



**HAL**  
open science

## The thin line between reality and imagination: The imagination inflation effect in Korsakoff's syndrome.

Mohamad El Haj, Frédérique Robin

### ► To cite this version:

Mohamad El Haj, Frédérique Robin. The thin line between reality and imagination: The imagination inflation effect in Korsakoff's syndrome.. *Neuropsychology*, 2020, 34 (5), pp.569-577. <10.1037/neu0000635>. <hal-04840421>

**HAL Id: hal-04840421**

**<https://hal.science/hal-04840421v1>**

Submitted on 19 Dec 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

Short title: imagination

The thin line between reality and imagination: the imagination inflation effect in  
Korsakoff's syndrome

Mohamad EL HAJ<sup>1, 2, 3</sup>

Frédérique ROBIN<sup>1</sup>

<sup>1</sup> Nantes Université, Univ Angers, Laboratoire de Psychologie des Pays de la Loire (LPPL - EA 4638), F-44000 Nantes, France

<sup>2</sup> Unité de Gériatrie, Centre Hospitalier de Tourcoing, Tourcoing, 59200, France

<sup>3</sup> Institut Universitaire de France, Paris, 75000, 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](mailto:mohamad.elhaj@univ-nantes.fr)

**Objective:** The imagination inflation effect, which is a **form** of memory distortion, **occurs when imagining** an event **that** never happened **may** increase the tendency to falsely remember that it really occurred. We investigated this effect in Korsakoff's syndrome.

**Methods:** Our procedures consisted of two sessions and a recognition test. In Session 1, patients with Korsakoff's syndrome and controls listened to **statements of actions** (e.g., "hold the pen"), **enacted** the actions, or imagined performing the actions. In Session 2, participants imagined **statements of actions** from Session 1 as well as new **statements of actions** **once** or three times. On the recognition test, participants had to decide whether **statements of actions** were or were not **enacted** during Session 1.

**Results:** Analysis demonstrated that imagining performing the actions increased the tendency of both patients with Korsakoff's syndrome and controls to falsely recall the actions as having been **enacted**.

**Discussion:** Our findings suggest that patients with Korsakoff's syndrome are prone to the imagination inflation effect, an effect that can be attributed to difficulties with source monitoring.

**Keywords:** false memories; imagination; imagination inflation; Korsakoff's syndrome; source monitoring;

### **Key Points**

Question: this study investigates imagination inflation in patients with Korsakoff syndrome

Findings: we found that patients with Korsakoff syndrome are prone to the imagination inflation

Importance: our findings provide the first experimental evidence to the assumption that imagining an event **that** never happened **may** increase the tendency to falsely remember that it actually occurred

Next Steps: clinical studies should explore methods to reduce imagination inflation in Korsakoff syndrome.

The imagination inflation effect (IIE), **which is** a particular dimension of memory distortion, **occurs when** imagining an event **that** never happened can increase the tendency to falsely remember that it actually **did** (Garry, Manning, Loftus, & Sherman, 1996). The IIE is of particular relevance in research on false memory (Thomas, Bulevich, & Loftus, 2003). Research suggests that imagination drives people to falsely believe childhood experiences that never actually occurred (Garry et al., 1996; Garry & Polaschek, 2000; Goff & Roediger, 1998; Pezdek, Blandon-Gitlin, & Gabbay, 2006). The IIE can be evaluated with the procedures of Goff and Roediger (1998), who presented healthy young adults with statements describing actions such as “put the match in the box” and asked them to either listen to the actions being read, to imagine performing the actions, or to perform the actions. In another condition, the participants were **given** the previous statements of actions and were invited to imagine performing the actions zero, one, three, or five times. Afterward, the participants had to decide whether they had **previously heard** each **action** and, if so, whether they had previously **enacted**, imagined, or listened to the action. Participants tended to falsely believe they had **enacted** the actions after repeated imagination. **Furthermore**, and the more the actions were imagined, **the more robust was the false belief**.

The present study investigated the IIE in Korsakoff’s syndrome (KS). KS is a neurocognitive disorder that is related to chronic alcohol abuse coupled with a thiamine deficiency (El Haj & Nandrino, 2016; El Haj, Nandrino, Kessels, et al., 2017; Kopelman, Thomson, Guerrini, & Marshall, 2009; Oudman, Nijboer, Postma, Wijnia, & Van der Stigchel, 2015). At the cognitive level, KS is characterized by a compromise of episodic memory (El Haj, Gandolphe, Moustafa, & Nandrino, 2018; El Haj et al., 2016; El Haj & Nandrino, 2018; Fama, Pitel, & Sullivan, 2012; Kessels & Kopelman, 2012; Kessels, Kortrijk, Wester, & Nys, 2008; Postma, Van Asselen, Keuper, Wester, & Kessels, 2006). As for the IIE, the evaluation of its effect in KS is important

because compromise of the ability to remember whether an event was previously encountered or imagined can have significant functional consequences. For instance, patients may mistakenly believe they turned off the oven, locked the door, or even took their medications when they only imagined doing these actions. In addition to these safety and medical healthy considerations, IIE may be important for understanding confabulations. Confabulations, the cognitive hallmark of KS (Dalla Barba, Cipolotti, & Denes, 1990), are memories that **are attributed erroneously** to events that occurred at another **moment** or during another ongoing reality (El Haj & Larøi, 2016; Gilboa et al., 2006; Kopelman, 2010). Confabulations in KS can be attributed to the difficulties of patients with KS to distinguish between imagined events and real ones (Johnson & Raye, 1998). Therefore, the evaluation of IIE in KS is important for understanding memory distortions in the syndrome.

The evaluation of IIE in KS can be compared with that of source monitoring, i.e., the ability to remember the circumstances under which information was previously acquired (Johnson, Hashtroudi, & Lindsay, 1993). Source monitoring also allows remembering whether information has been imagined or **enacted** (Johnson et al., 1993). According to Johnson et al. (1993), when deciding whether an event was previously encountered or imagined, people typically make the distinction based on the available amount of perceptual information (e.g., color and sound), contextual information (e.g., where and when), affective information (e.g., emotion), and cognitive operations **enacted** when the event took place (e.g., records of organizing, elaborating, retrieving, and identifying). Memories of real events typically include more information about perceptual, contextual, and affective details than imagined ones. When memory characteristics for imagined versus **enacted** events overlap, there is an increased likelihood that the events will be confused. Supporting the assumption of Johnson et al. (1993), research has demonstrated that events that were actually encountered and falsely remembered imagined events activate common brain areas

during the process of encoding and retrieval (Goldmann et al., 2003; Gonsalves et al., 2004). Overall, the IIE can be interpreted in terms of source monitoring failures. Notably, source monitoring failures have been observed in KS (Brion, de Timary, Pitel, & Maurage, 2017; El Haj, Nandrino, Coello, Miller, & Antoine, 2017; Holdstock, Mayes, Cezayirli, Aggleton, & Roberts, 1999; Kessels et al., 2008; Kessels, Postma, Wester, & de Haan, 2000; Kopelman, Stanhope, & Kingsley, 1997; Kovner, Dopkins, & Goldmeier, 1988; Mayes, Meudell, & MacDonald, 1991; Pitel et al., 2007; Postma et al., 2006). However, to our knowledge, no study has yet investigated the IIE in KS. In other words, no study in KS has assessed whether repeated imagination of an action would result in the false claim that the action was previously enacted.

To investigate the IIE in KS, we replicated the procedures of O'Connor et al. (2015) who investigated the IIE, as well as the relationship between it and source monitoring in Alzheimer's disease. Although their procedures replicated those of Goff and Roediger (1998), several modifications were implemented to fit with the cognitive characteristics of patients with dementia. The procedures of O'Connor et al. (2015) consisted of two sessions and a recognition test. In the first session, patients with Alzheimer's disease and healthy older adults were invited to listen to **statements of actions** (e.g., "put the pills in the pillbox"), to perform the actions, or to imagine performing the actions. In the second session, they were invited to imagine statements of action that were previously encountered as well as new statements **once** or three times. On the recognition test, they had to decide whether **statements of actions** were previously **enacted** or not. Findings demonstrated that imagining performing the actions increased the tendency of both Alzheimer's disease patients and control participants to falsely recall the actions as having been **enacted**. The authors (O'Connor et al., 2015) suggested that, like control participants, Alzheimer's disease patients were susceptible to the IIE, which may be attributed to decline in source monitoring.

Using the procedures of O'Connor et al. (2015), we investigated the IIE in KS since its consequences on the everyday life of patients with KS are considerable (e.g. repeated imagination of an action such as closing the door, resulting in the false believe that the door is open). We expected that repeated imagination of an action by KS patients would result in the false claim that the action was previously enacted (i.e. IIE).

## Method

### Participants

The study included 18 participants with KS (12 women and 6 men;  $M$  age = 56.94 years,  $SD = 5.59$ ;  $M$  years of formal education = 9.33,  $SD = 3.45$ ) and 20 control participants without previous or current substance addiction and without neurological or psychiatric history (12 women and 8 men;  $M$  age = 55.40 years,  $SD = 4.86$ ;  $M$  years of formal education = 9.70,  $SD = 4.28$ ). The controls participants were matched with the KS patients according to sex [ $\chi^2(1, N = 42) = .01, p > .10$ ], age [ $t(36) = .91, p > .10$ ] and educational level [ $t(36) = .28, p > .10$ ]. The KS patients underwent a full examination by an experienced psychiatrist as well as a neuropsychologist, confirming the DSM-IV-TR (2000) criteria for alcohol-induced amnestic disorder. All the patients had a long history of alcoholism and nutritional depletion, notably thiamine deficiency. All the patients were in a chronic (more than one-year post-onset) but stable condition. At the time of testing, none of the patients **was suffering from** confusional Wernicke psychosis or had signs of alcohol-related dementia. Amnestic syndrome was present when the initial diagnosis was made, which was confirmed by the neuropsychological examination (see below). This examination also confirmed the normal cognitive performance of the controls.

### **Cognitive characteristics**

Cognitive functioning of all participants were assessed with tests of general cognitive functioning, episodic memory, working memory and shifting. Scores are summarized in Table 1. General cognitive functioning was assessed with the Mini Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975), the maximum score was 30 points. Episodic memory was evaluated with the task of Grober and Buschke (1987). On this task, participants had to retain 16 words, each of which describes an item that belongs to a different semantic category. Immediate cued recall was succeeded by a distraction phase, during which participants had to count backwards from 374 in 20 s. This distraction phase was succeeded by two minutes of free recall and the score from this phase provided a measure of episodic recall (16 points maximum). Working memory was evaluated with the digit span task (Baddeley, 1992), in which participants had to repeat a string of single digits in the same order (i.e., forward spans) or in reverse order (i.e., backward spans). Shifting was assessed with the Plus–Minus task which includes three lists, each containing 20 numbers. On List 1, participants were instructed to add one to each number. On List 2 they were instructed to subtract one from each number. On List 3, they were instructed to add and subtract one alternately. The flexibility score (in seconds) referred to the difference between the time participants needed to complete List 3 and the average time that they needed to complete Lists 1 and 2. Thus, a high score indicated high difficulty.

INSERT TABLE 1 APPROXIMATELY HERE

### **Materials and procedure**

#### **Materials**

We used 136 **statements of actions** taken from Goff and Roediger (1998). To mimic everyday life situations, all the statements referred to actions that may be encountered in everyday

life, such as “hold the pen”. For counterbalancing purposes, we divided statements into 12 blocks of eight statements of actions. The 12 blocks were rotated through **number of imaginings and encoding conditions across participants**.

### **Procedure**

Procedures, depicted in Figure 1, consisted of two testing sessions (Session 1 = encoding, Session 2 = imagining) and a recognition session.

#### ***Session 1 (encoding)***

Participants were informed that they would hear **statements of actions** that involved simple requests. They were also informed that they had to 1) perform actions depicted in some statements, 2) imagine actions depicted in other statements, or 3) listen to the action being read. Participants were also informed that, only after listening to the statement, they would be **invited to count backward** from a given number. We implemented counting backward to prevent rehearsing or imagining the action. To eliminate any confusion, the experimenter placed an A4 paper printed with the word “perform”, “imagine”, or “listen”. **The experimenter read aloud 72 statements of actions (24 enacted, 24 imagined, as well as 24 only read)**. For each statement, the experimenter presented an object (the object needed to perform the action) on a table. Objects were presented for all conditions (i.e., performing, imagining, and listening to the statements of actions). Participants were allocated 15 seconds to perform, **to imagine, or to count backward after the experimenter read each action**. After the 72 statements of actions had been processed, participants **were informed this was the end of Session 1**.

#### ***Session 2 (imagining)***

Session 2 immediately followed Session 1. Participants were told that all statements of actions in this session are to be imagined. To avoid any confusion, a A4 paper printed with the

word “imagine” was provided. The examiner read aloud the statements of actions with simultaneous presentation of the referenced objects. Fifteen seconds were allocated for each statement. Sixty-four **statements of actions** were encountered in this session: 24 old **statements of actions** (eight old perform statements, eight old imagine statements and eight old listen statements) were imagined once + 24 old **statements of actions** (eight old perform statements, eight old imagine statements and eight old listen statements) were imagined three times + eight new statements of actions were imagined once + eight new statements of actions were imagined three times.

### ***Recognition***

The recognition session consisted of a recognition and a source monitoring test and took place 24 hours after Session 2. The session consisted of 136 **statements of actions** all the 96 **statements of actions** (including the 72 encoded in Session 1) + 40 filler **statements of actions**. Statements were presented in a fixed random order. Participants were invited to answer the recognition and source monitoring questions based only on what they remembered from Session 1. They were informed that Session 2 was not relevant for the recognition test. For each of the 136 statements, the **participants were invited to reply to the question**, “Did you perform this action?” **with the answer**: “yes” or “no”. When answering “no”, they were invited to make a judgment about the source. i.e., whether the statement of action had been imagined, only heard, or was new. To avoid any confusion, we **placed a sheet of** A4 paper with the question about recognition and **“yes” and “no” answers, as well as the answers about the source and confidence**, in front of the participants.

Note that in the procedures of O’Connor et al. (2015), both “yes” and “no” answers were followed with confidence judgment. We did not implement this confidence judgement to alleviate

the cognitive burden of the assessment in order to avoid fatigability and distractions in patients with KS.

INSERT FIGURE 1 APPROXIMATELY HERE

## Results

We first compared the IIE between patients with KS and controls, this effect was defined as the tendency to falsely remember the actions that were imagined as having been enacted (i.e., false alarms). We then assessed, in patients with KS and controls, whether imagining an action after performing it differentially would affect the ability to correctly remember that the action has been previously enacted (i.e., hits). We finally assessed differences between patients with KS and controls regarding source memory (i.e., remembering whether actions were heard, imagined, or new).

### Imagination Inflation Effect

Figure 2 shows the mean proportion of actions that were misjudged as being enacted (i.e., false alarms) depending on the number of imaginings. Table 2 shows the mean proportion of actions that were falsely misjudged as being enacted depending on the number of imaginings for each Session 1 condition.

A 2 (Group: patients with KS vs. controls) X 3 (Session 2 imaginings: 0, 1, 3 times) X 3 (Session 1 category: imagine, listen or new) analysis of variance (ANOVA) was carried out on false alarms. A significant effect of group was observed,  $F(1, 35) = 7.49, p < .01, \eta^2 = .22$ . In other words, patients with KS were more likely to misidentify statements of actions that were not enacted as having been enacted compared with controls. The effect of imagining was significant,  $F(2, 70) = 10.10, p < .001, \eta^2 = .27$ . In other words, the scores of both populations were determined by the number of times the statements of actions were imagined in Session 2. The effect of Session 1

**category** was also significant,  $F(2, 70) = 4.92, p < .05, \eta^2 = .17$ . Follow-up comparisons showed more false alarms in the Session 1 “imagine” condition compared with the “listen” condition,  $t(36) = 3.72, p < .001, d = .67$ . However, no significant differences were observed between false alarms in the “listen” and “new” conditions,  $t(36) = 1.02, p > .1$ , or “imagine” and “new” conditions,  $t(36) = 1.12, p > .1$ . Patients with KS were similarly susceptible to the IIE compared with controls, Group X imaginings ( $F < 1$ ). There was no significant effect of interaction between Session 1 **category** X Session 2 imaginings ( $F < 1$ ), nor between Session 1 **category** X Group interaction ( $F < 1$ ). The three-way interaction was not significant ( $F < 1$ ).

To summarize, we observed the IIE in both patients with KS and controls, but it did not differ between the groups.

INSERT FIGURE 2 APPROXIMATELY HERE

INSERT TABLE 2 APPROXIMATELY HERE

## Recognition

Hits were counted when the statements of actions were **enacted** during Session 1 and the participants succeeded to identify the statements of actions as having been **enacted** at test. The mean proportions of hits as a function of number of imaginings are shown in Figure 3.

A 2 (Group: patients with KS vs. controls) X 3 (Session 2 imaginings: 0, 1, 3) X 3 (Session 1 **category**: imagine, listen, new) ANOVA was carried out on hit rates. A significant effect of group was observed,  $F(1, 35) = 9.95, p < .001, \eta^2 = .24$ . In other words, patients with KS were less likely to successfully identify **enacted** actions compared with controls. The effect of imagining was significant,  $F(2, 70) = 5.51, p < .01, \eta^2 = .16$ . In other words, the scores of both populations were influenced by the amount of times the statements of actions were imagined in Session 2. Neither the effect of Session 1 **category** nor interactions were significant ( $F < 1$ ).

In summary, both KS patients and controls endorsed actions they enacted when their performances were followed imaginings. Also, both KS patients and controls were susceptible to the effect of imaginings on subsequent hits (i.e., on subsequent correct recognition).

INSERT FIGURE 3 APPROXIMATELY HERE

### Source monitoring

We examined the effects of imagining on source monitoring for statements of actions that were listened to, imagined, or new. Note that, when they answered “no” to the recognition question, all participants made source decisions by indicating whether the actions have been imagined, only heard, or were new. Correct source answers refer to correct identification of the way in which the statements of actions were proceeded during Session 1 (imagined, listened to vs. new). Table 3 shows the source performances by Session 1 category.

A 2 (Group: patients with KS vs. controls) X 3 (Session 2 imaginings: 0, 1, 3) X 3 (Session 1 category: imagine, listen, new) ANOVA was carried out on correct source identifications. A significant effect of group was observed,  $F(1, 35) = 33.51, p < .001, \eta^2 = .52$ . In other words, and compared with controls, patients with KS made less correct source identifications. The effect of imagining was significant,  $F(2, 70) = 7.82, p < .001, \eta^2 = .21$ . The effect of Session 1 category was also significant,  $F(2, 70) = 11.33, p < .001, \eta^2 = .29$ . Follow-up comparisons showed that both KS patients and controls made correct source identifications when statements of actions were not encountered in Session 1 compared with statements of actions that were only listened to,  $t(36) = 5.55, p < .001, d = .76$ . Both KS patients and controls made correct source identifications when statements of actions were not encountered in Session 1 compared with statements of actions that were only imagined,  $t(36) = 3.82, p < .001, d = .67$ . However, there was no significant differences

on source identifications for statements of actions in the listen compared with the imagine conditions,  $t(36) = 0.92$ ,  $p > .1$ . Regardless of the mode of presentation, correct source identification in both KS patients and controls was higher for new statements of actions (those never encountered in Session 1) compared with statements of actions that had already been encountered.

Regarding the interaction between Session 1 category X Session 2 imaginings, a significant effect was observed,  $F(4, 140) = 32.69$ ,  $p < .001$ ,  $\eta^2 = .57$ . Interactions between Group X Session 1 category and Group X Session 2 imaginings were not significant ( $F < 1$ ). These findings suggest that imagining statements of actions three times after the initial presentation increased source monitoring, regardless of if the statements of actions were previously imagined or listened to. However, imagining statements of actions once or three times for the new items (those never encountered in Session 1) decreased source monitoring.

Regarding the interaction between Group X Session 1 category X Session 2 imaginings, a significant effect was observed,  $F(4, 210) = 5.32$ ,  $p < .01$ ,  $\eta^2 = .14$ . In other words, imagining statements of actions in Session 2 impacted source monitoring differently in both KS patients and controls. To explore this significant interaction, we carried out three ANOVAs for each condition (listen, imagine, new). A significant interaction was found between the “new” condition of imagining by group,  $F(2, 70) = 5.82$ ,  $p < .05$ ,  $\eta^2 = .18$ , revealing higher overall correct source identification for statements of actions in the “new” modality in KS patients than in controls. Follow-up comparisons showed a significant interaction between “new” modality and zero imaginings,  $t(36) = 9.32$ ,  $p < .001$ ,  $d = 2.99$ . This was influenced by the zero imaginings condition in Session 2, because these differences were not observed after once and three imaginings ( $t < 1$ ). The effect of group differences on the effect of imagining on correct source identification in the

listen condition and the imagine condition was not significant. Together, for new statements of actions (those never encountered in Session 1), KS patients demonstrated poor source memory compared with controls. However, for these same statements of actions, **after once** and three imagining attempts, controls **did not demonstrate advantages and, instead, they demonstrated t source performances that were similar** to patients with KS. There were also no group differences in **source performances** for imagined or listened to statements of actions **encountered** in Session 1.

INSERT TABLE 3 APPROXIMATELY HERE

### Discussion

The aim of this study was to investigate the IIE in KS. In our procedures, it concerned the tendency to misidentify actions that were imagined in Session 2 as having **been enacted**. Our procedures demonstrated higher overall false alarms (i.e., IIE) and lower overall hits (i.e., correct recognition of **statements of actions**) in patients with KS than in controls. However, KS patients did not demonstrate **an effect of** imagination compared with controls. Both KS patients and controls incorrectly reported **enacting** more actions they had not **enacted** when they subsequently imagined the actions than when they had never imagined the actions (i.e., the IIE).

Previous research has demonstrated source monitoring difficulties in patients with KS. For instance, a study demonstrated lower performance in KS patients than in controls when they were tested for memory of location of line drawings in a  $2 \times 2$  grid (Kovner et al., 1988). These findings were replicated in experiments showing compromise in the ability to remember the location of words that were exposed in the corners of a screen (Mayes et al., 1991), the ability to remember the location of pictures of objects in a  $7 \times 7$  grid (Shoqeirat & Mayes, 1991), and the ability to remember the (top or bottom) location of pictures on cards (Kopelman et al., 1997). Regarding the ability to remember whether actions were previously enacted or imagined, a study assessed this

issue by asking KS patients and controls to either place objects or imagine themselves placing objects in a box (El Haj, Nandrino, Coello, et al., 2017). Afterwards, participants had to decide whether they had previously placed the objects in the box or imagined doing so. Analyses demonstrated similar performances between KS patients and controls on this task. Although these findings are at odds with those of the present study, this apparent controversy can be reconciled by highlighting several differences between the study of El Haj, Nandrino, Coello, et al. (2017) and the present one. Unlike in the latter, participants in the study by El Haj, Nandrino, Coello, et al. (2017) did not perform an item recognition test, i.e. they were not **encountered** with non-studied foils on the recognition test. They were exposed to two choices (i.e., whether actions were previously enacted or imagined) whereas, in the present paper, they were exposed to three choices (i.e., imagined, listened to, or new). Moreover, the number of actions (12 items) was relatively low compared with the present study. Critically, encoding and retrieval in the study of El Haj, Nandrino, Coello, et al. (2017) was separated by a one-minute intervening activity rather than by 24 hours, as in the present study. Together, these findings suggest that the ability to distinguish between enacted and imagined actions in simple tasks and with a short retention delay is preserved in KS, whereas the same ability but for complex tasks and with a long retention delay is compromised.

Regarding source monitoring for the new statements of actions (i.e., the statements never **encountered** in Session 1), imagining resulted in **source distortions**, with a high levels of **errors** in both KS patients and controls. In fact, the former made fewer correct source **decisions** than controls when new items were not imagined **during** Session 2. However, when new actions had been imagined once or three **times**, **correct source decisions** of both groups did not differ. Both groups

also made more correct source judgments when items were imagined in Session 2 after being enacted, imagined, or listened to during Session 1.

The IIE in our KS patients could be due to the fact that repetition increases familiarity (i.e., the general sense that a stimulus has been previously encountered without access to the encoding details). This is important because recollection is severely impaired in KS patients, as may be observed in confabulations where patients fail to recollect the context in which an event was encoded (Dalla Barba et al., 1990). Thus, in addition to source monitoring failures, the IIE in KS may also be attributed to deficits in processes used at retrieval. According to the dual process model of memory, retrieval involves recollection and familiarity (Yonelinas, 2002). Familiarity-based recognition decisions involve remembering that an information has been encountered without remembering the encoding context, which may result in the false believe that an action has been previously enacted, as may be the case in confabulations. Because our paradigm consisted of imagination of actions, the latter might have been misidentified as having been enacted when they had only been imagined. In other words, the IIE in our KS patients may be due to a high level of familiarity with the actions based on the times imaginations were repeated. Note that this high level of familiarity could even appear if the actions were not imagined but were simply repeated.

The IIE in our KS patients could be attributed to brain damages in KS, and more specifically, to histopathological damage due to ethanol neurotoxicity and thiamine deficiency. KS is characterized by damage to the frontal lobes due to ethanol neurotoxicity, and damage to the anterior thalamic nuclei due to thiamine deficiency (Arts, Walvoort, & Kessels, 2017). Damage to the frontal lobes results in general memory decline and, more specifically, in decreased source monitoring (Mitchell & Johnson, 2009). For instance, the anterior prefrontal cortex plays a key role in the ability to distinguish internally from externally generated information (Simons,

Garrison, & Johnson, 2017). Thus, damage to this brain region, as observed in KS (Arts et al., 2017), can lead to confusions between real and imagined experiences (e.g., IEE). Regarding the damage to the anterior thalamic nuclei in KS, converging evidence from anatomical studies, animal studies, and studies on vascular lesions in the thalamus, demonstrates how this damage results in anterograde amnesia and episodic memory decline in general (Aggleton & Sahgal, 1993; Carlesimo, Lombardi, & Caltagirone, 2011; Sullivan & Pfefferbaum, 2009; Van der Werf, Jolles, Witter, & Uylings, 2003).

The IEE in our KS patients can be compared with that observed in patients with Alzheimer's disease. Using a design similar to that used in our study, O'Connor et al. (2015) have demonstrated that imagining performing an action **increases the possibility that** patients with Alzheimer's disease falsely **decide that the action have** been **enacted**. The authors (O'Connor et al., 2015) suggested that patients with Alzheimer's disease can be susceptible to the IIE, an effect that can be attributed to difficulties with source monitoring. Thus, alike patients with KS, those with Alzheimer's disease can demonstrated IEE.

One shortcoming of our study was the lack of a confidence judgement. This evaluation is important to assess how imagination inflation may influence the confidence of patients regarding the accuracy of their judgement. Other suggestions for future research include the assessment of motor imagery, this to control for the effect of visual imagery on IEE in KS. Future research can also consider comparing IEE in patients with KS and those with other amnesic symptoms or even assessing IEE in patients with KS using voxel-based lesion-symptom mapping analyses.

To summarize, this study highlights the IIE in KS. Our findings are of clinical relevance because repeated imagination of an action may lead to the false belief that an action has taken place. Clinical research could explore methods to reduce this susceptibility to the IIE. A method

to achieve this goal might be distinctiveness heuristic, a retrieval-monitoring process in which people expect to remember vivid details of an event and make recognition decisions on the basis of these details (Budson, Dodson, Daffner, & Schacter, 2005; Budson, Dodson, Vatner, et al., 2005; El Haj & Kessels, 2013; Israel & Schacter, 1997). If a rehabilitation strategy could be developed, it would help KS patients to reject competitive imagined memories, thereby reducing the number of false memories (El Haj, 2016) and, hopefully, confabulations.

## References

- Aggleton, J. P., & Sahgal, A. (1993). The contribution of the anterior thalamic nuclei to anterograde amnesia. *Neuropsychologia*, *31*(10), 1001-1019. doi: 10.1016/0028-3932(93)90029-y
- Arts, N. J. M., Walvoort, S. J. W., & Kessels, R. P. C. (2017). Korsakoff's syndrome: a critical review. *Neuropsychiatric Disease and Treatment*, *13*, 2875-2890. doi: 10.2147/NDT.S130078
- Association, A. P. (2000). *Task Force on DSM-IV . Diagnostic and statistical manual of mental disorders: DSM-IV-TR*. Washington, DC: American Psychiatric Association.
- Baddeley, A. (1992). Working memory. *Science*, *255*(5044), 556-559.
- Brion, M., de Timary, P., Pitel, A. L., & Maurage, P. (2017). Source Memory in Korsakoff Syndrome: Disentangling the Mechanisms of Temporal Confusion. *Alcoholism, Clinical and Experimental Research*, *41*(3), 596-607. doi: 10.1111/acer.13318
- Budson, A. E., Dodson, C. S., Daffner, K. R., & Schacter, D. L. (2005). Metacognition and false recognition in Alzheimer's disease: further exploration of the distinctiveness heuristic. *Neuropsychology*, *19*(2), 253-258. doi: 10.1037/0894-4105.19.2.253
- Budson, A. E., Dodson, C. S., Vatner, J. M., Daffner, K. R., Black, P. M., & Schacter, D. L. (2005). Metacognition and false recognition in patients with frontal lobe lesions: the distinctiveness heuristic. *Neuropsychologia*, *43*(6), 860-871. doi: 10.1016/j.neuropsychologia.2004.09.011
- Carlesimo, G. A., Lombardi, M. G., & Caltagirone, C. (2011). Vascular thalamic amnesia: a reappraisal. *Neuropsychologia*, *49*(5), 777-789. doi: 10.1016/j.neuropsychologia.2011.01.026

- Dalla Barba, G., Cipolotti, L., & Denes, G. (1990). Autobiographical memory loss and confabulation in Korsakoff's syndrome: a case report. *Cortex*, 26(4), 525-534.
- El Haj, M. (2016). Memory suppression in Alzheimer's disease. *Neurological Sciences*, 37(3), 337-343. doi: 10.1007/s10072-015-2441-5
- El Haj, M., Gandolphe, M. C., Moustafa, A. A., & Nandrino, J. L. (2018). Tell about yourself to improve your autobiographical memory: A study of Korsakoff's syndrome. *Psychiatry Research*, 268, 37-41. doi: <https://doi.org/10.1016/j.psychres.2018.06.064>
- El Haj, M., Kessels, R. P., Matton, C., Bacquet, J. E., Urso, L., Cool, G., . . . Antoine, P. (2016). Destination Memory in Korsakoff's Syndrome. *Alcoholism, Clinical and Experimental Research*, 40(6), 1321-1327. doi: 10.1111/acer.13070
- El Haj, M., & Kessels, R. P. C. (2013). Context Memory in Alzheimer's Disease. *Dementia and Geriatric Cognitive Disorders EXTRA*, 3(1), 342-350. doi: 10.1159/000354187
- El Haj, M., & Larøi, F. (2016). Provoked and spontaneous confabulations in Alzheimer's disease: An examination of their prevalence and relation with general cognitive and executive functioning. *Psychiatry and Clinical Neurosciences*, n/a-n/a. doi: 10.1111/pcn.12468
- El Haj, M., & Nandrino, J. L. (2016). Feedback and repetition as a tool to rehabilitate time perception in Korsakoff's syndrome: a case study. *Journal of Systems & Integrative Neuroscience*, 3(1), 1-5. doi: 10.15761/JSIN.1000145
- El Haj, M., & Nandrino, J. L. (2018). Seeing life through rose-colored spectacles: Autobiographical memory as experienced in Korsakoff's syndrome. *Consciousness and Cognition*, 60, 9-16. doi: <https://doi.org/10.1016/j.concog.2018.02.007>

- El Haj, M., Nandrino, J. L., Coello, Y., Miller, R., & Antoine, P. (2017). Source monitoring in Korsakoff's syndrome: "Did I touch the toothbrush or did I imagine doing so?". *Cortex*. doi: 10.1016/j.cortex.2017.02.006
- El Haj, M., Nandrino, J. L., Kessels, R. P., Matton, C., Bacquet, J. E., Urso, L., & Antoine, P. (2017). Retrospective Time Perception in Korsakoff's Syndrome. *J Neuropsychiatry Clin Neuroscince*. doi: 10.1176/appi.neuropsych.16100206
- Fama, R., Pitel, A. L., & Sullivan, E. V. (2012). Anterograde episodic memory in Korsakoff syndrome. *Neuropsychology Review*, 22(2), 93-104. doi: 10.1007/s11065-012-9207-0
- Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, 12(3), 189-198.
- Garry, M., Manning, C. G., Loftus, E. F., & Sherman, S. J. (1996). Imagination inflation: Imagining a childhood event inflates confidence that it occurred. *Psychonomic Bulletin & Review*, 3(2), 208-214. doi: 10.3758/bf03212420
- Garry, M., & Polaschek, D. L. L. (2000). Imagination and Memory. *Current Directions in Psychological Science*, 9(1), 6-10. doi: 10.1111/1467-8721.00048
- Gilboa, A., Alain, C., Stuss, D. T., Melo, B., Miller, S., & Moscovitch, M. (2006). Mechanisms of spontaneous confabulations: a strategic retrieval account. *Brain*, 129(Pt 6), 1399-1414. doi: 10.1093/brain/awl093
- Goff, L. M., & Roediger, H. L., 3rd. (1998). Imagination inflation for action events: repeated imaginings lead to illusory recollections. *Memory and Cognition*, 26(1), 20-33.

- Goldmann, R. E., Sullivan, A. L., Droller, D. B., Rugg, M. D., Curran, T., Holcomb, P. J., . . . Budson, A. E. (2003). Late frontal brain potentials distinguish true and false recognition. *Neuroreport*, *14*(13), 1717-1720. doi: 10.1097/01.wnr.0000087908.78892.23
- Gonsalves, B., Reber, P. J., Gitelman, D. R., Parrish, T. B., Mesulam, M. M., & Paller, K. A. (2004). Neural Evidence That Vivid Imagining Can Lead to False Remembering. *Psychological Science*, *15*(10), 655-660. doi: 10.1111/j.0956-7976.2004.00736.x
- Grober, E., & Buschke, H. (1987). Genuine memory deficits in dementia. *Developmental Neuropsychology*, *3*(1), 13-36.
- Holdstock, J. S., Mayes, A. R., Cezayirli, E., Aggleton, J. P., & Roberts, N. (1999). A comparison of egocentric and allocentric spatial memory in medial temporal lobe and Korsakoff amnesics. *Cortex*, *35*(4), 479-501.
- Israel, L., & Schacter, D. L. (1997). Pictorial encoding reduces false recognition of semantic associates. *Psychonomic Bulletin & Review*, *4*(4), 577-581. doi: 10.3758/bf03214352
- Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin*, *114*(1), 3-28.
- Johnson, M. K., & Raye, C. L. (1998). False memories and confabulation. *Trends Cogn Sci*, *2*(4), 137-145.
- Kessels, R. P., & Kopelman, M. D. (2012). Context memory in Korsakoff's syndrome. *Neuropsychology Review*, *22*(2), 117-131. doi: 10.1007/s11065-012-9202-5
- Kessels, R. P., Kortrijk, H. E., Wester, A. J., & Nys, G. M. (2008). Confabulation behavior and false memories in Korsakoff's syndrome: role of source memory and executive functioning. *Psychiatry and Clinical Neurosciences*, *62*(2), 220-225. doi: 10.1111/j.1440-1819.2008.01758.x

- Kessels, R. P., Postma, A., Wester, A. J., & de Haan, E. H. (2000). Memory for object locations in Korsakoff's amnesia. *Cortex*, *36*(1), 47-57.
- Kopelman, M. D. (2010). Varieties of confabulation and delusion. *Cognitive Neuropsychiatry*, *15*(1), 14-37. doi: 10.1080/13546800902732830
- Kopelman, M. D., Stanhope, N., & Kingsley, D. (1997). Temporal and spatial context memory in patients with focal frontal, temporal lobe, and diencephalic lesions. *Neuropsychologia*, *35*(12), 1533-1545.
- Kopelman, M. D., Thomson, A. D., Guerrini, I., & Marshall, E. J. (2009). The Korsakoff syndrome: clinical aspects, psychology and treatment. *Alcohol and Alcoholism*, *44*(2), 148-154. doi: 10.1093/alcalc/agn118
- Kovner, R., Dopkins, S., & Goldmeier, E. (1988). Effects of instructional set on amnesic recognition memory performance. *Cortex*, *24*(3), 477-483.
- Mayes, A. R., Meudell, P. R., & MacDonald, C. (1991). Disproportionate intentional spatial-memory impairments in amnesia. *Neuropsychologia*, *29*(8), 771-784.
- Mitchell, K. J., & Johnson, M. K. (2009). Source monitoring 15 years later: what have we learned from fMRI about the neural mechanisms of source memory? *Psychological Bulletin*, *135*(4), 638-677.
- O'Connor, M. K., Deason, R. G., Reynolds, E., Tat, M. J., Flannery, S., Solomon, P. R., . . . Budson, A. E. (2015). The imagination inflation effect in healthy older adults and patients with mild Alzheimer's disease. *Neuropsychology*, *29*(4), 550-560. doi: 10.1037/neu0000195
- Oudman, E., Nijboer, T. C., Postma, A., Wijnia, J. W., & Van der Stigchel, S. (2015). Procedural Learning and Memory Rehabilitation in Korsakoff's Syndrome - a Review of the Literature. *Neuropsychology Review*, *25*(2), 134-148. doi: 10.1007/s11065-015-9288-7

- Pezdek, K., Blandon-Gitlin, I., & Gabbay, P. (2006). Imagination and memory: does imagining implausible events lead to false autobiographical memories? *Psychon Bull Rev*, *13*(5), 764-769.
- Pitel, A. L., Beaunieux, H., Witkowski, T., Vabret, F., Guillery-Girard, B., Quinette, P., . . . Eustache, F. (2007). Genuine episodic memory deficits and executive dysfunctions in alcoholic subjects early in abstinence. *Alcoholism, Clinical and Experimental Research*, *31*(7), 1169-1178. doi: 10.1111/j.1530-0277.2007.00418.x
- Postma, A., Van Asselen, M., Keuper, O., Wester, A. J., & Kessels, R. P. (2006). Spatial and temporal order memory in Korsakoff patients. *Journal of the International Neuropsychological Society*, *12*(3), 327-336.
- Shoqeirat, M. A., & Mayes, A. R. (1991). Disproportionate incidental spatial-memory and recall deficits in amnesia. *Neuropsychologia*, *29*(8), 749-769.
- Simons, J. S., Garrison, J. R., & Johnson, M. K. (2017). Brain Mechanisms of Reality Monitoring. *Trends Cogn Sci*, *21*(6), 462-473. doi: 10.1016/j.tics.2017.03.012
- Sullivan, E. V., & Pfefferbaum, A. (2009). Neuroimaging of the Wernicke-Korsakoff syndrome. *Alcohol and Alcoholism*, *44*(2), 155-165. doi: 10.1093/alcalc/agn103
- Thomas, A. K., Bulevich, J. B., & Loftus, E. F. (2003). Exploring the role of repetition and sensory elaboration in the imagination inflation effect. *Memory and Cognition*, *31*(4), 630-640.
- Van der Werf, Y. D., Jolles, J., Witter, M. P., & Uylings, H. B. (2003). Contributions of thalamic nuclei to declarative memory functioning. *Cortex*, *39*(4-5), 1047-1062. doi: 10.1016/s0010-9452(08)70877-3
- Yonelinas, A. P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of memory and language*, *46*(3), 441-517.



Table 1

*Cognitive characteristics of Korsakoff participants and controls*

	Task	Korsakoff	Controls	
		<i>n</i> = 18	<i>n</i> = 20	
<b>General cognitive functioning</b>	MMSE	25.28 (2.12)	28.85 (1.14)	<i>p</i> < .001
<b>Episodic memory</b>	Grober and Buschke	6.61 (2.03)	10.70 (1.78)	<i>p</i> < .001
<b>Working memory</b>	Forward Span	5.89 (1.28)	6.35 (1.35)	<i>p</i> > .1
	Backward Span	4.11 (.76)	4.95 (.99)	<i>p</i> < .01
<b>Shifting</b>	Plus-minus	13.06 (6.73)	6.06 (3.68)	<i>p</i> < .001

*Note.* Standard deviations are given between brackets; maximum score on the Mini Mental State Examination was 30 points; episodic memory score refers to free recall and maximum score was 16 points; performances on the forward and backward spans refers to number of correctly repeated digits; score on the Plus-minus refers to reaction time; comparisons for spans were established with Mann-Whitney's U test (abnormal distribution) whereas comparisons for remaining tasks were established with Student's *t*-test (normal distribution).

Table 2

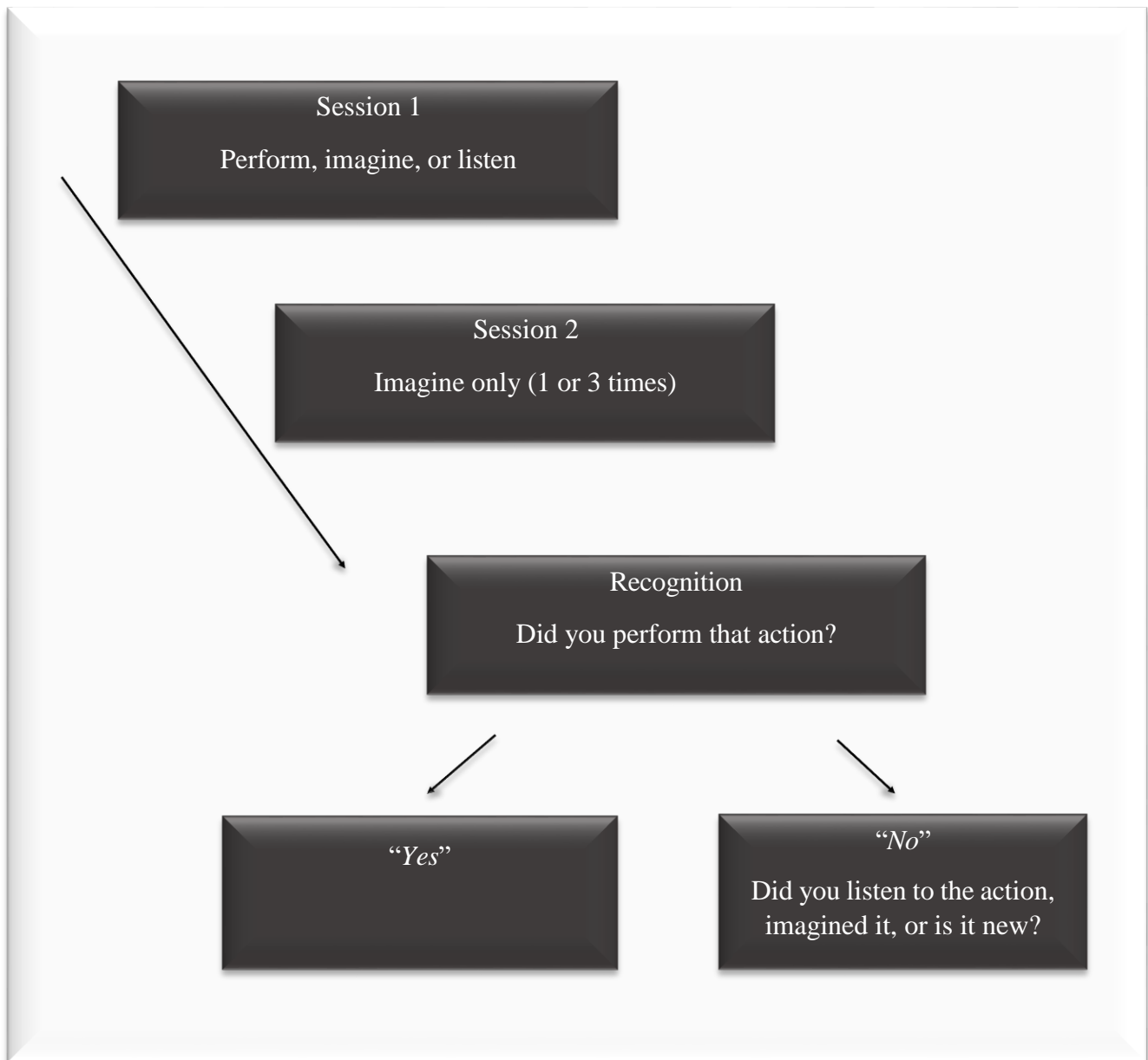
Means (and standard deviation) for incorrect “Perform” false alarms by Session 1 condition (Listen, Imagine, and New) and Session 2 imaginings (0, 1, 3 times) in patients with Korsakoff’s syndrome and control participants.

Session 1 condition		Korsakoff	Controls
<b>Listen</b>	0 times	.17 (.15)	.04 (.07)
	1 time	.30 (.22)	.10 (.15)
	3 times	.33 (.30)	.11 (.16)
<b>Imagine</b>	0 times	.22 (.23)	.10 (.10)
	1 time	.35 (.36)	.14 (.19)
	3 times	.43 (.33)	.16 (.20)
<b>New</b>	0 times	.24 (.26)	.01 (.01)
	1 time	.32 (.33)	.09 (.13)
	3 times	.30 (.29)	.15 (.17)

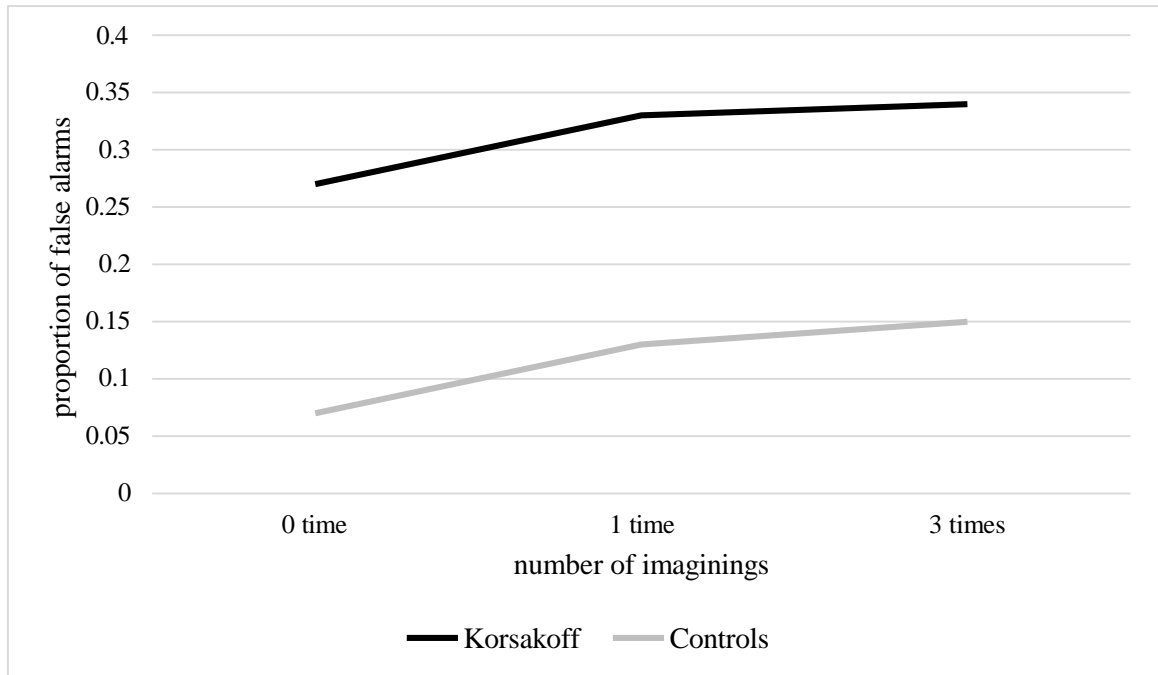
Table 3

Mean (and standard deviation) correct source identifications (hits) by Session 1 condition (Listen, Imagine, and New) and Session 2 imaginings (0, 1, 3 times) in patients with Korsakoff's syndrome and control participants.

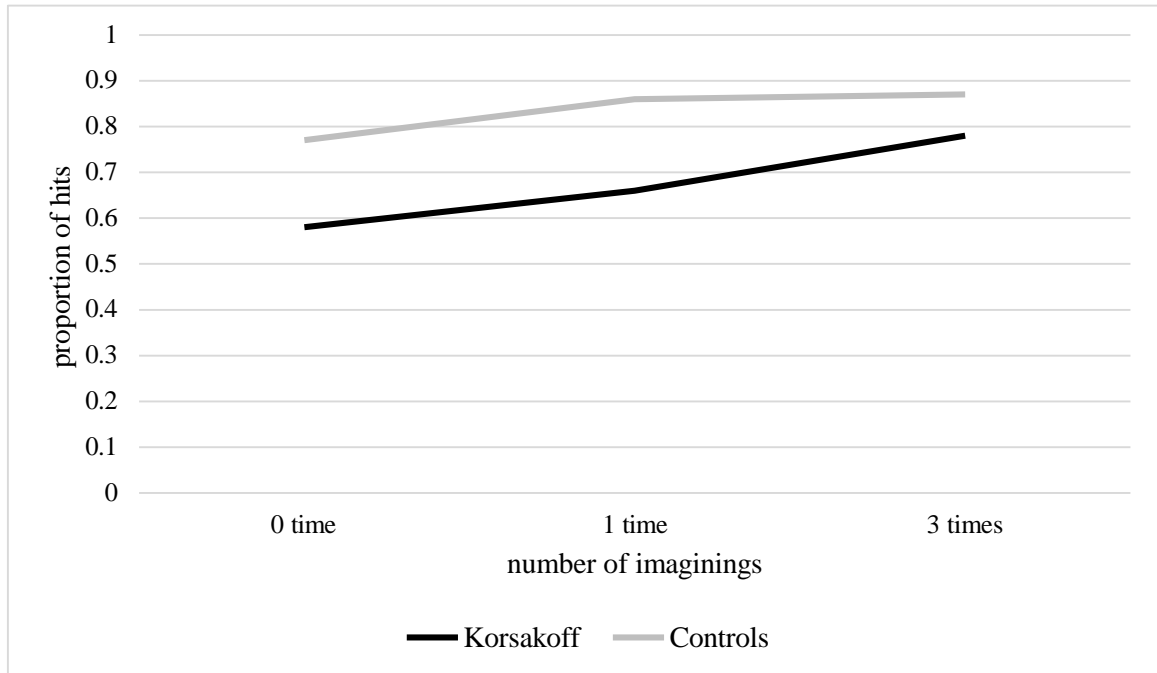
Session 1 condition		Korsakoff	Controls
Listen	0 times	.15 (.19)	.21 (.16)
	1 time	.15 (.18)	.26 (.19)
	3 times	.21 (.26)	.42 (.29)
Imagine	0 times	.22 (.20)	.22 (.22)
	1 time	.20 (.21)	.37 (.22)
	3 times	.26 (.22)	.40 (.24)
New	0 times	.60 (.30)	.88 (.33)
	1 time	.42 (.31)	.46 (.33)
	3 times	.24 (.20)	.17 (.21)



*Figure 1.* The imagination inflation paradigm consisted of three sessions: Session 1 (encoding), Session 2 (imagining), and recognition session. During Session 1, participants **had to enact an action, to imagine an action, or to listen** to an action being read. During Session 2, **they had to only enact** actions. During the recognition session, they had to remember whether they had **enacted** the action during Session 1. If not, a source memory decision was made (i.e., **participants had to decide if the statements of actions** had been imagined, only heard, or **were** new).



*Figure 2.* Proportion of actions **misidentified as being enacted** (i.e., imagination inflation effect, collapsed across Session 1 category) across Session 2 imaginings (zero, one, or three times) in patients with Korsakoff's syndrome and control participants.



*Figure 3.* Proportion of actions **misidentified as being enacted** (i.e., hits, collapsed across Session 1 condition) across Session 2 imaginings (zero, one, or three times) in patients with Korsakoff's syndrome and control participants.

