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## Visuospatial declarative learning despite profound verbal declarative amnesia in Korsakoff's syndrome

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### ABSTRACT

Korsakoff's syndrome (KS) is a neuropsychiatric disorder characterised by severe amnesia. Although the presence of impairments in memory has long been acknowledged, there is a lack of knowledge about the precise characteristics of declarative memory capacities in order to implement memory rehabilitation. In this study, we investigated the extent to which patients diagnosed with KS have preserved declarative memory capacities in working memory, long-term memory encoding or long-term memory recall operations, and whether these capacities are most preserved for verbal or visuospatial content. The results of this study demonstrate that patients with KS have compromised declarative memory functioning on all memory indices. Performance was lowest for the encoding operation compared to the working memory and delayed recall operation. With respect to the content, visuospatial memory was relatively better preserved than verbal memory. All memory operations functioned suboptimally, although the most pronounced disturbance was found in verbal memory encoding. Based on the preserved declarative memory capacities in patients, visuospatial memory can form a more promising target for compensatory memory rehabilitation than verbal memory. It is therefore relevant to increase the number of spatial cues in memory rehabilitation for KS patients.

**KEYWORDS** Amnesia; Korsakoff for learning; alcoholism; Korsakoff's syndrome; verbal memory; visuospatial memory

### Introduction

Korsakoff's syndrome (KS) is a neuropsychiatric disorder characterised by severe anterograde declarative amnesia, which is caused by thiamine deficiency and concomitant alcoholism. In KS, declarative memory is affected to a more extreme extent than other cognitive functions (Kopelman, 2002). What is currently less known is whether all declarative memory components are equally impaired in this specific instance of amnesia. This question is particularly relevant in the scope of understanding spared

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memory functioning and memory rehabilitation in KS. More specifically, any residual memory capacities in KS could possibly be employed to bypass the more severely compromised aspects of memory functioning (Oudman, Nijboer, Postma, Wijnia, & Van der Stigchel, 2015). It is therefore relevant to study spared memory capacities in KS.

Although memory deficits in KS have received considerable attention in the literature, it remains largely unknown whether residual capacities involve all memory operations or are restricted to demarcated subforms. Two relevant distinctions can be made in memory: first, the distinction of cognitive operations (including accessibility, storage and temporal properties); and second, the distinction in the format of content that needs to be memorised. With respect to the cognitive operations, there is ample evidence that working memory, which holds and operates on information for only a brief period, is better preserved than long-term memory, which holds and operates on information for a longer period (Cermak, Butters, & Goodglass, 1971; Haxby, Ludgren, & Morley, 1983; Joyce & Robbins, 1991; Kopelman, 1991; Mayes, Daum, Markowisch, & Sauter, 1997; Squire, 2009). Moreover, deficits in long-term memory are unrelated to working memory performance, suggesting that both forms of memory are likely to be functionally distinct in KS (Oscar-Berman, Hutner, & Bonner, 1992; Van Geldorp, Bergmann, Robertson, Wester, & Kessels, 2012). Deficits in working memory, if any, would most likely involve the transition between working memory and long-term memory encoding, which has also been referred to as the “episodic buffer” (Baddeley, 2001; Oudman, Van der Stigchel, Wester, Kessels, & Postma, 2011; Van Asselen, Kessels, Wester, & Postma, 2005). Regarding long-term memory itself, both the process of recalling information as well as encoding are severely compromised in KS (Kopelman, Thomson, Guerrini, & Marshall, 2009; Oscar-Berman, 2012; Van Damme & d’Ydewalle, 2008). Since it is debated whether or not there are still residual memory capacities in KS, one of the central aims of this study was to directly compare working memory, the encoding of information into long-term memory, and the recall from long-term memory in patients with KS.

A second question regarding memory abilities in KS is whether or not declarative memory capacities in KS generalise to all contents. In working memory literature a typical content distinction is made between verbal and visuospatial memory (Baddeley & Hitch, 1974). Visuospatial memory refers to the memory processes responsible for recording information about one’s environment and spatial orientation, such as the memory for the place an event occurs. In contrast, verbal memory involves the interpretation and recollection of words, digits and amodal linguistic units. Currently, most of the available forms of cognitive rehabilitation in KS are largely dependent on verbal memory (see Svanberg & Evans, 2013 for a review of the rehabilitation literature in KS). For instance, patients are verbally instructed to learn a novel skill by means of errorless learning (Komatsu, Mimura, Kato, Wakamatsu, & Kashima, 2000; Oudman et al., 2013), they learn written commands to handle an electronic device (Wilson, Baddeley, Evans, & Shiel, 1994), or they are verbally prompted to visit group meetings (Morgan, McSharry, & Sireling, 1990). Other potentially hopeful forms of rehabilitation, such as attention process training or goal management training have not yet been investigated in KS (Bertens, Fasotti, Boelen, & Kessels, 2013; Sohlberg & Mateer, 1987). Over the years, numerous studies have demonstrated compromised visuospatial memory in KS (see Kessels & Kopelman, 2012, for a review). Patients with KS have pronounced difficulties in remembering exact and relative object locations (Chalfonte, Verfaellie, Johnson, & Reiss, 1996; Kessels, Postma, Wester, & de Haan, 2000). Moreover,

forming associations between temporal order memory and visuospatial memory is even more problematic (Postma, Van Asselen, Keuper, Wester, & Kessels, 2006). Parallel to the evidence that visuospatial memory deficits are considerable, there are also multiple studies that demonstrate vastly diminished verbal memory functioning. Patients diagnosed with KS have impaired immediate recall, flat learning rates across learning trials, and poor retention over delay intervals on indices of verbal memory compared to healthy controls (Butters, Wolfe, Granholm, & Martone, 1986; Pitel et al., 2008). It is therefore of specific interest to investigate whether verbal or visuospatial memory is the most promising target for future memory rehabilitation interventions.

Although amnesia is the most central symptom of KS, no direct comparisons between declarative memory operations and content format have yet been attempted in KS. For successful memory rehabilitation, it is particularly relevant to know which aspects of memory are better preserved, because those preserved aspects can be trained to support difficulties in other memory domains. Therefore, the aim of the present study was twofold: First, we wanted to investigate whether patients diagnosed with KS have stronger spared working memory, long-term memory encoding or long-term memory recall operations, and, second, we aimed to assess whether these residual capacities are most pronounced in verbal or visuospatial memory content. Task performance in a group of KS patients was compared to the normed reference group task performance on two well-known verbal and two visuospatial neuropsychological tests for declarative memory, leading to indices for working memory, long-term memory encoding and long-term memory recall in both the visuospatial and verbal content domain. For long-term memory encoding, those indices included the summed learning trials of the Rey Auditory Verbal Learning Test (RAVLT) for verbal long-term encoding, also referred to as immediate recall of verbal information, and the summed learning trials for the Location Learning Test (LLT) as a visuospatial equivalent. For the working memory operation, the indices included Digit Span (DS) for verbal working memory and the Corsi Block Tapping Test (CBT) as a visuospatial counterpart. Finally, for long-term memory recall, indices included delayed recall in the RAVLT for verbal long-term memory recall and the LLT as an index for visuospatial long-term memory recall.

## Methods

### Participants

Twenty-five patients (mean age = 58.8 years;  $SD = 7.2$ ), diagnosed with KS participated in this study. The patients were inpatients of the Korsakoff Centre Slingsdael, Rotterdam, The Netherlands. All patients fulfilled the DSM-V criteria for substance/medication induced major neurocognitive disorder (American Psychiatric Association, 2013), and the clinical characteristics of KS described by Kopelman (2002) and Kopelman et al. (2009). The amnesic syndrome was confirmed by neuropsychological assessment. All patients were in the chronic stage of the syndrome, and none was in the confusional Wernicke encephalopathy or a state of delirium at time of testing. Premorbid IQ was estimated with the Dutch Adult Reading Test (Schmand, Lindeboom, & van Harskamp, 1992), which is the Dutch version of the National Adult Reading Test. All included patients had an estimated IQ score above 80, to ensure ability to engage with the testing procedure, and exclude possible cases of alcohol dementia (mean IQ = 93.9;

$SD = 10.5$ ) (Oslin, Atkinson, Smith, & Hendrie, 1998). For all patients education level was assessed using 7 categories, 1 being the lowest (less than primary school) and 7 being the highest (academic degree) (Verhage, 1964). General cognitive functioning was assessed with the Mini Mental State Examination (mean score = 23.5;  $SD = 2.9$ ) (MMSE; Folstein, Folstein, & McHugh, 1975). All patients had an extensive history of alcoholism and nutritional depletion, notably thiamine deficiency, verified through medical charts. Selected patients did not show neurological disorders (traumatic brain injury, epilepsy, etc.) or acute psychiatric conditions (psychosis, major depression, etc.) that could have interfered with the testing procedure. Informed consent was obtained for all participants, and the testing procedure was in compliance with the relevant guidelines and laws for experimental testing in human subjects. Table 1 shows a summary of demographic variables and neuropsychological test results for all patients.

## Materials

### *Verbal working memory—Digit Span*

The forward verbal working memory span is a verbal index of short-term or working memory (Lezak, 1995; Salamé, Danion, Peretti, & Cuervo, 1998) and was calculated with the Digit Span subtest from the Wechsler Adult Intelligence Scale—Third Edition (WAIS-III; Wechsler, 1997). Percentile scores for digit span were calculated based on recently available norms ( $n = 362$ ; Monaco, Costa, Caltagirone, & Carlesimo, 2013), as an index for verbal working memory.

### *Visuospatial working memory—Corsi Block Tapping Span*

Patients were administered the Corsi Block Tapping Test to index visuospatial working memory. The visuospatial span of the Corsi Block Tapping Test is a span task and, as such, a visuospatial analogue to the digit span as an index of verbal short-term memory or working memory (Kessels, van Zandvoort, Postma, Kappelle, & De Haan, 2000; Lezak, 1995). Percentile scores for the forward visuospatial span were calculated based on recently available norms ( $n = 362$ ; Monaco et al., 2013), as an index for visuospatial working memory.

### *Verbal long-term memory—Rey Auditory Verbal Learning Test*

The Rey Auditory Verbal Learning Test (RAVLT; Rey, 1958) was developed to index encoding and recall of verbal information in patients with acquired brain damage. In the RAVLT, 15 monosyllabic words are presented in five trials, with a free recall procedure immediately following each presentation. After a delay of about 20 minutes, there is an additional delayed free recall trial, followed by a recognition trial. The Dutch version (Brand & Jolles, 1985) was used in the current study. For the total score for the five subsequent trials and the delayed free recall trial, percentile scores were calculated based on the most recent available norms for the Dutch population ( $n = 847$ ; Schmand, Houx, & de Koning, 2012). The percentile scores on the five subsequent trials were used as an outcome measure for verbal long-term memory encoding, and the percentile scores on the delayed free recall (relative delayed free recall to learning phase, to facilitate the comparison with the scores on

**Table 1.** Demographic variables, neuropsychological test results, and radiological findings for the Korsakoff's patients

Patient	Gender	Age	Handedness <sup>a</sup>	Education <sup>b</sup>	IQ <sup>c</sup>	General cognitive functioning <sup>d</sup>	Verbal learning <sup>e</sup>	Executive functioning <sup>f</sup>
1	Male	60	Left	5	102	29	<5	18
2	Female	55	Right	5	108	21	<5	14
3	Male	65	Right	7	107	23	<5	8
4	Male	65	Right	4	97	22	<5	7
5	Male	56	Right	2	85	19	<5	n.a.
6	Male	44	Left	4	99	23	<5	8
7	Male	64	Right	5	96	22	<5	n.a.
8	Male	57	Right	5	111	29	<5	n.a.
9	Male	68	Right	3	85	22	<5	15
10	Male	48	Right	4	101	26	<5	15
11	Male	69	Right	4	94	28	<5	15
12	Male	56	Right	4	87	22	<5	9
13	Male	55	Right	7	115	25	<5	13
14	Male	49	Right	4	82	23	<5	17
15	Male	60	Right	2	102	20	<5	10
16	Male	49	Right	4	90	27	<5	15
17	Male	67	Right	6	84	22	<5	15
18	Male	59	Right	4	80	26	<5	12
19	Male	67	Right	4	84	25	<5	10
20	Female	63	Right	4	94	26	<5	7
21	Male	65	Right	3	83	20	<5	12
22	Male	54	Right	4	81	23	<5	15
23	Male	66	Right	7	104	22	<5	4
24	Male	52	Right	4	80	19	<5	4
25	Male	50	Right	5	97	23	<5	15
		<i>M</i> = 58.5 <i>SD</i> = 7.2		<i>M</i> = 4.4 <i>SD</i> = 2.8	<i>M</i> = 93.9 <i>SD</i> = 10.5	<i>M</i> = 23.5 <i>SD</i> = 2.9		

n.a. = not available, Education = education level, IQ = Intelligence Quotient .

<sup>a</sup>Handedness was assessed using the Edinburgh Handedness Inventory (Oldfield, 1971)

<sup>b</sup>Education level, was scored using 7 categories: 1 = lowest (less than primary school), 7 = highest (university degree) (Verhage, 1964).

<sup>c</sup>Intelligence Quotient was estimated with the Dutch Adult Reading Test (Schmand et al., 1992).

<sup>d</sup>General cognitive functioning was assessed with the Mini Mental State Examination (Folstein et al., 1975).

<sup>e</sup>Percentile scores for the total performance on the first five learning trials, measured with the Rey Auditory Verbal Learning Test, for measurement of long-term memory (Rey, 1958).

<sup>f</sup>Raw scores on the Frontal Assessment Battery . < 13 = severe impairment in executive functioning (Dubois, Slachevsky, Litvan, & Pillon, 2000).

visuospatial long-term memory) were used as an outcome measure for verbal long-term memory recall.

### *Visuospatial long-term memory—Location Learning Test*

The Location Learning Test was administered to examine visuospatial memory. This test was developed by Bucks and Willison (1997) and later modified by Kessels, Nys, Brands, van den Berg, and Van Zandvoort (2006). The LLT consists of a 40 × 40 cm board on which 10 grey-scaled pictures of easy-to-name objects (boot, wallet, umbrella, book, envelope, knife, cup, glasses, matches, and scissors) are placed at different locations in a 5 × 5 grid. In the current experiment, each trial board was presented for 30 seconds (procedure 1), after which cards of the 10 objects had to be relocated as accurately as possible on an empty 5 × 5 grid with the same dimensions as the board with the 10 grey-scaled pictures. After five learning trials, in which the same stimulus was shown, delayed recall was tested after 15 minutes. For each of the five learning trials and the delayed trial, the displacement score was determined, that is, the sum of the errors made for each object placement on that trial. A placement error was calculated by counting the number of cells the object had to be moved both horizontally and vertically to be in the correct location (Kessels, Bucks, Willison, & Byrne, 2012). The displacement score reflects the ability to bind objects to their locations in memory.

For the total score on the five subsequent trials and the delayed free recall trial, percentile scores were calculated based on the most recently available norms ( $n = 186$ ; Kessels et al., 2012). The percentile scores on the five subsequent trials were used as an outcome measure for visuospatial long-term memory encoding, and the percentile scores on the delayed free recall trial (relative delayed free recall to learning phase) were used as an outcome measure for visuospatial long-term memory recall.

### *Analysis*

In the statistical analysis, the indices for verbal working memory and visuospatial working memory are referred to as “working memory operation”. The indices for verbal long-term encoding and visuospatial long-term encoding are referred to as “encoding operation” in the statistical analysis. The indices for verbal long-term memory recall and visuospatial long-term memory recall are referred to as “recall operation”. For all indices of memory operation and content the standardised scores were used to compare task performance. A 2 × 3 ANOVA with “content” (visuospatial and verbal) and “operation” (working memory operation, encoding operation and recall operation) as within-group factors was performed. Mauchly’s test of sphericity indicated that the assumption of sphericity had been violated for the operation. Therefore, we used Greenhouse–Geisser corrected values for this ANOVA. Additionally, Bonferroni corrected pairwise comparisons were performed to further specify whether there were significant differences between the operations (working memory operation, learning operation and delayed recall operation). Since the normality assumption for the 2 × 3 ANOVA was violated, Friedman’s nonparametric tests were additionally performed to confirm the effects found in parametric testing. Moreover, post-hoc Wilcoxon Signed Rank tests were performed to further specify whether there were significant differences between the memory operations and content. To further elaborate the relationship between declarative memory “content” (visuospatial and verbal) and “operation”

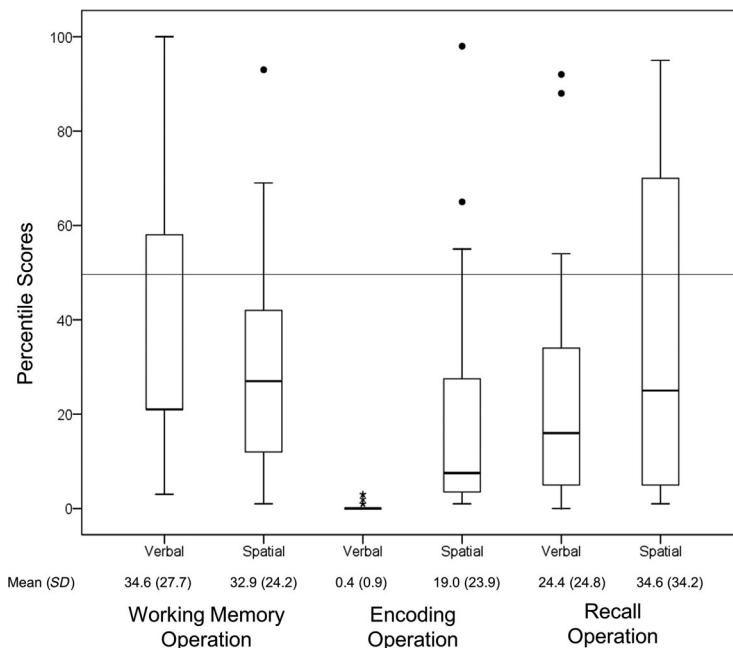
(working memory operation, encoding operation, and delayed recall operation), Pearson's parametric ( $r$ , two-tailed) and Spearman's nonparametric ( $p$ , two-tailed) correlation coefficients were reported.

## Results

Figure 1 depicts box-plots of percentile scores for the working memory operation, the encoding operation and the recall operation of the visuospatial and verbal memory tasks in patients with KS. A  $t$ -test was conducted on all declarative memory indices to evaluate whether or not their means were significantly different from the average percentile score in the normative group (see the reference line in Figure 1). All reported KS patient group scores on indices of declarative memory were significantly lower than the normative group ( $ps < .01$ ), suggesting that declarative memory performance was compromised in KS compared to a normative reference group.

### Parametric statistical testing

In parametric statistical testing, a main effect of content was observed,  $F(1, 24) = 11.1$ ,  $p < .05$ ,  $\eta_p^2 = .317$ , indicating that performance on the visuospatial memory tasks was better than performance on the verbal memory tasks. A main effect was also found for operation,  $F(1.5, 37.2) = 11.8$ ,  $p < .0001$ ,  $\eta_p^2 = .330$ , indicating discrepancies in memory performance between working memory, encoding and recall operations. No significant interaction between content and operation was observed,  $F(2, 48) = 2.0$ ,  $p$



**Figure 1.** Box-plot percentile scores for the working memory operation, the encoding operation and the recall operation on the verbal and spatial declarative memory tasks in patients with KS. The reference bar is the average percentile score in the normed reference groups.



$= .149$ ,  $\eta_p^2 = .076$ , suggesting that for both the verbal and visuospatial content the scores were comparable in the working memory, encoding and recall operations. Post hoc analysis indicated that performance was specifically higher in the working memory operation, compared with the encoding operation (mean difference: 24.0 percentile points,  $p < .001$ ) and the recall operation compared with the encoding operation (mean difference: 19.8 percentile points,  $p < .001$ ). Performance in the working memory operation was comparable with performance in the recall operation (mean difference: 4.2 percentile points,  $p = .999$ ).

### Nonparametric statistical testing

In nonparametric testing, the scores on the six indices of memory were significantly different,  $\chi^2(5, N = 25) = 54.6$ ,  $p < .01$ ;  $W = .44$ , suggesting a substantial discrepancy between the task performance on the memory indices. The main effect of operation was observed for the verbal memory tasks,  $\chi^2(2, N = 25) = 37.4$ ,  $p < .01$ ;  $W = .75$ , but not for the visuospatial memory tasks,  $\chi^2(2, N = 25) = 1.5$ ,  $p = .47$ ;  $W = .03$ , contradicting the interaction results of the parametric ANOVA. These results suggest that the performance for the verbal content was significantly different between working memory, encoding and recall operations, while this was not the case for visuospatial memory. For the verbal tests, post-hoc analysis confirmed the parametric finding that performance was specifically higher in the working memory operation compared with the encoding operation ( $Z = 4.37$ ,  $p < .001$ ), and the recall operation compared with the encoding operation ( $Z = 4.26$ ,  $p < .001$ ). Also, performance in the working memory operation was comparable with performance in the recall operation ( $Z = 1.55$ ,  $p = .122$ ).

Additional post-hoc analyses showed that performance was not significantly different between verbal working memory and visuospatial working memory ( $Z = 0.15$ ,  $p = .882$ ), or verbal recall and visuospatial recall ( $Z = 1.03$ ,  $p = .300$ ). However, visuospatial encoding performance was significantly better than verbal encoding performance ( $Z = 4.38$ ,  $p < .001$ ), suggesting that the better performance for visuospatial memory compared to verbal memory is mainly driven by better visuospatial encoding performance.

### Correlations between test results

As described, we observed relatively better preserved visuospatial than verbal content memory performance in KS. Moreover, there were differences in task performance

**Table 2.** Pearson (lower diagonal) and Spearman (upper diagonal) correlation matrix for the percentile scores for the declarative memory indices ( $n = 25$ ).

	Verbal working memory	Spatial working memory	Verbal encoding	Spatial encoding	Verbal recall	Spatial recall
Verbal working memory		.13	.20	.08	-.31	.00
Spatial working memory	.08		-.21	-.13	.25	-.16
Verbal encoding	.23	-.22		.10	-.54*	.16
Spatial encoding	.01	-.24	-.05		.12	.16
Verbal recall	-.32	.07	-.40*	.49*		.13
Spatial recall	.10	-.22	.14	.29	.28	

Note. \* = significance at  $p < .05$ .

between working memory, encoding and recall operations. To further elaborate the relationship between memory content and memory operation, we performed additional correlations on the declarative memory scores. Pearson's parametric and Spearman's nonparametric correlations are reported in [Table 2](#). Importantly, the majority of correlations between indices of memory were not interrelated between tests, possibly reflecting the detrimental effects of severe amnesia on all memory scores, thereby limiting the possibility of drawing firm conclusions based on the correlational analysis. Visuospatial encoding and verbal recall correlated positively in both parametric and nonparametric testing, possibly suggesting that, despite a floor effect on verbal learning, a subgroup of patients was able to encode at least some verbal and visuospatial information for a prolonged period of time. Moreover, verbal encoding and recall were negatively correlated in parametric correlation testing, but not in the nonparametric test. This correlation seems counterintuitive and we elaborate further on possible explanations in the discussion.

## Discussion

The aim of the present study was twofold: to investigate whether patients diagnosed with KS have stronger spared working memory, long-term memory encoding or long-term memory recall operations, and whether these residual capacities are most pronounced for verbal or visuospatial memory content. The results show that memory performance in patients with KS was significantly lower than in the normed reference groups on all indices of declarative memory functioning, consistent with the notion that a global amnesia is central to the KS diagnosis. Despite this general deficiency in memory functioning, the working memory operation and recall operation were better preserved than the encoding operation. Most compensation is required for verbal encoding of information. Importantly, visuospatial memory was relatively better preserved in KS compared to verbal memory, suggesting that residual visuospatial memory capacities can be employed in memory rehabilitation as a possible compensation for memory difficulties.

Although earlier research indicated global amnesia in KS, the current study found evidence for relatively preserved visuospatial learning. Following the context-memory deficit hypothesis, contextual memory is thought to be disproportionately compromised compared to target memory in KS (Mayes, Meudell, & MacDonald, 1991). Therefore, we expected greater memory deficits for visuospatial information than verbal memory. However, in the current study the exact opposite pattern of results was found: visuospatial memory was better preserved than verbal memory. The results of the present study therefore seem to contradict the context memory deficit hypothesis at first sight. A possible explanation for this inconsistency might be that the current visuospatial memory tasks (LLT and CBT) have response alternatives (i.e., locations and positions in a field) that are more restricted than in the RAVLT and DS (i.e., words or numbers to be produced without response alternatives). As such, these tasks can be considered to have more of a cued recall format. A likely consequence of the cued recall property of the visuospatial tasks is that they are overall easier to perform than are their verbal equivalent (cf. Kessels et al., 2006).

Currently, the research on memory rehabilitation that is available for patients diagnosed with KS is restricted to verbal methods of rehabilitation (see Oudman et al., 2015; Svanberg & Evans, 2013, for reviews of the literature). For instance, patients are instructed verbally to learn a novel skill by means of errorless learning (Oudman

et al., 2013), they learn written commands to handle an electronic device (Wilson et al., 1994), or they are prompted verbally to visit group meetings (Morgan et al., 1990). As the results of this study suggest, residual learning potential is more robust for visuospatial memory than for verbal memory, especially when environmental support is offered. Rehabilitation techniques for KS patients should therefore incorporate visuospatial cues and prompts in memory rehabilitation to optimise the effects of rehabilitation. Visual demonstrations as a visuospatial model for learning can be specifically effective in KS. Nevertheless, it is essential for a proper memory rehabilitation programme to include both verbal and spatial elements suitable for the individual needs of the client.

Earlier research on the LLT revealed that this task is prone to ceiling effects in a healthy population and that the learning phase of the LLT should therefore be accelerated to overcome this problem (Kessels et al., 2006). It is therefore possible that the LLT is relatively easier to perform than the RAVLT, explaining at least partially the better performance on this task in the current study. It is nevertheless unlikely that this possible difference in difficulty between the tasks could fully explain the difference between spatial and verbal learning, because of the intensity of the verbal amnesia in KS patients and the minimal performance levels that are observed on verbal long-term learning.

In the current study, the correlations between memory operation and content scores were calculated. It is important to note that the small sample size could mask possible effects. Verbal encoding and recall were negatively correlated in parametric, but not nonparametric correlational analysis. A possible explanation for this remarkable finding is that the performance scores for long-term recall are corrected for the number of items that are encoded in the learning phase. Moreover, a number of participants were unable to recall any item on the recall phase, possibly resulting in a negative correlation bias. This negative skewedness of the data was also reflected in its non-normal distribution. This negative correlation is therefore quite likely to reflect an artifact, instead of an actual negative relationship between encoding and recall. Of more interest, visuospatial encoding and verbal recall correlated moderately positively. This result shows that better visuospatial encoding performance was related to a verbal recall advantage. Based on the lack of statistical significance for the interaction effect, this finding seems counterintuitive. An explanation that could partially explain this phenomenon is the lack of variance in the performance on the RAVLT, with only a small number of participants remembering any item. It is possible that the scores of this subgroup of KS participants did explain the entire correlation effect.

### ***Strengths and limitations***

One of the strengths in the current study is the design that included both memory operations and content in KS. To our knowledge, there are no other such studies available. Moreover, this is the first report on the LLT in KS patients finding evidence for preserved learning potential during the encoding of locations. There are also some methodological considerations that have to be taken into account in the interpretation of our findings. In the present study, six individual neuropsychological test results were interpreted based on normative samples instead of including a matched healthy control group. Although one might argue that including more tests could have strengthened our investigation, the present results show a divergent pattern on the included memory domains in amnesia, thereby suggesting the innovative nature of our results in their own right. Moreover, in the present study we focused on the comparison of test

results with normative data instead of collecting a novel reference group of healthy subjects. In the trade-off between including a new control group of healthy subjects against applying large and robust normative samples, we chose instead to base our comparison on the normative samples. In future research, it might be beneficial for the generalisation of results to include a large and robust sample for all six memory domains, to further scrutinise performance on memory operations and content in KS. Also, one could argue that the use of co-normed standardised testing material, such as the Wechsler Memory Scale–IV (WMS-IV; Hendriks, Bouman, Kessels, & Aldenkamp, 2014; Wechsler, 2009), would have increased the comparability of results per memory domain, and also increased the possibilities of comparing the present results with available memory literature. The primary reason to include the Corsi Block Tapping Test instead of the Wechsler Spatial Span in the current testing procedure was that, according to recent papers, the Corsi Block Tapping Test is internationally still the most commonly applied spatial span test (see, for example, Claessen, van der Ham, & van Zandvoort, 2015; Woods, Wyma, Herron, & Yund, 2016). Moreover, the first three editions of the Wechsler Memory Span did not have Dutch normative data available, reducing the popularity of this test in The Netherlands. It would nevertheless be beneficial for the research in amnesia to apply standardised testing batteries in future research, such as the WMS-IV. Moreover, the sample size of this study was small, although it was comparable to other studies on neuropsychological functioning in KS (Postma, Kessels, & van Asselen, 2008; Van Damme & d'Ydewalle, 2008). Although there was evidence for robust significant effects, it might be possible that the relatively small sample size resulted in a lack of finding more significant effects. Future research might examine verbal and visuospatial memory and learning in larger samples of patients with KS.

## Conclusion

In conclusion, patients diagnosed with KS show severe memory disorders on regular neuropsychological examination, although visuospatial learning and memory seem better preserved than verbal learning and memory. Central to this effect is better visuospatial memory than verbal memory encoding performance. Based on the findings of this study, it seems relevant to increase the number of available visuospatial cues during the process of memory rehabilitation in patients with KS.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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## References

- American Psychiatric Association (2013). Diagnostic and statistical manual of mental disorders 5th edition. Washington DC, United States of America: American Psychiatric Association.
- Baddeley, A. D. (2001). Is working memory still working? *American Psychologist*, *56*, 851–864.
- Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. H. Bower (Eds.), *The psychology of learning and motivation (Vol. 8)* (pp. 47–89). London: Academic.
- Bertens, D., Fasotti, L., Boelen, D. H., & Kessels, R. P. C. (2013). A randomized controlled trial on errorless learning in goal management training: Study rationale and protocol. *BMC Neurology*, *13*, 1–9. doi:10.1186/1471-2377-13-64
- Brand, N., & Jolles, J. (1985). Learning and retrieval rate of words presented auditorily and visually. *Journal of General Psychology*, *112*, 201–210.
- Bucks, R. S., & Willison, J. R. (1997). Development and validation of the Location Learning Test (LLT): A test of visuo-spatial learning designed for use with older adults and in dementia. *Clinical Neuropsychologist*, *11*, 273–286.
- Butters, N., Wolfe, J., Granholm, E., & Martone, M. (1986). An assessment of verbal recall, recognition and fluency abilities in patients with Huntington's disease. *Cortex*, *22*, 11–32.
- Cermak, L., Butters, N., & Goodglass, H. (1971). The extent of memory loss in Korsakoff patients. *Neuropsychologia*, *9*, 307–315.
- Chalfonte, B. L., Verfaellie, M., Johnson, M. K., & Reiss, L. (1996). Spatial location memory in amnesia: Binding item and location information under incidental and intentional encoding conditions. *Memory*, *4*, 591–614.
- Claessens, M. H. G., van der Ham, I. J. M., & van Zandvoort, M. J. E. (2015). Computerization of the standard Corsi Block-Tapping task affects its underlying cognitive concepts: A pilot study. *Applied Neuropsychology: Adult*, *22*, 180–188.
- Dubois, B., Slachevsky, A., Litvan, I., & Pillon, B. (2000). The FAB: A Frontal assessment battery at bedside. *Neurology*, *12*, 1621–1626.
- 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*, 189–198.
- Haxby, J. V., Ludgren, S. L., & Morley, G. K. (1983). Short-term retention of verbal, visual shape, and visuo-spatial location information in normal and amnesic subjects. *Neuropsychologia*, *21*, 25–33.
- Hendriks, M. P. H., Bouman, Z., Kessels, R. P. C., & Aldenkamp, A. P. (2014). *Wechsler memory scale – Fourth edition, dutch edition (WMS-IV-NL)*. Amsterdam: Pearson.
- Joyce, E. M., & Robbins, T. W. (1991). Frontal lobe function in Korsakoff and non-Korsakoff alcoholics: Planning and spatial working memory. *Neuropsychologia*, *29*, 709–723.
- Kessels, R. P. C., Bucks, R. S., Willison, J. R., & Byrne, L. M. T. (2012). *Location learning test: Manual*. Bury St. Edmunds, UK: Thames Valley Test Company.
- Kessels, R. P. C., & Kopelman, M. D. (2012). Context memory in Korsakoff's syndrome. *Neuropsychology Review*, *22*, 117–131.
- Kessels, R. P. C., Nys, G. M. S., Brands, A. M. A., van den Berg, E., & Van Zandvoort, M. J. E. (2006). The modified Location Learning Test: Norms for the assessment of spatial memory function in neuropsychological patients. *Archives of Clinical Neuropsychology*, *21*, 841–846.
- Kessels, R. P. C., Postma, A., Wester, A. J., & de Haan, E. H. F. (2000). Memory for object locations in Korsakoff's amnesia. *Cortex*, *36*, 47–57.
- Kessels, R. P. C., van Zandvoort, M. J. E., Postma, A., Kappelle, L. J., & De Haan, E. H. F. (2000). The Corsi Block-Tapping Task: Standardization and normative data. *Applied Neuropsychology*, *7*, 252–258.
- Komatsu, S.-I., Mimura, M., Kato, M., Wakamatsu, N., & Kashima, H. (2000). Errorless and effortful processes involved in the learning of face-name associations by patients with alcoholic Korsakoff's syndrome. *Neuropsychological Rehabilitation*, *10*, 113–132.
- Kopelman, M. D. (1991). Non-verbal, short-term forgetting in the alcoholic Korsakoff syndrome and Alzheimer-type dementia. *Neuropsychologia*, *29*, 737–747.
- Kopelman, M. D. (2002). Disorders of memory. *Brain*, *125*, 2152–2190.
- Kopelman, M. D., Thomson, A. D., Guerrini, I., & Marshall, E. J. (2009). The Korsakoff syndrome: Clinical aspects, psychology and treatment. *Alcohol and Alcoholism*, *44*, 148–154.
- Lezak, M.D. (1995). *Neuropsychological assessment* (3rd ed.). New York: Oxford University Press.
- Mayes, A. R., Daum, I., Markowisch, H. J., & Sauter, B. (1997). The relationship between retrograde and anterograde amnesia in patients with typical global amnesia. *Cortex*, *33*, 197–217.

- Mayes, A. R., Meudell, P. R., & MacDonald, C. (1991). Disproportionate intentional spatial-memory impairments in amnesia. *Neuropsychologia*, *29*, 771–784.
- Monaco, M., Costa, A., Caltagirone, C., & Carlesimo, G. A. (2013). Forward and backward span for verbal and visuo-spatial data: Standardization and normative data from an Italian adult population. *Neurological Sciences*, *34*, 749–754.
- Morgan, J., McSharry, K., & Sireling, L. (1990). Comparison of a system of staff prompting with a programmable electronic diary in a patient with Korsakoff's syndrome. *International Journal of Social Psychiatry*, *36*, 225–229.
- Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia*, *9*, 97–113.
- Oscar-Berman, M. (2012). Function and dysfunction of prefrontal brain circuitry in alcoholic Korsakoff's syndrome. *Neuropsychology Review*, *22*, 154–169.
- Oscar-Berman, M., Hutner, N., & Bonner, R. T. (1992). Visual and auditory spatial and nonspatial delayed-response performance by Korsakoff and non-Korsakoff alcoholic and aging individuals. *Behavioral Neuroscience*, *106*, 613–622.
- Oslin, D., Atkinson, R. M., Smith, D. M., & Hendrie, H. (1998). Alcohol related dementia: Proposed clinical criteria. *International Journal of Geriatric Psychiatry*, *13*, 203–212.
- Oudman, E., Nijboer, T. C. W., Postma, A., Wijnia, J. W., Kerklaan, S., Lindsen, K., & Van der Stigchel, S. (2013). Acquisition of an instrumental activity of daily living in patients with Korsakoff's syndrome: A comparison of trial and error and errorless learning. *Neuropsychological Rehabilitation*, *23*, 888–913.
- Oudman, E., Nijboer, T. C. W., 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*, 134–148.
- Oudman, E., Van der Stigchel, S., Wester, A. J., Kessels, R. P. C., & Postma, A. (2011). Intact memory for implicit contextual information in Korsakoff's amnesia. *Neuropsychologia*, *49*, 2848–2855.
- Pitel, A. L., Beaunieux, H., Witkowski, T., Vabret, F., de la Sayette, V., Viader, F., ... Eustache, F. (2008). Episodic and working memory deficits in alcoholic Korsakoff patients: The continuity theory revisited. *Alcoholism: Clinical and Experimental Research*, *32*, 1229–1241.
- Postma, A., Kessels, R. P. C., & van Asselen, M. (2008). How the brain remembers and forgets where things are: The neurocognition of object-location memory. *Neuroscience and Biobehavioral Reviews*, *32*, 1339–1345.
- Postma, A., Van Asselen, M., Keuper, O., Wester, A. J., & Kessels, R. P. C. (2006). Spatial and temporal order memory in Korsakoff patients. *Journal of the International Neuropsychological Society*, *12*, 327–336.
- Rey, A. (1958). *L'examen clinique en psychologie*. Paris, France: Presses Universitaires de France.
- Salamé, P., Danion, J. M., Peretti, S., & Cuervo, C. (1998). The state of functioning of working-memory in schizophrenia. *Schizophrenia Research*, *30*, 11–29.
- Schmand, B., Houx, P., & de Koning, I. (2012). *Norms for word fluency, stroop color word test, trail making test, verbal learning test, and story recall of rivermead behavioural memory test. Dutch norms*. Amsterdam: Section Neuropsychology Dutch Institute of Psychologists.
- Schmand, B., Lindeboom, J., & van Harskamp, F. (1992). *Manual for the dutch reading test for adults*. Lisse, The Netherlands: Swets & Zeitlinger.
- Sohlberg, M. M., & Mateer, C. A. (1987). Effectiveness of an attention-training program. *Journal of Clinical and Experimental Neuropsychology*, *9*, 117–130.
- Squire, L. R. (2009). Memory and brain systems: 1969–2009. *Journal of Neuroscience*, *29*, 12711–12716.
- Svanberg, J., & Evans, J. J. (2013). Neuropsychological rehabilitation in Alcohol-Related brain damage: A systematic review. *Alcohol and Alcoholism*, *48*, 704–711.
- Van Asselen, M., Kessels, R. P. C., Wester, A., & Postma, A. (2005). Spatial working memory and contextual cueing in patients with Korsakoff amnesia. *Journal of Clinical and Experimental Neuropsychology*, *27*, 645–655.
- Van Damme, I., & d'Ydewalle, G. (2008). Elaborative processing in the Korsakoff syndrome: Context versus habit. *Brain and Cognition*, *67*, 212–224.
- Van Geldorp, B., Bergmann, H. C., Robertson, J., Wester, A. J., & Kessels, R. P. C. (2012). The interaction of working memory performance and episodic memory formation in patients with Korsakoff's amnesia. *Brain Research*, *1433*, 98–103.
- Verhage, F. (1964). *Intelligence and age*. Assen, NL: van Gorcum. (in Dutch).
- Wechsler, D. (1997). *Wechsler adult intelligence scale – Third edition*. San Antonio, TX: Psychological Corporation.

- Wechsler, D. (2009). *Wechsler memory scale – Fourth edition (WMS-IV)*. San Antonio, TX: Pearson.
- Wilson, B. A., Baddeley, A., Evans, J., & Shiel, A. (1994). Errorless learning in the rehabilitation of memory impaired people. *Neuropsychological Rehabilitation*, 4, 307–326.
- Woods, D. L., Wyma, J. M., Herron, T. J., & Yund, E. W. (2016). An improved spatial span test of visuospatial memory. *Memory*, 24, 1142–1155.