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

A. L. Pitel1, P. Perruchet2, F. Vabret1,3, B. Desgranges1, F. Eustache1* and H. Beaunieux1

1 Inserm-EPHE-Université de Caen/Basse-Normandie, Unité U923, GIP Cyceron, CHU Côte de Nacre, Caen, France
2 LEAD/CNRS, Université de Bourgogne, Dijon, France
3 Unité d’alcoologie, CHU Côte de Nacre, Caen, France

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.

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. 2007a), which have a harmful impact on new complex learning abilities including new label acquisition (Pitel et al. 2007b). 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
learning advantage: the implicit hypothesis developed by Baddeley & Wilson (1994) and the explicit hypothesis proposed by Hunkin et al. (1998). 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., 1998b). 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. 2007b) and were used as the control condition in the present investigation. Alcoholics were recruited by clinicians while they were receiving alcohol treatment as inpatients 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. 2007b). 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. 2007b), 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 [$F(1, 64) \leq 1$ 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
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. 1998a; 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. 1998b) 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


