Intentional and unintentional mind-wandering in Korsakoff syndrome

Mohamad El Haj, Jean-Louis Nandrino

Short title: mind-wandering

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Mohamad EL HAJ [1, 2, 3]

Jean-Louis NANDRINO [4]

[1] Nantes Université, Univ Angers, Laboratoire de Psychologie des Pays de la Loire (LPPL - EA 4638), F-44000 Nantes, France

[2] Unité de Gériatrie, Centre Hospitalier de Tourcoing, Tourcoing, France

[3] Institut Universitaire de France, Paris, France

[4] Univ. Lille, CNRS, CHU Lille, UMR 9193 SCALab, Sciences Cognitives et Sciences Affectives, F-59000 Lille, France

Correspondence concerning this manuscript should be addressed to :

Mohamad EL HAJ

Faculté de Psychologie, LPPL – Laboratoire de Psychologie des Pays de la Loire, Université de Nantes, Chemin de la Censive du Tertre, BP 81227, 44312 Nantes Cedex 3, France. E-Mail: mohamad.elhaj@univ-nantes.fr

Mind-wandering refers to the intentional and unintentional tendency to withdraw from the external environment and engage in internally generated thoughts. We investigated intentional and unintentional mind-wandering in patients with Korsakoff syndrome (KS). We invited 31 patients with KS and 33 control participants to answer a questionnaire probing intentional and unintentional mind-wandering. Analysis demonstrated higher intentional and unintentional mind-wandering in patients with KS than in controls. However, no significant differences were observed between intentional and unintentional mind-wandering in patients with KS or in controls. Significant positive correlations were observed between intentional and unintentional mind-wandering and depression in patients with KS but not with cognitive controls. Our results demonstrate a high intentional and unintentional tendency in patients with KS to shift attention away from the external environment to internal thoughts/feelings that are unrelated to the ongoing task. This tendency may be associated with the activation of negative thoughts/beliefs, as observed in depression.

Keywords*:* Korsakoff syndrome; mind-wandering; intentional mind-wandering; unintentional mind-wandering

1. Introduction

The human brain tends to shift from processing external stimuli to drift into internally generated thoughts that are unrelated to the external environment (Kane et al., 2007; Killingsworth & Gilbert, 2010). This mind-wandering experience can represent between 30% and 50% of our daily thoughts (Kane et al., 2007; Killingsworth & Gilbert, 2010). The study of mind-wandering is not only relevant due to its frequency but also because it can hamper cognitive performance and even safety. For instance, high levels of mind-wandering can decrease performance on intelligence tests (Mrazek et al., 2012a) and retention of university lecture content (Risko et al., 2012). The tendency to disengage from the ongoing task to shift toward unrelated thoughts (i.e., mind wandering) may thus decrease cognitive performances. We thus assessed mind wandering in patients with Korsakoff syndrome (KS) as mind wandering may decrease their attentional bias and even their performances during cognitive testing.

Mind-wandering is not a unitary concept but has two general dimensions: intentional and unintentional (Seli et al., 2017). Intentional mind-wandering involves the voluntary disengagement of consciousness experience from the external environment toward internal states, whereas unintentional mind-wandering involves the involuntary disengagement of consciousness experience toward internal states (Seli et al., 2017). Because both intentional and unintentional mind wandering can result in attentional bias and cognitive errors, and even depression (Figueiredo et al., 2020), we investigate mind wandering in patients with KS.

KS is an acute neurologic syndrome caused by prolonged heavy ingestion of alcohol coupled with malnutrition and thiamine deficiency (Arts et al., 2017). KS can be defined with the DSM-IV and ICD-10 criteria of “alcohol-induced amnesic syndrome” which refers to the negative effects of heavy ingestion of alcohol on memory and general cognitive functioning.

However, the key feature of KS is decline of episodic memory and confabulations, i.e., the production of memories that are unintentionally incongruous with respect to the person's history, background, and present situation (Borsutzky et al., 2008; Kessels et al., 2008; Rensen et al., 2017). Besides being associated with episodic memory decline, KS is associated with executive dysfunction (Brion et al., 2014; Moerman-van den Brink et al., 2018; Moerman-van den Brink et al., 2019; Pitel et al., 2008). Executive dysfunction in KS is characterized by general decline in the ability to plan and perform goal-directed actions, and especially by decline in the ability to suppress irrelevant responses (i.e., decline in inhibition) (Brion et al., 2014; El Haj, Kessels, & Nandrino, 2020; El Haj, Kessels, Urso, et al., 2020; Van Oort & Kessels, 2009).

In this paper, we investigated the relationship between intentional/unintentional mind-wandering and cognitive dysfunction in KS. We reasoned that decline in cognitive control in KS might hamper the ability of patients to maintain their focus on an ongoing task, resulting in a low ability to resist mind-wandering. Cognitive control, an umbrella term for a variety of cognitive processes such as working memory and executive function, serves to adjust our behavior so that performance on ongoing tasks is optimized (Botvinick et al., 2001). This control is typically involved in performing non-automated tasks, which are associated with low levels of mind-wandering (Smallwood & Schooler, 2006). Based on these considerations, we investigated the potential relationship between decline in cognitive control and mind-wandering in KS. We evaluated cognitive control with regard to working memory and inhibition. Working memory, as typically evaluated with the spans task, regulates thoughts, actions, and, critically, the ability to maintain activated goals and focus on the ongoing task (Conway et al., 2005; Hasher et al., 2007). Therefore, decline in working memory as observed in KS (El Haj, Kessels, Urso, et al.,

2020) may result in a tendency to shift from the ongoing task to internal thoughts and, consequently, in cognitive errors.

Besides the working memory account, we investigated the potential relationship between mind-wandering in KS and decline in inhibition. We targeted inhibition because it has been considered as a key executive function involved in cognitive control (Miyake et al., 2000). We also targeted inhibition because decline in inhibition hampers the ability to resist interference, resulting in the processing of task-unrelated information (Hasher & Zacks, 1988). We reasoned that decline in inhibition, as observed in KS (Brion et al., 2014), may lead to processing of task-irrelevant thoughts at the expense of the ongoing activity (i.e., in mind-wandering). Therefore, we assessed whether mind-wandering in KS is associated with decline in inhibition.

Besides the working memory and inhibition accounts, we investigated the potential relationship between mind-wandering and depression in KS. Individuals with depressive symptoms tend to demonstrate high levels of mind-wandering (Figueiredo et al., 2020; Ottaviani et al., 2013; Watts et al., 1988). According to Smallwood et al. (2009), negative mood decreases the amount of attentional commitment to a task, probably by enhancing the focus on task-irrelevant thoughts, resulting in decreased mind-wandering. In a related vein, Killingsworth and Gilbert (2010) conducted a mobile-based study in which they assessed ongoing the thoughts, feelings, and actions of 2,250 participants. They observed that “a wandering mind is an unhappy mind”. Together, research suggests a relationship between mind-wandering and depression. Because depression may be observed in KS (Cocksedge & Flynn, 2014), one would expect a relationship between mind-wandering and depression in patients with KS.

Taken together, although mind wandering can be associated with attentional bias and cognitive errors, and even depression, little is known about mind wandering in KS. We thus

evaluated mind wandering in patients with KS. More specifically, we assessed the relationship between intentional/unintentional mind wandering and decline in working memory and inhibition in KS. We reasoned that decline in working memory and inhibition in KS might be associated with a tendency to shift from the ongoing task to internal thoughts (i.e., mind-wandering). We further assessed the relationship between mind-wandering and depression in KS. We reasoned that negative mood might be associated with increased lapses and the frequency of task-irrelevant thoughts in KS (i.e. with increased mind-wandering).

2. Method

2.1. Participants

The study included 31 patients diagnosed with KS (18 women and 13 men; *M* age = 57.81 years, *SD* = 5.43; *M* years of formal education = 8.87, *SD* = 3.20). Diagnosis was made by psychiatrists using the DSM-V criteria for alcohol-induced persisting amnestic disorder. Diagnosis was also based on extensive history of alcoholism and nutritional depletion, notably thiamine deficiency. Patients were in a chronic (more than one-year post-onset) and stable condition at the time of testing, so they presented no confusional Wernicke psychosis or other signs of alcohol-related dementia. As a control group, the study included 33 participants without neurological or psychiatric history and without previous or current substance addiction (20 women and 13 men; *M* age = 55.91, years, *SD* = 5.36; *M* years of formal education = 9.91, *SD* = 4.51). The control participants were matched with KS patients on gender [$\chi^2(1, N = 64) = .04$, $p = .84$], age [$t(62) = 1.41$, $p = .16$] and educational level [$t(62) = 1.06$, $p = .29$]. The study was conducted in compliance with principles involving human volunteers in the Helsinki Declaration

and participants provided written informed consent to participate and were free to withdraw whenever they wished.

2.2. Cognitive and clinical assessment

We evaluated general cognitive functioning, working memory, inhibition, and depression. Scores are summarized in Table 1. General cognitive functioning was evaluated with the Montreal Cognitive Assessment (Nasreddine et al., 2005), a 30-point cognitive test that evaluates several cognitive domains such as orientation, attention, language, and visuospatial memory. Working memory was assessed using the digit span task (Wechsler, 2008), in which participants had to repeat a string of single digits in the same order as they were presented (i.e., digit span forward) or in reverse order (i.e., digit span backward). Regarding inhibition, we used the Stroop Color Word Test (Stroop, 1935) consisting of three subtests: word-reading, color-naming and color-word interference. In the word-reading subtest, participants were asked to read 100 color names printed in black ink. In the color-naming subtest, participants were asked to name the color of 100 colored ink squares. In the color-word interference subtest, participants were asked to name the color of 100 color-words printed in incongruously colored ink (for instance, the word "yellow" was written in green). The score was the completion time for the interference condition minus the average completion time for word-reading and color-naming; a higher score indicates lower inhibitory ability. We evaluated executive function regarding inhibition following the model of Miyake et al. (2000) who considered inhibition as a core process that encompasses main executive functions such as flexibility and updating. This model also proposed the Stroop task as a reliable evaluation of inhibition. Regarding depression, we used the Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983), a 7-item instrument in which

each item is scored from zero (not present) to three (considerable). The maximum score is 21 points.

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2.2.1. Mind-wandering assessment

We assessed mind-wandering with the 8-item scale developed by Seli et al. (Seli et al., 2017; Seli et al., 2016). Four items assess intentional mind-wandering: “I allow my thoughts to wander on purpose”, “I enjoy mind-wandering”, “I find mind-wandering is a good way to cope with boredom”, and “I allow myself to get absorbed in pleasant fantasy”. These items were followed by four other items assessing unintentional mind-wandering: “I find my thoughts wandering spontaneously”, “When I mind-wander, my thoughts tend to be pulled from topic to topic”, “It feels like I don’t have control over when my mind wanders”, and “I mind-wander even when I’m supposed to be doing something else”. Each item was scored on a 7-point Likert scale ranging from rarely (one point) to a lot (seven points). The scale was printed on an A4 sheet of paper and participants were invited to fill it in. Before this, we provided participants with the following instruction: “Mind-wandering refers to the situation in which attention shifts away from what you are doing to thoughts unrelated to what you are doing. For the following items, please select the degree that most accurately reflects your everyday mind-wandering”. We analyzed scores on the intentional and unintentional scales regarding means on each scale, high scores indicating a higher a greater tendency to engage in mind-wandering.

As for translation validity of our mind-wandering scale, the items were translated from English as proposed by Seli et al. (Seli et al., 2017; Seli et al., 2016), into French language by an expert in both French and English. Translation validity was afterward verified via reverse

translation using a different specialist translation to ensure the conceptual and functional equivalences of the translation. The Cohen Kappa between the original and reverse "English" version of the questionnaire = .94.

2.2.2. Data analysis

We analyzed the dependent variable by comparing mean scores (ranging from one to seven points) on the intentional and unintentional mind-wandering scales between patients with KS and controls. Non-parametrical tests were used due to the abnormal distribution of data observed with the Shapiro-Wilk test (see Annexe1). We compared between-group scores with the Mann-Whitney U test and within-group scores with the Wilcoxon signed rank test. We also carried-out Spearman correlations between mind-wandering, general cognitive function, span tasks, inhibition and depression in patients with KS and controls. For all tests, level of significance was set at $p \leq 0.05$, and p values between 0.051 and 0.10 was considered as trends, if any. Results were reported with effect size; $d = 0.2$ can be considered a small effect size, $d = 0.5$ represents a medium effect size and $d = 0.8$ refers to a large effect size. Effect size was calculated for non-parametric tests according to the recommendations of Rosenthal and DiMatteo (2001) and Ellis (2010).

2.3. Results

2.3.1. Higher mind-wandering in patients with KS than in controls

Mean scores on the intentional and unintentional mind-wandering scales in patients with KS and controls are shown in Figure 1. Compared to controls (*Median* = 4.00), patients with KS (*Median* = 2.00) reported higher intentional mind-wandering ($Z = -3.73$, $p < .001$, Cohen's $d = 1.04$). Compared to controls (*Median* = 4.00), patients with KS (*Median* = 2.00) also reported

higher unintentional mind-wandering (Z = -3.50, $p < .001$, Cohen's $d = .96$). No significant differences were observed between intentional and unintentional mind-wandering in patients with KS (Z = -.73, $p = .47$, Cohen's $d = .26$) or in controls (Z = -.87, $p = .38$, Cohen's $d = .31$).

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2.3.2. Correlations between depression and mind-wandering in patients with KS

As demonstrated in Table 2, significant correlations were observed between depression and intentional and unintentional mind-wandering in patients with KS.

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3. Discussion

We investigated intentional and unintentional mind-wandering in KS. Results demonstrated higher intentional and unintentional mind-wandering in patients with KS than in controls. However, no significant differences were observed between intentional and unintentional mind-wandering in patients with KS or in controls. Significant positive correlations were observed between intentional and unintentional mind-wandering and depression scores in patients with KS. In other words, higher scores on intentional and unintentional mind-wandering were correlated with higher depression scores in patients with KS.

Patients with KS demonstrated higher intentional and unintentional mind-wandering than controls. In other words, they showed high voluntary and involuntary disengagement of attention from ongoing task-unrelated thoughts and internal states. Despite being physically confined to the present, patients with KS seem both intentionally and unintentionally to shift from processing external stimuli to drifting into an introspective state of an internal world that may transcend

physical time and space. Interestingly, their tendency to shift toward these internal states seems to depend on both voluntary and involuntary processes. This assumption is supported by the lack of significant differences observed here between intentional and unintentional mind-wandering in patients with KS.

Another key finding is the significant correlation between mind-wandering and depression in patients with KS. This mirrors research demonstrating how negative mood results in mind-wandering (Killingsworth & Gilbert, 2010; Smallwood & O'Connor, 2011). Research has evidenced high levels of mind-wandering in individuals with depressive symptoms, especially those who are clinically depressed (Watts et al., 1988) and dysphoric (Carriere et al., 2008). While this research considers depression as a factor underlying mind-wandering, other research considers mind-wandering as a consequence of depression. The latter view is supported by a study by Killingsworth and Gilbert (2010), who collected real-time reports of mind-wandering and happiness in a large cohort and found that mood was lower after mind-wandering than before it. Regardless of the direction of this relationship, mind-wandering is intimately intertwined with depression, a relationship that may be mediated by mechanisms such as worry and rumination. The relationship between mind-wandering and worry and rumination was proposed by Ottaviani et al. (2013), who suggested that mind-wandering becomes an inflexible rigid process when occurring in forms of rumination or worry, and that it therefore fails to serve its adaptive function and becomes a risk factor for mental health. This hypothesis is appealing because rumination and worry have been typically described as major symptoms of depression as well as vulnerability factors for major depression disorder (Nolen-Hoeksema & Morrow, 1991). Thus, rumination and worry, which are key characteristics of depression, can influence mind-wandering in patients with KS through the activation of negative thoughts/beliefs, and/or

negative past and future thinking. This activation may exacerbate mind-wandering and increase the tendency of patients with KS to shift towards internal negative internal states and concerns. While appealing, this hypothesis should be confirmed by future research on the role of negative thoughts/beliefs, and even negative past and future thinking, in mind-wandering in KS.

Unlike our hypothesis about the relationship between mind-wandering and depression, the hypothesis about mind-wandering and cognitive function/cognitive control is disproven. While KS is characterized by decline in general cognitive performances, our analysis did not demonstrate any significant correlations between mind-wandering and scores on the Montreal Cognitive Assessment. Thus, general cognitive decline in KS seems to have little, in any, relationship with mind-wandering. The same thing can be said for working memory and inhibition. While working memory and inhibition may serve to maintain attention on the ongoing task and thus support resistance against mind-wandering, our analysis did not demonstrate any significant correlations between mind-wandering and working memory or inhibition. These findings are at odds with research demonstrating that low working memory results in a high occurrence of mind-wandering (McVay & Kane, 2009, 2011; Mrazek et al., 2012b; Unsworth & McMillan, 2013), and with a study demonstrating how executive function underlies mind-wandering (Kane & McVay, 2012). This apparent inconsistency can be attributed to the laboratory nature of research demonstrating a relationship between mind-wandering and cognitive control. It may be that in the laboratory, people with lower cognitive control mind-wander more frequently than those with higher cognitive control. In a similar vein, our assessment probes everyday mind-wandering rather than mind-wandering during demanding tasks. Thus, the lack of significant correlations between mind-wandering and working memory

or inhibition can be attributed to the fact that our assessment did not include mind-wandering during demanding tasks. This could be considered as a limitation of the study.

Although the distinction between intentional and unintentional mind wandering has been largely established by the literature, our study suggests that intentional and unintentional mind wandering are equally impacted by KS. In other words, our study demonstrates little differences between intentional and unintentional mind wandering in KS. This similarity can be attributed to neural factors. Both intentional and unintentional mind wandering involves the default mode network that includes the dorsal medial prefrontal cortex and medial temporal lobe (He et al., 2021; Mittner et al., 2017). These brain areas are negatively affected by ethanol neurotoxicity (Arts et al., 2017) and, consequently, by KS. Thus, damages in these brain areas may explain why both intentional and unintentional mind wandering are equally impacted by KS. This assumption should be however carefully considered because there is a lack of research on neural basis of mind wandering in KS.

Regarding control participants, normal aging has been associated with decreased mind-wandering (Giambra, 1993; Jackson & Balota, 2012; Krawietz et al., 2012; Seli et al., 2017). For instance, Krawietz et al. (2012) reported lower levels of mind-wandering in older adults than in younger ones. Interestingly, and in line with our findings, mind-wandering in the study by Krawietz et al. (2012) was not significantly correlated with the spans task. Similar findings were reported by Shake et al. (2016) who found that working memory did not account for mind-wandering in normal aging. Regarding the lack of significant correlations between mind-wandering and depression in control participants, this can be attributed to the low scores on the assessment of depression, not surprisingly as these participants were free of psychiatric and neurological disorders. In addition, the scores of control participants on the mind-wandering

scale might have prevented us from detecting significant correlations. The same applies for the near-to-ceiling effect on the Montreal Cognitive Assessment. This effect hampered not only correlations with mind-wandering but also with the other cognitive tasks. The small sample size might have prevented detection of the correlations.

Our study has several clinical implications. First, it would be of interest to evaluate whether mind-wandering hampers cognitive testing. Because our study demonstrates the tendency of patients with KS to disengage from the ongoing task to shift toward unrelated thoughts, it would be of interest to assess whether this tendency influences patients' performances during cognitive testing. Another clinical issue is the potentially positive effect of therapy such as mindfulness on mind-wandering in KS. This suggestion is based on a recent study assessing whether mind-wandering is decreased by mindfulness therapy in participants with depression; this study has demonstrated that both depression and mind-wandering may decrease after therapy. (Takahashi et al., 2020). It would be of interest to assess whether mindfulness can decrease excessive mind-wandering in patients with KS, especially when associated with rumination and negative thinking. Another suggestion for clinicians would be to consider strategies to decrease mind wandering in patients with KS, such as mindfulness. Research has suggested that mindfulness meditation training can foster on-task, sustained attention and, consequently, reduce mind-wandering (Mrazek et al., 2013). For instance, a study by Mrazek and Smallwood (2012) has demonstrated that mindfulness meditation training decreased mind-wandering in healthy adults.

To summarize, this is the first study to address mind-wandering in patients with KS. It demonstrates their tendency to shift from processing external stimuli to drifting into internally

generated thoughts that are unrelated to the external environment. This constitutes a valuable insight into the consciousness experience of patients with KS.

Conflict of interest

The authors declare no conflict of interest.

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Table 1

Cognitive and clinical performances of patients with Korsakoff syndrome and control participants

	Task	Korsakoff *n* = 31	Controls *n* = 33	Between-group comparisons
General cognitive functioning	MOCA	18.06 (1.96)	28.45 (1.46)	$t(62) = 24.11$, $p < .001$
Working memory	Forward spans	4.55 (.81)	5.88 (1.17)	$t(62) = 5.27$, $p < .001$
	Backward spans	3.90 (.75)	4.79 (1.08)	$t(62) = 3.78$, $p < .001$
Inhibition	Stroop	58.39 (10.55)	30.82 (10.84)	$t(62) = 10.48$, $p < .001$
Depression	HADS	6.90 (2.83)	3.64 (1.43)	$t(62) = 5.88$, $p < .001$

Note. Standard deviations are shown in parentheses; maximum score on MOCA (Montreal Cognitive Assessment) was 30 points; performances on forward and backward spans refer to number of correctly repeated digits; performances on Stroop task refer to reaction times, high scores indicating low inhibition; maximum score on HADS (Hospital Anxiety and Depression Scale) was 21 points.

Table 2.

Correlation matrix

		1.	2.	3.	4.	5.	6.	7.
Korsakoff	1. General cognitive functioning	-						
	2. Forward spans	r = .51, p = .003	-					
	3. Backward spans	r = .53, p = .002	r = .51, p = .003	-				
	4. Inhibition	r = -.51, p = .003	r = -.48, p = .006	r = -.50, p = .004	-			
	5. Depression	r = .-24, p = .063	r = .-32, p = .079	r = .-22, p = .23	r = .25, p = .17	-		
	6. Intentional mind-wandering	r = -.10, p = .59	r = .-29, p = .11	r = .-21, p = .24	r = .17, p = .36	r = .52, p = .003	-	
	7. Unintentional mind-wandering	r = -.08, p = .67	r = .-13, p = .48	r = .-11, p = .60	r = .18, p = .33	r = .51, p = .003	r = .55, p = .001	-
Controls	1. General cognitive functioning	-						
	2. Forward spans	r = .09, p = .62	-					
	3. Backward spans	r = .07, p = .70	r = .49, p = .004	-				
	4. Inhibition	r = -.10, p = .58	r = .46, p = .007	r = .48, p = .005	-			
	5. Depression	r = -.13, p = .47	r = .-09, p = .76	r = .-05, p = .78	r = -.12, p = .51	-		
	6. Intentional mind-wandering	r = -.06, p = .74	r = .-09, p = .76	r = .-10, p = .58	r = -.06, p = .74	r = .13, p = .47	-	
	7. Unintentional mind-wandering	r = -.05, p = .78	r = .10, p = .58	r = .08, p = .65	r = -.04, p = .82	r = .06, p = .74	r = .-09, p = .76	-

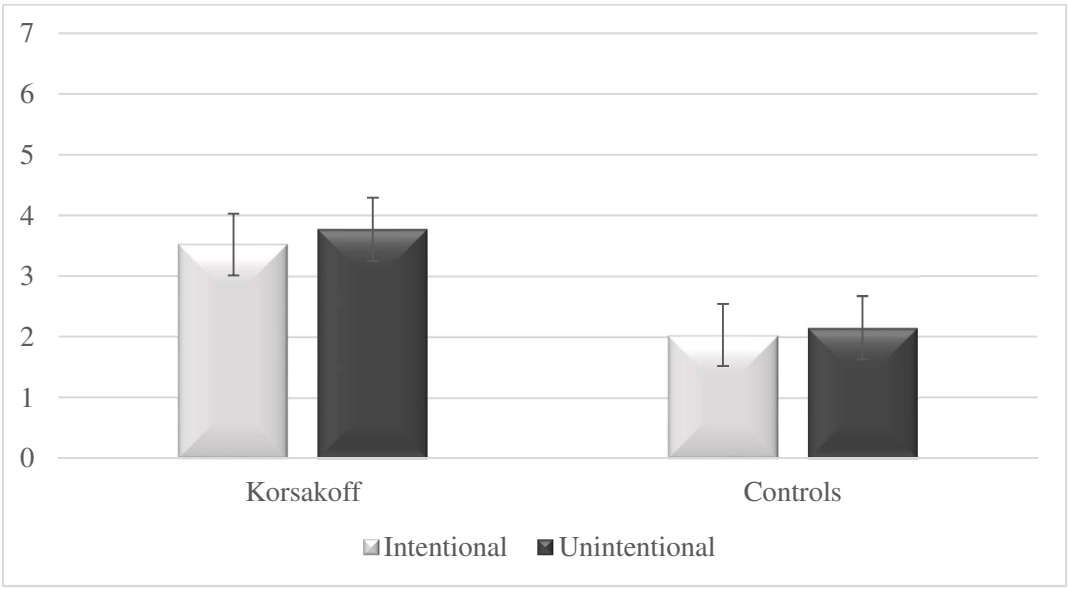

Figure 1.

Means on intentional and unintentional mind-wandering scales in patients with Korsakoff syndrome and controls; error bars are within 95% confidence interval

Note. Scores ranged from one to seven points.

Annexe1

Results of Shapiro-Wilk test related to all data:

	Korsakoff	Controls
Age	$W(31) = .82, p < .001$	$W(33) = .84, p < .001$
Educational level	$W(31) = .89, p < .001$	$W(33) = .90, p < .001$
MOCA	$W(31) = .83, p < .001$	$W(33) = .85, p < .001$
Forward spans	$W(31) = .80, p < .001$	$W(33) = .81, p < .001$
Backward spans	$W(31) = .89, p = .038$	$W(33) = .80, p < .001$
Stroop	$W(31) = .86, p = .001$	$W(33) = .90, p = .007$
HADS	$W(31) = .82, p < .001$	$W(33) = .85, p < .001$
Intentional mind wandering	$W(31) = .96, p = .269$	$W(33) = .94, p = .106$
Unintentional mind wandering	$W(31) = .95, p = .174$	$W(33) = .95, p = .153$