecting more than 253 million individuals worldwide [1] which is associated with tremendous personal and social costs [2]. Much like MDD, Bipolar Disorder (BD) type I, is a debilitating disorder affecting 45 million people worldwide [1] and imposing a high burden on the affected individuals and the society as a whole [3]. Although currently a variety of effective treatment strategies (including cognitive psychotherapy, brain-based therapies, and psychopharmacotherapy) exist for the treatment of MDD and BD, these treatments can be further improved to create more efficacious treatment options. For instance, despite their efficacy, current treatment strategies have proved to have a high relapse rate among MDD and BD patients [4, 5]. The relapse rates for MDD after cognitive behavioral therapy are estimated to be 70 percent after 12 months [6] and 50 percent within 24 month [7], and 29 percent within a 17-month follow-up after cognitive therapy [8]. The relapse rate of BD over 12-month follow-up after cognitive therapy is 64 percent [9].

A promising avenue for devising more efficacious treatment strategies is to gain more

in-depth knowledge about the novel underlying factors that can modulate diagnostic symptoms of mental disorders, such as MDD and BD. Two such diagnostic symptoms for MDD are negative mood and lowered cognitive function. Negative mood is a core diagnostic symptom of MDD and is one of the diagnostic symptoms of the depressive state of BD [10].

One of the factors that have been shown to be correlated with and cause the depressive mood is Mind Wandering (MW) colloquially referred to as the autopilot mode. According to multiple research projects, individuals spend between 15 and 46 percent of their awake time in MW including daydreaming, thinking about memories, and planning for the future [11-13]. Several studies have shown a positive correlation between MW and depressive mood [14-17]. However, these studies focused on the content of MW rather than the direction of thoughts and investigating MW while doing the cognitive tasks. Further analysis of the relationship between MW and depressive mood has been conducted by a large scale (2250 participants), which showed that MW is the cause of negative mood [11], not its consequence [18].

The other important diagnostic factor for MDD and BD is diminished cognitive functions [10]. Much like it is the case with negative mood, MW has also been reported to have a negative effect on different aspects of cognitive function from working memory capacity, attention control, reading comprehension, to fluid intelligence since during MW people are engaged with self-related thoughts which are related to their internal world [19-24]. Studies have investigated the MW using various experimental definitions including task-unrelated thoughts, stimulus-independent thoughts [25, 26], inner speech [27], spontaneous thoughts [28], and self-generated thoughts [29, 30]. However, a more detailed definition of MW considers it as the change in the content and direction of thoughts in a way that shifts away from the task at hand or external environment to internal environment such as memories, spontaneous thoughts, and emotions. Based on this definition, MW has two aspects: one is the content and the other is the dynamic [13, 31]. MW describes the capacity to yield spontaneous thoughts, including both internally- and externally-oriented thoughts [28, 31-33]. Internally-oriented thought includes concern, events, and objects related to the self, including memories, while externally-oriented thoughts are related to external events, including their sensory constellation [33, 34]. Depressed subjects suffering from MDD and BD show typically increased frequency of internally-oriented thought contents which are abnormally negative, past-oriented, highly self-related, and less social [17, 30, 35, 36].

Although there are many studies that have examined the relationship between the content of MW with depressive mood [30], there are only a few studies which have focused on the number and duration of thought direction in MW. Moreover, these studies have all been done in healthy participants rather than a clinical population. A novel method for measuring the dynamic of MW is utilizing the experience sampling method to record the

internal and external awareness during the brain's resting state [33].

Despite its potential importance, the dynamic features of MW have not been studied among patients with MDD and BD. Furthermore, the difference of dynamics between the healthy and clinical population has not been investigated and more specifically, the relationship between the dynamics of MW and depressive mood has not been addressed, neither in healthy individuals nor in individuals with MDD and BD.

The present study aimed to investigate potential differences in the duration and number of external to internal direction thoughts during the mind wandering between healthy participants and MDD and BD patients. Furthermore, this study aimed to clarify whether these features of MW are correlated to the present symptoms of depression in MDD and BD patients.

## Method

Participants included 30 healthy controls, 30 acute depressed MDD diagnosed participants, and 30 acute depressed BD diagnosed participants (Table 1, more details and descriptive demographic data can be found in the online Supporting Information, prefixed as "S1").

The volunteer, healthy control subjects were screened by a licensed mental health clinician using the SCID-5-RV Screening Form [37]. Our control group did not meet the criteria for any current or lifetime Axis I disorders assessed. The control participants scored below standardized cut-offs on the BDI-II. For all of the groups, the inclusion age criteria were considered to be 18 to 59 years old. The exclusion criteria for all groups included a history of severe head trauma (TBI), stroke, neurological disease, severe medical illness (e.g., autoimmune disorder), and current alcohol or substance abuse.

MDD and BD participants were recruited from the Royal Mental Health Centre affiliated by the University of Ottawa via recruitment emails at the Royal Mental Health Centre, through the internal information bank of patients, Meditech, and direct contact with psychiatrists and mental health centers. It was ensured that MDD and BD were the primary diagnoses. The current depressive mood status for all subjects was verified according to DSM-5 criteria and cut-off scores from the BDI-II. All MDD and BD participants were receiving psychotropic medication.

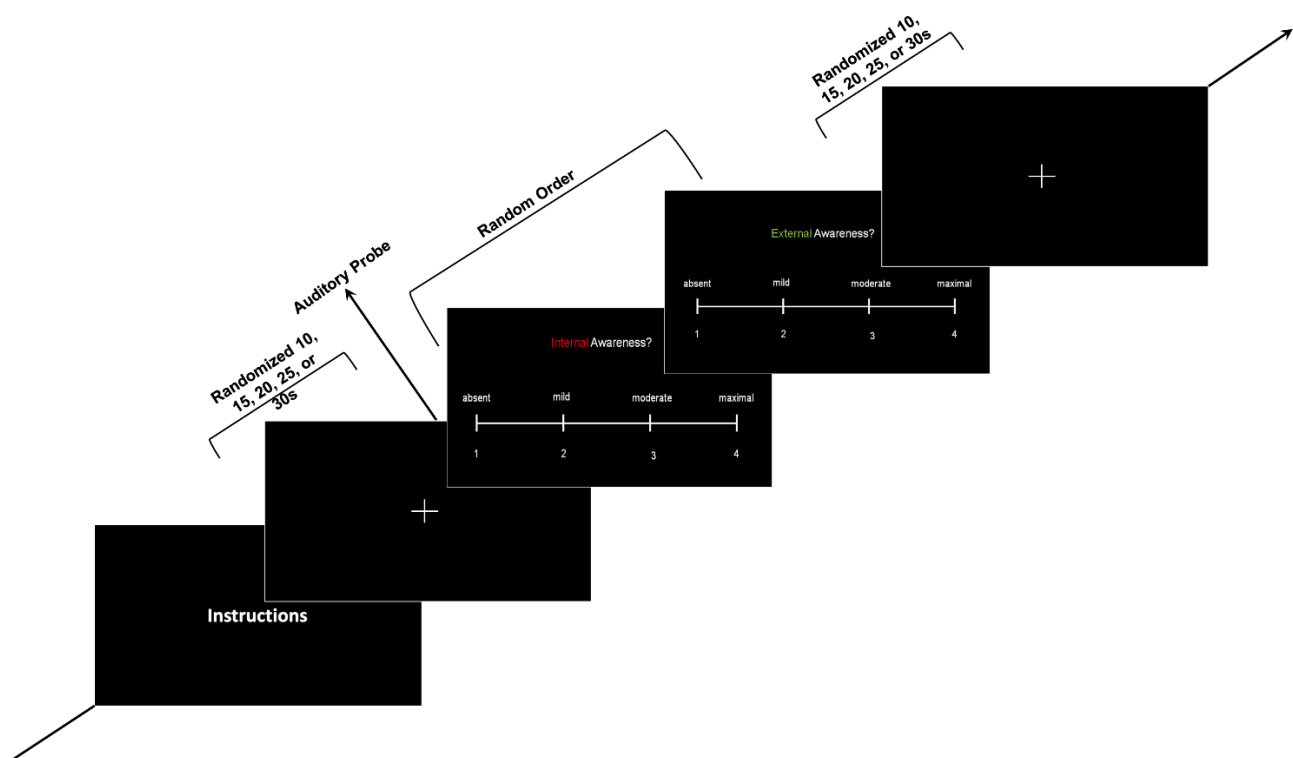
Subjects were studied individually. At first, informed consent was obtained prior to the study. Then, the screening interview was performed by a licensed mental health practitioner in terms of accessing the inclusion and exclusion criteria. Next, subjects completed the MW experiment. Finally, they filled out the psychological questionnaire, BDI-II.

**Mind Wandering Experiment:** This behavioral experiment was designed based on the probe-caught Experience Sampling Method (ESM) to assess the dynamics of mind wandering based on the shift between the internal and external awareness. Before each experiment, subjects received the following instruction: "During the following time period, we ask you to keep your eyes open and to avoid prolonged structured

thinking, such as counting or singing. When you hear a beep, please use the keyboard to communicate the intensity of 'external awareness' and 'internal awareness' ongoing prior to the beep. 'External' is here defined as the perception of environmental sensory stimuli (e.g., auditory, visual, olfactory, or somesthetic). 'Internal' here refers to all environmental stimuli-independent thoughts (e.g., inner speech, autobiographical memories, or wandering thoughts)." The rates of the external and internal direction of thoughts were recorded using a keyboard. The experiment took place in a quiet room where the subjects sat comfortably in a chair facing the keyboard used for recording awareness scores. Subjects placed four fingers of both hands (not the thumb) on the keyboard. For the first behavioral study, for half of the subjects, the left hand corresponded to external awareness (for the other half, the left hand corresponded to internal awareness; randomized order). All subjects

instructed to start responding by using button presses of their left hand on a four-point scale (0 = absent; 1 = mild; 2 = moderate; 3 = maximal). The subjects' task was to rate both external and internal awareness (prompted by a 60-dB beep will present via headphones), as defined in the instruction mentioned above. Only when the two scores were given, could the next beep be elicited. Inter-stimulus interval was randomized between 10s and 30s with 5 intervals – 10s, 15s, 20s, 25s, 30s. A familiarization session (11 responses) preceded the main experiment (66 responses) (Figure 1) [33]. This experiment was coded and performed through PsychToolbox in MATLAB.

In terms of reliability, this experimental protocol was performed for healthy subjects by Demertzi et al. [38]. The results of Vanhaudenhuyse et al.'s study [33] was repeated in their experiment and the same dynamic for the internal and external thoughts was observed.



**Figure 1.** Schema of Probe-caught Experience Sampling Paradigm during Mind Wandering

Screening Module of Structured Clinical Interview for DSM-5, Research Version (SCID-5-RV)

The patient and non-patient versions of screening module of SCID-5 were applied to screen the inclusion and exclusion criteria in participants. This module includes the open-ended questions which contains demographic information, educational and occupational history, history of psychiatric disorders, hospitalization history, suicidal ideation, suicide attempts, current problems, alcohol and substance abuse and addiction in the non-patient form, in addition to the chief complain, history if mental disorder, symptoms, relapse, and treatment history parts in the patient form [37].

**Beck Depression Inventory-II (BDI-II):** This self-report inventory is the revised version of the Beck Depression

Inventory which was designed for assessing the severity of depression. The current version contains 21 items and covers all the factors of depression based on the cognitive theory of depression. The scale provides a total score and a grade on the depression severity (subclinical, mild, moderate, and severe). The BDI-II is answered on a scale ranging from 0 to 3, with a final score between 0 and 63 points. The higher the score, the greater the symptoms' severity. When analyzing the scores, individual's scores are added up and the 0-9 score is considered as without depression, 10-18 light depression, 19-29 moderate depression and 30-63 as major depression [39]. Different studies have confirmed psychometric characteristics of the questionnaire. In a study, the alpha Cronbach of the questionnaire was reported 92, its inter- item coefficient

reported .35, correlation with other instruments including anxiety .53 and behaviors related to suicide was reported .57 for this questionnaire [40].

To assess the dynamics of thought during the MW, first, we calculated the number of events, change in events with respect to internal vs external awareness, that is, the direction of thoughts. Also, we calculated the duration of events. Then, using Chi-square and analysis of variance (ANOVA) methods, we investigated the difference between groups.

The Spearman correlation method calculated the correlation between the occurrence of internal and external thoughts and current depressive symptoms (BDI-II), and Pearson correlation coefficient calculated the correlation between the duration of thoughts and BDI-II scores. The statistical analyses were calculated by IBM SPSS Statistics 26 software.

**Results**

The demographic information and descriptive data related to BDI and MW are presented in Table 1. The differences between BDI scores have also been

investigated between groups using ANOVA.

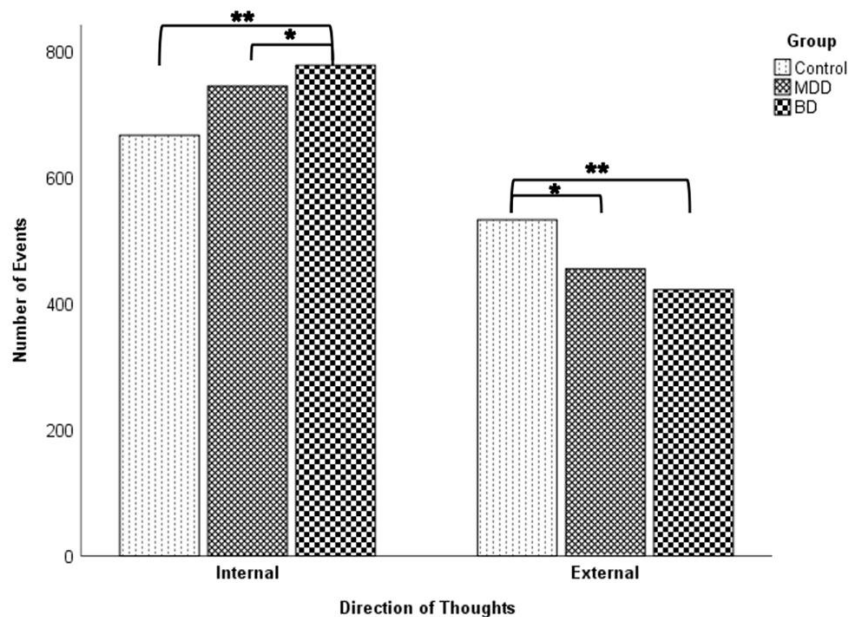
To investigate the number of internally- and externally-oriented thoughts, we calculated the number of internally- and externally-oriented thoughts in our groups using the Chi-square test. As the results showed, groups are significantly different based on the number of internally- and externally-oriented thoughts, Control and MDD:  $\chi^2(1, 2400) = 10.47, p < .001$ ; Control and BD:  $\chi^2(1, 2400) = 21.43, p < .001$ . There was no significant difference between the MDD and BD groups in the number of external and internal thoughts during MW. The control group had a significantly lower number of internally-oriented thoughts in comparison with MDD and BD groups. Moreover, the number of internally-oriented thoughts in MDD was lower than in BD. The control group had a significantly higher level of externally-oriented thoughts than both MDD and BD (Figure 2).

To examine the difference in duration of internally- and externally-oriented thoughts between groups, a one-way analysis of variance (ANOVA) test was performed after running the Levene's test (Table 2).

**Table 1. Demographic and Descriptive Data**

	HC	MDD	BD
Number of Samples	30	30	30
Number of Female Participants	25	25	16
Age -- Mean (SD)	29 (8.99)	30.26 (9.63)	32.47 (9)
BDI-II -- Mean (SD)	6 (4.88)	27.06 (11.83)	23.80 (11.41)
Number of Internal Thoughts	667	745	778
Number of External thoughts	533	455	422
Duration of Internal Thoughts -- Mean (SD)	446500 (189528.22)	546166.67 (130962.5)	555833.33 (172217.2)
Duration of External Thoughts -- Mean (SD)	353500 (189528.23)	253833.33 (130962.5)	244000 (172233.8)

The duration of thoughts are based on millisecond



**Figure 2.** The Differences of Internal and External Thoughts during Mind Wandering between Groups using Chi-square Test

**Table 2. ANOVA Test Results of Duration of Thoughts during Mind Wandering between Groups**

	Sum of Squares	df	Mean Square	F	p
Duration of Internal Thoughts	21980666666.66	2	10990333333.33	3.98	0.02
Duration of External Thoughts	22020388888.88	2	11010194444.44	3.99	0.02

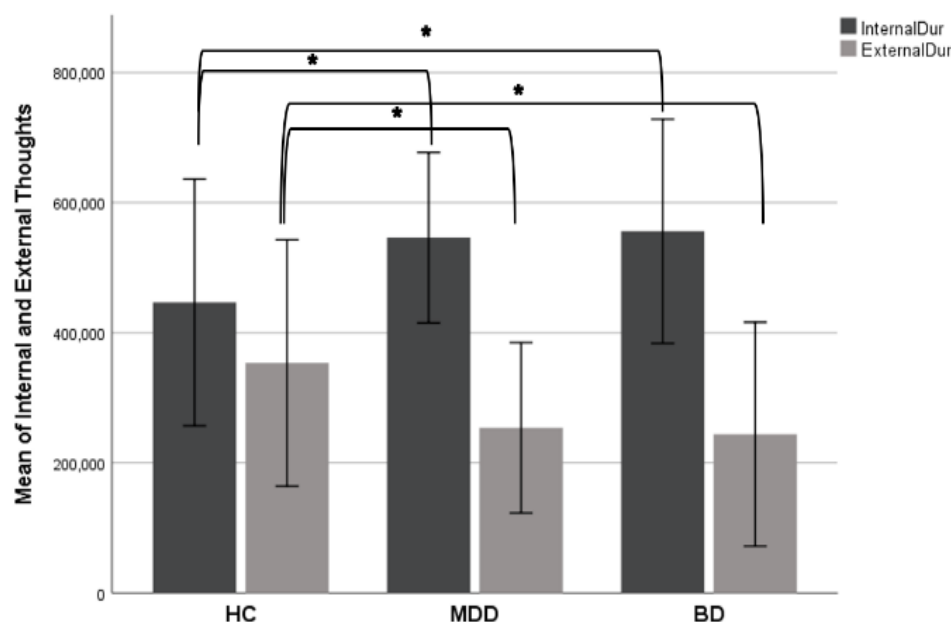
The analysis of the duration of internally-oriented thoughts showed that their duration was significantly different between groups,  $F(2, 89) = 3.98, p < .05$ . The Least Significant Difference (LSD) post hoc test revealed that this duration was the longest in the BD group compared to MDD ( $p < .05$ ) and control ( $p < .05$ ) groups. The results showed that the duration of externally-oriented thoughts was significantly different between groups,  $F(2, 89) = 3.99, p < .05$ . LSD post hoc test revealed a significantly longer duration of externally-oriented thoughts in the control group than in BD ( $p < .05$ ). Moreover, this duration was longer in the MDD group compared to the BD group ( $p < .05$ ) (Figure 3).

By converting the unit from millisecond to minute, these results become more observable and applicable. It showed that healthy individuals spend about five minutes of the whole experiment time (13 minutes), on internal thoughts. This is while the MDD group spent 9.10 minutes

and the BD group spent 9.26 minutes on the internally-oriented thoughts during this experiment.

To investigate the relationship between the direction of thoughts during the MW and depression, we first correlated the measures of number of thoughts and duration of thoughts with the current depressive symptoms score in all participants (Table 3). This yielded a significant correlation of the duration of internally- and externally-oriented thoughts with the current depressive symptoms.

Generally, the following relationships were obtained: the longer internal thoughts during MW, the higher degrees of depressive symptoms,  $r = .23, p < .05$ . The result showed a significant negative correlation between the duration of external thoughts and BDI scores as well (Figures of correlations can be found in the online Supporting Information, prefixed as "S2").



**Figure 3.** LSD Post Hoc results for Differences of Duration of Internal and External Thoughts during Mind Wandering between Groups

**Table 3.** Spearman and Pearson Correlation between the Features of MW and Depressive Symptoms

	Number of Internal Thoughts	Number of External Thoughts	Duration of Internal Thoughts	Duration of External Thoughts
BDI-II	0.179	-0.204	.232*	-.232*

## Discussion

The current study investigated how the abnormal thought contents in acute depressed MDD and depressed BD individuals, are related to their changes over time, i.e., thought dynamics. The obtained results indicated that: (I) increased number and duration of internally-oriented thought contents in both MDD and BD patients (compared to healthy individuals); (II) positive correlation between internally-oriented thoughts during MW and depressive symptoms; (III) calculation of spending time on internally-oriented thoughts in healthy individuals, patients with MDD and BD for clinical purposes.

The presence and higher level of self-focused thoughts are well known in depression [16, 32, 35, 36, 41-44]. This converges well with our first finding of an increased number of internally-oriented thoughts in depressed

MDD and BD compared to healthy individuals. Besides, internally-oriented thoughts also showed a longer duration compared to externally-oriented thoughts. This suggests that the direction of the thought content (i.e., internally- or externally-oriented) is accompanied by differential temporal characterization: shorter duration of externally-oriented thoughts and longer duration of internally-oriented thoughts.

Our results are also consistent with previous studies [17, 30, 35, 36] regarding the significant relationship between the duration of MW and depressive mood while there was no significant correlation between the number of internal thoughts with the severity of depression. However, there have not been any studies found on the duration of MW among the clinical populations, specifically free of a cognitive task and in the controlled laboratory setting.



These findings offer a novel understanding of MW and the importance of paying attention to the direction of thoughts beside the content of thoughts in depression, which carry major implications for both the clinical diagnosis and therapy of depression in MDD and BD. Future studies can consider the factor of contents of thoughts during MW with the direction of thoughts to assess, for example, to what extent the 5-minute internally-oriented thoughts in healthy individuals is related to the emotional and socio-temporal contents. It can provide more clarification about the difference of MW between patients and healthy individuals. Moreover, further research can investigate whether there is a difference between the other psychiatric disorders in terms of the duration of direction and content of thoughts during MW.

### Conclusion

The findings of the present study demonstrated abnormal thought dynamics in acute depressed MDD and BD. Specifically, we observed a higher number and longer duration of internally-oriented thoughts. Further investigations based on our study may yield insights about clinical implications for the therapy of MDD and BD. Our data showed both similarities and differences in thought dynamics of MDD and BD. Even more important, considering the meaningful difference of duration of internal thoughts between groups (about 5 minutes for healthy individuals and 9 minutes for patients) may facilitate creation of more individually-tailored therapeutic interventions such as rumination-focused psychotherapy methods [45] and mindfulness-based psychotherapeutic methods; for example, focused attention meditation [46] which focus on making the balance between attention to our internal and external world.

### Conflict of Interest

The authors declare that they have no conflicts of Interest.

### Ethical Approval

The study was carried out with the approval of the research ethics committee of the University of Ottawa Institute of Mental Health Research (REB#2016004), and all aspects of the experiment were performed according to the relevant guidelines and regulations of the University of Ottawa and its associated research institute. Informed written consent was obtained from all subjects prior to study participation.

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