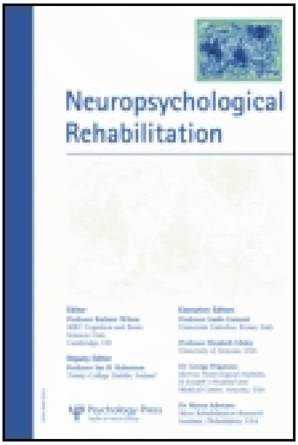

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Acquisition of an instrumental activity of daily living in patients with Korsakoff's syndrome: A comparison of trial and error and errorless learning

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Patients with Korsakoff's syndrome show devastating amnesia and executive deficits. Consequently, the ability to perform instrumental activities such as making coffee is frequently diminished. It is currently unknown whether patients with Korsakoff's syndrome are able to (re)learn instrumental activities. A good candidate for an effective teaching technique in Korsakoff's syndrome is errorless learning as it is based on intact implicit memory functioning. Therefore, the aim of the current study was two-fold: to investigate whether patients with Korsakoff's syndrome are able to (re)learn instrumental activities, and to compare the effectiveness of errorless learning with trial and error learning in the

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acquisition and maintenance of an instrumental activity, namely using a washing machine to do the laundry. Whereas initial learning performance in the errorless learning condition was superior, both intervention techniques resulted in similar improvement over eight learning sessions. Moreover, performance in a different spatial layout showed a comparable improvement. Notably, in follow-up sessions starting after four weeks without practice, performance was still elevated in the errorless learning condition, but not in the trial and error condition. The current study demonstrates that (re)learning and maintenance of an instrumental activity is possible in patients with Korsakoff's syndrome.

Keywords: Korsakoff's syndrome; Amnesia; Errorless learning; Neuropsychological Rehabilitaton; Cognitive Rehabilitation

INTRODUCTION

Korsakoff's syndrome is a brain disorder predominantly caused by alcoholism resulting in thiamine (vitamin B1) deficiency. Neurological damage in Korsakoff's syndrome is frequently found in the diencephalic and cerebellar structures. The disorder is characterised by severe anterograde amnesia for declarative knowledge (Kopelman, 1995; Sechi & Serra, 2007). There is evidence that the most pronounced problems in Korsakoff's syndrome are found in remembering contextual information, such as spatial memory for exact locations of objects in space and relative object-to-location binding (Chalfonte, Verfaellie, Johnson, & Reiss, 1996; Kessels, Postma, Wester, & de Haan, 2000). Also, forming associations between temporal order information and spatial information is severely hampered (Postma, Van Asselen, Keuper, Wester, & Kessels, 2006). Besides problems with contextual memory, deficits in executive functions have also been reported in Korsakoff's syndrome (Brand et al., 2005; Jacobsen, Acker, & Lishman, 1990; Van der Stigchel, Reichenbach, Wester, & Nijboer, 2012). The combination of memory and executive deficits has a massive impact on the patient's ability to carry out daily routines. In particular, Korsakoff's syndrome patients are frequently reported to be unable to perform instrumental activities of daily living, such as making coffee or performing the laundry without assistance.

The present study investigated whether Korsakoff's syndrome patients still have some potential for learning an instrumental activity of daily living, and, if so, which conditions would be most beneficial. Until now, this topic has received almost no consideration, although learning or relearning of potentially useful instrumental activities of daily living may increase the patient's functional autonomy (Kok, 1991; Oudman & Zwart, 2012; Wilson, 2008). Moreover, investigations into application of intact memory in Korsakoff's syndrome in everyday situations might contribute to existing literature on memory processes in the condition. Most of the current literature on intact long-term memory processes in Korsakoff's syndrome has been devoted to implicit memory. It is currently unresolved whether implicit memory is intact in Korsakoff's syndrome, although a variety of studies has suggested that implicit memory is relatively spared; more specifically implicit contextual learning (Oudman, Van der Stigchel, Wester, Kessels, & Postma, 2011; Postma, Antonides, Wester, & Kessels, 2008), verbal repetition priming (Graf, Shimamura, & Squire, 1985), and perceptual priming (Cermak, Verfaellie, Milberg, Letourneau, & Blackford, 1991; d'Ydewalle & Van Damme, 2007; Fama, Pfefferbaum, & Sullivan, 2006) have been found to be intact. Nevertheless, motor sequence learning, conceptually driven implicit memory and picture-fragment completion are relatively impaired compared to healthy control subjects (Brunfaut & d'Ydewalle, 1996; Van Tilborg, Kessels, Kruijt, Wester, & Hulstijn, 2011; Verfaellie, Gabrieli, Vaidya, Croce, & Reminger, 1996). A recent review suggested that implicit memory in Korsakoff's syndrome is restricted to operating in a rigid automatic fashion (Hayes, Fortier, Levine, Milberg, & McGlinchey, 2012). Korsakoff's syndrome patients may exhibit normal implicit memory performance on a variety of tasks, however, when the task requires additional cognitive processes, such as executive functioning, task performance is impaired (Beaunieux et al., 2013).

A memory rehabilitation technique that has been shown to be effective in teaching new information and new procedures to individuals with severe memory impairment is errorless learning (Ehlhardt et al., 2008; Kessels & de Haan, 2000). Errorless learning is a teaching technique using feed-forward instructions, thereby preventing mistakes during the learning process. Feed-forward instructions (i.e., how to perform a certain action) are given before actions to prevent learners from making mistakes. At each step the learner receives cues (see Table 1 for an explanation of the procedure and examples of cues). In their now classical experiment, Wilson, Baddeley, and Evans (1994) reported five severely impaired amnesic patients with mixed aetiology who successfully learned five tasks resembling everyday activities, for example, learning how to programme an electronic aid. The authors argued that implicit memory is responsible for the consolidation of erroneous responses in errorful learning, whereas errorless learning helps implicit memory to overcome this failure in that only the correct response is strengthened. In particular, the literature associates the positive effects of errorless learning with a neuropsychological profile of significantly impaired explicit, conscious memory with relatively preserved implicit, unconscious memory (Cohen, Ylvisaker, Hamilton, Kemp, & Claiman, 2010; Evans et al., 2000). Nevertheless, in some experiments on healthy (Kessels, Boekhorst, & Postma, 2005) and memory-impaired individuals (Hunkin, Squires, Parkin, & Tidy, 1998) no relationship between the learned material and assessments of implicit memory became clear. Whether explicit memory is necessary for errorless learning has been the topic of an ongoing debate (see Clare & Jones, 2008 and Li & Liu, 2012 for reviews). A possible explanation for the inconsistent results was provided by Page, Wilson, Shiel, Carter, and Norris (2006). The authors suggested that while both implicit and explicit memory (when functionally adequate) could contribute to learning in amnesia, implicit memory alone is sufficient to account for the observed errorless learning advantage. Nevertheless, this could be enhanced by explicit memory when sufficient residual explicit memory functioning is available. Support for the sufficiency of implicit memory was found in studies that showed that the severity of explicit memory problems increased the effectiveness of errorless learning in a group of severe amnesiacs (Klimkowicz-Mrowiec, Slowik, Krzywoszanski, Herzog-Krzywoszanska, & Szczudlik, 2008; Page et al., 2006).

The errorless learning technique might be beneficial for learning an instrumental activity. In fact, recent pilot trials and case studies suggest that errorless learning techniques may have positive effects on activities of daily living in dementia compared to learning techniques with errors (Thivierge, Simard, Jean, & Grandmaison, 2008; Clare & Jones, 2008). For example, Dechamps et al. (2011) showed that errorless learning was an effective method to relearn instrumental activities of daily living in Alzheimer's dementia. Errorless learning was more effective than trial and error learning during a follow-up after one and three weeks, suggesting long-lasting beneficial effects for relearning instrumental activities of daily life with errorless learning. Thus far only few experimental studies have attempted errorless learning in Korsakoff's syndrome and their results are inconclusive with respect to the question of whether or not errorless learning is beneficial compared to learning with errors. The errorless learning technique was successfully applied for learning fictitious face–name associations (Komatsu, Mimura, Kato, Wakamatsu, & Kishima, 2000). In this study, errorless learning was more effective than a learning condition with errors. However, Kessels, van Loon, and Wester (2007) showed that both errorless learning and trial and error learning were equally effective methods to learn routes in Korsakoff's syndrome.

The main objective of the current study was to examine whether Korsakoff's syndrome patients still have some potential for learning an instrumental activity of daily living. Moreover, we wanted to investigate whether errorless learning could more effectively support the (re)learning and maintenance of an instrumental activity of daily living in Korsakoff's syndrome than trial and error learning. Based on earlier studies in dementia (e.g., Dechamps et al., 2011) and a meta-analysis on memory-impaired individuals (Kessels & de Haan, 2000), we expected performance in the errorless learning condition to be superior to the trial and error condition. It would be relevant to rehabilitation of Korsakoff's syndrome patients to employ the most successful (re)learning and maintenance of an instrumental activity, since this would increase the autonomy of Korsakoff's syndrome patients.

As a model for instrumental activities, we chose a laundry activity, since this is a complex but regular instrumental activity of daily living. To test whether the learning effect was long lasting, we included four follow-up sessions after four weeks without training or any form of practice, after eight regular learning sessions. Currently, little research has been devoted to generalisations of learned material without errors to a different context in patients with amnesia. The available evidence, however, indicates that new knowledge acquired using errorless learning is often inflexible and recall is best when there is a strong correspondence between contextual cues at recall with cues that were present when information was encoded (see Ptak, Van der Linden, & Schnider, 2010, for a review). Some generalisations follow from overlearning (Butters, Glisky, & Schachter, 1993). Moreover, some case studies suggest that full transference of a learned response is possible (Van der Linden, Meulemans, & Lorrain, 1994). Therefore, the second objective of the current study was to investigate whether new knowledge that was acquired transfers to a different spatial context.

METHODS

Participants

Thirty patients (mean age = 58.9; *SD* = 6.9; 28 males) with severe anterograde amnesia, diagnosed with Korsakoff's syndrome participated in this study. Eight patients were excluded from analysis to avoid a ceiling effect in the learning and follow-up sessions. Their initial performance was higher than 85% on the first learning session, suggesting that they were already able to perform the complex task at near optimal level prior to training. Hence no learning or follow-up effects could be established. Six Korsakoff's syndrome patients dropped out of the study during the learning or follow-up sessions; four because of motivational problems interfering with the testing procedure and two because of a medical condition that prevented them from completing all sessions. The remaining 16 (8 errorless learning, 8 trial and error learning) patients completed all sessions. The patients were inpatients of the Korsakoff Centre, "Slingedael", Rotterdam, The Netherlands. All patients fulfilled the DSM-IV criteria for alcohol-induced persisting amnestic disorder (American Psychiatric Association, 2000) and the criteria for Korsakoff's syndrome described by Kopelman (2002). The amnestic syndrome was confirmed by extensive neuropsychological testing. All patients were in the chronic, amnestic stage of the syndrome; none of the patients had confusional Wernicke psychosis at the time of testing. The current intelligence level of each participant had to be in concordance with the estimation of premorbid functioning based on occupational and educational history in order to exclude cases of dementia (Oslin, Atkinson, Smith, & Hendrie, 1998). 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 (Christensen, Hazdi-Pavlovic, & Jacomb, 1991; McGurn et al., 2004). The score on this test is a predictor of premorbid intelligence in brain-damaged patients. General cognitive functioning was assessed with the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975; Kok, Verhey, & Schmand, 2004). Only patients with estimated premorbid IQ scores higher than 80 and MMSE scores higher than 18 were included in the test protocol, to exclude patients with low intellectual or cognitive functioning, possibly caused by alcohol dementia, which could interfere with the testing procedure (Kok et al., 2004; Schmand et al., 1992). In addition, all patients were younger than 70 years to minimise the possibility of senile dementia. All patients had an extensive history of alcoholism and nutritional depletion, notably thiamine deficiency, verified through medical charts. Other general exclusion criteria were presence of neurological disorders (head injury, stroke, epilepsy, etc.), illiteracy, and acute psychiatric conditions (psychosis, major depression, etc.), or physical conditions interfering with the testing procedure. The patients gave informed consent according to the standards of the Declaration of Helsinki. This project was approved by the institutional review board.

Materials

A laundry task was selected since it requires multiple steps and is a commonly applied instrumental activity. Moreover, before this study took place, the laundry was performed by an external cleaning service. This minimised the chance that patients were already acquainted with the task prior to the procedure. The task was broken into small action sequences (see Table 1). The action sequences were transformed into verbal instructions. Motor sequences and explicit knowledge were scored using the same assessment procedure which was validated in a multidisciplinary team composed of a psychologist, an occupational therapist, a social worker and two members of the nursing staff.

Task

During a face-to-face interview with the patient, the aim of the project was explained in further detail, namely the (re)learning of a laundry activity. For all patients, the primarily responsible nurse was asked whether or not

TABLE 1
Description of the errorless learning and trial and error learning condition: The action sequence verbalised by the therapist and examples of verbal cues

	Errorless learning	*Trial and error learning*
Technique	Errorless learning refers to the use of feed-forward instruction (i.e., how to do) before actions to prevent learners from making mistakes.	Trial and error learning refers to the regular unstructured learning and is considered as control condition.
Guidance	At each step the patient receives verbal cues. Before the task is performed, the participant receives verbal instructions.	Guessing and errors are corrected after they have been performed by verbal instructions.
Instructions	"Here is the washing machine. I will ask you to perform your own the laundry on the 40 degrees express programme. I will help you if you are unable to perform steps during the task."	
Error correction	The therapist allows the participant to find the solution (maximum of 5 seconds), if the answer or action is not immediately given, the participant receives a cue ("do the step"). If the participant is still unable to perform the task, additional verbal instructions are given. If no verbal instructions lead to the correct response, the step is performed by the therapist.	Erroneous responses are corrected by verbal cues after 2 trials or 20 seconds (approximately). The patient is encouraged to continue.
Action sequence	*Examples of verbal cues*	*Examples of verbal cues*
1. Bring the laundry basket to the washing machine	Cue: We take this basket. Cue: We bring the basket to the laundry machine.	Cue: We need to bring this basket, not this pile of clothes. Cue: We need to bring the basket to the laundry machine.
2. Put the clothes in the washing machine	Cue: Put them in the machine.	Cue: This is not the correct machine, put them in the washing machine.
3. Close the door of the washing machine	Cue: Close the door.	Cue: First, close the door of the machine.
4. Open the soap box and put one spoon of soap in it	Cue: Open the box. Cue: Put a spoon of soap in the box	Cue: The machine is not ready to start yet, first put in the soap. Cue: You should put a spoon of it in it.

5. Select the "40 degrees express" programme on the programme display by turning the switch	Cue: Select 40 express. Cue: Turn on the switch.	Cue: The Select 40 express programme should be selected. Cue: Turn on the switch
6. Start the machine. After you pushed start we see each other in 30 minutes	Cue: Now start the machine.	Cue: You first need to start the machine.
7. Open the washing machine	Cue: Open the machine.	Cue: You first need to open the machine.
8. Put the clothes in the basket	Cue: Put the clothes in the basket.	Cue: Put the clothes in this basket
9. Hang the clothes on the laundry rack	Cue: Hang them on the rack.	Cue: The clothes should be hanged on the rack.

the patient was able to perform the laundry task. For all patients the nurse agreed that the patient was unable to perform the task and/or had never performed the task during his/her stay in the clinic. Subsequently, the performance on the selected task was assessed. Half of the patients were instructed following the errorless learning condition, the other half were instructed following the trial and error condition. In the errorless learning condition, the therapist gave cues before the completion of the sequence according to the protocol as described in Table 1. The errorless learning method is described as a teaching technique that prevents people from making mistakes during learning. This contrasts with trial and error learning, in which guessing and errors are corrected after they have been performed. In the trial and error condition participants were allowed to make up to three guesses (or for a maximum duration of 20 seconds) before correction. Cues were only provided if the participant was unable to find and complete the next step correctly. The therapist prompted the patient to find a solution, using different questions related to the task. No errors were intentionally introduced in either condition.

Primary outcome measures

The assessment procedure remained the same for all participants during all assessment sessions. The laundry activity was broken into action sequences (see Table 1). The assessment of each action step was made using three categories: (1) Deficit; (2) Questionable; and (3) Competent.

Deficit. This term designates the absence of answers or reactions. A patient who stopped and was not able to perform the task with additional repetitions of the verbal instructions was classified as having a deficit in this specific step (Score = 1).

Questionable. This term refers to all actions from the patient that cannot be classified as correct (competent). A patient who showed hesitation and doubt in performing this step was classified as having a questionable performance in this specific step. This category involves planning problems; the repetition of a step that has already been performed; verbal hesitation, asking questions such as "is it correct?"; and motor hesitation, such as touching the object and quickly retrieving the hand, and making small or aimless movements were also classified in this category (Score = 2).

Competent. The step is successfully performed without instructions (Score = 3).

The therapist filled in the assessment form for each step of the task sequence following its completion. For total score comparisons, the total scores per tasks were adjusted to a 100-point scale using the following formula: performance = (total score/27) x 100. A performance of 100% therefore indicated perfect actions and planning (see Dechamps et al., 2011 for more details).

Procedure

The therapists followed a two-day instruction on errorless learning at the care facility Krönnenzommer, Hellendoorn, The Netherlands before the start of the study. The training encompassed a course on the concept of errorless learning and training sessions on accurately rating the patients' performance. Moreover, the therapists followed two instruction sessions on differences between trial and error learning and errorless learning at the care facility Slingedael, Rotterdam, The Netherlands. For the task, patients with Korsakoff's syndrome were visited at their facilities eight times over a four-week period (twice a week) for a total of eight sessions. Five follow-up assessments (assessments occurred twice a week) (see Figure 1) were performed after four weeks without training. During the four weeks without training, patients did not perform the laundry task. The laundry was performed by an internal laundry service. The goal of the first follow-up assessment was to investigate

Session 1 & 2	Session 3 & 4	Session 5 & 6	Session 7 & 8	No Session	No Session	No Session	No Session	Follow-Up 1 & 2	Follow-Up 3 & 4	Follow – Up Spatial
Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8	Week9	Week10	Week11

Figure 1. Time-frame of the experiment. Sessions were conducted twice a week, with a four-week pause. Five follow-up sessions were conducted, four within the same spatial layout. The fifth follow-up session was in a different spatial layout.

Figure 2. Left: The spatial layout of the eight learning sessions and four follow-up sessions. Right: the altered spatial layout for the session with a different spatial layout.

whether patients with Korsakoff's syndrome were still able to perform the instrumental activity. The goal of the second to the fourth follow-up was to examine whether patients were able to improve their performance on the instrumental activity. In the fifth follow-up assessment, the spatial layout of the procedure was changed such that patients performed the task in a washing room with a different spatial layout (see Figure 2). Only one follow-up assessment included a changed spatial layout to minimise the possible discomfort involved with performing the task in a different set-up. During each session, the participant learned the laundry task using the schedule presented in Table 1.

Assessment

All participants completed a short neuropsychological examination within one month of starting the learning procedure. Patients were administered the Dutch version of the Rey Auditory Verbal Learning Test (RAVLT; Van Der Elst, Van Boxtel, Van Breukelen, & Jolles, 2005) which measures immediate and long-term verbal memory. Verbal working memory capacity was assessed using the digit span of the Wechsler Adult Intelligence Scale (WAIS; Uterwijk, 2000). In addition, the Action Programme test of the Behavioural Assessment of the Dysexecutive Syndrome (BADS) was also conducted (Wilson, Alderman, Burgess, Emslie, & Evans, 1996). In the Action Programme test, participants are required to remove a cork from a small tube, making use of certain tools. This test shows adequate concurrent validity to assess executive functions, and assesses planning, problem solving and shifting (Norris & Tate, 2000; Van Oort & Kessels, 2009). Education level was assessed using seven categories, 1 being the lowest (less than primary school) and 7 being the highest (academic degree) (Verhage, 1964). These categories were converted to the internationally applied classification using years of education (Hochstenbach, Mulder, Van Limbeck, Donders, & Schoonderwaldt, 1998).

RESULTS

Demographic and neuropsychological characteristics

Demographic variables and neuropsychological test results of the patients are presented in Table 2. No statistically significant differences between the errorless learning and trial and error learning condition with respect to the demographic variables and neuropsychological test results of the Korsakoff's syndrome patients were found.

Laundry task

Figure 3 depicts the performance on the laundry task over time. Each data point reflects the performance on each assessment and was scored by a trained therapist.

Learning phase

Both groups performed equally well on the first learning session, $t(14) = 1.1$, $p = .291$, indicating no performance differences at the start of the protocol. To investigate whether errorless learning and trial and error learning techniques could effectively support the (re)learning of the laundry task in Korsakoff's syndrome, performance in eight consecutive learning sessions was examined for both conditions separately. Mauchly's test of sphericity indicated that the assumption of sphericity had been violated for sessions in the errorless learning condition, but not for the trial and error condition. Therefore, we used Greenhouse–Geisser corrected values for the results of the repeated measures ANOVA of this variable in the errorless learning condition. Importantly, a main effect for Session was found in the errorless learning condition, $F(4.755, 33.288) = 4.5$, $MSE = 47.1$, $p = .003$, $\eta_p^2 = .392$, and in the trial and error condition, $F(7, 49) = 9.8$, $MSE = 20.6$, $p < .0001$, $\eta_p^2 = .582$. The results suggest that during the learning phase both learning conditions improved. In order to inspect the benefits of the learning phase, performance on the first and the eighth session were compared in post-hoc 2 x 2 ANOVA on the first and last session of the learning phase. Prominently, a main effect for Session, $F(1, 14) = 40.5$, $MSE = 40.5$, $p < .0001$, $\eta_p^2 = .743$, was found, indicating a learning effect over sessions. The Condition effect was not significant, $F(1, 14) = 1.3$, $MSE = 124.5$, $p = .281$, $\eta_p^2 = .083$, suggesting that performance was not statistically different between Errorless learning and Trial and Error

TABLE 2
Demographic variables and neuropsychological test results for the Korsakoff's patients

	Rrrorless learning	*Trial and error learning*	*Statistic*	*p-value*
Number of participants (m:f)	8 (8:0)	8 (8:0)		
Age (Mean, *SD*)	58.9 (6.9)	58.9 (7.2)	$t(14) = 0.76$	.46
Years of Education (Mode, range) [a]	10.3 (8–19)	10.4 (6–19)	*Mann-Whtney* $U = 28.5$	.72
MMSE (Mean, *SD*) [b]	23.0 (3.3)	22.5 (2.7)	$t(14) = 0.33$	.74
IQ (Mean, *SD*)[c]	92.1 (8.7)	91.9 (12.4)	$t(14) = 0.05$	.96
BADS Action Programme test (Mean, *SD*)[d]	2.4 (1.8)	2.8 (1.5)	$t(14) = 0.46$	.65
WAIS III Digit Span Forward (Mean, *SD*)[e]	5.0 (0.5)	5.1 (1.1)	$t(14) = 0.28$	.78
WAIS III Digit Span Backward (Mean, *SD*)[e]	3.4 (0.5)	3.8 (0.7)	$t(14) = 1.21$	.25
Rey Auditory Verbal Learning total score 1-5 (Mean, *SD*)[f]	16.7 (4.5)	12.9 (5.3)	$t(14) = 1.47$	.17
Rey Auditory Verbal Learning free recall (Mean, *SD*)[f]	2.6 (6.2)	0.6 (0.9)	$t(14) = 0.90$	.39
Rey Auditory Verbal Learning recognition (Mean, *SD*) [f]	18.5 (5.9)	20.0 (4.8)	$t(14) = 0.56$	.58

MMSE = Mini Mental State Examination; IQ = Intelligence Quotient; BADS = Behavioural Assessment Dysexecutive Syndrome; WAIS III = Wechsler Adult Intelligence Scale III;

[a] Years of Educations was scored using 7 categories: 1 = lowest (less than primary school), 7 = highest (university degree) (Verhage, 1964) and converted to the internationally applied classification (Hochstenbach et al., 1998)

[b]The standardised Dutch version of the Mini Mental State Examination was assessed (Kok et al., 2004).

[c]IQ was estimated with the Dutch Adult Reading Test (Schmand et al., 1992).

[d]In the Action Programme test participants are required to remove a cork from a small tube, making use of certain tools. This test shows adequate concurrent validity to assess executive functions, and assesses planning, problem solving and shifting in Korsakoff's syndrome (Norris & Tate, 2000; Van Oort & Kessels, 2009).

[e]Working memory span for the Wechsler Adult Intelligence Scale, raw scores (WAIS; Uterwijk, 2000).

[f]Raw score for the Dutch version of Reys Auditory Verbal Learning test. All patients scored within the first five percentiles for the total score 1–5 and free recall (Van der Elst et al., 2005).

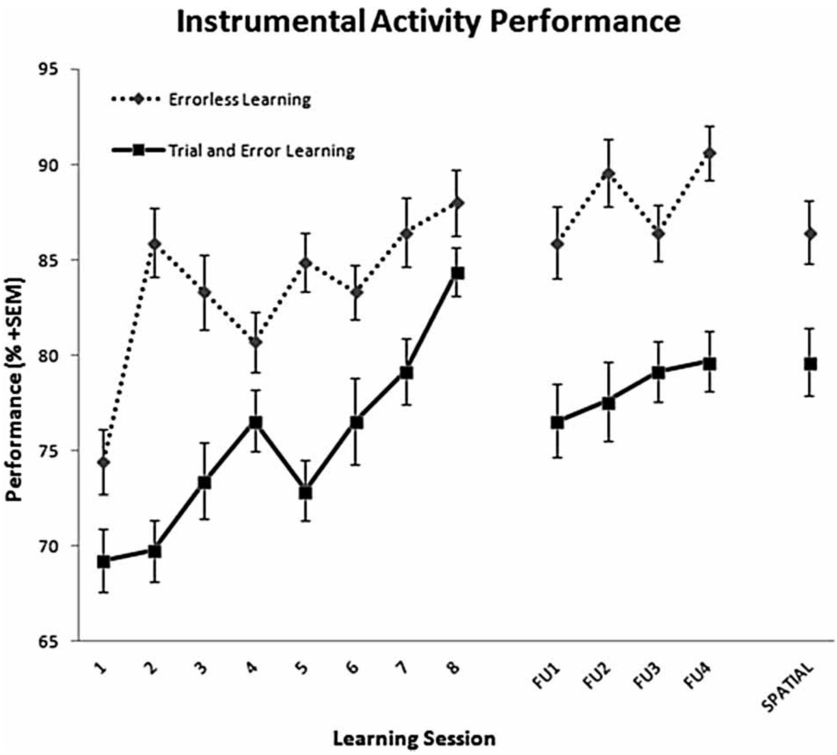

Figure 3. Performance on each learning session for Korsakoff's syndrome patients (n = 16) in the errorless learning and trial and error learning condition. For total score comparisons, the total scores per session were adjusted to a 100-point scale.

learning. The interaction of Session x Condition was not significant, $F(1, 14) = 4.9$, $MSE = 40.5$, $p = .734$, $\eta_p^2 = .009$. For the Errorless learning condition an average improvement of 13.5% was found (SD = 10.4%), while for the Trial and Error learning condition this was 15.1% (SD = 7.4%). The results suggest that during the learning phase, both learning conditions improved to an equal extent.

Based on visual inspection of the results (see Figure 3), it appeared that the errorless learning condition demonstrated an evident improvement in the second learning session compared to the first learning session. To investigate this expectation, the first and second sessions were compared in post-hoc repeated measures. The effect for Session was significant (first versus second) in the errorless learning condition, $F(1, 7) = 12.6$, $MSE = 41.5$, $p = .009$, $\eta_p^2 = .644$, but not for the trial and error condition, $F(1, 7) = 0.0$, $MSE = 33.2$, $p = .862$, $\eta_p^2 = .005$. Notably, for the errorless learning condition an average improvement of 11.5% was found ($SD = 9.1\%$), while for the trial and error condition this was 0.5% ($SD = 8.2\%$). Moreover, it was expected that in the errorless learning condition, learning flattened after the second learning session. To investigate this expectation, the second and eighth session were compared in post-hoc repeated measures. The effect for Session (second versus eighth) was not significant in the errorless learning condition, $F(1, 7) = 1.4$, $MSE = 12.4$, $p = .275$, $\eta_p^2 = .167$, but was for the trial and error condition, $F(1, 7) = 68.6$, $MSE = 12.4$, $p < .001$, $\eta_p^2 = .907$. The post-hoc analyses suggest that the performance in the errorless learning condition showed a significant increase in the second learning session, while this was not evident for the trial and error condition. After the second learning session, learning plateaued in the errorless learning condition, while it increased in the trial and error condition.

Without training

To inspect whether four weeks without any training or practice resulted in an inferior performance compared to the last learning session, the last learning session and the first follow-up session were compared for both conditions separately. Importantly, for the errorless learning condition, no significant effect for Session (eighth versus first follow-up) was found, $F(1, 7) = 0.8$, $MSE = 22.3$, $p = .41$, $\eta_p^2 = .100$, indicating that four weeks without training or practice had no significant effect on task performance for the errorless learning condition. For the trial and error condition a negative trend was found, $F(1, 7) = 5.1$, $MSE = 48.2$, $p = .059$, $\eta_p^2 = .42$, suggesting that four weeks without training or practice had a negative effect on task performance in the trial and error condition.

To examine whether four weeks without any training or practice resulted in a better performance compared to the first learning session, the first learning session and the first follow-up session were compared for both conditions separately. Importantly, for the errorless learning condition, a significant effect for Session (first versus first follow-up) was found, $F(1, 7) = 6.9$, $MSE = 76.3$, $p = 0.03$, $\eta_p^2 = .50$, while no significant effect for Session (first versus first follow-up) was found in the trial and error condition, $F(1, 7) = 3.3$, $MSE = 63.9$, $p = .11$, $\eta_p^2 = .32$. Compared to the first learning session, for the errorless learning condition an average improvement of 11.5% was found ($SD = 12.4\%$), while for the trial and error learning condition this was 7.3% ($SD = 11.3\%$). Together, the statistical analyses on the first follow-up session suggest that performance was still elevated in the errorless learning condition after four weeks without practice or training, without a significant decline in performance. In the trial and error condition performance was not significantly elevated compared to baseline.

Follow-up phase

To see whether four follow-up sessions would result in reinstatement of the initial learning effect in both learning conditions, performance in four follow-up sessions was examined for both conditions. Here the main effect of Session was not significant for the errorless learning condition, $F(3, 21) = 1.9$, $MSE = 22.7$, $p = .165$, $\eta_p^2 = .211$, nor the trial and error condition, $F(3, 21) = .95$, $MSE = 17.2$, $p = .433$, $\eta_p^2 = .120$. The results suggest that neither condition showed a significant improvement in the follow-up phase.

Spatial layout

To investigate whether the benefits of a learning technique would generalise to a different spatial context, the fifth follow-up session was compared to the last session with a different spatial context for both conditions. The Session effect was significant for the errorless learning condition, $F(1, 7) = 7.0$, $MSE = 9.9$, $p = .03$, $\eta_p^2 = .500$, but not significant for the trial and error condition, $F(1, 7) = 0$, $MSE = 12.4$, $p = 1$, $\eta_p^2 = .0$. This suggests that a different spatial layout has a negative impact on performance in the errorless learning condition, but not in the trial and error condition. To scrutinise whether the training programme did have a positive impact on task performance in both learning conditions in a different spatial layout, the fifth follow-up session was compared to the first learning session. Here, the Session effect was significant for the errorless learning condition, $F(1, 7) = 7.1$, $MSE = 80.4$, $p = .032$, $\eta_p^2 = .505$, and the trial and error condition, $F(1, 7) = 12.5$, $MSE = 34.7$, $p = .010$, $\eta_p^2 = .641$, suggesting that both conditions benefited from the training programme. Compared to the first learning session, for the errorless learning condition an average improvement of 12.0% was found ($SD = 12.7\%$), while for the trial and error learning condition this was 10.4% ($SD = 8.3\%$). Together these results suggest that a different spatial layout did result in a lower task performance for the errorless learning condition, but not for the trial and error condition. However, task performance did show an improvement of 12.0% in the errorless condition and 10.4% in the trial and error condition after the training programme, which was a significant improvement for both learning conditions.

Correlations between test results

To further investigate the nature of instrumental learning, we performed additional correlations on the various neuropsychological test results and demographic variables. Correlations between neuropsychological test results and task performance in the first learning session are presented in Table 3. The correlations suggest that initial task performance showed a positive association with tasks intended to index encoding into long-term memory

TABLE 3
Pearson's correlations between the demographic variables, neuropsychological test results and task performance in the difference phases ($n = 16$)

	Peformance first learning session[a]	*Learning in the learning phase*[b]	*Learning in the follow-up phase*[c]	*Learning in a different spatial layout*[d]
Age (r, p-value)	−.18, p = .52	.26, p = .34	−.01, p = .99	.24, p = .38
Years of Education (r, p-value)	.07, p = .81	−.13, p = .64	−.08, p = .76	.11, p = .69
MMSE (r, p-value)	.52, p = .04	−.45, p = .08	−.35, p = .19	−.20, p = .45
IQ (r, p-value)	.06, p = .83	−.07, p = .80	−.04, p = .89	.07, p = .80
BADS Action Programme test (r, p-value)	.71, p = .00	−.46, p = .07	−.36, p = .17	−.36, p = .18
WAIS III Digit Span Forward (r, p-value)	−.45, p = .08	.06, p = .83	.05, p = .86	.10, p = .70
WAIS III Digit Span Backward (r, p-value)	−.57, p = .02	.00, p = .99	.14, p = .60	.16, p = .55
Rey Auditory Verbal Learning total score 1–5 (r, p-value)	.56, p = .04	−.59, p = .03	−.40, p = .15	−.48, p = .08
Rey Auditory Verbal Learning free recall (r, p-value)	-.06, p = .84	-.50, p = .05	-.13, p = .64	-.07, p = .79
Rey Auditory Verbal Learning recognition (r, p-value)	.46, p = .08	-.09, p = .74	.08, p = .78	.09, p = .75

For total score comparisons, the total scores per tasks were adjusted to a 100-point scale using the following formula: performance = (total score / 27) x 100. MMSE = Mini Mental State Examination; IQ = Intelligence Quotient; BADS = Behavioural Assessment Dysexecutive Syndrome; WAIS III = Wechsler Adult Intelligence Scale III; RAVLT = Rey Auditory Verbal Learning Test.

[a]Task performance in the first learning session

[b]Learning in the learning phase was assessed by subtracting the performance score for the first learning session from the performance score in the eighth learning session.

[c]Learning in the follow-up phase was assessed by subtracting the performance score for the first learning session from the performance score in the first follow-up session.

[d]Learning in a different spatial layout was assessed by subtracting the performance score for the first learning session from the performance score in a different spatial layout.

(Rey Auditory Verbal Learning Test, trial 1–5), executive planning skills (BADS Action Programme Test), and general cognitive functioning (Mini Mental State Examination). Initial task performance demonstrated a negative correlation with a task intended to index working memory (WAIS – Digit Span Backward). Moreover, initial task performance showed a negative trend with a task intended to assess speed of processing (WAIS – Digit Span Forward), and a positive trend with a task intended to assess recognition of verbal material (Rey Auditory Verbal Learning Test, Recognition). Task performance in the first learning session did not significantly correlate with any other reported neuropsychological test scores or demographic variables in Table 3 (ps $> .52$). The results suggest that the performance of an activity of daily living (e.g., a washing activity) requires a complex set of cognitive functions rather than a single cognitive function. Implications of this finding are elaborated on in the discussion.

To further investigate the nature of the learning effect in the learning phase, we performed additional correlations on the various neuropsychological test results (see Table 3) and the learning effect in the learning phase. Task learning in the learning phase was defined as the difference between task performance in the eighth learning session and the first learning session. The correlations suggest that task learning did show a negative association with a task intended to index encoding into verbal long-term memory (Rey Auditory Verbal Learning Test, trial 1–5). Moreover, a negative trend was found between task learning and a task intended to index verbal long-term memory (Rey Auditory Verbal Learning Test, Free Recall) and executive planning skills (BADS Action Programme Test). Task learning did not significantly correlate with any other reported neuropsychological test scores or demographic variables in Table 3 (ps $> .08$). The correlations suggest that the effectiveness of the teaching methods relates to tasks intended to index long-term memory and executive planning skills (BADS Action Programme Test). The implications of this pattern of results are considered in the discussion section below.

As described, we observed that four weeks without any training or practice still resulted in better performance than in the first learning session. The difference between the performance score on the first session and the first follow-up session did not correlate with any of the reported neuropsychological test scores or demographic variables in Table 3 (ps $> .17$). Moreover, the difference between the performance score on the first session and the session with a different spatial layout did show a negative trend with a task intended to assess verbal long-term memory (Rey Auditory Verbal Learning Test, Free Recall). The difference between the performance score on the first session and the session with a different spatial layout did not correlate significantly with any of the reported neuropsychological test scores or demographic variables in Table 3. It has to be noted that the relatively small sample size is likely to contribute to the lack of significant correlations.

DISCUSSION

The aim of this study was two-fold: to investigate whether patients with Korsakoff's syndrome are able to (re)learn instrumental activities and to compare the effectiveness of errorless learning with trial and error learning. Further, in order to examine whether (re)learning of an instrumental activity generalises to a different context, we altered the spatial layout in the last phase of the study. The results of the present study clearly indicate that even severely amnesic patients can learn an instrumental activity in eight biweekly learning sessions. Interestingly, the errorless learning condition showed a sharp increase in task performance at the start of the learning sessions, while this was not evident for the trial and error condition. After the second trial, learning in the errorless learning condition plateaued, while for the trial and error condition it increased. Moreover, after one month without any training or practice, performance was similar to the achievements on the final learning session for the errorless learning condition, but for the trial and error condition task performance had dropped again to baseline level. In the follow-up phase, consisting of four sessions, neither condition showed improvements in task performance. Improvements generalised to a different context, namely a different spatial layout for both conditions. A change in spatial layout had a negative impact on task performance in the errorless learning condition, compared to task performance in the normal spatial layout, but task performance was still improved compared to baseline. Correlations suggested that initial task performance was positively associated with tasks intended to assess general cognitive functioning, verbal long-term memory and executive planning skills, but negatively with working memory. Instrumental learning, however, showed a negative association with a task intended to assess long-term memory and executive planning skills.

This is the first study to investigate whether an instrumental activity of daily living can be (re)learned by patients with Korsakoff's syndrome. The positive results are promising for applying learning techniques in rehabilitation of Korsakoff's syndrome patients. This is particularly noteworthy as the loss of autonomy is a characteristic of patients with Korsakoff's syndrome and (re)learning of instrumental activities might contribute considerably to the autonomy of the patients. Our results corroborate and extend previous studies that suggest that errorless learning can be successfully applied in Korsakoff's syndrome and other patients with memory problems (Kessels & de Haan, 2000; Kessels et al., 2005; Komatsu et al., 2000). Moreover, the results indicate a parallel to recent research on instrumental activities of daily living learning in patients with dementia by means of errorless learning (Dechamps et al., 2011). It seems to be possible to obtain reliable improvements on task performance in both dementia and Korsakoff's syndrome. Importantly, also in dementia, superior performance for errorless learning became evident in a follow-up after weeks without training. A favourable task performance after a prolonged period of time in both studies suggests that errorless learning results in better consolidation of the learned material than trial and error learning. A possible explanation for the successful delayed recall of the learned material in errorless learning is that implicit memory contributes to the consolidation of the learned material. This explanation would be in line with Baddeley and Wilson's hypothesis (1994) which states that impaired explicit memory results in errors that interfere with learning and memory. If errors are eliminated, effective learning would result through the operation of relatively spared implicit memory. Furthermore, the results of superior performance for errorless learning in the follow-up are also compatible with the observations of Page et al. (2006). In their view, implicit memory for errors generated during trial and error learning leads to reduced performance, since the implicit memory system does not distinguish between errors and correct responses. It has to be noted, however, that residual explicit memory could have a favourable effect on learning in both conditions in the current experiment, despite the severity of the amnestic syndrome.

A major finding of the present study is that errorless learning yielded faster improvement at the start of the learning sessions than trial and error learning. As far as we know, the learning trajectory for (re)learning an instrumental activity has never been explicitly investigated in amnesiacs. Nevertheless, as supportive figures in earlier studies on errorless instrumental activity learning in dementia suggest, errorless learning leads to faster improvement compared to a slower improvement with errors, and this finding is in line with earlier results (Dechamps et al., 2011; Lekeu, Wojtasik, Van der Linden, Salmon, 2002). It has to be noted that the instrumental task in the current experiment, but also in the aforementioned experiments in dementia, are relatively easy to perform for healthy subjects. In fact, a fast task improvement on instrumental tasks would be typical for healthy subjects. Nevertheless, amnesiacs and patients with dementia are severely hampered in the detection and correction of errors (Evans et al., 2000; Klimkowicz-Mrowiec et al., 2008). Therefore, a slower increase in performance for a condition with errors compared to a condition without errors could be explained by diminished cognitive functions (Rodriguez-Fornells, Kofidis, & Munte, 2004).

In the current experiment it was found that performance showed a plateau phase for the errorless learning condition after the second learning session, while it increased for the trial and error condition. A statistical explanation for the apparent plateau in performance is that performance was essentially quite high in the second learning session and showing a regression toward the mean after this learning session. Based on earlier research in instrumental learning in dementia showing a comparable plateau in the errorless learning condition compared to the trial and error condition (Dechamps et al., 2011) it could also be argued that a plateau phase is an essential aspect of instrumental learning through errorless learning. This plateau could possibly reflect the transition of learning to maintenance of the instrumental task.

One of the remarkable findings of the current study is that performance levels were maintained to some extent even after a change in spatial layout for both learning conditions. A possible explanation for the current finding is that the generalisation in our experiment was task specific. Although the spatial layout was changed, the required steps to perform the task were not changed. Task-specific generalisations have been found in studies on different forms of amnesia (Berg, Koning-Haanstra, & Deelman, 1991; Schmidt, Berg, & Deelman, 2001), but have not been described for the spatial domain in Korsakoff's syndrome. It is commonly assumed that a full correspondence between the situation at encoding and recall is necessary to obtain robust improvements in errorless learning paradigms (Thöne, 1996; Kessels & de Haan, 2000; Ptak et al., 2010). To our knowledge the importance of correspondence between encoding and recall was not discussed for trial and error learning specifically. In the current experiment, we found a small but significant decline in performance for the errorless learning condition in a different spatial layout suggesting that in memory rehabilitation for Korsakoff's syndrome through errorless learning, the correspondence between the encoding and test situation should be maximised. It has to be acknowledged that even though the generalisation manipulation in the current experiment was fairly limited in nature and extent, the current findings as such open a new perspective on transference of learning to a different spatial layout.

Since there is a large discrepancy between performing an instrumental task or a neuropsychological test, correlational analysis between task performance and cognitive tests is difficult to interpret in the current experiment. Nevertheless, we found that initial task performance was positively correlated with neuropsychological tasks intended to assess general cognitive functioning, verbal long-term memory and executive planning skills, but negatively with a task intended to assess working memory. These results suggest that a combination of cognitive skills is required to perform an instrumental activity of daily living, instead of a single cognitive function. Recent studies by Beaunieux et al. (2013) and Swinnen, Puttemans, and Lamote (2005) also suggest that long-term memory, working memory, and executive functioning are related to performance on a procedural task in Korsakoff's syndrome. To our knowledge, a negative correlation between procedural performance and working memory was not found in earlier research. This result should be interpreted with caution, since the sample sizes are relatively small and a large number of correlations are examined. A possible explanation for this finding, however, is the relatively small variation in scores on the working memory task in the current Korsakoff's syndrome sample.

In the correlational analysis examining the severity of memory and executive impairment and gain from both learning techniques, long-term memory and executive functioning were negatively correlated to the acquisition of the instrumental activity. This finding suggests that the more severely impaired patients did gain greater benefit from the learning techniques than less severely impaired patients. A possible explanation for this finding is that long-term memory and executive functioning, two cognitive domains that are essentially restrained in Korsakoff's syndrome (Van der Stigchel et al., 2012), negatively affect learning mechanisms in learning an instrumental activity of daily living. This finding is in line with an earlier study by Klimkowicz-Mrowiec and colleagues (2008) suggesting that patients with more severe amnesia due to Alzheimer's dementia outperformed patients with less severe amnesia on a task intended to assess procedural learning. Also, Evans and colleagues (2000) found a comparable negative relationship between a task intended to assess daily memory (Rivermead Behavioural Memory Test; Wilson, Cockburn, & Baddeley, 1985) and learning names, specifically for the errorless learning condition in patients with acquired memory deficits. To our knowledge, relationships between executive functioning and memory rehabilitation through errorless learning have not been the scope of recent literature. Recent attempts to employ errorless learning as a rehabilitation technique for aphasia suggest that executive functions do have an influence on successful rehabilitation (Fillingham, Sage, & Ralph, 2005).

Importantly, not only memory functioning seems to have an impact on the effectiveness of teaching techniques in Korsakoff's syndrome in our study. As the negative relationship between a neuropsychological task intended to assess executive functioning indicates, executive functioning is also relevant to the effectiveness of a teaching technique.

It should be noted that both the errorless learning condition and the trial and error condition did not show a significant task improvement in the follow-up phase, although this could be expected as the task is repeated in the follow-up sessions. An explanation for this finding is a ceiling effect in the follow up phase. The average performance in the first follow-up session was already quite high (81.3%), suggesting a near to perfect task performance.

There are also some methodological considerations that have to be taken into account in the interpretation of the present findings. Although 30 Korsakoff's syndrome patients were initially included in the experiment, results of only 16 patients were considered for data analysis. This has negative implications for the statistical power of the current experiment. Nevertheless, no statistically significant differences between the errorless learning and trial and error learning condition with respect to the demographic variables and neuropsychological test results of the Korsakoff's syndrome patients were found. Moreover, we would like to stress that in a recent review on procedural learning in Korsakoff's syndrome, only a small minority of studies included more than

10 Korsakoff's syndrome patients (Hayes et al., 2012). We suggest that our results require replication in larger samples of Korsakoff's syndrome patients.

Although all of our patients were severely hampered on long-term memory and diagnosed with Korsakoff's syndrome after neuropsychological testing and multidisciplinary diagnostics (Table 1), not all patients initially showed impaired task abilities on the first learning session of the laundry activity. A methodological concern is the exclusion of eight participants who were already able to perform the laundry. Before the experiment took place, we tried to control for this by asking the primary responsible nurse whether a patient was able to perform or did perform the laundry during the stay at the clinic. Apparently, a number of participants did not perform the laundry before the experiment, but were able to perform the laundry when asked. The exclusion of participants could suggest that both learning methods in our study are only successful for Korsakoff's syndrome patients who are unable to perform the instrumental task in our experiment, but are not successful for more complicated instrumental tasks. This would require further investigation in a group of high-functioning Korsakoff's syndrome patients.

In the current study the patients in the trial and error learning condition did benefit from the training programme in the learning phase. We suggest that both implicit and explicit memory could have contributed to successful trial and error learning in the current study. An important finding by Kessels et al. (2007) was that trial and error learning was effective for route learning in Korsakoff's syndrome although patients had no explicit knowledge of prior sessions, suggesting that implicit memory could also be involved in trial and error learning. In the current study, however, there is the possibility that residual explicit memory did contribute to trial and error learning since the trial and error learning condition did score higher than zero on neuropsychological tasks intended to assess long-term memory (see Table 2). The neurocognitive basis of trial and error learning warrants future investigation.

In conclusion, the results of the present study indicate that Korsakoff's syndrome patients could (re)learn and maintain an instrumental activity by means of errorless learning and trial and error learning. Errorless learning was, however, more effective for maintaining the instrumental task. Improvements generalised to a different context, namely a different spatial layout. The current study suggests that despite the severity and chronicity of the amnesia, patients with Korsakoff's syndrome have a residual memory potential to learn and maintain instrumental activities of daily living.

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