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

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ABSTRACT

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.

Methods. 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 photos from those used in the learning sessions but representing the same concepts. All 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 one 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, naming score in the learning test was correlated with the explicit memory score but not with the implicit memory one.

Conclusions. Thanks to 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 memory processes rather than on implicit ones 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 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 learning process" (Clare & Jones, 2008). Indeed, according to Baddeley and 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 the 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 most of the time successfully used (Clare & Jones, 2008 for review), several questions remain regarding notably the flexibility of the new knowledge and the nature of the memory processes involved.

The 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) 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 rather 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 and Wilson (1994) and the explicit hypothesis proposed by Hunkin *et al.* (1998b). 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 using an inappropriate measure of implicit memory (Hunkin *et al.* 1998b). The use of an implicit learning task, described as a non-episodic incidental learning of complex information without any consciousness of learning (Seger, 1994), may be particularly relevant because it has been showed to prevent from the intervention of explicit processes.

The present investigation had then three main goals: 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; 3) to test whether errorless learning results relies on explicit or implicit memory processes in alcoholics.

METHODS

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 previously published (Pitel *et al.* 2007b) and are used as control conditions in the present investigation. Alcoholic subjects 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 (American Psychiatric Association, 1994). Controls were interviewed to check that they did not meet the criteria for alcohol abuse or dependence. Demographical and clinical data are provided in Table 1. All the participants gave their informed consent to the neuropsychological procedure, which was approved by the local ethical committee.

Table 1 about here

Semantic learning paradigm

Learning design

The semantic learning task, which consists of the acquisition of ten novel concepts' labels existing in the real world but quite rare, has been fully described elsewhere (Pitel *et al.* 2007b). Briefly, it consisted of five stages: a pre-learning assessment, the presentation of the labels, a learning phase, a learning test and a flexibility task. Thus, 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 in a naming task with the same photos 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 photos 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 photo (colored photo of a ratel for example) 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. All along the learning sessions, subjects were asked not to answer if they were unsure, in order to meet 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 "explicit memory score" since 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 6 blocks of 100 trials. For approximately half of the participants in each group, each trial had a 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 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 ways analysis of variance. We then analysed implicit memory results in the two groups in the errorless learning condition by means of an analysis of variance on the reaction times

collected on the final blocks (Block 4 to 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 hand.

RESULTS

Pre-learning assessment

The description of the results obtained by the four groups in the pre-learning assessment is summarized in table 1.

Naming performance in the learning test and in the flexibility task

The repeated measures analysis of variance showed an overall significant effect of the 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 one ($p<0.01$) 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, Figure 1).

Figure 1 about here

Explicit memory task

The two ways analysis of variance 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 [$F(1, 64)=1.01$; $p=0.32$] nor 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 whole alcoholic patients performed significantly lower than the whole control subjects ($p<0.01$, table 1).

Implicit memory task

The analysis of variance revealed a main effect of the sequence factor ($F(1, 28)=18.50$; $p<0.001$), reflecting the fact that learning 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, 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 one ($r=-0.01$; $p=0.96$).

DISCUSSION

The present findings showed firstly 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. The 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 performance of new label acquisition. However, it is worthwhile to specify that the comparisons between the alcoholic group in the errorless learning condition and the two control groups revealed tendencies for 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 thanks to errorless learning is flexible (Hunkin *et al.* 1998a; Clare *et al.* 1999; Martins *et al.* 2006) because there was no significant difference between 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 memory processes (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).

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Figure 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)