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Abstract

Background: Alcoholism affects various cognitive processes, including components of memory. Metamemory, though of particular interest for patient treatment, has not yet been extensively investigated.

Methods: A feeling-of-knowing (FOK) measure of metamemory was administered to 28 alcoholic patients and 28 healthy controls during an episodic memory task including the learning of 20 pairs of items, followed by a 20-minute delayed recall and a recognition task. Prior to recognition, participants rated their ability to recognize each nonrecalled word among four items. This episodic FOK measure served to compare predictions of future recognition performance and actual recognition performance. Furthermore, a subjective measure of metamemory, the Metamemory In Adulthood (MIA) questionnaire, was completed by patients and controls. This assessment of alcoholic patients' metamemory profile was accompanied by an evaluation of episodic memory and executive functioning.

Results: FOK results revealed deficits in accuracy, with the alcoholic patients providing overestimations. There were also links between FOK inaccuracy, executive decline and episodic memory impairment in patients. MIA results showed that although alcoholics did display memory difficulties, they did not differ from controls on questions about memory capacity.

Conclusions: Chronic alcoholism affects both episodic memory and metamemory for novel information. Patients were relatively unaware of their memory deficits and believed that their memory was as good as that of the healthy controls. The monitoring measure (FOK) and the subjective measure of metamemory (MIA) showed that patients with chronic alcoholism overestimated their memory capacities. Episodic memory deficit and executive dysfunction would explain metamemory decline in this clinical population.

1. Introduction

The concept of metamemory refers to the knowledge people have of their general memory function and their memory capacities and strategies, which contribute to optimum learning (Flavell, 1971; Flavell and Wellman, 1977). This metamemorial knowledge can be investigated using subjective measures of metamemory, notably questionnaires collected without any accompanying memory task. Those questionnaires evaluate the subjective representations or beliefs that people construct of memory function in general and their own memory in particular.

Metamemory can also be defined as knowledge of the cognitive processes involved in the monitoring and control of memory (Nelson and Narens, 1990). As such, metamemory can be examined using monitoring measures collected during semantic or episodic memory tasks. Those objective measures, enabling to assess monitoring abilities for specific information, are conducted using the comparison between predictions about memory performance during a memory task and actual memory performance. The most frequently used measure of metamemory in research is the feeling-of-knowing paradigm (FOK; Hart, 1965). FOK is experimentally assessed during a memory task, when participants rate their ability to recognize nonrecalled targets with the aid of a cue. The resulting FOK memory measure (gamma index) refers to the comparison between predictions of future recognition performance and actual recognition performance.

Koriat and Levy-Sadot (2001) proposed a model combining the cue familiarity account (Metcalfe et al., 1993; Reder, 1987) and the accessibility account (Koriat, 1993) to explain FOK judgments creation. In the first step, FOK is based on assessment of familiarity of the cue proposed during the recall (Metcalfe et al., 1993; Reder, 1987). If cue familiarity is sufficiently strong, then, in a second step, accessibility processes occur (Koriat, 1993). When a subject attempts to recall target information and fails to do so, he can nevertheless retrieve

partial information related to the target and therefore, he provides his FOK judgment on the basis of the quantity and the relevance of these partial information retrieved in memory.

Whereas metamemory was very much the preserve of cognitive psychology in the past, studies are now frequently conducted of neurological patients, allowing a better understanding of the neuropsychological basis of metamemory including links with episodic memory and executive functions.

Episodic memory is currently described as the memory system in charge of the encoding, storage, and retrieval of personally experienced events, associated with a precise spatial and temporal context of encoding. Episodic memory allows the conscious recollection of personal happenings and events from one's personal past and the mental projection of anticipated events into one's subjective future (Wheeler et al., 1997). Furthermore, recollection of episodic events includes autonoetic awareness: the impression of re-experiencing or reliving the past and mentally traveling back in subjective time (Tulving, 2001). A parallel can be drawn between the recollective experience and the second step of accessibility account (Koriat, 1993) where the FOK judgment is based on the assessment of the accessibility of relevant partial information related to the target. Studies using episodic FOK tasks have highlighted various types of metamemory impairment in subjects with episodic memory decline, such as the overestimation of memory capacities by subjects with Alzheimer's disease (Pappas et al., 1992; Souchay et al., 2002) or mild cognitive impairment (Perrotin et al., 2007). Moreover, Bacon et al. (1998) observed a reduction in FOK accuracy in healthy subjects after they had been administered benzodiazepine, which impairs episodic memory, compared with subjects who took a placebo. These findings suggest a strong relation between episodic memory and metamemory deficits. More specifically, Souchay et al. (2007) showed that episodic FOK accuracy deficit was linked with a deficit of recollection in older adults using a Remember-Know paradigm.

Shimamura and Squire (1986), however, showed that amnesic patients with anterograde amnesia due to mixed etiology (anoxia, brain injury, low blood pressure) predicted their episodic memory performances as accurately as healthy controls, unlike Korsakoff patients, who exhibited metamemory deficits. This study shows that metamemory may be either spared or impaired in amnesic patients. These findings may reflect the involvement of executive functions in metamemory, especially as measured in an episodic FOK task. Unlike other amnesic patients, Korsakoff patients display executive dysfunctions (Pitel et al., 2008), which may account for their metamemory deficits. This idea is supported by the observation of metamemory impairments in an episodic FOK measure administered to patients with frontal lesions (Janowsky et al., 1989; Pinon et al., 2005; Schnyer et al., 2004) and healthy subjects with poor performances on executive tests (Perrotin et al., 2006; Souchay et al., 2000, 2004). Most of the previous studies used an executive composite score (Perrotin et al., 2006; Souchay et al., 2002) or an unspecific executive task (Wisconsin Card Sorting test, Souchay et al., 2004) to study the relations between episodic FOK accuracy and executive functions. Only Perrotin et al. (2008) specified that shifting function decline was related to less accurate episodic FOK judgments in older adults with executive decrease. Furthermore, in light of the accessibility account (Koriat, 1993), other hypotheses could be explored such as the contribution of organizational strategies of research in memory or inhibition to take into account only partial relevant information linked with target while ignoring irrelevant information.

This finding is reinforced by brain lesions studies demonstrating that an episodic FOK deficit is consecutive to medial prefrontal cortex damages (Modirrousta et al., 2008; Schnyer et al., 2004). Furthermore, a neuroimaging studies using fMRI (Schnyer, Nicholls, and Verfaelli, 2005) showed that the accuracy of the FOK judgment in healthy subjects is supported by a frontotemporal brain network including the inferior prefrontal cortices, the

hippocampi, the temporal cortices, and the ventromedial prefrontal cortices, also involved in the monitoring of retrieval processes in memory.

Episodic memory and executive functions are disturbed in chronic alcoholism. There is now evidence that heavy and prolonged alcohol consumption leads to brain damage (Chanraud et al., 2007; Rosenbloom et al., 2003; Sullivan and Pfefferbaum, 2005) and cognitive deficits (Parsons and Nixon, 1993; Sullivan et al., 2000), even in alcoholics without Korsakoff's syndrome. Episodic memory impairments (Beatty et al., 1995; Couvilliers et al., 2005; Fama et al., 2004; Nixon et al., 1998; Pitel et al. 2007) and executive functions (Moselhy et al., 2001; Pitel et al., 2007; Sullivan et al., 2000; Zinn et al., 2004) are the most salient cognitive disorders of non-Korsakoff alcoholic patients. From a clinical perspective, it is important to investigate metamemory abilities in chronic alcoholic patients. Indeed, an optimal metamemory functioning is essential to improve memory ability which is a high-level cognitive process involved in alcohol treatment and subsequent abstinence.

Only the acute affects of alcohol on a FOK measure have been examined (Nelson et al., 1986). Using a semantic task, the authors found that acute alcohol consumption had no impact on FOK accuracy. To date, no study has specifically investigated metamemory function in non-Korsakoff alcoholic patients using the episodic FOK task. Although chronic alcoholics were examined as controls in a study of Korsakoff patients (Shimamura and Squire, 1986), the sample size of the alcoholic group was small and we now know that there is a high level of individual variability in the neuropsychological deficits of such patients (50 to 80% of alcoholics have neuropsychological deficits according to Bates et al., 2002). Furthermore, Shimamura and Squire (1986) did not provide any information about the neuropsychological profiles of the non-Korsakoff alcoholic patients in terms of episodic memory impairment and executive dysfunction, making it difficult to interpret the results for this group.

The present study therefore had two main goals. First, we sought to specify metamemory function in chronic alcoholic patients early in abstinence from alcohol, by administering both a subjective measure (MIA questionnaire) and an objective measure (FOK) during an episodic memory task. We hypothesized that chronic alcoholism would have harmful effects on metamemory, leading to an overestimation of memory capacities. Second, we examined whether episodic memory and executive function deficits could explain metamemory performances in alcoholics. To this end, we conducted an assessment of episodic memory and executive functions in addition to the metamemory evaluation. Given the accessibility model (Koriat, 1993) and the study of Souchay et al. (2007), we chose to focus our measure of episodic memory on an assessment of the subject's mental states of consciousness. Given Koriat's FOK theory (1993) and the study of Perrotin et al. (2008), we chose to focus our measure of executive functions on abilities previously showed to be affected by chronic alcoholism: shifting function (Noël et al., 2001a, 2001b), faculties of strategic research in memory (Dao-Castellana et al., 1998; Noël et al., 2001b; Pitel et al., 2007; Tedstone & Coyle, 2004) and inhibition capacities (Brokate et al., 2003; Dao-Castellana et al., 1998; Joyce and Robbins, 1991; Pitel et al., 2007). In the light of previous studies of metamemory in neurological populations (for a review, see Pannu and Kazniak, 2005), we hypothesized that impaired metamemory in alcoholics is a consequence of the combined impairment of episodic memory and executive functions.

2. Method

2.1. Participants

Two groups of participants were included in this study: 28 chronic alcoholic patients early in abstinence from alcohol (mean age: 47.9 years; S.D.: 5.4; range: 39-60) and 28

control subjects (mean age: 47.8 years; S.D.: 5.3; range: 39-60) matched for age and education. There were 14 men in the control group and 21 men in the alcoholic group.

The subjects' ages, educational backgrounds, verbal and visuospatial abilities and Mini Mental State Examination (MMSE) scores are summarized in Table 1. Performances on the MMSE (Folstein et al., 1975), visuospatial (Block Design and Matrix Reasoning subtests; Wechsler, 2001) and verbal (Vocabulary subtest; Wechsler, 2001) assessments were significantly poorer for chronic alcoholic patients than for control subjects. The depression level, measured on the self-assessment Beck Depression Inventory (Beck, 1961), was higher in the alcoholic group than in the control group. Moreover, we used a self-report measure of anxiety, the State-Trait Anxiety Inventory (STAI) for adults (Spielberger, 1983) with two forms: Y-A for "state anxiety" and Y-B for "trait anxiety". There was no difference in the anxiety level at the time of the assessment (STAI Y-A) between alcoholic patients and control subjects. Nevertheless, the STAI Y-B score was significantly higher for the alcoholic group. All the participants gave their informed consent to the neuropsychological procedure, which was approved by the local ethics committee. Alcoholic subjects were recruited by clinicians while they were receiving alcohol treatment as patients at Caen University Hospital, according to the DSM-IV criteria for alcohol dependence (American Psychiatric Association, 1994). Patients had no history of other types of substance dependence (except tobacco), and they had already been weaned off alcohol when they were included. They were interviewed to determine the age at which they had had their first alcoholic drink, the age of onset of alcoholism, the length of time they had drunk to excess, and their usual daily alcohol consumption (Table 1). No participants (alcoholic patients and control subjects) were taking psychotropic medication, displayed psychiatric problems or had any history of pathology (head injury, coma, epilepsy, Wernicke's encephalopathy, cirrhosis, depression, etc.) that might have affected cognitive functions. Control participants were interviewed to check that

they did not meet the criteria for alcohol abuse or dependence (World Health Organization criteria) corresponding to no more than 21 or 14 weekly standard drinks for men or women respectively and 4 at the same time. None control subjects had history of drug abuse. Before inclusion, they were all given a health questionnaire including information about drug consumption. Controls with history of drug abuse were not included in the experiment.

Insert Table 1

2.2. Materials and procedure

2.2.1. Episodic memory

Spondee test: The Spondee test ("spon" for spontaneous and "dee" for deep; Pitel et al., 2007) enables to examine the state of consciousness associated with the memories using the Remember-Know paradigm (Gardiner et al., 2002). It is a verbal learning test during which participants are warned that they will be tested on their memory capacities. This test comprises two lists of 16 words belonging to 16 different categories. It is derived from the Double Memory Test (Grober and Kawas, 1997). The words in the first list were encoded spontaneously, according to the strategies that subjects were able to implement on their own. In this condition, subjects had to point to words as they were read out by the experimenter. The words in the second list were deeply encoded in a semantic mode: subjects had to point to words in response to their semantic category. A free recall test, a semantic cued recall test and a recognition task were then carried out for each list. During the recognition phase, subjects were asked to specify their state of consciousness for each correctly-recognized word, using the "Remember/Know/Guess" paradigm. "R answers" signified that subjects remembered the learning episode and were able to provide details about it, so it refers to conscious recollection concept. "K answers" indicated that subjects knew that they had learned the information but were unable to give details about the learning episode; it corresponds to the familiarity

concept. "G answers" were given when subjects were supposed to have learned the word but were not at all sure about it. Episodic memory performance was expressed as percentage scores on free recall, semantic cued recall, recognition, and R and K answers for spontaneous and deep conditions.

2.2.2. Executive functions

Verbal fluency tasks (organization): The verbal fluency tasks (Cardebat et al., 1990; adapted version by the Groupe de Réflexion pour l'Evaluation des Fonctions EXécutives (GREFEX), 2001) constituted an assessment of organizational abilities and strategic search abilities in memory. For letter fluency, subjects had 120 seconds to say aloud as many words beginning with the letter "p" as possible. For categorical fluency, subjects had 120 seconds to say aloud as many words in the animal category as possible. The total verbal fluency score was the number of correctly generated words minus perseverative answers for each letter and category subtest.

Trail-making test (shifting): The Trail-making test (Reitan, 1958; adapted GREFEX version) is a reactive mental flexibility task consisting of two parts. In Part A, subjects have to join numbers up from 1 to 25 on a sheet of paper as quickly as possible. In Part B, subjects have to join numbers and letters up in an alternating pattern (1-A-2-B-3-C, etc.) as quickly as possible. The number of errors and the time taken to complete Part B were used as indicators of flexibility performance.

Stroop test (inhibition in nonverbal condition): Inhibition ability was assessed by means of the Stroop test (Stroop, 1935; adapted GREFEX version). This test was composed of three conditions: (1) a color-naming task (Color condition); (2) a reading task (Word condition); and (3) an interference task (Color-Word condition). The Color condition involves naming areas of color as quickly as possible. The Word condition involves reading the names of colors printed in black as quickly as possible, while in the Color-Word condition, subjects

have to name the incongruous color in which a word is printed as quickly as possible. The number of errors and the time spent on the interference task (Color-Word condition) were recorded to gauge inhibition ability.

Hayling Sentence Completion Test (inhibition in verbal condition): The Hayling test (Burgess and Shallice, 1996; French adapted version by Meulemans et al., 2001) is an inhibition task encompassing two subtests. In the first subtest (Hayling A), the examiner reads 15 sentences aloud and participants have to complete each sentence with the most appropriate word (i.e., "The hen laid an …"). In the second subtest (Hayling B), the subjects are asked to complete each sentence with a word that does not fit the meaning of the rest of the sentence. The inhibition scores were the time taken to complete all the sentences and the number of penalties for incorrect answers on the second subtest.

2.2.3. Metamemory measures

Monitoring measure of metamemory: Feeling-of-knowing and episodic memory: An episodic memory task (Pinon et al., 2005) was administered to all the subjects, requiring them to learn 20 cue-target pairs (half semantically related), with immediate cued recall. After a 20-min interval, delayed cued recall was assessed by presenting cues (the first word of each pair of items) and asking participants to retrieve the associated word. Participants also performed a recognition task for each nonrecalled item. Two measures of episodic memory were recorded: total delayed recall (number of words recalled after 20 min plus number of recognized words) and the recognition success rate (%).

Prior to the recognition task, participants were asked to answer the following question "How confident are you that you will be able to recognize the right answer (target word) among 4 words?". Each nonrecalled word was presented among 4 items (target plus phonological distractor, semantic distractor and neutral distractor) without participants being informed about the nature of the distractors. These FOK judgments were recorded on a

Likert-type scale (definitely won't recall, 20% sure, 40% sure, 60% sure, 80% sure, and definitely will recall). Any judgment below 50% corresponded to a "NO" judgment; the participant estimated that he or she would not recognize the target. Any judgment above 50% corresponded to a "YES" judgment; the participant estimated that he or she would recognize the target (Fig. 1). The proportion of "YES" and "NO" judgments was measured for each group (healthy controls and alcoholic patients). More qualitative information such as the proportion of correct YES prediction (HITS yes), incorrect YES prediction (MISSES yes), incorrect NO prediction (MISSES no) and correct NO prediction (HITS no) were measured.

An episodic FOK accuracy measure was then calculated (Goodman-Kruskal Gamma statistic; Nelson, 1984) to evaluate the agreement between predictions of future recognition performance and actual recognition performance. This index varies from -1 to +1, with positive values corresponding to a strong association between recognition performance and FOK judgments, values close to zero indicating the absence of association, and negative values designating an inverse relation.

Insert Figure 1

Subjective measure of metamemory: MIA questionnaire: The MIA questionnaire (Dixon et al., 1983) is made up of 108 items divided into 7 subscales. On a 5-point Likert-type scale, subjects were asked to rate frequency (from "never" to "always") or agreement (from "strongly agree" to "really don't agree") relating to questions or assertions about their beliefs on their own and most people memory function and processes. The seven subscales referred to Strategy (use of internal and external memory strategies: "Do you try to concentrate very hard on something you want to retain?" or "Do you write notes as a reminder?"), Tasks (knowledge of memory processes and memory tasks: "Most of people find it easier to remember pictures than words"), Capacity (knowledge of our own memory abilities: "I have no difficulty remembering my appointments"), Change (perception of

change in memory function: "Now I don't remember things as well as I used to"), Anxiety (knowledge of the effects of anxiety on memory performance and tendency to feel anxious about memory tasks: "I become anxious when I'm asked to remember something"), Achievement (perceived importance of having a good memory: "Having a good memory is important to me") and, finally, Locus (subject's feeling of having control over his or her memory: "My memory will not decline, providing I maintain it"). This questionnaire was translated and calibrated for a French-speaking population by Baillargeon and Neault (1989) and Boucheron (1995).

2.3. Statistical analysis

Our data were analyzed in three steps. First, we investigated the effects of alcoholism on episodic memory and executive functions using an unpaired two-sample t-test. To control for multiple comparisons, we applied Bonferoni corrections for each condition ("spontaneous" and "deep") of the Spondee test. To examine the impact of alcoholism on metamemory functioning, regarding the monitoring measure (FOK), gamma scores were analyzed by means of an unpaired two-sample t-test. Furthermore, to verify if gamma scores were different from 0, we utilized a one-sample t-test. Finally, regarding the subjective measure of metamemory (MIA questionnaire), we compared scores for different subscales using a nonparametric Kolmogorov-Smirnov test.

Our second objective was to determine whether executive functions and episodic memory were linked with metamemory performance. To this end, correlations (Bravais-Pearson) were carried out within each group to examine the relationships between metamemory (FOK gamma) on the one hand, and episodic memory and executive functions on the other. Finally, within the context of the correlations we had observed, a stepwise regression analysis was conducted to highlight the best predictors of metamemory (FOK

gamma) in each group. We then compared the relationships between metamemory, episodic memory and executive functions in the two groups by comparing β coefficients.

As preliminary analyses failed to reveal any gender differences in neuropsychological performance, men and women's data were pooled together. As cognitive (MMSE, Block Design, Matrix Reasoning and Vocabulary subtests) and psychiatric (the depression level "Beck Depression Inventory" and anxious personality "STAI Y-B score") and drinking variables (days of abstinence before inclusion, years of alcohol use, of alcohol abuse, and of alcoholism and quantity per day of alcohol in units of alcohol) in the alcoholic group were not linked with metamemory results (FOK Gamma), these variables were not included as covariates in any of the analyses.

Third, to refine our interpretation and determine whether executive dysfunction and episodic memory impairments could explain metamemory performance in alcoholism, we conducted an analysis of covariance, controlling for the episodic memory and executive scores that were significantly linked to the FOK gamma in the alcoholic group.

A probability level of .05 was adopted for all analyses except for the Spondee test with a probability level of .025 using Bonferoni corrections.

3. Results

3.1. Effects of alcoholism on episodic memory and executive functions

Episodic memory: On the Spondee test in the "spontaneous" condition, the alcoholic group recalled fewer words in the cued recall [$t(54) = -3.56$, $p < 0.001$], and gave fewer R answers [$t(54) = -2.72$, $p < 0.01$] than the control group. There were no significant differences for the other episodic memory scores.

Executive functions: Results revealed that alcoholic patients performed more poorly than control subjects on numerous executive tasks. For the verbal fluency tests, alcoholic

patients produced fewer words [$t(54) = -2.53, p < 0.05$]. For the inhibition tasks, alcoholic patients also performed significantly worse than controls, in terms of the Stroop Color-Word time [$t(54) = 3.02, p < 0.01$], the number of Stroop Color-Word errors [$t(54) = 2.15, p < 0.05$], the Hayling B time [$t(54) = 2.30, p < 0.05$] and the number of Hayling B penalties [$t(54) = 4.15, p < 0.001$]. There was no significant group effect on TMT Part B for time [$t(54) = 1.73, p = 0.09$] and for number of errors [$t(54) = 1.50, p = 0.14$].

3.2. Effects of alcoholism on the objective measure of metamemory: FOK and episodic memory

Proportion of YES and NO judgments: alcoholic patients gave significantly more NO judgments [$t(54) = 3.59, p < 0.001$] and fewer YES judgments (in %) [$t(54) = -3.59, p < 0.001$] than control subjects. Alcoholics and controls didn't use similarly the Likert-type scale presented to record FOK judgment.

FOK accuracy: The results show that alcoholic patients produced significantly fewer Hits [$t(54) = -4.01, p < 0.001$] and more Misses for YES judgments [$t(54) = 4.01, p < 0.001$] than healthy control subjects (Fig. 2). No significant differences were found on Hits [$t(54) = 1.32, p = 0.19$] and Misses [$t(54) = -1.32, p = 0.19$] for NO judgments (Fig. 2).

Insert Figure 2

The relationship between FOK and recognition performance was determined using the gamma correlation index. The gamma index for healthy control subjects was reliably nonzero, [$t(27) = 2.08, p < 0.05$] but not for alcoholic patients [$t(27) = 1.87, p = 0.07$].

The chronic alcoholic group was significantly more impaired than the healthy control group for the FOK gamma correlation index [$t(54) = -2.80, p < 0.01$] (Fig. 3).

Insert Figure 3

Episodic memory: The total recall and recognition percentage scores of the alcoholics were lower than those of the control subjects ([$t(54) = -3.44$, $p < 0.001$] and [$t(54) = -3.70$, $p < 0.001$]).

3.3. Effects of alcoholism on the subjective measure of metamemory: MIA questionnaire

There was a significant difference between the control subjects and the alcoholic patients for the Change ($p<.05$) and Anxiety categories ($p<.05$), with the alcoholic patients having stronger beliefs about the fact that memory changes with age , that anxiety have negative effects on their memory abilities and stronger endorsements that they feel anxious during memory tasks. The results did not, however, show any significant group effect on the Strategy, Tasks, Capacity or Achievement categories.

3.4. Links between episodic memory, executive functions and FOK (gamma index)

Episodic Memory: Broadly speaking, if we consider all raw episodic memory scores, there was no relationship in the control group between FOK measures (gamma index) and episodic memory scores. In the alcoholic group, the gamma index was correlated with the percentage of "Remember" answers (R) in both the spontaneous condition of the Spondee test ($r = 0.5$, $p = 0.007$) and the deep one ($r = 0.43$, $p = 0.02$).

Executive functions: Broadly speaking, if we consider all the executive scores for the control group, correlations showed that the gamma index was only linked with time spent on the Stroop interference task (Color-Word condition) ($r = -0.39$, $p = 0.04$). In the alcoholic group, the gamma index was significantly correlated with the verbal fluency score ($r = 0.48$, $p = 0.009$) and with the time spent on the Stroop interference task (Color-Word condition), in the same proportion as that of the control group ($r = -0.37$, $p = 0.05$).

3.5. Episodic memory and executive functions: Predictors of FOK accuracy (gamma index)

In the control group, the best predictor of the FOK gamma index was the time spent on the Stroop interference task (Color-Word condition), which accounted for 15% of the variance. In the alcoholic group, in the first step, 25% of the variance in FOK accuracy was accounted for by the percentage of "Remember" answers (R) in the spontaneous condition. The second factor making a significant contribution to FOK accuracy in alcoholics was the verbal fluency score (accounting for 14% of the variance) (Fig. 4).

Insert Figure 4

There was no significant difference between the slopes (β coefficient) of the two groups regarding the controls' predictors. The slope differences were, however, significant for the predictors of the alcoholic group. These data are summarized in Table 2.

Insert Table 2

3.6. Contribution of episodic memory and executive deficits on metamemory decline (FOK gamma correlation score) in chronic alcoholics

With regard to the correlation results for the raw cognitive scores, both memory and executive functions seem to be linked with metamemory performance, and their deficits could explain the decline of metamemory in chronic alcoholism. To confirm this hypothesis, we conducted an analysis of covariance. First, when we controlled for the percentage of R answers in the spontaneous condition, the group effect on the gamma correlation score was still significant [$F_{(1, 53)} = 5.41$, $p < 0.03$]. Moreover, when we controlled for the verbal fluency variable, there was still a significant difference in the gamma index between patients and control subjects [$F_{(1, 53)} = 4.59$, $p < 0.04$]. After controlling for both the episodic memory score (% R answers in spontaneous condition) and the verbal fluency score, however, the group effect was no longer significant [$F_{(1,52)} = 3.02$, $p = 0.09$].

4. Discussion

The objectives of the present study were first to gain a better understanding of metamemory function in chronic alcoholics early in abstinence from alcohol and at alcohol treatment entry using a subjective measure (MIA questionnaire) and an objective measure (FOK), and second to analyze the contributions of episodic memory and executive functions to metamemory decline in alcoholism.

First of all, the alcoholic patients in our study performed more poorly than controls on the episodic memory and executive tasks. On episodic memory, more particularly, conscious recollection in chronic alcoholic is significantly reduced, while familiarity is not. These data confirmed a previous study (Pitel et al., 2007), which highlighted a deficit of autonoetic consciousness in chronic alcoholism. Concerning executive functions, patients exhibited general impairment of executive functions, confirming previous researches that have brought to light the harmful effects of alcoholism on executive functioning (Brokate et al., 2003; Dao-Castellana et al., 1998; Joyce and Robbins, 1991; Noel et al., 2001a, 2001b; Pitel et al., 2007; Tedstone and Coyle, 2004). Chronic alcoholic patients were also less accurate (negative gamma index value) than the control group (positive gamma index value) regarding FOK in the episodic memory task. Our results showed that alcoholic patients overestimated their recognition performance, as confirmed by the MIA questionnaire measure. Furthermore, our statistical analysis yielded a strong argument in favor of a link between episodic memory deficits, executive dysfunction and metamemory decline in chronic alcoholism.

4.1. Metamemory in chronic alcoholism

The first aim of our study on chronic alcoholism was to establish the clinical profile of metamemory consecutive to excessive alcohol consumption. In this study, metamemory function was explored in alcoholism using two measures to assess different aspects of it.

First, we used a measure of metamemory, collected during an episodic memory task: FOK. This metamemory measure is an indicator of the monitoring processes in metamemory

and the Goodman-Kruskal gamma correlation was calculated between the FOK judgment and recognition performance. Our results showed a significant effect of chronic alcoholism on the prediction of future memory performance: the FOK gamma index was significantly lower in the alcoholic group than in the control group. The gamma index for the alcoholic group was significantly and reliably zero, suggesting that the accuracy of FOK judgments was no better than chance in alcoholic patients, whereas the gamma index for the healthy controls was significantly and reliably nonzero. Taken together, these results suggest that alcoholic patients were less accurate than controls when gauging their ability to recognize previously nonrecalled words. Going one step further, from a qualitative point of view, alcoholic patients behaved differently from controls when estimating their recognition ability. Our results underline the fact that alcoholic subjects generated significantly fewer hits and more misses than controls for YES judgments. This observation suggests that patients have a tendency to overestimate their memory capacities, believing themselves capable of recognizing the correct word when in fact they subsequently fail to do so.

The results on the subjective measure of metamemory (MIA) provided more information about this tendency toward overestimation in chronic alcoholic patients and also about emotional aspects of metamemory, such as anxiety. First, alcoholics seemed to have stronger beliefs about the negative impact of anxiety on general memory function, as well as on their own memory performances. This greater awareness of anxiety effects could be explained by the alcoholics' more anxious personality, revealed by the STAI Y-B. Moreover, alcoholics reported to have stronger feelings of anxiety during memory task. This observation would attest indirectly that patients have a partial consciousness of memory decline. Indeed, their difficulties of remembering could generate anxiety during everyday live activities requiring memory. However, this emotional component does not account for the lack of FOK accuracy in this sample, as shown by the analysis of covariance with STAI Y-B (Trait

anxiety) as the controlled variable. Second, alcoholic patients seem to perceive the age-related changes in their memory faculties better than healthy controls. This category of the MIA questionnaire was originally intended to assess the perception of age-related modifications in the memory capacities of healthy subjects. Given the nature of our clinical population, the 'Change' category was regarded as reflecting memory changes due to both age and alcohol. In the light of these results, we would expect alcoholic patients to have a rather defeatist perception of their memory abilities. And yet the alcoholics did not differ from the controls on any of the other MIA categories, including Capacity and Strategy. These findings once more emphasize the tendency for alcoholics to overestimate their memory faculties. Alcoholics seem to have only a partial awareness of memory deficits and we suggest that this should lead us to reconsider the concept of 'denial' that is often used in this disease. The notion of 'denial' has its origins in psychoanalysis and refers to the refusal to acknowledge an outside reality that is nevertheless perceived, as it could be traumatic. It illustrates the behavior of patients who deny their excessive alcohol consumption and its consequences. Nevertheless, our results indicate that chronic alcoholics' unawareness of their memory deficits stems not only from a psychopathological mechanism of 'denial', but also from a cognitive dysfunction. This decline in metamemory and the notion of overestimation have unquestionable clinical implications. From a clinical point of view, after being physically weaned off alcohol, patients suffering from chronic alcoholism often undergo cognitive-behavioral treatment. This uses methods whereby alcoholic patients are taught to anticipate situations "with the risk of relapse". They require efficient learning abilities so that patients can fully take in knowledge on alcoholism and effective strategies for avoiding future high-risk situations. However, if patients overestimate their memory faculties, they will benefit only partially from their clinical treatment, as they will labor under the illusion that they have sufficiently consolidated

this important clinical information for everyday life, whereas the reality is actually very different.

4.2. Link between episodic memory, executive functions and metamemory

The second aim of our study was to explore links between metamemory, episodic memory and executive functions. We therefore looked for predictive cognitive factors of metamemory decline in alcoholics.

Concerning the episodic memory assessment, our results demonstrated that the gamma index was correlated with the percentage of R answers given by the alcoholic group in both the spontaneous and the deep conditions of the Spondee test. Conversely, no correlation with episodic memory scores was found in the control group. This finding suggests that metamemory decline may be related to autonoetic consciousness in alcoholics. According to Koriat's accessibility model (1993), they might have difficulties to collect partial relevant information which could help to have a strong feeling of remembering about the target. It is in line with a recent study by Souchay et al. (2007), showing that the FOK accuracy decrease is significantly correlated to lower production of R judgments but not of K judgments in older adults.

Concerning the executive component, shifting function (Trail-Making test) was not correlated with the gamma index in the alcoholic group, whereas Perrotin et al. (2008) had showed a contribution of shifting function in episodic FOK accuracy in healthy older adults. Nevertheless, the absence of shifting deficit in our study could explain the absence of correlation with metamemory decline in alcoholics. Moreover, we demonstrated that the gamma score was linked to the inhibition score (Stroop Color-Word time) in both groups. Nevertheless, only the verbal fluency score was specifically correlated in the alcoholic group. This correlation suggests that a decline in strategic search faculties in memory may be a cognitive factor contributing to reduced metamemory accuracy in this clinical population.

This result fits in perfectly with the metamemory conception, which refers to knowledge of one's own memory abilities and also knowledge of the best strategies for organizing and retrieving information from memory. It fits also with the FOK model (Koriat and Levy-Sadot, 2001), notably the accessibility account (Koriat, 1993). Indeed, the fluency score involves organizational ability and strategies to search information in memory, essential cognitive function to retrieve only pertinent information linked with target while ignoring irrelevant information and therefore to generate accurate FOK judgment. This measure combines both memory and executive functions. Pitel et al. (2007) revealed that only performance on fluency tasks were significantly predictive of episodic memory disorders, including recollection impairments, in chronic alcoholic patients early in abstinence. Thus, the deficit on the fluency task could contribute to alcoholics' recollection difficulties and thus indirectly could increase their metamemory decline.

We then conducted a stepwise regression analysis to investigate the respective contributions of memory and executive factors to the decline in metamemory in chronic alcoholism. Our results showed that episodic memory accounted for the alcoholics' FOK deficit more than executive functions, in line with the study by Souchay et al. (2002) in Alzheimer's disease. In our study, executive function also contributed significantly to FOK accuracy, in line with previous research showing reduced FOK accuracy in patients with frontal lesions (Janowsky et al., 1989; Modirrousta et al., 2008; Pannu and Kazniak, 2005; Pinon et al., 2005; Schnyer et al., 2004) and healthy subjects with low performances on executive tests (Perrotin et al., 2006; Souchay et al., 2000). This observation has been backed up by several functional magnetic resonance imaging studies reporting prefrontal cortex involvement in accurate FOK judgments (Kikyo and Miyashita, 2004; Maril et al., 2003; Schnyer et al., 2005).

An association of episodic memory impairment and executive deficit therefore seems to participate to metamemory decline in alcoholism, as confirmed by an analysis of covariance. These findings are in accordance with previous investigations conducted in neurological populations displaying associated episodic memory and executive deficits, such as Alzheimer's disease (Souchay et al., 2002), Parkinson's disease (Souchay et al., 2006) and Korsakoff's syndrome patients (Shimamura and Squire, 1986), as well as in healthy older adults (Perrotin et al., 2008). The present research also indicates that an isolated deterioration in episodic memory or executive functions is not enough to contribute to a lack of accuracy in metamemory in alcoholism. It confirms the findings of Shimamura and Squire (1986), who showed that amnesic patients without executive deficits were as accurate as healthy subjects; only patients with Korsakoff's syndrome with amnesia and an executive impairment exhibited metamemory damage. The present study reports new findings but does not allow us to provide definitive answer on the links between alcoholics' metamemory deficits and their episodic and executive deficits. Furthermore, our interpretation is based solely on correlational patterns and needs to be confirmed by behavioural and imaging experiments.

To conclude, the present study revealed for the first time a decline in metamemory in chronic alcoholism. This decline appears to be influenced by the joint deficit in episodic memory and executive functions that is characteristic of this clinical population. In view of our results and the growing interest in the brain substrates of metamemory, it would be useful to study links between metamemory dysfunction and brain lesions consecutive to chronic alcohol consumption.

REFERENCES

American Psychiatric Association (1994) Diagnostic and statistical manual of mental disorders. American Psychiatric Association, Washington.

Bacon E, Danion JM, Kauffmann-Muller F, Schelstraete MA, Bruant A, Sellal F, Grange D (1998) Confidence level and feeling-of-knowing for episodic and semantic memory: An investigation of lorazepam effects on metamemory. Psychopharmacology (Berl) 138: 318-325.

Baillargeon J, Neault S (1989) Les modifications de la métamémoire reliées au vieillissement: Nouvelle évidence auprès d'un échantillon francophone. Can J Aging 8: 343-354.

Bates ME, Labouvie EW, Voelbel GT (2002) Individual differences in latent neuropsychological abilities at addictions treatment entry. Psychol Addict Behav 16: 35-46.

Beatty WW, Katzung VM, Moreland VJ, Nixon SJ (1995) Neuropsychological performance of recently abstinent alcoholics and cocaine abusers. Drug Alcohol Depend 37: 247-253.

Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J (1961) An inventory for measuring depression. Arch Gen Psychiatry 4: 561-567.

Boucheron C (1995) Version française du MIA (Metamemory In Adulthood). Eur Rev Appl Psychol 45: 163-170.

Brokate B, Hildebrandt H, Eling P, Fichtner H, Runge K, Timm C (2003) Frontal lobe dysfunctions in Korsakoff's syndrome and chronic alcoholism: Continuity or discontinuity? Neuropsychology 17: 420-428.

Burgess PW, Shallice T (1996) Response suppression, initiation and strategy use following frontal lobe lesions. Neuropsychologia 34: 263-273.

Cardebat D, Doyon B, Puel M, Goulet P, Joanette Y (1990) Formal and semantic lexical evocation in normal subjects. Performance and dynamics of production as a function of sex, age and educational level. Acta Neurol Belg 90: 207-217.

Chanraud S, Martelli C, Delain F, Kostogianni N, Douaud G, Aubin HJ, Reynaud M, Martinot JL (2007) Brain morphometry and cognitive performance in detoxified alcohol-dependents with preserved psychosocial functioning. Neuropsychopharmacology 32: 429-438.

Couvilliers F, Quaglino V, Valot L, Lecercle C, Czternasty G (2005) Evaluation de la mémoire épisodique et des fonctions exécutives chez des alcooliques sevrés. Alcoologie et Addictologie 27: 13-19.

Dao-Castellana MH, Samson Y, Legault F, Martinot JL, Aubin HJ, Crouzel C, Feldman L, Barrucand D, Rancurel G, Féline A, Syrota A (1998) Frontal dysfunction in neurologically normal chronic alcoholic subjects: Metabolic and neuropsychological findings. Psychol Med 28: 1039-1048.

Dixon RA, Hultsch DF (1983) Structure and development of metamemory in adulthood. J Gerontol 38: 682-688.

Fama R, Pfefferbaum A, Sullivan EV (2004) Perceptual learning in detoxified alcoholic men: Contributions from explicit memory, executive function, and age. Alcohol Clin Exp Res 28: 1657-1665.

Flavell JH (1971) First discussant's comments: What is memory development the development of ? Hum Dev 14: 272-278.

Flavell JH, Wellman HM (1977) Metamemory, in *Perspectives on the development of memory and cognition* (Kail RV, Hagen JW eds), pp. 3-34. Lawrence Erlbaum Associates, Hillsdale, NJ.

Folstein MF, Folstein SE, McHugh PR (1975) "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 12: 189-198.

Gardiner JM, Ramponi C, Richardson-Klavehn A (2002) Recognition memory ans decision processes: a meta-analysis of remember, know and guess responses. Memory 10: 83-98.

Grober E, Kawas C (1997) Learning and retention in preclinical and early Alzheimer's disease. Psychol Aging 12: 183-188.

Groupe de Réflexion sur l'Evaluation des Fonctions EXécutives (2001) L'évaluation des fonctions exécutives en pratique clinique. Rev Neuropsychol 11: 383-434.

Hart JT (1965) Memory and the feeling-of-knowing experience. J Educ Psychol 56: 208-216.

Janowsky JS, Shimamura AP, Squire LR (1989) Memory and metamemory: Comparisons between patients with frontal lobe lesions and amnesic patients. Psychobiol 17: 3-11.

Joyce EM, Robbins TW (1991) Frontal lobe function in Korsakoff and non-Korsakoff alcoholics: Planning and spatial working memory. Neuropsychologia 29: 709-723.

Kikyo H, Miyashita Y (2004) Temporal lobe activations of "feeling-of-knowing" induced by face-name associations. Neuroimage 23: 1348-1357.

Koriat A (1993) How do we know that we know? The accessibility model of the feeling of knowing. Psychol Rev 100: 609-639.

Koriat A, Levy-Sadot R (2001) The combined contributions of the cue-familiarity and accessibility heuristics to feelings of knowing. J Exp Psychol Learn Mem Cogn 27: 34-53.

Maril A, Simons JS, Mitchell JP, Schwartz BL, Schacter DL (2003) Feeling-of-knowing in episodic memory: An event-related fMRI study. Neuroimage 18: 827-836.

Metcalfe J, Schwartz BL, Joaquim SG (1993) The cue-familiarity heuristic in metacognition. J Exp Psychol Learn Mem Cogn 19: 851-861.

Meulemans T, Steyaert M, Vincent E (2001, May) *Evaluation des déficits d'inhibition chez les patients traumatisés crâniens à l'aide du test de Hayling*. Poster session presented at the Journées de Printemps of the Société de Neuropsychologie de Langue Française, Lyon, France.

Modirrousta M, Fellows LK (2008) Medial prefrontal cortex plays a critical and selective role in 'feeling of knowing' meta-memory judgments. Neuropsychologia 46: 2958-2965.

Moselhy HF, Georgiou G, Kahn A (2001) Frontal lobe changes in alcoholism: A review of the literature. Alcohol Alcohol 36: 357-368.

Nelson TO (1984) A comparison of current measures of the accuracy of feeling of knowing predictions. Psychol Bull 95: 109-133.

Nelson TO, McSpadden M, Fromme K, Marlatt A (1986) Effects of alcohol intoxication on metamemory and on retrieval from long-term memory. J Exp Psychol Gen 115: 247-254.

Nelson TO, Narens L (1990) Metamemory: A theoretical framework and new finding, in *The psychology of learning and motivation* (Bower GH ed), pp 125-141. Academic Press, New York.

Nixon SJ, Tivis RD, Jenkins MR, Parsons OA (1998) Effects of cues on memory in alcoholics and controls. Alcohol Clin Exp Res 22: 1065-1069.

Noel X, Paternot J, Van der Linden M, Sferrazza R, Verhas M, Hanak C, Kornreich C, Martin P, De Mol J, Pelc I, Verbanck P (2001a) Correlation between inhibition, working memory and delimited frontal area blood flow measure by 99mTc-Bicisate SPECT in alcohol-dependent patients. Alcohol Alcohol 36: 556-563.

Noel X, Van der Linden M, Schmidt N, Sferrazza R, Hanak C, Le Bon O, De Mol J, Kornreich C, Pelc I, Verbanck P (2001b) Supervisory attentional system in nonamnesic alcoholic men. Arch Gen Psychiatry 58: 1152-1158.

Pannu JK, Kaszniak W (2005) Metamemory experiments in neurological populations: A review. Neuropsychol Rev 15: 105-130.

Pappas B, Sunderland T, Weingartner H, Vitiello B, Martinson H, Putman K (1992) Alzheimer's disease and feeling-of-knowing for knowledge and episodic memory. J Gerontol 47: 159-164.

Parsons OA, Nixon SJ (1993) Neurobehavioral sequelae of alcoholism. Neurol Clin 11: 205-218.

Perrotin A, Isingrini M, Souchay C, Clarys D, Taconnat L (2006) Episodic feeling-of-knowing accuracy and cued recall in the elderly: Evidence for double dissociation involving executive functioning and processing speed. Acta Psychol (Amst) 122: 58-73.

Perrotin A, Belleville S, Isingrini M (2007) Metamemory monitoring in mild cognitive impairment: Evidence of a less accurate episodic feeling-of-knowing. Neuropsychologia 45: 2811-2826.

Perrotin A, Tournelle L, Isingrini M (2008) Executive functioning and memory as potential mediators of the episodic feeling-of-knowing accuracy. Brain Cogn 67: 76-87.

Pinon K, Allain P, Kefi MZ, Dubas F, Le Gall D (2005) Monitoring processes and metamemory experience in patients with dysexecutive syndrome. Brain Cogn 57: 185-188.

Pitel AL, Beaunieux H, Witkowski T, Vabret F, Guillery-Girard B, Quinette P, Desgranges B, Eustache F (2007) Genuine episodic memory deficits and executive dysfunctions in alcoholic subjects early in abstinence. Alcohol Clin Exp Res 31: 1169-1178.

Pitel AL, Beaunieux H, Witkowski T, Vabret F, De La Sayette V, Viader F, Desgranges B, Eustache F (2008) Episodic and working memory deficits in alcoholic Korsakoff patients: The continuity theory revisited. Alcohol Clin Exp Res 32: 1229-1241.

Reder RD (1987) Strategy selection in question answering. Cogn Psychol 19: 90-138.

Reitan RM (1958) The validity of the Trail Making test as an indicator of organic brain damage. Percept Mot Skills 8: 271-276.

Rosenbloom M, Sullivan EV, Pfefferbaum A (2003) Using magnetic resonance imaging and diffusion tensor imaging to assess brain damage in alcoholics. Alcohol Res Health 27: 146-152.

Schnyer DM, Verfaellie M, Alexander MP, LaFleche G, Nicholls L, Kaszniak AW (2004) A role for right medial prefrontal cortex in accurate feeling-of-knowing judgments: Evidence from patients with lesions to frontal cortex. Neuropsychologia 42: 957-966.

Schnyer DM, Nicholls L, Verfaellie M (2005) The role of VMPC in metamemorial judgments of content retrievability. J Cogn Neurosci 17: 832-846

Shimamura AP, Squire LR (1986) Memory and metamemory: A study of the feeling-of-knowing phenomenon in amnesic patients. J Exp Psychol Learn Mem Cogn 12: 452-460.

Souchay C, Isingrini M, Espagnet M (2000) Aging, episodic memory feeling-of-knowing, and frontal functioning. Neuropsychology 14: 299-309.

Souchay C, Isingrini M, Gil R (2002) Alzheimer's disease and feeling-of-knowing in episodic memory. Neuropsychologia 40: 2386-2396.

Souchay C, Isingrini M, Clarys D, Taconnat L, Eustache F (2004) Executive functioning and judgement-of-learning versus feeling-of-knowing in older adults. Exp Aging Res 30: 47-62.

Souchay C, Isingrini M, Gil R (2006) Metamemory monitoring and Parkinson's disease. J Clin Exp Neuropsychol 28: 618-630

Souchay C, Moulin CJA, Clarys D, Taconnat L, Isingrini M (2007) Diminished episodic memory awareness in older adults: Evidence from feeling-of-knowing and recollection. Conscious Cogn 16: 769-784.

Spielberger CD, Gorsuch RL, Lushene R, Vagg PR, Jacobs GA (1983) Manual for the State-Trait Anxiety Inventory (form Y). Consulting Psychologists Press, Palo Alto, CA.

Stroop J (1935) Studies of interference in serial verbal reactions. J Exp Psychol 18: 643-662.

Sullivan EV, Rosenbloom MJ, Pfefferbaum A (2000) Pattern of motor and cognitive deficits in detoxified alcoholic men. Alcohol Clin Exp Res 24: 611-621.

Sullivan EV, Pfefferbaum A (2005) Neurocircuitry in alcoholism: A substrate of disruption and repair. Psychopharmacology (Berl) 180: 583-594.

Tedstone D, Coyle K (2004) Cognitive impairments in sober alcoholics: Performance on selective and divided attention tasks. Drug Alcohol Depend 75: 277-286.

Tulving E (2001) Episodic memory and common sense: how far apart? Philos Trans Roy Soc Lond B Biol Sci 356: 1505-1515.

Weschler D (2001) Wechsler Adult Intelligence Scale. 3rd ed. EAP, Paris.

Wheeler MA, Stuss DT, Tulving E (1997) Toward a theory of episodic memory: the frontal lobes and autonoetic consciousness. Psychol Bull 121: 331-354.

Zinn S, Stein R, Swartzwelder HS (2004) Executive functioning early in abstinence from alcohol. Alcohol Clin Exp Res 28: 1338-1346.

Fig. 1. Design of the experiment used to collect feeling-of-knowing (FOK) monitoring measure during an episodic memory task (learning of 20 'cue-target' pairs)

Fig. 2. Assessment of Hits and Misses for YES and NO judgments in control subjects and alcoholic patients

* Significant difference between alcoholic patients and control subjects ($p < 0.05$) for parametric Student's non-paired t test

Fig. 3. Assessment of Feeling-Of-Knowing (FOK) accuracy using the Gamma index in control subjects and alcoholic patients

* Significant difference between alcoholic patients and control subjects ($p < 0.05$) for parametric Student's non-paired t test

Fig. 4. Scatterplot illustrating the relationship between FOK Gamma index and and % « R » after spontaneous encoding (A) and verbal fluency score (B) in the alcoholic group.