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ORIGINAL ARTICLE

# The advantage of errorless learning for the acquisition of new concepts' labels in alcoholics

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**Background.** Previous findings revealed that the acquisition of new semantic concepts' labels was impaired in uncomplicated alcoholic patients. The use of errorless learning may therefore allow them to improve learning performance. However, the flexibility of the new knowledge and the memory processes involved in errorless learning remain unclear.

**Method.** New concepts' labels acquisition was examined in 15 alcoholic patients and 15 control participants in an errorless learning condition compared with 19 alcoholic patients and 19 control subjects in a trial-and-error learning condition. The flexibility of the new information was evaluated using different photographs from those used in the learning sessions but representing the same concepts. All of the participants carried out an additional explicit memory task and an implicit memory task was also performed by subjects in the errorless learning condition.

**Results.** The alcoholic group in the errorless condition differed significantly from the alcoholic group in the trial-and-error condition but did not differ from the two control groups. There was no significant difference between results in the learning test and the flexibility task. Finally, in the alcoholic group, the naming score in the learning test was correlated with the explicit memory score but not with the implicit memory score.

**Conclusions.** Using errorless learning, alcoholics improved their abilities to learn new concepts' labels. Moreover, new knowledge acquired with errorless learning was flexible. The errorless learning advantage may rely on explicit rather than implicit memory processes in these alcohol-dependent patients presenting only mild to moderate deficits of explicit memory capacities.

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**Key words**: Alcoholism, errorless learning, explicit memory, implicit memory, semantic learning.

## Introduction

It is now clear that recently detoxified alcoholics present cognitive deficits such as episodic memory disorders and executive dysfunctions (Noel *et al*. 2001; Pitel *et al*. 2007*a*), which have a harmful impact on new complex learning abilities including new label acquisition (Pitel *et al*. 2007*b*). The use of rehabilitation methods such as errorless learning (Baddeley & Wilson, 1994) may be relevant when teaching new concepts' labels to alcoholics is considered.

Errorless learning refers to a learning condition that involves the elimination of errors during the learning process (Clare & Jones, 2008). Indeed, according to Baddeley & Wilson (1994), amnesic patients repeat their errors in the course of the acquisition, learning them instead of the correct answers (Squires *et al*. 1997) and leading to learning impairments. Thus, the main goal of errorless learning is to compensate for the deficits of episodic memory, which is assumed to be in charge of error elimination (Baddeley & Wilson, 1994). Even though errorless learning has been used successfully many times (see Clare & Jones, 2008 for review), several questions remain regarding notably the flexibility of the new knowledge and the nature of the memory processes involved.

Flexibility is the capacity of knowledge to be generalized or transferred to other situations. Only single case studies of memory impaired patients (e.g. Clare *et al*. 1999; Martins *et al*. 2006; Pitel *et al*. 2006) have suggested that information acquired with errorless learning may be flexible. Flexible new knowledge may result from the involvement of explicit memory mechanisms whereas rigid new knowledge may instead reflect implicit memory processes. Thus, two hypotheses are currently the topic of a debate about the memory processes responsible for the errorless

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**Table 1.** *Demographical variables, drinking history, pre-learning assessment and explicit and implicit memory results in the four groups*

| | Trial-and-error learning | | Errorless learning | |
|---|---|---|---|---|
| | Control subjects | Alcoholic patients | Control subjects | Alcoholic patients |
| Demographical variables | | | | |
| Size of the sample | 19 | 19 | 15 | 15 |
| Age (years) | 49.15 (4.83) | 46.68 (5.34) | 48.68 (3.76) | 48.36 (5.29) |
| Years of education | 11.58 (2.29) | 10.11 (2.92) | 11.00 (1.41) | 10.67 (2.06) |
| Drinking history | | | | |
| Alcohol use (years) | N.A. | 28.41 (8.16) | N.A. | 33.07 (7.07) |
| Alcohol misuse (years) | N.A. | 21.73 (8.81) | N.A. | 16.43 (8.84) |
| Alcohol consumption per day (standard drink) | N.A. | 18.23 (9.09) | N.A. | 22.97 14.32) |
| Pre-learning assessment | | | | |
| Naming score (maximum = 10) | 0 (0) | 0 (0) | 0.20 (0.41) | 0 (0) |
| Explicit memory task | | | | |
| Sum of the three free recalls[a] (maximum = 48) | 31.37 (4.50) | 26.74 (7.36) | 31.73 (4.58) | 29.00 (4.39) |
| Implicit memory task | | | | |
| Reaction times difference (ms) | N.A. | N.A. | 33.78 (41.74) | 20.90 (26.09) |

N.A., Not applicable.
Values given as mean (standard deviation).
[a] Significant difference between the control groups and the alcoholic groups.

learning advantage: the implicit hypothesis developed by Baddeley & Wilson (1994) and the explicit hypothesis proposed by Hunkin *et al*. (1998*b*). Recent studies addressing this issue did not provide consensual findings, notably because the relationships between errorless learning and implicit/explicit memory have been examined indirectly (e.g. Tailby & Haslam, 2003; Anderson & Craik, 2006; Page *et al*. 2006) or an inappropriate measure of implicit memory was used (Hunkin *et al*. 1998*b*). The use of an implicit learning task, described as non-episodic incidental learning of complex information without any consciousness of learning (Seger, 1994), may be particularly relevant because it has been shown to prevent the intervention of explicit processes.

The present investigation had three main aims: (1) to determine the efficacy of the errorless learning technique on new label acquisition in alcoholics; (2) to specify whether knowledge acquired with errorless learning is flexible; and (3) to test whether errorless learning results rely on explicit or implicit memory processes in alcoholics.

## Method

### *Participants*

Two groups of subjects (15 controls and 15 alcoholics) in an errorless learning condition were compared with two other groups of subjects in a trial-and-error learning condition (19 controls and 19 alcoholics). The four groups were matched for age and number of years of schooling (Table 1). Trial-and-error learning data have been published previously (Pitel *et al*. 2007*b*) and were used as the control condition in the present investigation. Alcoholic subjects were recruited by clinicians while they were receiving alcohol treatment as in-patients at Caen University Hospital, according to the DSM-IV criteria of alcohol dependence (APA, 1994). Controls were interviewed to check that they did not meet the criteria for alcohol abuse or dependence. Demographic and clinical data are presented in Table 1. All participants gave their informed consent to the neuropsychological procedure, which was approved by the local ethical committee.

### *Semantic learning paradigm*

#### *Learning design*

The semantic learning task, which consists of the acquisition of 10 novel concepts' labels existing in the real world but fairly rare, has been fully described elsewhere (Pitel *et al*. 2007*b*). In brief, it consisted of five stages: a pre-learning assessment, the presentation of the labels, a learning phase, a learning test and a flexibility task. After the pre-learning assessment and the presentation of the labels on the first day the subjects performed seven daily learning sessions according to the two learning conditions (trial-and-error *versus* errorless). On the ninth day, a learning test consisting of a naming task with the same photographs as those used during learning was carried out. Finally, on the tenth day and to evaluate the flexibility of the new knowledge, subjects performed another naming task with new photographs of the same concepts. The scores corresponded to the number of correct answers provided.

*Learning conditions*

In the trial-and-error condition (Pitel *et al*. 2007*b*), subjects had to provide, for each concept, the label when they were shown the photograph (e.g. a coloured photograph of a ratel) on the screen of a computer. Subjects had to correct their errors themselves from one session to the next, using feedback from the experimenters. In the errorless condition, the modified vanishing cues technique was used (Glisky *et al*. 1986; Glisky & Delaney, 1996) to teach the concepts' labels to the subjects. During the learning sessions, subjects were asked not to answer if they were unsure, to meet the errorless learning principle (Baddeley & Wilson, 1994).

### *Explicit memory task*

We selected a French version of the Free and Cued Selective Reminding Test (FCSRT) to evaluate episodic memory and more precisely explicit memory processes (Grober & Buschke, 1987; Grober *et al*. 1988). We chose to use only the sum of the three free recall trials as the 'explicit memory score' because free recalls are assumed to be variables sensitive to deficits in alcoholics (Weingartner *et al*. 1996).

### *Implicit memory task*

Subjects in the errorless learning condition carried out an additional computerized (gSRT-Soft; Chambaron *et al*. 2008) implicit learning task to evaluate implicit memory capacities. The task was a standard Serial Reaction Time (SRT) task (Nissen & Bullemer, 1987), in which participants had to respond as quickly as possible to a stimulus (blue squares) appearing at one of four locations on the screen by pushing one of four keys. The learning session comprised six blocks of 100 trials. For approximately half of the participants in each group, each trial had an 85% chance of being consistent with sequence A (probable trials) and a 15% chance of being consistent with sequence B (improbable trials). For the remaining participants these were reversed. The 'implicit memory score' corresponded to the difference between the mean reaction time for the improbable trials minus the mean reaction time for the probable trials.

### *Statistical analyses*

To examine the effect of errorless learning, we conducted a repeated-measures analysis of variance (ANOVA) with the naming score in the learning test and the flexibility task as repeated variables, and the groups (control *versus* alcoholic) and learning conditions (trial-and-error *versus* errorless) as between-subject factors.

We also compared explicit memory results in the four groups using a two-way ANOVA. We then analysed implicit memory results in the two groups in the errorless learning condition by means of an ANOVA on the reaction times collected on the final blocks (blocks 4–6) with the groups (control *versus* alcoholic) as a between-subject factor and the sequences (probable *versus* improbable) as a repeated measure.

Finally, we carried out Pearson's correlations between explicit and implicit memory scores on the one hand and the naming score in the learning test on the other.

## Results

### *Pre-learning assessment*

The results obtained by the four groups in the pre-learning assessment are summarized in Table 1.

### *Naming performance in the learning test and in the flexibility task*

The repeated-measures ANOVA showed an overall significant effect of group [$F(1, 64) = 42.09$, $p < 0.001$], a significant effect of the learning conditions [$F(1, 64) = 7.80$, $p < 0.01$] and a significant effect of interaction between group and learning conditions [$F(1, 64) = 6.58$, $p = 0.01$]. *Post-hoc* comparisons revealed that the alcoholic group in the errorless condition differed significantly from the alcoholic group in the trial-and-error condition ($p < 0.01$) but did not differ significantly from the two control groups ($p = 0.07$ for the trial-and-error learning and $p = 0.06$ for the errorless learning condition). There was no significant effect of the repeated variable (learning test *versus* flexibility task) and no interaction with this factor [$F(1, 64) \leqslant 1$ in all cases; Fig. 1].

### *Explicit memory task*

The two-way ANOVA revealed that there was a significant effect of group [$F(1, 64) = 7.89$, $p < 0.01$] but no significant effect of the learning conditions [$F(1, 64) = 1.01$, $p = 0.32$] or interaction [$F(1, 64) = 0.52$, $p = 0.47$] on the sum of the three free recalls. *Post-hoc* tests conducted on the significant group effect revealed that, on

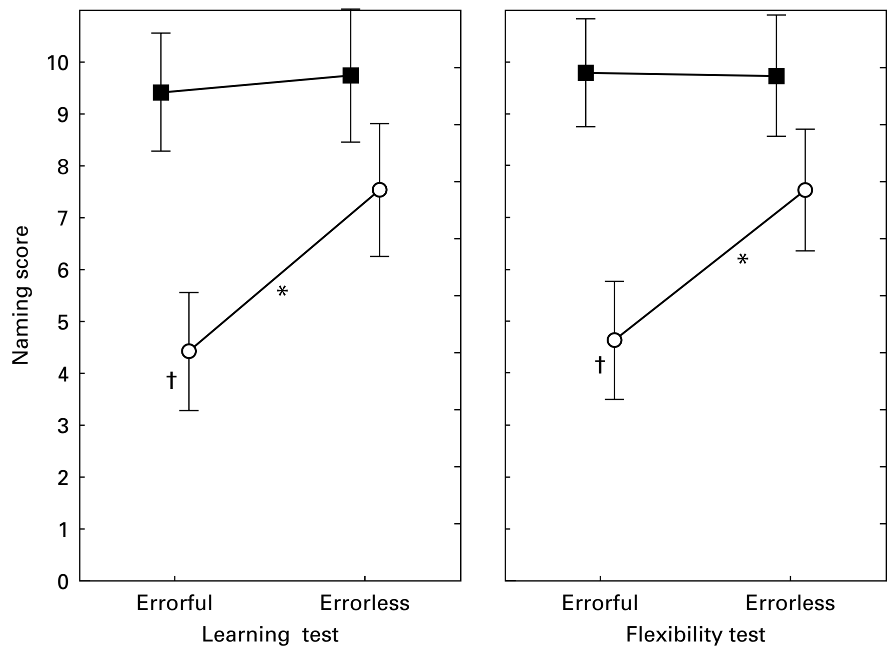


**Fig. 1.** Results in the learning test and the flexibility task according to the two groups [control (■) *versus* alcoholic (○)] and the two learning conditions (trial-and-error *versus* errorless). * Significant effect of learning conditions (trial-and-error *versus* errorless). † Significant effect of groups (alcoholic *versus* control).

this task, the alcoholic patients performed significantly worse as a group than the control subjects ($p<0.01$, Table 1).

### *Implicit memory task*

The ANOVA revealed a main effect of the sequence factor [$F(1, 28)=18.50$, $p<0.001$], reflecting the fact that learning had occurred. The effect of groups was also significant [$F(1, 28)=19.20$, $p<0.001$], with the mean reaction times being longer for alcoholics than for control participants. However, there was no significant interaction between groups and conditions [$F(1, 28)=1.03$, $p=0.32$], indicating that the amount of learning did not differ between control and alcoholic participants. Subsequent planned analyses confirmed that the difference in reaction times between probable and improbable trials (implicit memory score) was significant for both control participants [$t(14)=3.13$, $p=0.007$] and alcoholic patients [$t(14)=3.10$, $p=0.008$]. There was no significant difference between the alcoholics and the controls regarding the implicit memory score [$t(28)=-1.01$, $p=0.32$; Table 1].

### *Relationships between errorless learning and explicit and implicit memory in the alcoholic group*

In the alcoholic group, the naming score in the learning test was correlated with the explicit memory score ($r=0.82$, $p<0.001$) but not with the implicit memory score ($r=-0.01$, $p=0.96$).

## Discussion

Our results show that the alcoholic group in the errorless learning condition performed significantly better than the alcoholic group in the trial-and-error learning condition, confirming the efficacy of the errorless learning in memory-impaired subjects (Wilson *et al*. 1994; Komatsu *et al*. 2000; Kalla *et al*. 2001) even when episodic memory deficits are only mild to moderate. Practical application of the errorless principle to alcohol treatment could be considered when clinicians intend to teach new knowledge and, more particularly, new labels to alcoholic patients with episodic memory disorders.

Moreover, alcoholic patients in the errorless learning condition did not differ significantly from control subjects in the two learning conditions regarding the naming score in session 8. Errorless learning may therefore allow alcoholic patients to normalize the performance of new label acquisition. However, it is worth noting that the comparisons between the alcoholic group in the errorless learning condition and the two control groups revealed tendencies in the $p$ values suggesting that, even when using errorless learning, more learning sessions may be required to allow alcoholic patients to completely normalize learning results.

Our findings also confirm that information acquired by errorless learning is flexible (Hunkin *et al*. 1998*a*; Clare *et al*. 1999; Martins *et al*. 2006) because there was no significant difference between the results in the learning test and the flexibility task in the two groups. The fact that new labels are flexible is in accordance with the correlational results. Indeed, errorless learning performance was significantly correlated with explicit memory results whereas there was no significant relationship with implicit memory results. Taken together, these findings suggest that errorless learning may rely on explicit (Hunkin *et al*. 1998*b*) rather than implicit memory processes (Baddeley & Wilson, 1994) in uncomplicated alcoholic patients. However, these results concern mechanisms involved in errorless learning in subjects exhibiting only mild to moderate explicit memory disorders and a different conclusion may be drawn in amnesic patients (Page *et al*. 2006; Clare & Jones, 2008). Indeed, errorless learning may be supported by different processes according to the memory profile (Tailby & Haslam, 2003). Further studies including explicit and implicit memory assessment in addition to errorless and trial-and-error learning are therefore required in amnesic patients. Such investigations would allow us to determine whether implicit memory processes are involved by default during label learning when explicit memory is severely impaired, resulting in the use of an alternative slow learning route in amnesia (Pitel *et al*. 2009).

### Declaration of Interest

None.

### References

**Anderson ND, Craik FI** (2006). The mnemonic mechanisms of errorless learning. *Neuropsychologia* **44**, 2806–2813.

**APA** (1994). *Diagnostic and Statistical Manual of Mental Disorders*, 4th edn. American Psychiatric Association: Washington, DC.

**Baddeley A, Wilson BA** (1994). When implicit learning fails: amnesia and the problem of error elimination. *Neuropsychologia* **32**, 53–68.

**Chambaron S, Ginhac D, Perruchet P** (2008). *gSRT-Soft*: a generic software and some methodological guidelines to investigate implicit learning through visual-motor sequential tasks. *Behavior Research Methods* **40**, 493–502.

**Clare L, Jones SP** (2008). Errorless learning in the rehabilitation of memory impairment: a critical review. *Neuropsychology Review* **18**, 1–23.

**Clare L, Wilson BA, Breen K, Hodges JR** (1999). Errorless learning of face–name associations in early Alzheimer's disease. *Neurocase* **5**, 37–46.

**Glisky EL, Delaney SM** (1996). Implicit memory and new semantic learning in posttraumatic amnesia. *Journal of Head Trauma Rehabilitation* **11**, 31–42.

**Glisky EL, Schacter DL, Tulving E** (1986). Learning and retention of computer-related vocabulary in memory-impaired patients: method of vanishing cues. *Journal of Clinical and Experimental Neuropsychology* **8**, 292–312.

**Grober E, Buschke H** (1987). Genuine memory deficits in dementia. *Developmental Neuropsychology* **3**, 13–36.

**Grober E, Buschke H, Crystal H, Bang S, Dresner R** (1988). Screening for dementia by memory testing. *Neurology* **38**, 900–903.

**Hunkin NM, Squires EJ, Aldrich FK, Parkin AJ** (1998*a*). Errorless learning and the acquisition of word processing skills. *Neuropsychological Rehabilitation* **8**, 433–449.

**Hunkin NM, Squires EJ, Parkin AJ, Tidy JA** (1998*b*). Are the benefits of errorless learning dependent on implicit memory? *Neuropsychologia* **36**, 25–36.

**Kalla T, Downes JJ, van den Broek M** (2001). The pre-exposure technique: enhancing the effects of errorless learning in the acquisition of face–name associations. *Neuropsychological Rehabilitation* **11**, 1–16.

**Komatsu S, Mimura M, Kato M, Wakamatsu N, Kashima H** (2000). Errorless and errorfull processes involved in the learning of face–names associations by patients with alcoholic Korsakoff's syndrome. *Neuropsychological Rehabilitation* **10**, 113–132.

**Martins S, Guillery-Girard B, Jambaque I, Dulac O, Eustache F** (2006). How children suffering severe amnesic syndrome acquire new concepts. *Neuropsychologia* **44**, 2792–2805.

**Nissen MJ, Bullemer P** (1987). Attentional requirements of learning: evidence from performance measures. *Cognitive Psychology* **19**, 1–32.

**Noel X, Van der Linden M, Schmidt N, Sferrazza R, Hanak C, Le Bon O, De Mol J, Kornreich C, Pelc I, Verbanck P** (2001). Supervisory attentional system in nonamnesic alcoholic men. *Archives of General Psychiatry* **58**, 1152–1158.

**Page M, Wilson BA, Shiel A, Carter G, Norris D** (2006). What is the locus of the errorless-learning advantage? *Neuropsychologia* **44**, 90–100.

**Pitel AL, Beaunieux H, Guillery-Girard B, Witkowski T, de la Sayette V, Viader F, Desgranges B, Eustache F** (2009). How do Korsakoff patients learn new concepts? *Neuropsychologia* **47**, 879–886.

**Pitel AL, Beaunieux H, Lebaron N, Joyeux F, Desgranges B, Eustache F** (2006). Two case studies in the application of errorless learning techniques in memory impaired patients with additional executive deficits. *Brain Injury* **20**, 1099–1110.

**Pitel AL, Beaunieux H, Witkowski T, Vabret F, Guillery-Girard B, Quinette P, Desgranges B, Eustache F** (2007*a*). Genuine episodic memory deficits and executive dysfunctions in alcoholic subjects early in abstinence. *Alcoholism: Clinical and Experimental Research* **31**, 1169–1178.

**Pitel AL, Witkowski T, Vabret F, Guillery-Girard B, Desgranges B, Eustache F, Beaunieux H** (2007*b*). Effect of episodic and working memory impairments on semantic and cognitive procedural learning at alcohol treatment entry. *Alcoholism: Clinical and Experimental Research* **31**, 238–248.

**Seger CA** (1994). Implicit learning. *Psychological Bulletin* **115**, 163–196.

**Squires EJ, Hunkin NM, Parkin AJ** (1997). Errorless learning of novel associations in amnesia. *Neuropsychologia* **35**, 1103–1111.

**Tailby R, Haslam C** (2003). An investigation of errorless learning in memory-impaired patients: improving the technique and clarifying theory. *Neuropsychologia* **41**, 1230–1240.

**Weingartner HJ, Andreason PJ, Hommer DW, Sirocco KY, Rio DE, Ruttimann UE, Rawlings RR, Eckardt MJ** (1996). Monitoring the source of memory in detoxified alcoholics. *Biological Psychiatry* **40**, 43–53.

**Wilson BA, Baddeley A, Evans J, Shiel A** (1994). Errorless learning in the rehabilitation of memory impaired people. *Neuropsychological Rehabilitation* **4**, 307–326.