



**HAL**  
open science

## Validation of a brief screening tool for alcohol-related neuropsychological impairments (BEARNI)

Ludivine Ritz, Coralie Lannuzel, Céline Boudehent, François Vabret, Nadège Bordas, Shailendra Segobin, Francis Eustache, Anne Lise Pitel, Helene Beaunieux

### ► To cite this version:

Ludivine Ritz, Coralie Lannuzel, Céline Boudehent, François Vabret, Nadège Bordas, et al.. Validation of a brief screening tool for alcohol-related neuropsychological impairments (BEARNI). *Alcoholism: Clinical and Experimental Research*, 2015, 39 (11), pp.2249-60. inserm-01236103

**HAL Id: inserm-01236103**

**<https://inserm.hal.science/inserm-01236103v1>**

Submitted on 1 Dec 2015

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



**Validation of a brief screening tool for alcohol-related neuropsychological impairments (BEARNI)**

Journal:	<i>Alcoholism: Clinical and Experimental Research</i>
Manuscript ID:	ACER-15-2026.R2
Wiley - Manuscript type:	Original Research Article
Date Submitted by the Author:	n/a
Complete List of Authors:	Ritz, Ludivine; Inserm-EPHE-UCBN-CHU, U1077 research unit, Lannuzel, Coralie; Inserm-EPHE-UCBN-CHU, U1077 research unit, Boudehent, Celine; Inserm-EPHE-UCBN-CHU-Service d'addictologie, U1077 research unit,, Vabret, François; Inserm-EPHE-UCBN-CHU-Service d'addictologie, U1077 research unit,, Bordas, Nadège; Centre Hospitalier Universitaire Paul Brousse, Segobin, Shailendra; Inserm-EPHE-UCBN-CHU, U1077 research unit, Eustache, Francis; Inserm-EPHE-UCBN-CHU, U1077 research unit, Pitel, Anne-Lise; Inserm-EPHE-UCBN-CHU, U1077 research unit, Beaunieux, Helene; Inserm-EPHE-UCBN-CHU, U1077 research unit,
Category:	mood, affect, learning, cognition < CONSEQUENCES OF DRINKING - HUMAN, brain < PATHOLOGY - HUMAN AND ANIMAL
Keyword:	alcoholism, neuropsychological impairment, brief cognitive screening tool, exploratory factor analysis, ROC curve
Abstract:	<p>Background: Alcohol-related neuropsychological impairments mainly affect episodic memory, working memory and visuospatial abilities, as well as executive and motor functioning. These impairments can prevent alcoholic patients early in abstinence from benefiting fully from treatment, and reduce their ability to remain abstinent. A neuropsychological assessment at alcohol treatment entry therefore seems essential for making the relevant clinical decisions. However, very few alcohol treatment departments have the financial and human resources needed to conduct an extensive neuropsychological examination of each alcoholic patient. The goal of the present study was therefore to assess the validity and the psychometric properties of the Brief Evaluation of Alcohol-Related Neuropsychological Impairments (BEARNI), a new screening tool especially designed to assess patients at alcohol treatment entry.</p> <p>Methods: A total of 254 healthy controls completed the BEARNI, and 58 of them also performed an extensive neuropsychological battery. 73 alcoholic patients underwent both the BEARNI and the neuropsychological battery. This extensive neuropsychological battery of proven classification accuracy served as the reference (i.e., gold standard) for determining the alcoholic patients' cognitive status.</p> <p>Results: An exploratory factor analysis validated the BEARNI's underlying</p>

	<p>structure, highlighting five factors that reflected visuospatial abilities, executive functions, ataxia, verbal episodic memory and verbal working memory. The standardization of each BEARNI subtest and the two total scores revealed that this test has sufficient diagnostic accuracy for the detection of alcoholic patients with cognitive and motor impairments. Conclusion: The present study indicates that the BEARNI is a useful screening tool in clinical settings for detecting alcoholic patients' motor and cognitive impairments at treatment entry.</p>

SCHOLARONE™  
Manuscripts

For Review Only

1 **Validation of a brief screening tool for alcohol-related neuropsychological impairments**

2 **(BEARNI)**

3 Ludivine Ritz<sup>a,b,c,d</sup>, Coralie Lannuzel<sup>a,b,c,d</sup>, Céline Boudehent<sup>a,b,c,d,e</sup>, François Vabret<sup>a,b,c,d,e</sup>,

4 Nadège Bordas<sup>f</sup>, Shailendra Segobin<sup>a,b,c,d</sup>, Francis Eustache<sup>a,b,c,d</sup>, Anne-Lise Pitel<sup>a,b,c,d</sup> and

5 Hélène Beaunieux<sup>a,b,c,d</sup>

6

7 <sup>a</sup> U1077, INSERM, Caen, France

8 <sup>b</sup> UMR-S1077, Université de Caen Basse-Normandie, Caen, France

9 <sup>c</sup> UMR-S1077, Ecole Pratique des Hautes Etudes, Caen, France

10 <sup>d</sup> U1077, Centre Hospitalier Universitaire, Caen, France

11 <sup>e</sup> Centre Hospitalier Universitaire, service d'addictologie, Caen, France

12 <sup>f</sup> Centre Hospitalier Universitaire Paul Brousse, Villejuif, France

13

14 Corresponding author: Prof. Hélène Beaunieux, UFR de Psychologie, Université de Caen

15 Basse Normandie, Esplanade de la Paix, 14032 Caen Cedex, France; Tel.: +33 (0)2 31 56 56

16 25; e-mail: [helene.beaunieux@unicaen.fr](mailto:helene.beaunieux@unicaen.fr)

17

18

1       **ABSTRACT**

2       **Background:** Alcohol-related neuropsychological impairments mainly affect episodic  
3       memory, working memory and visuospatial abilities, as well as executive and motor  
4       functioning. These impairments can prevent alcoholic patients (ALs) early in abstinence from  
5       benefiting fully from treatment, and reduce their ability to remain abstinent. A  
6       neuropsychological assessment seems essential for making the relevant clinical decisions.  
7       However, very few alcohol treatment departments have the financial and human resources  
8       needed to conduct an extensive neuropsychological examination of each alcoholic patient.  
9       The goal of the present study was therefore to assess the validity and the psychometric  
10      properties of the Brief Evaluation of Alcohol-Related Neuropsychological Impairments  
11      (BEARNI), a new screening tool especially designed to assess alcohol-related  
12      neuropsychological impairments.

13      **Methods:** A total of 254 healthy controls (HCs) completed the BEARNI, and 58 of them also  
14      performed an extensive neuropsychological battery. 73 ALs underwent both the BEARNI and  
15      the neuropsychological battery. This extensive neuropsychological battery of proven  
16      classification accuracy served as the reference (i.e., gold standard) for determining the ALs'  
17      cognitive status.

18      **Results:** An exploratory factor analysis validated the BEARNI's underlying structure,  
19      highlighting five factors that reflected visuospatial abilities, executive functions, ataxia,  
20      verbal episodic memory and verbal working memory. The standardization of each BEARNI  
21      subtest and the two total scores revealed that this test has sufficient diagnostic accuracy for  
22      the detection of ALs with cognitive and motor impairments.

23      **Conclusion:** The present study indicates that the BEARNI is a useful screening tool in  
24      clinical settings for detecting ALs' motor and cognitive impairments.

25

- 1 **Keywords:** alcoholism, neuropsychological impairment, brief cognitive screening tool,
- 2 exploratory factor analysis, ROC curve

For Review Only

## 1 INTRODUCTION

2 Chronic alcoholism results in brain damage and compromised motor and cognitive  
3 functioning, even in alcoholic patients (ALs) with no severe neurological complications (i.e.  
4 those without Korsakoff's syndrome (KS), or alcoholic dementia). The neuropsychological  
5 impairments mainly encompass executive dysfunction (Ihara et al., 2000), working memory  
6 deficits (Pitel et al., 2007; Uekermann et al., 2007) and visuospatial disabilities (Fama et al.,  
7 2004). Genuine episodic memory impairments (i.e., not resulting solely from executive  
8 dysfunctions) are also observed in ALs (Noël et al., 2012), but are generally less severe than  
9 executive and visuospatial impairments (Sullivan et al., 2000). Deficits in motor functions  
10 including ataxia of gait and balance (Fein and Greenstein, 2013) are just as severe as the  
11 visuospatial deficits (Sullivan et al., 2000). These cognitive and motor impairments have been  
12 estimated to affect more than two thirds of ALs (Ihara et al., 2000). The deficits range from  
13 mild-to-moderate (Sullivan et al., 2000), that is, about one standard deviation from the mean  
14 for non-alcoholic healthy controls (HCs) (Goldstein et al., 2004), to severe impairments  
15 comparable to those observed in KS patients (Kopelman et al., 2009).

16 The treatment of alcohol-dependence includes several types of therapy such as Motivational  
17 Enhancement Therapy, Twelve-Step Facilitation or cognitive behavioral therapy, which all  
18 require attending to and receiving new information, and being able to integrate and translate it  
19 into behavioral changes (Bates et al., 2006). To benefit from these therapies, ALs must  
20 implement cognitive functions such as episodic memory, planning, inhibition and problem-  
21 solving abilities, which have been repeatedly found as impaired. Episodic memory deficits  
22 and executive dysfunction hinder complex learning, such as the learning of semantic  
23 information and cognitive procedures (Pitel et al., 2007), affect readiness to change (Blume et  
24 al., 2005), ability to elaborate alternative behavioral responses (Bates et al., 2006) and  
25 decision making (Noël et al., 2007). These cognitive disabilities impact treatment compliance

1 and treatment outcomes (Bates et al., 2006). Thus, ALs with impaired cognitive functions  
2 may be unable to benefit fully from therapy interventions. The detection of  
3 neuropsychological impairments is therefore essential for making the appropriate clinical  
4 decisions regarding the nature and timing of treatment.

5 Few alcohol departments and clinics have the financial and human resources needed to  
6 administer an extensive neuropsychological examination to each ALs. Previous studies have  
7 proposed a range of screening instruments for the detection of cognitive impairments in  
8 patients with substance use disorders (SUDs), including the Neurobehavioral Cognitive Status  
9 Examination (NCSE; (Kiernan et al., 1987), the Repeatable Battery for Assessment of  
10 Neuropsychological Status (RBANS; (Randolph et al., 1998) and the Montreal Cognitive  
11 Assessment (MOCA; (Nasreddine et al., 2005). According to (Shulman, 2000), an ideal  
12 cognitive screening test should fulfill the following criteria: a) be readily administered; b) be  
13 easy to score; c) have concurrent validity; and d) have high levels of sensitivity, specificity  
14 and predictive validity. Despite the fact that existing screening tools can be administered  
15 within 10-30 minutes and have satisfactory sensitivity to cognitive impairment in SUD  
16 patients (Copersino et al., 2009; Fals-Stewart, 1997), they have several limitations. In addition  
17 to poor specificity in detecting impaired patients (36% for NCSE and 69% for MOCA; Fals-  
18 Stewart, 1997; Wester et al., 2013), these tools assess cognitive functions that are not usually  
19 reported as impaired in ALs, including orientation, attention and concentration, language and  
20 naming. Even though total MOCA and RBANS scores are lower for SUD patients than for  
21 controls, analysis of individual subscores has shown that only memory, executive and  
22 visuospatial abilities are impaired in patients compared with controls (Alarcon et al., 2015;  
23 Green et al., 2010; Wester et al., 2013). More specifically, in a recent study (Alarcon et al.,  
24 2015), performances of ALs with low ( $\leq 21$ ), medium (22-25) and high ( $\geq 26$ ) MOCA total  
25 score were compared on each subscore of this test. The most affected domains concerned



1 abstraction and fluency. The authors raised a limitation to the MOCA that is the narrow range  
2 of these subscores (respectively from 0 to 1 and 2) that can limit the assessment of the  
3 severity of cognitive deficits and its improvement with abstinence and treatment.

4 Overall, these screening tools do not have a satisfactory level of content validity for chronic  
5 alcoholism probably because they were initially designed to detect cognitive impairments  
6 either in older individuals (Nasreddine et al., 2005; Randolph et al., 1998) or else in patients  
7 receiving neurosurgical care for brain lesions (Kiernan et al., 1987). A screening tool must be  
8 validated against a gold standard, in order to avoid misdiagnosis due to false negatives or  
9 false positives. In the above-mentioned studies conducted in SUD patients, these patients'  
10 cognitive profile was either not reported (Alarcon et al., 2015; Wester et al., 2013) or else  
11 determined using the Neuropsychological Screening Battery (Heaton et al., 1990) or the  
12 Neuropsychological Assessment Battery–Screening Module (White and Stern, 2003). These  
13 short neuropsychological batteries both have poor specificity (Fals-Stewart, 1996) and have  
14 been validated in SUD patients (Fals-Stewart, 1996; Grohman and Fals-Stewart, 2004) but not  
15 specifically in alcoholic ones. Moreover, a main limitation of a previous study (Wester et al.,  
16 2013) was that the MOCA was administered to patients at admission whereas the extensive  
17 neuropsychological battery was conducted 6 to 8 weeks later. Since some of the cognitive  
18 functions can recover, even after a short time of abstinence (from 3-5 weeks of abstinence;  
19 (Mann et al., 1999)), the delay between the MOCA and the extensive battery substantially  
20 limits the determination of the psychometric properties of the MOCA. Other brief screening  
21 tools have been used in previous studies to describe the general cognitive status of alcoholic  
22 patients, such as the MMSE (Folstein et al., 1975) and DRS Mattis (Mattis and Inc, 1988).  
23 Results are discrepant since some of them reported impairments (Le Berre et al., 2010;  
24 Rosenbloom et al., 2007) whereas other did not (Pitel et al., 2011). These tools are mainly

1 used as inclusion criteria in studies conducted in ALs and to exclude patients with low scores  
2 that may be explained by dementia.

3 The goal of the present study was therefore to validate a new screening tool especially  
4 designed for the rapid assessment of alcohol-related neuropsychological deficits. The Brief  
5 Examination of Alcohol-Related Neuropsychological Impairment (BEARNI) is intended to be  
6 short and easy to score, making it usable by non-psychologists. It is expected to enable  
7 physicians or nurses to rapidly determine whether a patient can attend and gain from standard  
8 alcohol treatment or whether some adjustments are required. More specifically, we sought to  
9 assess the BEARNI's validity and its psychometric properties in order to determine whether it  
10 is an appropriate tool for identifying cognitive and motor impairments in ALs. A value of  
11 80% or above indicates high psychometric quality (Blazer and Hays, 1998), and we expected  
12 the BEARNI's psychometric properties to meet this criterion.

13

## 14 **MATERIALS AND METHODS**

### 15 ***Participants***

16 A total of 254 HCs completed the BEARNI, and 58 of them also performed an extensive  
17 neuropsychological battery. We administered both the BEARNI and the extensive battery to  
18 73 ALs. None of the participants had a history of neurological pathologies, endocrine or  
19 infectious diseases, mental illness (psychiatric disorders assessed by the MINI 500;  
20 (American Psychiatric Association, 2004), depression (Beck Depression Inventory, BDI-II;  
21 (Beck et al., 1961), or other forms of substance misuse or dependence (except tobacco) over  
22 the lifetime. None were under psychotropic medication that might have had an effect on their  
23 cognitive functioning. All the participants were informed about the study (approved by the  
24 local ethics committee) and provided their written informed consent before their inclusion.  
25 Their demographic characteristics (age, sex ratio and education) with their scores on the Mini

1 Mental State Examination (MMSE; Folstein et al., 1975) and the Mattis Dementia Rating  
2 Scale (DRS; Mattis and Inc, 1988) are reported in Table 1.

3 The ALs were recruited by clinicians while they were receiving withdrawal treatment as  
4 inpatients at Caen University Hospital. All the patients met the DSM-IV criteria for alcohol-  
5 dependence (American Psychiatric Association, 2004). None of them had severe, enduring  
6 and global amnesia defining the Korsakoff's syndrome nor alcoholic dementia, Marchiafava-  
7 Bignami or central pontine myelinolysis. Although the patients were early in abstinence, none  
8 of them presented physical symptoms of alcohol withdrawal at inclusion. They were  
9 interviewed with the Alcohol Use Disorders Identification Test (AUDIT; (Gache et al., 2005)  
10 and a modified version of the semistructured Lifetime Drinking History questionnaire.  
11 Measures included the duration of alcohol use (in years), alcohol misuse (in years), number of  
12 withdrawals, and daily alcohol consumption prior to treatment (in standard drinks, a standard  
13 drink corresponding to a beverage containing about 10 g of pure alcohol) (Table 1).

14 All the HCs were interviewed with the AUDIT (Gache et al., 2005) to ensure that they did not  
15 meet the criteria for alcohol abuse or dependence over the lifetime (AUDIT <7 for men and  
16 <6 for women) (Table 1). None of the HCs had a MMSE (Folstein et al., 1975) or a Mattis  
17 DRS (Mattis and Inc, 1988) scores below the cut-off score of 24 and 127 respectively.

18

### 19 *Material*

20 Participants completed the BEARNI and the extensive battery of neuropsychological tests  
21 over 2-3 days to minimize fatigue and interference. Only 58 of the HCs completed the  
22 neuropsychological battery (demographic characteristics in Table 1) in addition to the  
23 BEARNI. The latter was administered on the first day to avoid the possible influence of the  
24 extensive battery on performances. The order of the test administration was fixed because  
25 some of the BEARNI subtests were inspired by neuropsychological tests administered to

1 participants (see below the description of the BEARNI subtests). Thus, in administering the  
2 BEARNI before the extensive neuropsychological battery, all the subjects in our study were  
3 in the same situation than patients in clinical settings who would first undergo the BEARNI  
4 and then, an extensive neuropsychological examination. Raw scores of the BEARNI and the  
5 extensive neuropsychological battery are provided in Supporting Information B table 4.

6

### 7 **Brief Examination of Alcohol-Related Neuropsychological Impairments** 8 **(BEARNI)**

9 The BEARNI is designed to assess the cognitive and motor functions that are impaired in  
10 ALs, namely episodic memory, working memory, executive functions, visuospatial abilities,  
11 and ataxia (Table 2). It takes approximatively 15-20 minutes to administer the BEARNI. In  
12 order to avoid errors, instructions for administration and scoring are provided in Supporting  
13 Information A. Examples of the working memory, flexibility, visuospatial and ataxia subtests  
14 are provided to participants prior to data collection. The BEARNI is provided in Supporting  
15 Information A.

16 The *episodic memory* subtest was inspired by the California Verbal Learning Test (Delis et  
17 al., 1988). It consists of two learning trials of a 12-word list (4 words x 3 semantic  
18 categories). The list is read aloud by the examiner. After each trial, the patient is instructed to  
19 freely recall as many words as possible, in any order (1 minute per trial, no points scored).  
20 Once the remaining tests from the BEARNI have been administered, delayed free recall is  
21 performed (one trial lasting 1 minute). The episodic measure is the number of correct  
22 responses (0.5 point per response) minus the number of errors (intrusions and perseverations;  
23 0.5 point per error) during the delayed free recall task (maximum score: 6 points).

24 *Working memory* is assessed with an alphabetical span subtest adapted from the alpha-span  
25 task (Belleville et al., 1998). This task probes the ability to manipulate information stored in

1 verbal working memory. Increasingly long letter sequences are read out loud, and for each  
2 sequence the patient has to repeat the letters in alphabetical order. Two trials are performed  
3 for each sequence. The task ends when the participant fails both two trials of a sequence (0.5  
4 point per trial; maximum score: 5 points).

5 **Flexibility abilities** are assessed with the alternating verbal fluency subtest. Patients are given  
6 120 seconds to generate as many words as possible from two alternating categories (“color  
7 name” and “city name”). Depending on the number of correct responses, points range from 0  
8 to 6 (for scoring details, see Supporting Information A).

9 **Visuospatial abilities** are assessed with an adapted version of the Hidden Figures Test  
10 (Corkin, 1979; Thurstone, 1944). This subtest includes five complex figures, each containing  
11 two separate hidden figures that the patient has to find. An example is provided and explained  
12 to the patient by the examiner. For each complex figure, one point is provided when the  
13 patient finds both hidden figures within 1 minute (maximum score: 5 points).

14 Finally, the **ataxia** subtest, drawn from the Walk-a-Line Ataxia Battery (Fregly, 1971),  
15 requires patients to stand on each foot in turn for 30 seconds, first with eyes open, then with  
16 eyes closed. There are up to two trials per condition. For each condition, 2 points are awarded  
17 when patients successfully perform the task at the first trial, 1 point when they successfully  
18 perform the task at the second trial, and 0 point when they fail both trials (maximum score: 8  
19 points).

20 The BEARNI yields seven scores: five subscores (one for each of the subtests), a total score  
21 (maximum score: 30 points) and a total *cognitive* score (excluding the ataxia subtest;  
22 maximum score: 22 points).

23

24 **Neuropsychological examination**

1 The extensive neuropsychological battery we administered targeted a broad range of cognitive  
2 and motor functions: *verbal episodic memory* (French adaptation of the CVLT (Delis et al.,  
3 1988)); *working memory* (verbal and visuospatial spans of the MEM-III (Wechsler, 2001a)  
4 and the Letter-Number Sequencing subtest of the WAIS-III (Wechsler, 2001b)); *executive*  
5 *functions* (the Trail Making Test (Reitan, 1955), the Ruff Figural Fluency Test (RFFT;  
6 (Foster et al., 2005), the Stroop test (Stroop, 1935), and fluency tasks (Cardebat et al., 1990);  
7 *visuospatial abilities* (the Rey-Osterrieth Complex Figure (ROCF; (Osterrieth, 1944)) and  
8 *ataxia* (the Walk-a-Line Ataxia Battery). The data collected for each test are summarized in  
9 Table 2.

10

### 11 *Data analysis*

#### 12 **Validation of the BEARNI's internal structure**

13 The first step consisted of an exploratory factor analysis (EFA) to determine the BEARNI's  
14 factorial structure, the explained variance for each factor and the total variance. An orthogonal  
15 rotation (normalized varimax rotation) was used because the latent factors were not correlated  
16 with each other (data not shown). The number of factors was determined by three criteria: a)  
17 eigenvalues above 1 (Kaiser criterion; (Kaiser, 1960); b) proportion of variance explained by  
18 the factor above 5%; and c) number of theoretical variables in the integrated model. Given the  
19 number of cognitive and motor functions targeted by the BEARNI (delayed verbal memory,  
20 verbal working memory, flexibility, visuospatial abilities and ataxia), we expected to extract  
21 five factors reflecting these five domains. A threshold  $\geq 0.50$  was used to determine the factors  
22 on which each variable loaded. Any factor below the threshold of 0.50 was assigned to the  
23 factor on which it most highly loaded. The EFA was conducted with the 58 HCs and 73 ALs  
24 who had completed both the BEARNI and the extensive battery.

1 In addition, we compared the performance profiles of the ALs and HCs on each of the  
2 BEARNI subtests. The objective was to determine whether the BEARNI's  
3 neuropsychological profile was consistent with that described in the literature. To do so, we  
4 carried out multivariate analyses of variance (MANOVAs; 2 groups x 5 subtests x 2 sexes;  
5 age and education entered as covariates) and Tukey's tests for post-hoc comparisons.

6

7

### **Standardization of the BEARNI**

8

#### ***Total scores***

9 For the BEARNI's two total scores (total score and total cognitive score), the standardization  
10 was performed for the 58 HCs who had completed the neuropsychological battery. We used  
11 the method described in (Godefroy et al., 2014) and reported in Supporting Information B.

12

13

#### ***Psychometric properties of the BEARNI total scores***

14 Sensitivity, specificity, positive and negative predictive values, diagnostic accuracy (% of  
15 patients well classified; i.e., reliability of the screening test) and Yule's Q coefficient  
16 (coefficient measuring the association between two attributes, ranging from 0 to 1, where a Q  
17 coefficient of 0.70-1 is deemed to represent a very strong association) were computed using  
18 the ALs' results on the BEARNI.

19

20

21

22

23

24

#### ***BEARNI subtests***

25 For each subtest, we determined cut-off scores using the data collected from the 254 HCs who  
26 had completed the BEARNI with the method described in (Godefroy et al., 2014) and in  
27 Supporting Information B. We then investigated the predictive value of these cut-off scores

1 for detecting ALs with impaired performances on the neuropsychological battery. Based on  
2 the cut-off scores, patients were classified as either impaired or preserved on each BEARNI  
3 subtest. Performances on the tasks in the extensive neuropsychological battery were thus  
4 compared across three groups (HCs ( $n=58$ ), ALs with impaired BEARNI performances, and  
5 ALs with preserved BEARNI performances) using an ANOVA. Tukey's tests were then  
6 carried out for post-hoc comparisons. For each subtest, we regarded the BEARNI cut-off  
7 score as predictive when ALs classified as impaired on a specific BEARNI subtest performed  
8 more poorly on the corresponding domain of the neuropsychological battery than ALs with  
9 preserved results on that subtest and HCs.

10

11 Statistical analyses were performed using Statistica and MedCalc software and the probability  
12 significance threshold was set at  $p \leq 0.05$ . Where necessary, Bonferroni corrections were  
13 applied to prevent Type-I errors.

14

## 15 **RESULTS**

### 16 *Validation of the BEARNI's internal structure*

17 The results of the EFA analysis are reported in Table 3. All the factors met the criteria of an  
18 eigenvalue above 1 (Kaiser, 1960) and more than 5% of variance explained by the factor.  
19 Consistent with our hypothesis, five factors were extracted. Factor 1 was deemed to reflect  
20 executive and visuospatial abilities, factor 2 was represented by ataxia, factor 3 included  
21 variables related to verbal episodic memory, factor 4 was represented by fluency tasks and  
22 factor 5 included variables related to verbal working memory. Taken together, these five  
23 factors accounted for 60.08% of the total variance. When restricted to HCs ( $n=58$ ), the EFA  
24 yielded the same results.



1 The two (group: ALs vs. HCs) x two (sexes) x five (BEARNI subtests) MANOVA on  
2 BEARNI performances revealed significant effects of group,  $F_{(1, 324)} = 53.53, p < 0.001$ , age,  
3  $F_{(1, 327)} = 11.28, p < 0.001$ , and education,  $F_{(1, 327)} = 69.72, p < 0.001$ , the Subtest x Group  
4 interaction,  $F_{(4, 1308)} = 16.02, p < 0.001$ , and the Subtest x Education interaction,  $F_{(4, 1308)} = 3.55,$   
5  $p = 0.007$ , but no other significant effects. Tukey's post-hoc tests revealed that ALs performed  
6 more poorly than HCs (effect of group), and this effect was found for each of the BEARNI  
7 subtests (Subtest x Group interaction) except for delayed verbal memory (Figure 1).

8

### 9 ***Standardization of the BEARNI***

10 Most of the raw scores (both for the BEARNI and for the extensive neuropsychological  
11 battery) deviated from normality and were influenced by age, education, sex, or all three.

12

### 13 **Standardization of the BEARNI's total scores**

14 On the extensive neuropsychological battery, 86% of ALs were classified as having at least a  
15 mild impairment, 53% as having a moderate-to-severe impairment, and 14% having no  
16 impairment. Regarding the neuropsychological battery with only cognitive functions (i.e.,  
17 excluding performances on the Walk-a-Line Ataxia Battery), 84% of ALs were classified as  
18 having at least a mild impairment, 45% as having a moderate-to-severe impairment and 16%  
19 as having no impairment.

20 The ROC curve analysis performed to standardize the total BEARNI score (cognitive  
21 functions plus ataxia) showed that a cut-off score of  $\leq 19$  yielded the best balance between  
22 sensitivity and specificity for detecting mild impairment in the neuropsychological battery  
23 (Supporting Information B Table 2, Figure 2A). For moderate-to-severe impairment, a cut-off  
24 score of  $\leq 16$  yielded the best balance between sensitivity and specificity (Supporting  
25 Information B Table 2, Figure 2B).

1 Regarding the total cognitive score (excluding the ataxia BEARNI subtest), a cut-off score of  
2  $\leq 15$  yielded the best balance between sensitivity and specificity for detecting mild impairment  
3 in the neuropsychological battery (Supporting Information B Table 2, Figure 2C). For  
4 moderate-to-severe impairment, a cut-off score of  $\leq 11.5$  yielded the best balance between  
5 sensitivity and specificity (Supporting Information B Table 2, Figure 2D).

6 Linear regression analysis (forward stepwise) conducted in HCs and ALs showed a significant  
7 effect of education on these two total BEARNI scores, indicating that participants with more  
8 than 12 years of schooling had better performances. Thus, in order to correct for this  
9 education effect, we adjusted the cut-off scores for participants with more than 12 years of  
10 schooling. This adjustment of the cut-off scores was determined by the best balance between  
11 true positive and true negative on the extensive neuropsychological battery. All total cut-off  
12 scores are summarized in Table 5.

13

#### 14 ***Psychometric properties of the BEARNI***

15 The psychometric properties of the BEARNI total scores are reported in Table 5. The  
16 sensitivity, positive and negative predictive values, Yule's Q coefficient and diagnostic  
17 accuracy to identify ALs showing mild or moderate-to-severe impairments on the extensive  
18 neuropsychological battery range from acceptable to excellent. However, the specificity of the  
19 BEARNI total scores for identifying ALs with mild impairments was low.

20 Only 9.59% and 8.22% of alcoholic patients were impaired on the MMSE and Mattis DRS  
21 respectively. Although the specificity and the positive predictive value were excellent for the  
22 MMSE (Folstein et al., 1975) and the Mattis DRS (Mattis and Inc, 1988) in identifying  
23 alcoholic patients with mild impairment, the positive predictive value for moderate-to-severe  
24 impairment as well as the sensitivity, negative predictive value, Yule's Q coefficient and  
25 diagnostic accuracy were poor for mild and moderate-to severe impairments (Table 5).

1

2

### **Standardization of the BEARNI subtests and predictability**

3 Each of the subtest scores yielded sensitivity values of 100%, specificity values ranging from  
4 75.21% to 99.59%, and AUC values ranging from 0.950 to 0.998 (Supporting Information B  
5 Table 3). ROC analyses provided cut-off scores for the following BEARNI subtests: delayed  
6 verbal memory  $\leq 2$ ; alphabetical span  $\leq 2.5$ ; alternating fluency  $\leq 2$ ; visuospatial  $\leq 1$ ; and ataxia  
7  $\leq 3$ .

8 These cut-off scores indicated that 16% of the ALs were impaired on the episodic memory  
9 subtest, 32.91% on the alphabetical span subtest, 21.52% on the alternating fluency subtest,  
10 45.57% on the visuospatial subtest, and 49.36% on the ataxia subtest.

11 We then compared the HCs, ALs with impaired BEARNI results, and patients with preserved  
12 BEARNI results on cognitive performances. Using the cut-off scores of each BEARNI  
13 subtest, we compared these three groups on the corresponding domain of the  
14 neuropsychological battery. As the raw scores on the neuropsychological battery were  
15 influenced by demographic factors, each comparison was conducted using standard residuals.

16 All ANOVA results are provided in Table 6. The cut-off score of  $\leq 2$  for the delayed verbal  
17 memory BEARNI subtest was predictive of performances on CVLT. Regarding the  
18 alphabetical span BEARNI subtest, the cut-off score of  $\leq 2.5$  was predictive of performances  
19 on verbal forward span and Letter-Number Sequencing. The cut-off of  $\leq 2$  for the flexibility  
20 subtest was predictive of performances on the verbal fluency tasks and the TMT (Part B  
21 minus Part A;  $F_{(1, 128)} = 9.25$ ,  $p < 0.001$ , Tukey's post-hoc: impaired ALs < (preserved ALs  
22 =HCs)). Regarding the visuospatial BEARNI subtest, the cut-off score of  $\leq 1$  was predictive of  
23 performances on visuospatial backward span, Stroop, TMT and RFFT (total design but not  
24 total strategies). For the ROCF and visuospatial forward span, although impaired ALs had  
25 lower performances than preserved ALs and HCs (who did not differ between each other), no

1 statistical differences were found between the two patient groups. Finally, the cut-off of  $\leq 3$   
2 for the ataxia subtest was predictive of performances on the Walk-a-Line Ataxia Battery.

3

#### 4 **DISCUSSION**

5 The goal of the present study was to assess the validity and psychometric properties of the  
6 BEARNI, a new screening tool especially designed for the rapid assessment of alcohol-related  
7 neuropsychological deficits. An extensive neuropsychological battery of proven classification  
8 accuracy (Godefroy et al., 2014) served as the reference (i.e., gold standard) for determining  
9 the ALs' cognitive status.

10 In agreement with our theoretical hypothesis, the EFA validated the BEARNI's underlying  
11 structure, as it highlighted five factors that accounted for 60% of the total variance: a first  
12 factor including visuospatial and visual executive abilities, a second one reflecting ataxia, a  
13 third one verbal episodic memory, a fourth one spontaneous cognitive flexibility, and a fifth  
14 one verbal working memory. Three of these factors involved executive functions and  
15 visuospatial abilities, which are impaired in two thirds of ALs (Ihara et al., 2000), and more  
16 severely so than other cognitive deficits (Sullivan et al., 2000). The second factor, which  
17 pertained to ataxia, was in agreement with deficits in gait and balance described in previous  
18 studies (Fein and Greenstein, 2013) as being just as severe as the visuospatial impairments  
19 (Sullivan et al., 2000). The delayed verbal memory factor represented a smaller proportion of  
20 the explained variance in the present study, in accordance with a less severe and consistent  
21 impairment of this function in ALs compared with other deficits (Ihara et al., 2000; Sullivan  
22 et al., 2000). Thus, these results suggest that the BEARNI has satisfactory content validity.

23 Even though the BEARNI includes most of the cognitive domains known to be impaired in  
24 ALs, such a brief screening tool cannot allow for the assessment of all cognitive functions.  
25 For example, there is no evaluation of inhibition abilities, even though inhibition deficits have

1 repeatedly been reported in alcoholism (Ihara et al., 2000; Lusher et al., 2004) and have been  
2 linked to poorer delayed recall in episodic memory (Noël et al., 2012) and motivation to  
3 change (Blume et al., 2005). The EFA revealed that inhibition abilities contributed to the  
4 variability of the visuospatial BEARNI subtest, which requires participants to find two figures  
5 hidden in a complex figure. Impaired visuospatial global-local processing in alcoholism has  
6 also been found to reflect difficulty inhibiting local information (Müller-Oehring et al., 2009).  
7 Thus, performances on the visuospatial BEARNI subtest seem to be cognitively multi-  
8 determined and may also reflect inhibition abilities.

9 This interpretation is confirmed by the high concurrent validity we observed when we  
10 standardized the BEARNI subtests. ALs classified as impaired on the BEARNI subtests using  
11 the cut-off scores were also impaired on the corresponding cognitive and motor domains of  
12 the extensive battery. Those classified as preserved did not differ from HCs. Performances on  
13 the visuospatial BEARNI subtest were predictive of results for the visuospatial abilities  
14 assessed by the extensive neuropsychological battery, as well as for visuospatial working  
15 memory, inhibition and flexibility. The episodic memory, verbal working memory, flexibility  
16 and ataxia subtests were similarly predictive. Thus, the cut-off scores computed for each  
17 BEARNI subtest had high diagnostic efficiency in terms of accurately detecting the cognitive  
18 impairments observed on the extensive neuropsychological battery. In addition, performances  
19 on each BEARNI subtest were only predictive of results on the corresponding cognitive  
20 domains, and not of all the domains evaluated by the extensive battery. Taken together, these  
21 findings indicate that the BEARNI could be used in clinical settings to obtain a reliable  
22 estimation of neuropsychological performances, including episodic memory, executive  
23 functions, working memory, visuospatial abilities and ataxia. Compared to other screening  
24 tools, such as the MOCA (Alarcon et al., 2015; Wester et al., 2013), the BEARNI provides

1 larger scales of cut-off score for each subtest, that may lead to a more accurate assessment of  
2 the severity and the improvement of neuropsychological deficits with abstinence.

3 Analysis of the BEARNI's psychometric properties showed that the two total scores made it  
4 possible to distinguish between ALs with no impairment, mild deficits or moderate-to-severe  
5 impairments, with satisfactory sensitivity, predictive validity and diagnostic accuracy (Blazer  
6 and Hays, 1998). This finding suggests that 1) even ALs with mild impairments can be  
7 detected with the BEARNI, and 2) the BEARNI identifies alcohol-related cognitive and  
8 motor impairments with a high degree of accuracy. Yule's Q coefficients highlighted a strong  
9 association between the cognitive profiles identified by the extensive neuropsychological  
10 battery and by the BEARNI, suggesting a high reliability of our screening tool. Whereas it  
11 takes 20 minutes at most to administer the BEARNI, an extensive neuropsychological battery  
12 takes at least 90, if not 120 minutes, to complete, hand-score and interpret. Moreover, the  
13 latter is not accessible to non-psychologists, making its routine use impracticable in clinical  
14 settings. When an extensive neuropsychological battery cannot be readily conducted, the  
15 BEARNI is therefore a useful and reliable screening tool for detecting cognitive and motor  
16 impairments in ALs.

17 Compared to the BEARNI, the MMSE and DRS Mattis were found in our study to have poor  
18 sensitivity, negative predictive value and diagnostic accuracy. 50% and more of the alcoholic  
19 patients were not well identified by these screening tools. This finding could be explained by  
20 the fact that these screening tools were initially designed to detect cognitive decline  
21 associated with dementia. They are therefore neither relevant nor sensitive to assess cognitive  
22 functioning in alcoholic patients. However, the use of the MMSE, the DRS Mattis as well as  
23 the MOCA should not be disregarded in older alcoholic patients and/or in a context of  
24 differential diagnosis. Our findings do not aim at convincing the readers they should not use

1 these tools any more. We believe that BEARNI is more relevant to detect alcohol-related  
2 neuropsychological deficits but that these tools would be useful, as a complement.

3 The main limitation of the BEARNI is its relatively low specificity, especially for detecting  
4 patients with mild impairment. Between 7 and 14% of patients were classified as impaired on  
5 the BEARNI, whereas they had preserved results on the extensive neuropsychological battery.

6 This result cannot be attributed to incorrect sampling, as the prevalence of no, mild, and  
7 moderate-to-severe impairments among the patients included in the present investigation,  
8 according to the neuropsychological battery, matched that reported in previous study (Ihara et  
9 al., 2000). The BEARNI therefore tends to overestimate motor and cognitive impairments in  
10 ALs. As this screening tool has been developed to identify patients who should be referred to  
11 a psychologist for a more comprehensive neuropsychological evaluation, the BEARNI seems  
12 unlikely to miss impaired patients, instead referring some who may actually have a preserved  
13 cognitive profile. It is important to stress that the BEARNI is not intended as a substitute for  
14 an extensive neuropsychological examination, as it does not cover all the cognitive domains  
15 and does not assess specific processes within a given domain. An extensive  
16 neuropsychological examination will still be crucial when a differential diagnosis is required  
17 or when a detailed profile is needed to ensure adequate treatment in relation to cognitive  
18 rehabilitation.

19 In the light of these findings, we can make several recommendations for the clinical use of the  
20 BEARNI (Figure 3). In this study, all alcoholics underwent both the BEARNI and the  
21 neuropsychological battery while they were inpatients at treatment entry immediately after  
22 withdrawal from alcohol. In this clinical context, ALs diagnosed as having preserved abilities  
23 on the BEARNI can attend and benefit from standard alcohol treatment. For patients  
24 identified by the BEARNI as having mild impairments, several clinical and medical factors  
25 need to be considered to determine whether the treatment needs to be adjusted. Alcohol

1 history, including repeated withdrawals (Duka et al., 2003), bouts of thiamine deficiency  
2 (Thomson, 2000), liver complications (Arria et al., 2007) and level of motivation (Blume et  
3 al., 2005) have all been reported to be related to neuropsychological impairments in ALs.  
4 Finally, ALs identified by the BEARNI as having moderate-to-severe impairments are  
5 unlikely to benefit fully from treatment and should be referred for an extensive  
6 neuropsychological examination. As the neuropsychological impairments present at treatment  
7 entry are partially reversible, even after a short time of abstinence (Mann et al., 1999), a safe  
8 and enriched environment (withdrawal from alcohol and nutrition treatment) may prove  
9 beneficial for these impaired patients before they undergo standard alcohol treatment. A re-  
10 test after this recovery period would determine whether their cognitive abilities were  
11 sufficient for them to benefit from the standard treatment. A parallel version of the BEARNI,  
12 allowing for this second assessment, is therefore required. More generally, the BEARNI aims  
13 at determining the neuropsychological profile of ALs and whether a patient is able to attend  
14 and gain from standard alcohol treatment or whether some adjustments are required.  
15 Depending on the clinical context or the time when the BEARNI is administered, it will  
16 enable to adjust alcohol treatment to the neuropsychological profile or to assess the  
17 modification of neuropsychological performance with abstinence, reduction of alcohol  
18 consumption or relapse.

19 To conclude, the present study suggests that the BEARNI has high content validity, as it  
20 assesses the cognitive functions known to be impaired in chronic alcoholism, and reliable  
21 diagnostic accuracy in detecting ALs with cognitive and motor impairments. It provides a  
22 cognitive and motor profile that can guide the adjustment of alcohol treatment and further  
23 cognitive assessments. As such, the BEARNI seems to be a useful screening tool in clinical  
24 settings for detecting motor and cognitive impairments present at alcohol treatment entry. An



- 1 English/US version is ongoing to make available the BEARNI to native English speaker
- 2 patients.

For Review Only

1 **CONFLICT OF INTEREST**

2 Authors declare no conflict of interest.

For Review Only

1       **REFERENCES**

- 2       Alarcon R, Nalpas B, Pelletier S, Perney P (2015) MoCA as a Screening Tool of  
3       Neuropsychological Deficits in Alcohol-Dependent Patients. *Alcohol Clin Exp Res*.  
4       American Psychiatric Association AP (2004) DSM-IV-TR Manuel diagnostique et  
5       statistique des troubles mentaux: Texte révisié Elsevier Masson.  
6       Arria AM, Tarter RE, Kabene MA, Laird SB, Moss H, Thiel DV (2007) The role of  
7       cirrhosis in memory functioning of alcoholics. *Alcohol Clin Exp Res* 15:932–937.  
8       Bates ME, Pawlak AP, Tonigan JS, Buckman JF (2006) Cognitive impairment influences  
9       drinking outcome by altering therapeutic mechanisms of change. *Psychol Addict Behav*  
10      20:241–253.  
11      Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J (1961) An inventory for measuring  
12      depression. *Arch Gen Psychiatry* 4:561–571.  
13      Belleville S, Rouleau N, Caza N (1998) Effect of normal aging on the manipulation of  
14      information in working memory. *Mem Cognit* 26:572–583.  
15      Blazer DG, Hays JC (1998) *An Introduction to Clinical Research in Psychiatry*. 1 edition.  
16      ed New York: Oxford University Press.  
17      Blume AW, Schmalting KB, Marlatt GA (2005) Memory, executive cognitive function, and  
18      readiness to change drinking behavior. *Addict Behav* 30:301–314.  
19      Cardebat D, Doyon B, Puel M, Goulet P, Joannette Y (1990) [Formal and semantic lexical  
20      evocation in normal subjects. Performance and dynamics of production as a function of sex,  
21      age and educational level]. *Acta Neurol Belg* 90:207–217.  
22      Copersino ML, Fals-Stewart W, Fitzmaurice G, Schretlen DJ, Sokoloff J, Weiss RD  
23      (2009) Rapid cognitive screening of patients with substance use disorders. *Exp Clin*  
24      *Psychopharmacol* 17:337.  
25      Corkin S (1979) Hidden-figures-test performance: lasting effects of unilateral penetrating  
26      head injury and transient effects of bilateral cingulotomy. *Neuropsychologia* 17:585–605.  
27      Delis DC, Freeland J, Kramer JH, Kaplan E (1988) Integrating clinical assessment with  
28      cognitive neuroscience: construct validation of the California Verbal Learning Test. *J Consult*  
29      *Clin Psychol* 56:123–130.  
30      Duka T, Townshend JM, Collier K, Stephens DN (2003) Impairment in Cognitive  
31      Functions After Multiple Detoxifications in Alcoholic Inpatients. *Alcohol Clin Exp Res*  
32      27:1563–1572.  
33      Fals-Stewart W (1996) Intermediate length neuropsychological screening of impairment  
34      among psychoactive substance-abusing patients: A comparison of two batteries. *J Subst*  
35      *Abuse* 8:1–17.  
36      Fals-Stewart W (1997) Detection of neuropsychological impairment among substance-  
37      abusing patients: Accuracy of the Neurobehavioral Cognitive Status Examination. *Exp Clin*  
38      *Psychopharmacol* 5:269.  
39      Fama R, Pfefferbaum A, Sullivan EV (2004) Perceptual Learning in Detoxified Alcoholic  
40      Men: Contributions From Explicit Memory, Executive Function, and Age. *Alcohol Clin Exp*  
41      *Res* 28:1657–1665.  
42      Folstein MF, Folstein SE, McHugh PR (1975) “Mini-mental state”. A practical method for  
43      grading the cognitive state of patients for the clinician. *J Psychiatr Res* 12:189–198.  
44      Foster PS, Williamson JB, Harrison DW (2005) The Ruff Figural Fluency Test: heightened  
45      right frontal lobe delta activity as a function of performance. *Arch Clin Neuropsychol Off J*  
46      *Natl Acad Neuropsychol* 20:427–434.  
47      Fregly AR (1971) Walk on floor eyes closed (WOFEC): a new addition to an ataxia test  
48      battery DTIC Document.  
49      Gache P, Michaud P, Landry U, Accietto C, Arfaoui S, Wenger O, Daepfen J-B (2005)

- 1 The Alcohol Use Disorders Identification Test (AUDIT) as a Screening Tool for Excessive  
2 Drinking in Primary Care: Reliability and Validity of a French Version. *Alcohol Clin Exp Res*  
3 29:2001–2007.
- 4 Godefroy O, Gibbons L, Diouf M, Nyenhuis D, Roussel M, Black S, Bugnicourt JM,  
5 GREFEX study group (2014) Validation of an integrated method for determining cognitive  
6 ability: Implications for routine assessments and clinical trials. *Cortex J Devoted Study Nerv*  
7 *Syst Behav* 54:51–62.
- 8 Goldstein RZ, Leskovjan AC, Hoff AL, Hitzemann R, Bashan F, Khalsa SS, Wang GJ,  
9 Fowler JS, Volkow ND (2004) Severity of neuropsychological impairment in cocaine and  
10 alcohol addiction: association with metabolism in the prefrontal cortex. *Neuropsychologia*  
11 42:1447–1458.
- 12 Green A, Garrick T, Sheedy D, Blake H, Shores EA, Harper C (2010) The Effect of  
13 Moderate to Heavy Alcohol Consumption on Neuropsychological Performance as Measured  
14 by the Repeatable Battery for the Assessment of Neuropsychological Status. *Alcohol Clin*  
15 *Exp Res* 34:443–450.
- 16 Grohman K, Fals-Stewart W (2004) The detection of cognitive impairment among  
17 substance-abusing patients: the accuracy of the neuropsychological assessment battery-  
18 screening module. *Exp Clin Psychopharmacol* 12:200–207.
- 19 Heaton RK, Thompson LL, Nelson LM, Filley CM, Franklin GM (1990) Brief and  
20 intermediate length screening of neuropsychological impairment in multiple sclerosis. In:  
21 *Neurobehavioral Aspects of Multiple Sclerosis* New York: Oxford University Press. p. 149–  
22 160.
- 23 Ihara H, Berrios GE, London M (2000) Group and case study of the dysexecutive  
24 syndrome in alcoholism without amnesia. *J Neurol Neurosurg Psychiatry* 68:731–737.
- 25 Kaiser HF (1960) The application of electronic computers to factor analysis. *Educ Psychol*  
26 *Meas* 20:245–276.
- 27 Kalafat M, Hugonot-Diener L, Poitrenaud J (2003) Standardisation et étalonnage français  
28 du Mini Mental State (MMS) version GRÉCO. *Rev Neuropsychol* 13:209–236.
- 29 Kiernan RJ, Mueller J, Langston JW, Van Dyke C (1987) The Neurobehavioral Cognitive  
30 Status Examination: a brief but quantitative approach to cognitive assessment. *Ann Intern*  
31 *Med* 107:481–485.
- 32 Kopelman MD, Thomson AD, Guerrini I, Marshall EJ (2009) The Korsakoff syndrome:  
33 clinical aspects, psychology and treatment. *Alcohol Alcohol* 44:148.
- 34 Le Berre A-P, Pinon K, Vabret F, Pitel A-L, Allain P, Eustache F, Beaudieux H (2010)  
35 Study of Metamemory in Patients With Chronic Alcoholism Using a Feeling-of-Knowing  
36 Episodic Memory Task. *Alcohol Clin Exp Res* 34:1888–1898.
- 37 Lucas JA, Ivnik RJ, Smith GE, Bohac DL, Tangalos EG, Kokmen E, Graff-Radford NR,  
38 Petersen RC (1998) Normative data for the Mattis Dementia Rating Scale. *J Clin Exp*  
39 *Neuropsychol* 20:536–547.
- 40 Lusher J, Chandler C, Ball D (2004) Alcohol dependence and the alcohol Stroop paradigm:  
41 evidence and issues. *Drug Alcohol Depend* 75:225–231.
- 42 Mann K, Günther A, Stetter F, Ackermann K (1999) Rapid recovery from cognitive  
43 deficits in abstinent alcoholics: a controlled test-retest study. *Alcohol Alcohol Oxf Oxfs*  
44 34:567–574.
- 45 Mattis S, Inc PAR (1988) DRS, Dementia Rating Scale Psychological Assessment  
46 Resources, Incorporated.
- 47 Müller-Oehring EM, Schulte T, Fama R, Pfefferbaum A, Sullivan EV (2009) Global-local  
48 interference is related to callosal compromise in alcoholism: a behavior-DTI association  
49 study. *Alcohol Clin Exp Res* 33:477–489.
- 50 Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I,

- 1 Cummings JL, Chertkow H (2005) The Montreal Cognitive Assessment, MoCA: a brief  
2 screening tool for mild cognitive impairment. *J Am Geriatr Soc* 53:695–699.
- 3 Noël X, Bechara A, Dan B, Hanak C, Verbanck P (2007) Response inhibition deficit is  
4 involved in poor decision making under risk in nonamnesic individuals with alcoholism.  
5 *Neuropsychology* 21:778.
- 6 Noël X, Van der Linden M, Brevers D, Campanella S, Hanak C, Kornreich C, Verbanck P  
7 (2012) The contribution of executive functions deficits to impaired episodic memory in  
8 individuals with alcoholism. *Psychiatry Res*.
- 9 Osterrieth PA (1944) Le test de copie d'une figure complexe; contribution à l'étude de la  
10 perception et de la mémoire. [Test of copying a complex figure; contribution to the study of  
11 perception and memory.]. *Arch Psychol* 30:206–356.
- 12 Pitel AL, Witkowski T, Vabret F, Guillery-Girard B, Desgranges B, Eustache F,  
13 Beaunieux H (2007) Effect of Episodic and Working Memory Impairments on Semantic and  
14 Cognitive Procedural Learning at Alcohol Treatment Entry. *Alcohol Clin Exp Res* 31:238–  
15 248.
- 16 Pitel A-L, Zahr NM, Jackson K, Sassoon SA, Rosenbloom MJ, Pfefferbaum A, Sullivan  
17 EV (2011) Signs of preclinical Wernicke's encephalopathy and thiamine levels as predictors  
18 of neuropsychological deficits in alcoholism without Korsakoff's syndrome.  
19 *Neuropsychopharmacol Off Publ Am Coll Neuropsychopharmacol* 36:580–588.
- 20 Randolph C, Tierney MC, Mohr E, Chase TN (1998) The Repeatable Battery for the  
21 Assessment of Neuropsychological Status (RBANS): preliminary clinical validity. *J Clin Exp*  
22 *Neuropsychol* 20:310–319.
- 23 Reitan RM (1955) The relation of the trail making test to organic brain damage. *J Consult*  
24 *Psychol* 19:393–394.
- 25 Rosenbloom MJ, Rohlifing T, O'Reilly AW, Sassoon SA, Pfefferbaum A, Sullivan EV  
26 (2007) Improvement in memory and static balance with abstinence in alcoholic men and  
27 women: selective relations with change in brain structure. *Psychiatry Res* 155:91–102.
- 28 Shulman KI (2000) Clock-drawing: is it the ideal cognitive screening test? *Int J Geriatr*  
29 *Psychiatry* 15:548–561.
- 30 Stroop JR (1935) Studies of interference in serial verbal reactions. *J Exp Psychol* 18:643–  
31 662.
- 32 Sullivan EV, Rosenbloom MJ, Pfefferbaum A (2000) Pattern of motor and cognitive  
33 deficits in detoxified alcoholic men. *Alcohol Clin Exp Res* 24:611–621.
- 34 Thomson AD (2000) Mechanisms of vitamin deficiency in chronic alcohol misusers and  
35 the development of the Wernicke-Korsakoff syndrome. *Alcohol Alcohol Oxf Oxf Suppl*  
36 35:2–7.
- 37 Thurstone L (1944) A factorial study of perception Chicago, IL, US: University of  
38 Chicago Press.
- 39 Uekermann J, Channon S, Winkel K, Schlebusch P, Daum I (2007) Theory of mind,  
40 humour processing and executive functioning in alcoholism. *Addiction* 102:232–240.
- 41 Wechsler D (2001a) MEM-III, Échelle clinique de mémoire de Wechsler: manuel les Éd.  
42 du Centre de psychologie appliquée.
- 43 Wechsler D (2001b) WAIS-III: Wechsler Adult Intelligence Scale, Third Edition :  
44 Canadian Technical Manual Harcourt Canada.
- 45 Wester AJ, Roy J, Kessels RPC, Egger JIM (2013) The Montreal Cognitive Assessment  
46 (MoCA) as a measure of severity of amnesia in patients with alcohol-related cognitive  
47 impairments and Korsakoff syndrome. *Clin Neuropsychiatry* 10:134.
- 48 White T, Stern R (2003) NAB Neuropsychological Assessment battery Psychological  
49 Assessment Resources, Incorporated.
- 50

1 **TABLES**

2

Table 1: Participants' Demographic Characteristics

	Alcoholic patients	Control participants		p-values
Number	73	254	58 <sup>1</sup>	
Men/women	53/20	154/100	27/31	0.06; 0.002*
Age (years)	45.47 ± 8.85	43.22 ± 9.32	42.81 ± 10.86	0.07; 0.13
Range	26-67	20-66	31-60	
Education (years of schooling)	11.18 ± 1.69	12.83 ± 2.61	12.76 ± 2.47	<0.001*; <0.001
Range	8-15	6-21	5-18	
MMSE	27.90 ± 1.90	-	28.79 ± 1.13	0.002*
Range	21-30		26-30	
DRS Mattis	136.96 ± 6.07	-	141.76 ± 2.31	<0.001*
Range	115-144		134-144	
AUDIT	29.90 ± 6.33	3.07 ± 1.68	2.84 ± 1.68	<0.001*; <0.001
Range	9-40	0-6	0-6	
Days of sobriety before inclusion	13.17 ± 6.73	-	-	
Range	4-50			
Alcohol use (years)	30.25 ± 9.07	-	-	
Range	10-51			
Alcohol misuse (years)	17.49 ± 9.23	-	-	
Range	5-43			
Daily alcohol consumption (units)	23.48 ± 35.36	-	-	
Range	0-300			
Number of withdrawals	3.52 ± 6.05	-	-	
Range	0-52			

3 Data are shown as means ± standard deviation. Only 58 of the control participants underwent the extensive  
 4 neuropsychological battery. AUDIT = Alcohol Use Disorders Identification Test.

5 \* Significant difference between alcoholic patients and control participants (n=254 ; n=58) at p<0.05 (t-tests)

6

1 Table 2: Cognitive and Motor Domains Assessed by the Brief Evaluation of Alcohol-Related  
 2 Neuropsychological Impairments (BEARNI) and the Extensive Neuropsychological Battery

Domains	BEARNI subtests	Neuropsychological battery tests
<i>Verbal episodic memory</i>	Learning	CVLT Learning (sum of correct responses across 5 trials)
	Delayed free recall	CVLT Delayed free recall (number of correct responses)
		CVLT Delayed free recall (number of errors)
<i>Working memory</i>	Alphabetical span	Verbal Span (forward span)
		Verbal Span (backward span)
		Letter-Number Sequencing (standard score)
		Visuospatial Span (forward span)
		Visuospatial Span (backward span)
<i>Executive function</i>	Alternating fluency	TMT Part B - Part A (time)
		Fluency task (letter <i>p</i> ; number of correct responses)
		Fluency task (animal category; number of correct responses)
		Stroop Interference-Naming (time)
		RFFT (total design)
		RFFT (total strategies)
<i>Visuospatial abilities</i>	Visuospatial	ROCF (copy accuracy /36)
	(hidden figures)	
<i>Ataxia</i>	Ataxia (balance)	Stand in Romberg position (one foot in front of the other placed heel to toe) (two 60-s trials; eyes open)
		Stand in Romberg position (one foot in front of the other placed heel to toe) (two 60-s trials; eyes closed)
		Walk heel-to-toe (two 10-step trials, eyes open)
		Walk heel-to-toe (two 10-step trials, eyes closed)

3 CVLT = California Verbal Learning Test; TMT B-A = Trail Making Test Part A minus Part B; RFFT = Ruff  
 4 Figural Fluency Test; ROCF = Rey Osterrieth Complex Figure.

5

1

Table 3 Results of the Exploratory Factor Analysis (EFA)

Variables	Factors				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
<b>Eigenvalues</b>	6.70	2.24	1.65	1.31	1.10
<b>Explained variance</b>	30.45%	10.18%	7.48%	5.97%	5.00%
BEARNI Delayed free recall			0.49*		
BEARNI Alphabetical span					0.69
BEARNI Fluency				0.57	
BEARNI Visuospatial	0.67				
BEARNI Ataxia		0.63			
Feet placed heel-to-toe (eyes open)		0.74			
Feet placed heel-to-toe (eyes closed)		0.77			
Walk heel-to-toe (eyes open)		0.78			
Walk heel-to-toe (eyes closed)		0.68			
CVLT Learning			0.85		
CVLT Delayed free recall (correct responses)			0.80		
CVLT Delayed free recall (errors)			-0.75		
Letter ( <i>p</i> ) fluency				0.67	
Categorical (animals) fluency				0.78	
Verbal forward span					0.69
Verbal backward span					0.73
Letter-Number Sequencing					0.77
ROCF (copy accuracy)	0.30*				
Visuospatial forward span	0.69				
Visuospatial backward span	0.72				
Stroop Interference-Naming (time)	-0.61				
TMT B-A (time)	-0.47*				
RFFT (total strategies)	0.59				
RFFT( total design)	0.62				

2 Marked factor loadings with significance threshold set at 0.5. \* Variable not significant at established threshold of 0.5, but  
3 assigned to the factor on which it most highly loaded. CVLT = California Verbal Learning Test; ROCF = Rey Osterrieth  
4 Complex Figure; TMT B-A = Trail Making Test Part A minus Part B; RFFT = Ruff Figural Fluency Test.

5



1 Table 4: Summary of Total BEARNI Cut-Off Scores Adjusted for Education Level

BEARNI total score	Criteria	Education (years of schooling)	
		≤ 12	> 12
Total score /30 (cognitive functions plus ataxia)	Mild impairment	≤ 19	≤ 21
	Moderate-to-severe impairment	≤ 16	≤ 17
Total cognitive score /22 (excluding the Ataxia subtest)	Mild impairment	≤ 15	≤ 16
	Moderate-to-severe impairment	≤ 11.5	≤ 12.5

2

3

For Review Only

1 Table 5: Psychometric properties of the BEARNI, MMSE (Folstein et al., 1975; Kalafat et al.,  
2 2003) and Mattis DRS (Lucas et al., 1998; Mattis and Inc, 1988)

Psychometric properties	BEARNI (total score)	BEARNI (total "cognitive" score)	MMSE	Mattis DRS
<b><i>Mild impairment</i></b>				
Sensitivity	98.41 %	93.44 %	9.52 %	7.94 %
Specificity	50.00 %	50.00 %	90.00 %	90.00 %
Positive predictive value	92.54 %	90.48 %	85.71 %	83.93 %
Negative predictive value	83.33 %	60.00 %	13.64 %	13.43 %
Yule's Q coefficient	0.97	0.87	0.03	0.13
Diagnostic accuracy	91.78 %	86.30 %	20.54 %	19.17 %
<b><i>Moderate-to-severe impairments</i></b>				
Sensitivity	94.87 %	81.82 %	7.69 %	7.69 %
Specificity	70.59 %	85.00 %	88.24 %	91.18 %
Positive predictive value	78.72 %	81.82 %	42.86 %	50.00 %
Negative predictive value	92.31 %	85.00 %	45.45 %	46.27 %
Yule's Q coefficient	0.96	0.92	0.23	0.07
Diagnostic accuracy	83.56 %	83.56 %	24.09	46.57 %

3

4

1 Table 6: Predictive Value of the Cut-Off Scores of Each BEARNI Subtest for Detecting the  
 2 Neuropsychological Impairments Identified by the Extensive Battery

NP battery tasks	Alcoholic patients		Controls	Statistics	Tukey post hoc
	AL <sup>-</sup>	AL <sup>+</sup>	(n = 58) HC		
<i>Episodic memory (BEARNI cut-off score ≤ 2)</i>					
CVLT Learning	-1.41 ± 1.23	-0.24 ± 1.14	0.00 ± 1.00	$F_{(2,128)} = 9.02$ ; $p < 0.001^*$	AL <sup>-</sup> < AL <sup>+</sup> = NC
CVLT Delayed recall (correct response)	-1.64 ± 1.20	-0.55 ± 1.56	0.00 ± 0.98	$F_{(2,128)} = 9.12$ ; $p < 0.001^*$	AL <sup>-</sup> < AL <sup>+</sup> = NC
CVLT Delayed recall (error)	-1.36 ± 2.02	-0.24 ± 1.53	0.00 ± 0.99	$F_{(2,128)} = 5.15$ ; $p = 0.007^*$	AL <sup>-</sup> < AL <sup>+</sup> = NC
<i>Verbal working memory (BEARNI cut-off score ≤ 2.5)</i>					
Verbal forward span	-1.01 ± 0.94	-0.23 ± 0.88	0.00 ± 1.00	$F_{(2,128)} = 9.25$ ; $p < 0.001^*$	AL <sup>-</sup> < AL <sup>+</sup> = NC
Verbal backward span	-1.41 ± 0.64	-0.50 ± 0.90	0.00 ± 1.00	$F_{(2,128)} = 19.68$ ; $p < 0.001^*$	AL <sup>-</sup> < AL <sup>+</sup> < NC
Letter-Number Sequencing	-1.69 ± 0.78	-0.21 ± 0.80	0.00 ± 1.00	$F_{(2,128)} = 29.73$ ; $p < 0.001^*$	AL <sup>-</sup> < AL <sup>+</sup> = NC
<i>Flexibility (BEARNI cut-off score ≤ 2)</i>					
Letter (p) fluency	-0.66 ± 0.93	0.00 ± 0.93	0.00 ± 1.00	$F_{(2,128)} = 3.30$ ; $p = 0.04$	AL <sup>-</sup> < AL <sup>+</sup> = NC
Categorical (animals) fluency	-0.96 ± 1.20	-0.32 ± 1.20	0.00 ± 1.00	$F_{(2,128)} = 5.20$ ; $p = 0.007^*$	AL <sup>-</sup> < AL <sup>+</sup> = NC
<i>Visuospatial abilities (BEARNI cut-off score ≤ 1)</i>					
ROCF (copy accuracy)	-0.61 ± 1.11	-0.22 ± .092	0.00 ± 1.00	$F_{(2,128)} = 3.86$ ; $p = 0.02$	AL <sup>-</sup> < NC AL <sup>+</sup> = NC
Visuospatial forward	-0.83 ± 0.67	-0.38 ± 0.93	0.00 ± 1.00	$F_{(2,128)} = 9.12$ ;	AL <sup>-</sup> < AL <sup>+</sup>

span				$p < 0.001^*$	$AL^+ = NC$
Visuospatial	$-0.74 \pm 0.80$	$-0.18 \pm 0.79$	$0.00 \pm 1.00$	$F_{(2,128)} = 7.34;$	$AL^- < AL^+ = NC$
backward span				$p < 0.001^*$	
Stroop Interference-	$-1.97 \pm 3.10$	$-0.50 \pm 1.94$	$0.00 \pm 1.00$	$F_{(2,128)} = 10.42;$	$AL^- < AL^+ = NC$
Naming (time)				$p < 0.001^*$	
TMT Part A-Part B	$-2.77 \pm 6.57$	$-0.45 \pm 1.40$	$0.00 \pm 1.00$	$F_{(2,128)} = 7.20;$	$AL^- < AL^+ = NC$
(time)				$p = 0.001^*$	
RFFT	$-0.73 \pm 0.74$	$-0.44 \pm 0.89$	$0.00 \pm 1.00$	$F_{(2,128)} = 2.59;$	<i>ns</i>
(total strategies)				$p = 0.07$	
RFFT( total design)	$-1.10 \pm 1.02$	$-0.18 \pm 1.21$	$0.00 \pm 1.00$	$F_{(2,128)} = 11.64;$	$AL^- < AL^+ = NC$
				$p < 0.001^*$	
<b>Ataxia (BEARNI cut-off score <math>\leq 3</math>)</b>					
Heel-to-toe	$-1.68 \pm 2.15$	$-0.06 \pm 0.89$	$0.00 \pm 1.00$	$F_{(2,128)} = 18.68;$	$AL^- < AL^+ = NC$
(eyes open)				$p < 0.001^*$	
Heel-to-toe	$-0.92 \pm 0.94$	$-0.37 \pm 0.92$	$0.00 \pm 1.00$	$F_{(2,128)} = 10.19;$	$AL^- < AL^+ < NC$
(eyes closed)				$p < 0.001^*$	
Walk heel-to-toe	$-1.56 \pm 2.05$	$-0.21 \pm 1.21$	$0.00 \pm 1.00$	$F_{(2,128)} = 14.57;$	$AL^- < AL^+ = NC$
(eyes open)				$p < 0.001^*$	
Walk heel-to-toe	$-0.92 \pm 0.82$	$0.01 \pm 1.12$	$0.00 \pm 1.00$	$F_{(2,128)} = 11.61;$	$AL^- < AL^+ = NC$
(eyes closed)				$p < 0.001^*$	

- 1 Data are shown as standard residuals (i.e., *z* scores) mean  $\pm$  standard deviation.
- 2 NP = neuropsychological; CVLT = California Verbal Learning Test; ROCF = Rey Osterrieth Complex Figure;
- 3 TMT B-A = Trail Making Test Part A minus Part B; RFFT = Ruff Figural Fluency Test;
- 4  $AL^+$  = preserved alcoholic patients;  $AL^-$  = impaired alcoholic patients; HC = healthy controls.
- 5 \* still significant after Bonferroni correction.
- 6 *ns* = not significant ( $p > 0.05$ ).
- 7

1        **FIGURE LEGENDS**

2        Figure 1: Results of the comparison between ALs (in red) and HCs (in black) on each  
3        BEARNI subtest. Data are shown as mean  $\pm$  standard error of mean, taking the significant  
4        effects of age and education into account.  
5        (*ns*: nonsignificant).

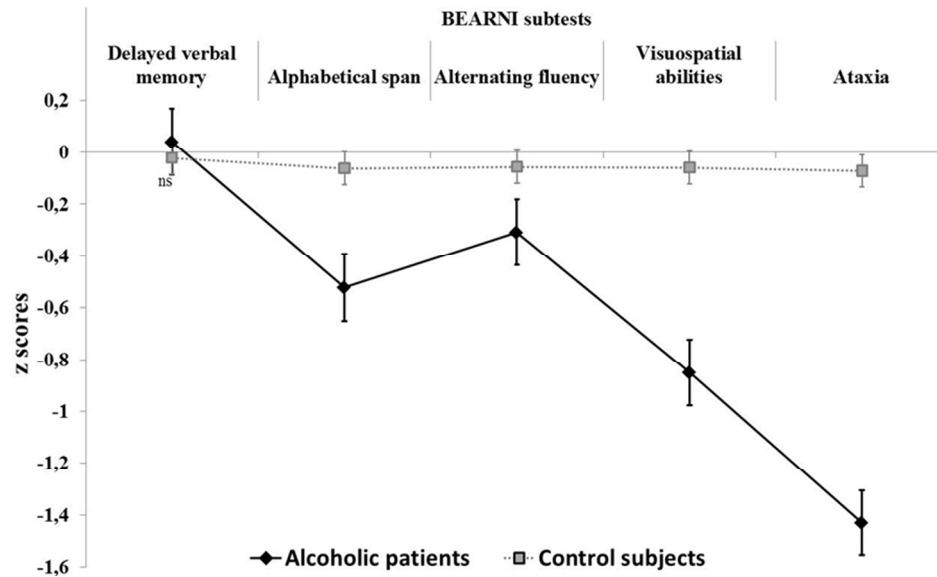
6

7        Figure 2: ROC curve analyses for determining the total BEARNI (A and B) and total  
8        cognitive BEARNI (C and D) cut-off scores reflecting mild impairment (A and C) and  
9        moderate-to-severe impairment (B and D).

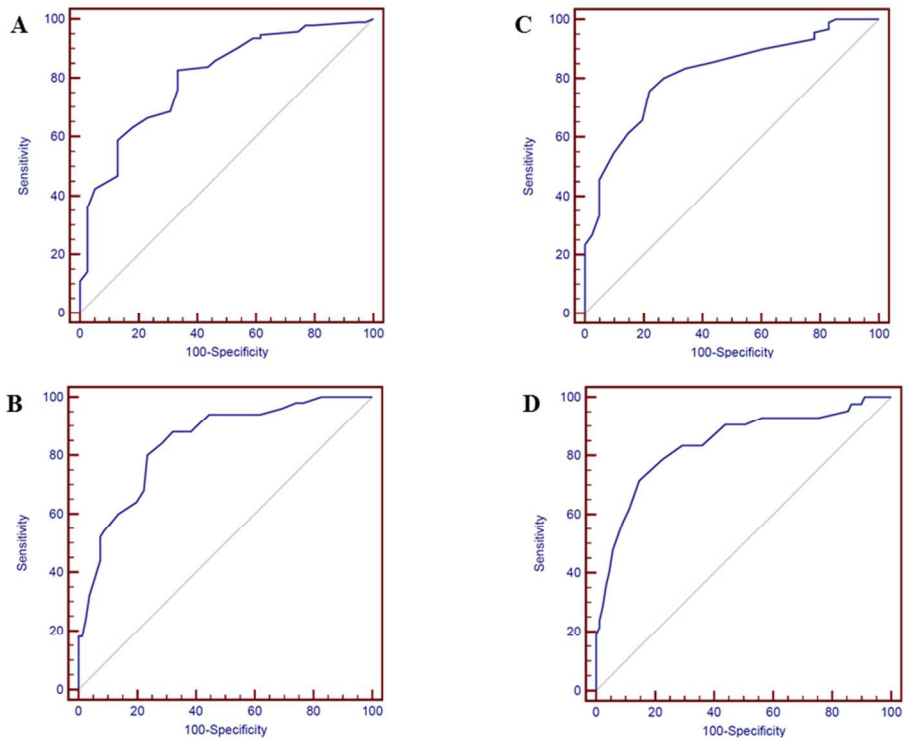
10

11        Figure 3: Clinical recommendations according to the cognitive status of alcoholic patients at  
12        treatment entry as diagnosed by the BEARNI.

13

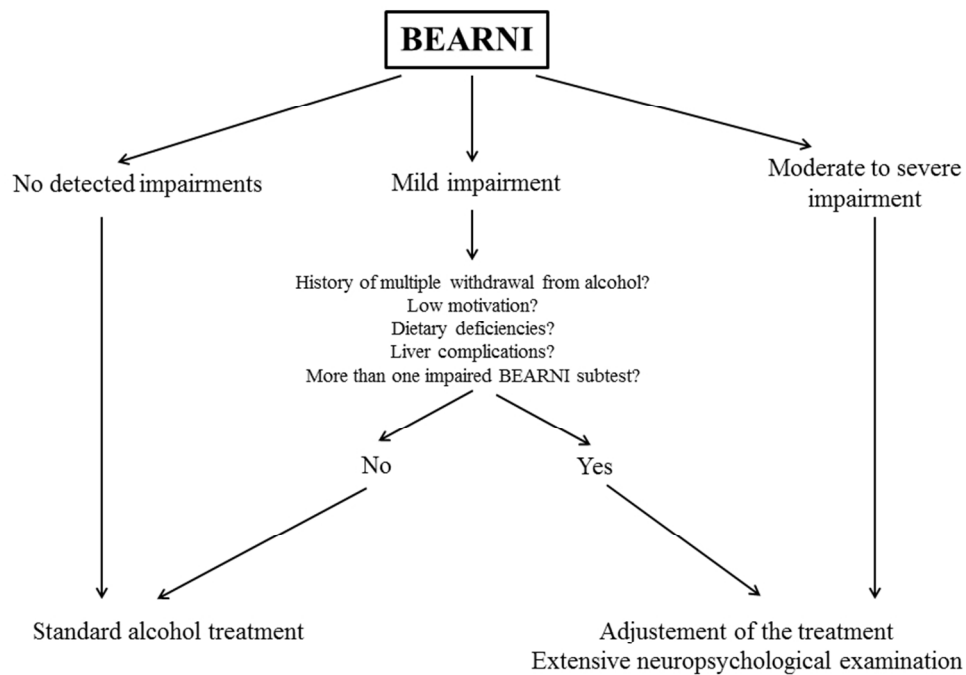


Results of the comparison between alcoholic patients (in black) and controls (in grey) on each BEARNI subtest. Data are shown as mean  $\pm$  standard error of mean, taking the significant effects of age and education into account. Alcoholic patients were impaired on all the BEARNI subtests except for episodic delayed free recall (ns: nonsignificant).  
254x190mm (96 x 96 DPI)



ROC curve analyses for determining the total BEARNI (A and B) and total cognitive BEARNI (C and D) cut-off scores reflecting mild impairment (A and C) and moderate-to-severe impairment (B and D).  
254x190mm (96 x 96 DPI)

Only



Clinical recommendations according to the cognitive status of alcoholic patients at treatment entry as diagnosed by the BEARNI.  
254x190mm (96 x 96 DPI)

Only



**BEARNI****Brief Evaluation of Alcohol Related Neuropsychological Impairment**

**NOM :** \_\_\_\_\_ **Prénom :** \_\_\_\_\_  
**Date de naissance (âge) :** \_\_\_\_\_ **Années de scolarité :** \_\_\_\_\_  
**Date de l'examen :** \_\_\_\_\_

**I. Mémoire verbale**

	Liste de mots	Rappel libre 1	Rappel libre 2
1.	Plage		
2.	Tenaille		
3.	Blouson		
4.	Fleuve		
5.	Pioche		
6.	Jupe		
7.	Râteau		
8.	Montagne		
9.	Chapeau		
10.	Bêche		
11.	Jungle		
12.	Ceinture		
<b>Pas de points</b>			

**II. Ataxie en équilibre**

<i>Yeux ouverts</i>	
Jambe droite au sol	Jambe gauche au sol
Essai 1	Essai 1
Essai 2	Essai 2
<i>Yeux fermés</i>	
Jambe droite au sol	Jambe gauche au sol
Essai 1	Essai 1
Essai 2	Essai 2
<b>Score total (score max 8) :</b>	

**III. Fluences alternées**

Maximum de mots en alternant catégories des « couleurs » et « noms de ville » en 2 minutes

**Score total (score max 6):**

**IV. Ordination alphabétique**

Items/essai	(Bonnes réponses)	Note
1/ Essai 1 : V-K (K-V) Essai 2 : U-T (T-U)		
2/ Essai 1 : R-H-L (H-L-R) Essai 2 : I-F-B (B-F-I)		
3/ Essai 1 : A-X-T-H (A-H-T-X) Essai 2 : L-G-R-U (G-L-R-U)		
4/ Essai 1 : P-N-I-G-V (G-I-N-P-V) Essai 2 : Q-O-J-D-E (D-E-J-O-Q)		
5/ Essai 1 : C-T-H-E-V-S (C-E-H-S-T-V) Essai 2 : L-T-A-D-R-I (A-D-I-L-R-T)		
<b>Score total (score max 5):</b>		

**V. Capacités visuo-spatiales**

**Score total (score max 5):**

**VI. Mémoire verbale différée**

	Liste de mots	Rappel différé
1.	Plage	
2.	Tenaille	
3.	Blouson	
4.	Fleuve	
5.	Pioche	
6.	Jupe	
7.	Râteau	
8.	Montagne	
9.	Chapeau	
10.	Bêche	
11.	Jungle	
12.	Ceinture	
<b>Score total (score max 6):</b>		

Figure d'exemple

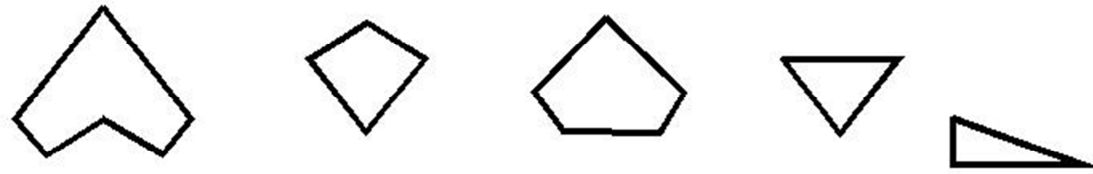
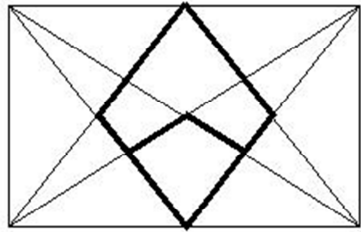


Figure 1

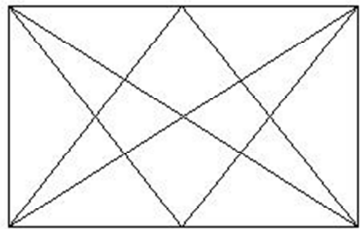


Figure 2

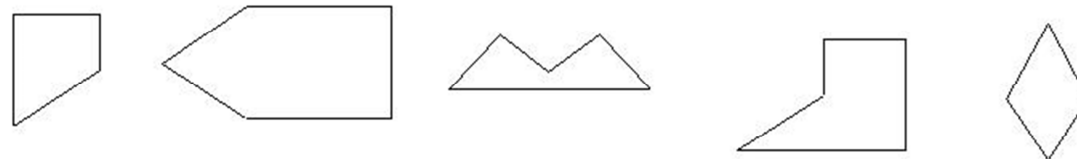
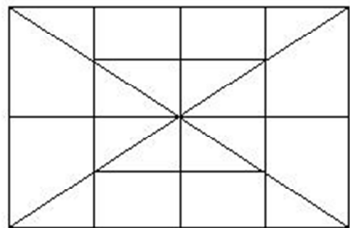


Figure 3

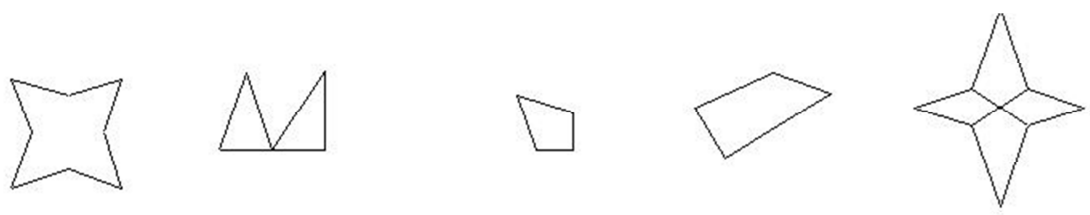
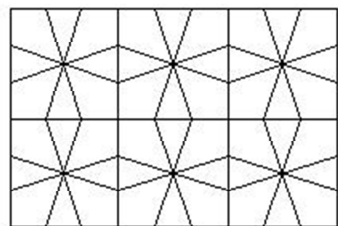


Figure 4

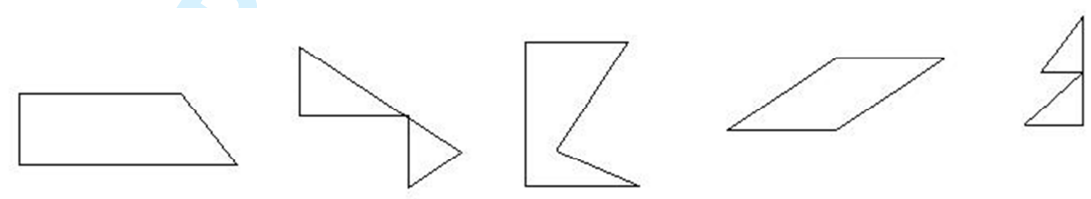
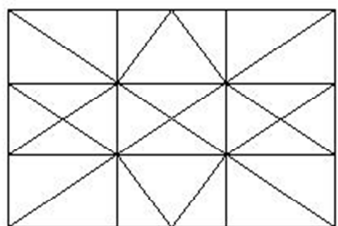
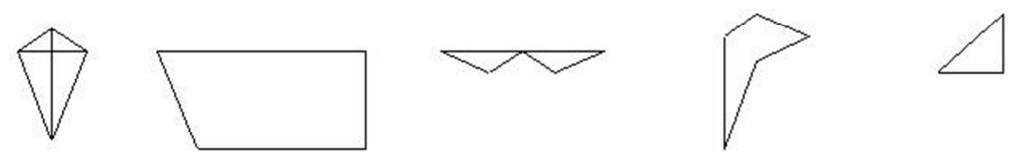
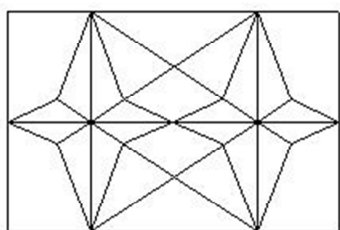


Figure 5



**BEARNI****Brief Evaluation of Alcohol Related Neuropsychological Impairment****Instructions pour l'administration et la cotation****I- Mémoire verbale****Consigne**

1<sup>er</sup> rappel : Je vais vous lire une liste de mots que vous aurez à retenir. Ecoutez attentivement et quand j'aurais terminé, je veux que vous me redonniez le plus de mots possible dont vous vous rappelez, et dans l'ordre que vous voulez.

2<sup>ème</sup> rappel : Maintenant je vais vous relire la même liste de mots. Essayez de vous rappeler du plus grand nombre de mots possible y compris ceux que vous avez déjà énoncés.

*(Temps maximum pour chaque rappel : 1 minute. Relire la liste complète avant chaque rappel. Au dernier rappel, ne pas préciser au patient que la liste lui sera à nouveau demandée à la fin du test)*

**Cotation**

*Score total : pas de points*

**II- ATAXIE En équilibre****Consigne**

Maintenant nous allons tester votre équilibre sur une jambe. Dans un premier temps, aidez-vous du mur si besoin. Ensuite, croisez les bras et levez la jambe comme ceci (à hauteur du genou), sans vous appuyer sur votre genou. Si à un moment vous sentez que vous risquez de tomber, posez votre pied par terre et appuyez-vous contre le mur.

*Durée maximum : 30 secondes par essai. Indiquer le temps pendant lequel le sujet réussit à maintenir la position.*

*Préciser si le sujet réussit dès le premier essai ou au second.*

**Cotation**

2 points par condition si le sujet réussit dès le premier essai à tenir en équilibre pendant 30 secondes.

1 point par condition si le sujet ne réussit qu'au second essai à tenir en équilibre pendant 30 secondes.

0 point en cas d'échec aux deux essais.

*Score total : maximum 8 points*

**III- Fluences alternées****Consigne**

Je vous demande de me donner le plus de noms que vous connaissez dans les catégories des couleurs et des noms de ville, pendant 2 minutes sans vous répéter. Vous devrez alterner les deux catégories, vous me donnerez d'abord une couleur, puis un nom de ville, une couleur, un nom de ville, etc... Je ne vous demande pas de faire un lien entre les villes et les couleurs.

*(Noter toutes les réponses du sujet, y compris celles qui ont déjà été données et les erreurs). Arrêt de l'épreuve au bout de deux minutes.*

### **Cotation**

0 point si entre 0 et 4 mots (alternance et catégorie respectées)

1 point si entre 5 et 9

2 points si entre 10 et 14

3 points si entre 15 et 19

4 points si entre 20 et 24

5 points si entre 25 et 29

6 points si  $\geq 30$

**Score total : maximum 6 points**

Les erreurs de catégorie correspondent à tous les mots fournis n'étant ni des couleurs, ni des noms de villes.

Les erreurs d'alternance correspondent à la production de deux mots dans la même catégorie (lorsque le sujet fournit deux noms de villes ou deux couleurs à la suite).

**Exemple de cotation** : si le patient fournit les mots « Paris ; vert ; Angers ; Caen ; bleu ; Rouen ; orange », 7 mots sont fournis mais il y a une erreur d'alternance (deux noms de ville à la suite : Angers ; Caen). Ainsi, 6 mots corrects sont fournis car Caen ; bleu sont considérés comme des mots correctement fournis car catégorie et alternance respectée.

## **IV- Ordination alphabétique**

### **Consigne**

Je vais vous lire des séries de lettres et je vous demanderai de me les rappeler dans l'ordre alphabétique. Par exemple si je vous donne « C-B », vous devrez me dire « B-C » car la lettre B se situe avant la lettre C dans l'alphabet.

*(Les séries de lettres ne doivent être lues qu'une seule fois. Arrêter l'épreuve si le patient échoue aux deux essais d'un même item. Les deux essais d'une même longueur doivent être administrés, même si le premier essai est correctement réussi.)*

### **Cotation**

0,5 point par essai correctement rappelé

**Score total : maximum 5 points**

## **V- Capacités visuo-spatiales**



### **Consigne**

A l'intérieur de chacune des figures complexes sont cachées deux figures simples. Je vous demande d'essayer de retrouver, parmi les 5 figures de droite, quelles sont les deux figures cachées. *(Préciser au sujet que les formes à découvrir sont de même taille et de même forme/orientation)*

(Montrer un exemple avec la figure d'exemple.) Vous voyez ici par exemple dans cette figure, on peut retrouver celle-ci (1<sup>ère</sup> figure) ici et celle-ci ici (2<sup>ème</sup> figure).

**Durée maximum : 1 minute par figure.**

Pour chacune des figures, l'épreuve s'arrête après 1 minute même si le patient n'a pas retrouvé les deux éléments de la figure complexe.

### Cotation

1 point si le sujet trouve les deux figures cachées.

0 point si le sujet ne trouve qu'une figure ou aucune sur les deux.

**Score total : maximum 5 points**

### Bonnes réponses :

Figure complexe 1 : figures 1 et 3

Figure complexe 2 : figures 1 et 4

Figure complexe 3 : figures 1 et 3

Figure complexe 4 : figures 2 et 4

Figure complexe 5 : figure 3 et 4

## VI- Mémoire verbale différée



### Consigne

Au début du test, vous avez appris une liste de mots. Je vous demande à présent de me redonner le plus possible de mots dont vous vous souvenez, dans l'ordre que vous voulez.

Ne pas relire la liste de mots au participant.

(rappel : 1 minute)

### Cotation

Nombre de réponse correcte	0,5 point par réponse correcte
Nombre d'erreur (intrusion)	Retirer 0,5 point par erreur
Total	Réponses correctes - erreurs

**Score total : maximum 6 points**

Les erreurs d'intrusions correspondent à tous les mots produits qui n'étaient pas dans la liste de mots. Par exemple : manteau, outils, robe ...

Les répétitions ne sont pas considérées comme des erreurs.

**SCORES TOTAUX**

Additionnez les points de chacun des subtests. Le score total est de 30 points.

Il est possible de calculer un score cognitif, ne comprenant pas la cotation du subtest d'ataxie, lorsque les patients ne peuvent pas réaliser la tâche. Ce score total est de 22 points.

Subtests	Note maximum	Cut-off score
Mémoire : <ul style="list-style-type: none"> <li>• Mémoire verbale</li> <li>• Mémoire verbale différée</li> </ul>	<b>Pas de points</b> 6	$\leq 2$
Ataxie en équilibre	<b>8</b>	$\leq 3$
Fluence alternée	<b>6</b>	$\leq 2$
Ordination alphabétique	<b>5</b>	$\leq 2,5$
Capacités visuospatiales	<b>5</b>	$\leq 1$
<b>SCORE TOTAL</b>	<b>30</b>	
<b>SCORE COGNITIF</b>	<b>22</b>	

**Cut-off scores des scores totaux**

Etant donné que les scores totaux du BEARNI sont influencés par le nombre d'années de scolarité, les cut-offs ont été adaptés.

Le baccalauréat correspond à 12 années d'études (ne pas compter les redoublements ni la maternelle).

		<b>SCORE TOTAL</b>	<b>SCORE COGNITIF</b>
<b><math>\leq</math> BAC</b>	Trouble léger	$\leq 19$	$\leq 15$
	Trouble modéré	$\leq 16$	$\leq 11,5$
<b><math>&gt;</math> BAC</b>	Trouble léger	$\leq 21$	$\leq 16$
	Trouble modéré	$\leq 17$	$\leq 12,5$

**Supplementary B: Standardization of the BEARNI total scores**

First of all, we examined the normality of the distribution of all scores of the neuropsychological battery in HCs, using kurtosis, skewness and Shapiro-Wilk tests. Scores deviating from normality were transformed using the Box-Cox transformation. The potential effects of age, education and sex were then tested with linear regression analysis (forward stepwise) and only significant factors were retained. Standardized residuals (i.e.,  $z$ -scores; poor performance corresponding to a negative  $z$ -score) were computed, and cut-off scores for each scores of the battery were then determined using the 5<sup>th</sup> percentile, in order to maintain a false-positive rate (i.e., percentage of HCs classified as impaired) equal to or below 5%. The 5<sup>th</sup> percentile was found to provide the most appropriate cut-off score (compared with the commonly used -1.50 or -1.65 standard deviation), as it was not influenced by variation from the normal distribution (Godefroy et al., 2014). The participants' performances were dichotomized (normal = 0; impaired = 1) and based on these cut-offs, we determined the cognitive profile of each participant (HCs and ALs) on the neuropsychological battery according to the following criteria:

- Mild impairment: one affected domain (i.e., one impaired score for episodic memory, working memory or visuospatial abilities, or two impaired scores for ataxia or executive functions (Godefroy and GREFEX, 2008; Pitel et al., 2011; Sullivan et al., 2000a);
- Moderate-to-severe impairment: at least two affected domains.

As the BEARNI's total cognitive score does not include the ataxia subtest, we did not consider the profile for the Walk-a-Line Ataxia Battery (Fregly, 1971) in its standardization.

We ran ROC curve analyses on the BEARNI's two total scores to determine their cut-off scores (one for mild impairment, the other for moderate-to-severe impairment). These scores



were determined by the best balance between sensitivity and specificity, based on the ALs' and HCs' profiles on the battery.

For Review Only

**Supplementary B: Standardization of the BEARNI subtests**

Based on the dichotomized participants' performances (normal = 0; impaired = 1), cut-off scores for each subtest were determined using receiver operating characteristic (ROC) curve analysis (sensitivity, specificity and area under the curve, AUC). The cut-off score was determined with this method in order to provide only one cut-off score for each BEARNI subtest that considers the effects of demographic factors. This choice was made to simplify the scoring of the BEARNI and the determination of impaired performance as reported in (Godefroy et al., 2014). This method also enabled us to have more statistical power for the determination of the cut-off score on each BEARNI subtest based on the 254 healthy controls rather than the 58 ones.

Supplementary B Table 1: Cut-off scores for the Mini Mental State Examination (Folstein et al., 1995; Kalafat et al., 2003) taking into account of education (years of schooling)

	Education (years of schooling)			
	<9	9-10	11	≥12
MMSE cut-off score	22	23	25	26

For Review Only

## Supplementary B Table 2

*Results of the ROC curve analysis: the Sensitivity, Specificity, Area Under the Curve (AUC) and 95% Confidence Interval (CI) for Determining the Cut-Off Scores for the Total BEARNI Scores*

<b>Cut-off scores</b>	<b>Sensitivity</b>	<b>95% CI</b>	<b>Specificity</b>	<b>95% CI</b>	<b>AUC</b>	<b>95% CI</b>
<b><i>Total BEARNI score</i></b>						
Mild impairment	82.61	73.30-89.70	66.67	49.80-80.90	0.802	0.724-0.867
Moderate-to-severe impairment	80.00	66.30-90.00	76.54	65.80-85.20	0.842	0.769-0.900
<b><i>Total cognitive BEARNI score</i></b>						
Mild impairment	82.76	73.20-90.00	61.36	45.50-75.60	0.796	0.716-0.861
Moderate-to-severe impairment	71.43	55.40-84.30	85.39	76.30-92.90	0.839	0.765-0.898

## Supplementary B Table 3

*Results of the ROC curve analysis: the Sensitivity, Specificity, Area Under the Curve (AUC) and 95% Confidence Interval (CI) for Determining the Cut-Off Scores for Each BEARNI*

*Subtest*

<b>BEARNI subtests</b>	<b>Sensitivity</b>	<b>95% CI</b>	<b>Specificity</b>	<b>95% CI</b>	<b>AUC</b>	<b>95% CI</b>
Delayed verbal memory	100	73.50-100	90.08	85.60-93.50	0.990	0.968-0.998
Alphabetical span	100	73.50-100	75.21	69.30-80.50	0.950	0.915-0.973
Alternated fluency	100	73.50-100	99.59	97.70-100	0.998	0.983-1.000
Visuospatial	100	73.50-100	89.26	84.70-92.90	0.980	0.955-0.994
Ataxia	100	73.50-100	96.69	93.60-98.60	0.997	0.981-1.000

Supplementary B Table 4: Raw scores for Cognitive and Motor Domains Assessed by the Brief Evaluation of Alcohol-Related Neuropsychological Impairments (BEARNI) and the Extensive Neuropsychological Battery

Cognitive and motor domains	Alcoholic patients	Healthy controls	
	(N=73)	(N=58)	(N=254)
<i>Episodic memory</i>			
BEARNI Learning	6.62 ± 1.65	7.47 ± 1.75	7.43 ± 1.75
BEARNI Delayed free recall	3.49 ± 1.27	4.10 ± 1.04	3.62 ± 1.27
CVLT Learning	54.92 ± 9.62	6.57 ± 8.50	na
CVLT Delayed free recall (number of correct responses)	11.81 ± 3.19	13.67 ± 2.02	na
CVLT Delayed free recall (number of errors)	1.14 ± 1.50	0.67 ± 0.92	na
<i>Working memory</i>			
BEARNI alphabetical span	2.60 ± 1.13	3.45 ± 0.83	3.27 ± 0.87
Verbal span (forward span)	6.05 ± 1.29	6.69 ± 1.50	na
Verbal span (backward span)	4.33 ± 1.27	5.40 ± 1.41	na
Letter-Number Sequencing (standard score)	9.07 ± 3.01	10.96 ± 2.89	na
Visuospatial span (forward span)	5.78 ± 1.28	6.62 ± 1.45	na
Visuospatial span (backward span)	5.29 ± 1.33	6.00 ± 1.61	na
<i>Executive functions</i>			
BEARNI alternating fluency	4.24 ± 1.09	4.69 ± 1.10	4.67 ± 1.05
TMT part B- part A (time)	77.52 ± 108.90	37.33 ± 24.53	na
Fluency task (letter <i>p</i> ; number of correct responses)	22.11 ± 7.24	23.22 ± 7.52	na
Fluency task (animal category; number of correct responses)	29.90 ± 9.39	33.64 ± 8.14	na
Stroop Interference-Naming (time)	64.24 ± 41.28	44.83 ± 15.91	na
RFFT (total design)	80.40 ± 22.62	91.57 ± 18.69	na
RFFT (total strategies)	18.18 ± 19.21	31.36 ± 22.99	na
<i>Visuospatial abilities</i>			

BEARNI visuospatial	1.77 ± 1.36	3.00 ± 1.18	2.92 ± 1.34
ROCF (copy accuracy /36)	33.55 ± 2.73	34.61 ± 2.67	na
<i>Ataxia</i>			
BEARNI ataxia	2.63 ± 1.76	4.43 ± 2.10	5.65 ± 1.99
Stand in Romberg position (one foot in front of the other placed heel to toe) (two 60-s trials; eyes open) <sup>1</sup>	-0.86 ± 1.82	0.00 ± 1.00	na
Stand in Romberg position (one foot in front of the other placed heel to toe) (two 60-s trials; eyes closed) <sup>1</sup>	-0.64 ± 0.97	0.00 ± 1.00	na
Walk heel-to-toe (two 10-step trials, eyes open) <sup>1</sup>	-0.88 ± 1.80	0.00 ± 1.00	na
Walk heel-to-toe (two 10-step trials, eyes closed) <sup>1</sup>	-0.45 ± 1.08	0.00 ± 1.00	na

CVLT = California Verbal Learning Test; TMT B-A = Trail Making Test Part A minus Part B; RFFT = Ruff

Figural Fluency Test; ROCF = Rey Osterrieth Complex Figure.

Na: not applicable

<sup>1</sup> data are shown as z-score

**BEARNI*****Brief Evaluation of Alcohol Related Neuropsychological Impairment*****Administration and scoring instructions****I- Verbal memory****Instruction**

*First free recall:* I am going to read a list of words. Listen carefully because your job is to remember as many of these words as possible. *Say the list of words in 13 to 15 seconds.*

Ok, now, tell me as many words as you can remember in any order.

*Second free recall:* I am going to read the list of words again. As before, try to remember as many words as possible. You will be asked to recall them afterwards.

*Maximum time for each recall: 1 minute. DO NOT tell the participant that she/he will be asked to recall the words at the end of the test.*

**Scoring**

***Total score : no point***

**II- ATAXIA of balance****Instruction**

Now, we are going to test your balance. First, you will stand on one leg. Use the wall to support yourself. Then, put one foot on the line, cross your arms, and lift your other leg like this (*up to knee*). Be sure not to press your leg on your standing leg. If at any time you feel as if you're going to fall, open your eyes, put your foot down and use the wall for support.

*2 trials for each condition*

*30 seconds maximum for each trial. Record the time reached for each trial in that position.*

*Specify whether the participant successfully performs the task at first trial or at second trial.*

**Scoring**

2 points for each condition when the participant successfully performs the task on the first trial.

1 point for each condition when the participant successfully performs the task on the second trial.

0 point when the participant fails two trials.

***Total score: max 8 points***

**III- Alternating fluency****Instruction**

For this task, you will have **2 minutes** to list as many different colors and cities. You must alternate between these two categories: start with one color, then one city, then a different color, and a different city, etc. The cities and the colors do not have to be related.

*(Report all the responses of the participant, including perseverations and errors).*

*Stop the task after 2 minutes*



**Scoring**

0 point for 0-4 words (alternating and category respected)

1 point for 5-9 words

2 points for 10-14 words

3 points for 15-19

4 points for 20-24

5 points for 25-29 words

6 points  $\geq$  30 words

**Total score: maximum 6 points**

Error of category refers to the words produced that are not colors nor cities.

Error of alternating refers to the production of two words consecutively in the same category (for example when the subject produces two cities or two colors consecutively).

**Exemple of scoring :** if the patient produces the words : « Paris, green, New-York, Amsterdam ; blue ; San Francisco ; orange », 7 words are produced but there is one alternating error (two cities consecutively: “New-York; Amsterdam”). So, 6 words are correct because “Amsterdam ; blue” are considered as word well produced (category and alternating respected).

**IV- Alphabetical span****Instructions**

I am going to read aloud a series of letters. Your job is to say those letters in alphabetical order. For example, if I say « C-B », you must say « B-C » because the letter B comes before C in the alphabet.

*(The series of letters must be read only once. Stop the subtest if the participant fails both trials of the same item.)*

**Scoring**

0.5 point for each successful trial

**Total score : maximum 5 points**

**V- Visuospatial abilities****Instruction**

I am going to show you some figures. Each complex figure contains 2 separate figures. Your job is to find those two hidden figures. The hidden figures and those on the right side are exactly the same size (*Show the example of the first figure*). See, for example, in this figure, you can find this hidden figure (1st one) and this other one (2nd one).

**Duration: 1 minute maximum per figure.**

**Scoring**

1 point when the participant finds the two hidden figures

0 point when the participant finds one or none of the hidden figures

**Total score : maximum 5 points**

**Correct answers :**

Complexe figure 1 : figures 1 et 3

Complexe figure 2 : figures 1 et 4

Complexe figure 3 : figures 1 et 3

Complexe figure 4 : figures 2 et 4

Complexe figure : figures 3 et 4

**VI- Delayed verbal memory**



**Instructions**

At the beginning of this test, you learned a list of words. Now, I would like you to recall as many of those words as possible in any order.

*DO NOT read the list of word.*

(recall : **1 minute**)

**Scoring**

Number of correct response	0,5 point for each correct answer
Number of error (intrusion)	Remove 0,5 point per error
Total	-Correct answer - error

**Total score : maximum 6 points**

An error of intrusion refers to the production of a word that was not in the list. For example: dress, tools...

Repetitions are not scored as errors.

**TOTAL SCORES**

Add-up the points of each subtest. The total score is /30 points.

It is possible to compute a total « cognitive » score (excluding the ataxia subtest; maximum score: 22 points).

Subtests	Maximum score	Cut-off score
Memory : <ul style="list-style-type: none"> <li>• Verbal memory</li> <li>• Delayed verbal memory</li> </ul>	<b>No point</b> <b>6</b>	$\leq 2$
Ataxia of balance	<b>8</b>	$\leq 3$
Alternating fluency	<b>6</b>	$\leq 2$
Alphabetical span	<b>5</b>	$\leq 2,5$
Visuospatial abilities	<b>5</b>	$\leq 1$

**Total score cut-**

Since the BEARNI total scores were influenced by education (years of schooling), cut-off score were adjusted.

Years of schooling		<b>TOTAL SCORE (30 max.)</b>	<b>TOTAL COGNITIVE SCORE (22 max.)</b>
$\leq 12^*$	Mild impairment	$\leq 19$	$\leq 15$
	Moderate-to-severe impairment	$\leq 16$	$\leq 11,5$
$> 12$	Mild impairment	$\leq 21$	$\leq 16$
	Moderate-to-severe impairment	$\leq 17$	$\leq 12,5$

\* corresponding approximately to high school diploma

1 **Validation of a brief screening tool for alcohol-related neuropsychological impairments**2 **(BEARNI)**3 Ludivine Ritz<sup>a,b,c,d</sup>, Coralie Lannuzel<sup>a,b,c,d</sup>, Céline Boudehent<sup>a,b,c,d,e</sup>, François Vabret<sup>a,b,c,d,e</sup>,4 Nadège Bordas<sup>f</sup>, Shailendra Segobin<sup>a,b,c,d</sup>, Francis Eustache<sup>a,b,c,d</sup>, Anne-Lise Pitel<sup>a,b,c,d</sup> and5 Hélène Beaunieux<sup>a,b,c,d</sup>

6

7 <sup>a</sup> U1077, INSERM, Caen, France8 <sup>b</sup> UMR-S1077, Université de Caen Basse-Normandie, Caen, France9 <sup>c</sup> UMR-S1077, Ecole Pratique des Hautes Etudes, Caen, France10 <sup>d</sup> U1077, Centre Hospitalier Universitaire, Caen, France11 <sup>e</sup> Centre Hospitalier Universitaire, service d'addictologie, Caen, France12 <sup>f</sup> Centre Hospitalier Universitaire Paul Brousse, Villejuif, France

13

14 Corresponding author: Prof. Hélène Beaunieux, UFR de Psychologie, Université de Caen

15 Basse Normandie, Esplanade de la Paix, 14032 Caen Cedex, France; Tel.: +33 (0)2 31 56 56

16 25; e-mail: [helene.beaunieux@unicaen.fr](mailto:helene.beaunieux@unicaen.fr)

17

18

1        **ABSTRACT**

2        **Background:** Alcohol-related neuropsychological impairments mainly affect episodic  
3        memory, working memory and visuospatial abilities, as well as executive and motor  
4        functioning. These impairments can prevent alcoholic patients (ALs) early in abstinence from  
5        benefiting fully from treatment, and reduce their ability to remain abstinent. A  
6        neuropsychological assessment seems essential for making the relevant clinical decisions.  
7        However, very few alcohol treatment departments have the financial and human resources  
8        needed to conduct an extensive neuropsychological examination of each alcoholic patient.  
9        The goal of the present study was therefore to assess the validity and the psychometric  
10       properties of the Brief Evaluation of Alcohol-Related Neuropsychological Impairments  
11       (BEARNI), a new screening tool especially designed to assess alcohol-related  
12       neuropsychological impairments.

13       **Methods:** A total of 254 healthy controls (HCs) completed the BEARNI, and 58 of them also  
14       performed an extensive neuropsychological battery. 73 ALs underwent both the BEARNI and  
15       the neuropsychological battery. This extensive neuropsychological battery of proven  
16       classification accuracy served as the reference (i.e., gold standard) for determining the ALs'  
17       cognitive status.

18       **Results:** An exploratory factor analysis validated the BEARNI's underlying structure,  
19       highlighting five factors that reflected visuospatial abilities, executive functions, ataxia,  
20       verbal episodic memory and verbal working memory. The standardization of each BEARNI  
21       subtest and the two total scores revealed that this test has sufficient diagnostic accuracy for  
22       the detection of ALs with cognitive and motor impairments.

23       **Conclusion:** The present study indicates that the BEARNI is a useful screening tool in  
24       clinical settings for detecting ALs' motor and cognitive impairments.

25

- 1 **Keywords:** alcoholism, neuropsychological impairment, brief cognitive screening tool,
- 2 exploratory factor analysis, ROC curve

For Review Only

## 1 INTRODUCTION

2 Chronic alcoholism results in brain damage and compromised motor and cognitive  
3 functioning, even in alcoholic patients (ALs) with no severe neurological complications (i.e.  
4 those without Korsakoff's syndrome (KS), or alcoholic dementia). The neuropsychological  
5 impairments mainly encompass executive dysfunction (Ihara et al., 2000), working memory  
6 deficits (Pitel et al., 2007; Uekermann et al., 2007) and visuospatial disabilities (Fama et al.,  
7 2004). Genuine episodic memory impairments (i.e., not resulting solely from executive  
8 dysfunctions) are also observed in ALs (Noël et al., 2012), but are generally less severe than  
9 executive and visuospatial impairments (Sullivan et al., 2000). Deficits in motor functions  
10 including ataxia of gait and balance (Fein and Greenstein, 2013) are just as severe as the  
11 visuospatial deficits (Sullivan et al., 2000). These cognitive and motor impairments have been  
12 estimated to affect more than two thirds of ALs (Ihara et al., 2000). The deficits range from  
13 mild-to-moderate (Sullivan et al., 2000), that is, about one standard deviation from the mean  
14 for **non-alcoholic** healthy controls (HCs) (Goldstein et al., 2004), to severe impairments  
15 comparable to those observed in KS patients (Kopelman et al., 2009).

16 The treatment of alcohol-dependence includes several types of therapy such as Motivational  
17 Enhancement Therapy, Twelve-Step Facilitation or cognitive behavioral therapy, which all  
18 require attending to and receiving new information, and being able to integrate and translate it  
19 into behavioral changes (Bates et al., 2006). To benefit from these therapies, ALs must  
20 implement cognitive functions such as episodic memory, planning, inhibition and problem-  
21 solving abilities, which have been repeatedly found as impaired. Episodic memory deficits  
22 and executive dysfunction hinder complex learning, such as the learning of semantic  
23 information and cognitive procedures (Pitel et al., 2007), affect readiness to change (Blume et  
24 al., 2005), ability to elaborate alternative behavioral responses (Bates et al., 2006) and  
25 decision making (Noël et al., 2007). These cognitive disabilities impact treatment compliance

1 and treatment outcomes (Bates et al., 2006). Thus, ALs with impaired cognitive functions  
2 may be unable to benefit fully from therapy interventions. The detection of  
3 neuropsychological impairments is therefore essential for making the appropriate clinical  
4 decisions regarding the nature and timing of treatment.

5 Few alcohol departments and clinics have the financial and human resources needed to  
6 administer an extensive neuropsychological examination to each ALs. Previous studies have  
7 proposed a range of screening instruments for the detection of cognitive impairments in  
8 patients with substance use disorders (SUDs), including the Neurobehavioral Cognitive Status  
9 Examination (NCSE; (Kiernan et al., 1987), the Repeatable Battery for Assessment of  
10 Neuropsychological Status (RBANS; (Randolph et al., 1998) and the Montreal Cognitive  
11 Assessment (MOCA; (Nasreddine et al., 2005). According to (Shulman, 2000), an ideal  
12 cognitive screening test should fulfill the following criteria: a) be readily administered; b) be  
13 easy to score; c) have concurrent validity; and d) have high levels of sensitivity, specificity  
14 and predictive validity. Despite the fact that existing screening tools can be administered  
15 within 10-30 minutes and have satisfactory sensitivity to cognitive impairment in SUD  
16 patients (Copersino et al., 2009; Fals-Stewart, 1997), they have several limitations. In addition  
17 to poor specificity in detecting impaired patients (36% for NCSE and 69% for MOCA; Fals-  
18 Stewart, 1997; Wester et al., 2013), these tools assess cognitive functions that are not usually  
19 reported as impaired in ALs, including orientation, attention and concentration, language and  
20 naming. Even though total MOCA and RBANS scores are lower for SUD patients than for  
21 controls, analysis of individual subscores has shown that only memory, executive and  
22 visuospatial abilities are impaired in patients compared with controls (Alarcon et al., 2015;  
23 Green et al., 2010; Wester et al., 2013). More specifically, in a recent study (Alarcon et al.,  
24 2015), performances of ALs with low ( $\leq 21$ ), medium (22-25) and high ( $\geq 26$ ) MOCA total  
25 score were compared on each subscore of this test. The most affected domains concerned



1 abstraction and fluency. The authors raised a limitation to the MOCA that is the narrow range  
2 of these subscores (respectively from 0 to 1 and 2) that can limit the assessment of the  
3 severity of cognitive deficits and its improvement with abstinence and treatment.

4 Overall, these screening tools do not have a satisfactory level of content validity for chronic  
5 alcoholism probably because they were initially designed to detect cognitive impairments  
6 either in older individuals (Nasreddine et al., 2005; Randolph et al., 1998) or else in patients  
7 receiving neurosurgical care for brain lesions (Kiernan et al., 1987). A screening tool must be  
8 validated against a gold standard, in order to avoid misdiagnosis due to false negatives or  
9 false positives. In the above-mentioned studies conducted in SUD patients, these patients'  
10 cognitive profile was either not reported (Alarcon et al., 2015; Wester et al., 2013) or else  
11 determined using the Neuropsychological Screening Battery (Heaton et al., 1990) or the  
12 Neuropsychological Assessment Battery–Screening Module (White and Stern, 2003). These  
13 short neuropsychological batteries both have poor specificity (Fals-Stewart, 1996) and have  
14 been validated in SUD patients (Fals-Stewart, 1996; Grohman and Fals-Stewart, 2004) but not  
15 specifically in alcoholic ones. Moreover, a main limitation of a previous study (Wester et al.,  
16 2013) was that the MOCA was administered to patients at admission whereas the extensive  
17 neuropsychological battery was conducted 6 to 8 weeks later. Since some of the cognitive  
18 functions can recover, even after a short time of abstinence (from 3-5 weeks of abstinence;  
19 (Mann et al., 1999)), the delay between the MOCA and the extensive battery substantially  
20 limits the determination of the psychometric properties of the MOCA. Other brief screening  
21 tools have been used in previous studies to describe the general cognitive status of alcoholic  
22 patients, such as the MMSE (Folstein et al., 1975) and DRS Mattis (Mattis and Inc, 1988).  
23 Results are discrepant since some of them reported impairments (Le Berre et al., 2010;  
24 Rosenbloom et al., 2007) whereas other did not (Pitel et al., 2011). These tools are mainly

1 used as inclusion criteria in studies conducted in ALs and to exclude patients with low scores  
2 that may be explained by dementia.

3 The goal of the present study was therefore to validate a new screening tool especially  
4 designed for the rapid assessment of alcohol-related neuropsychological deficits. The Brief  
5 Examination of Alcohol-Related Neuropsychological Impairment (BEARNI) is intended to be  
6 short and easy to score, making it usable by non-psychologists. It is expected to enable  
7 physicians or nurses to rapidly determine whether a patient can attend and gain from standard  
8 alcohol treatment or whether some adjustments are required. More specifically, we sought to  
9 assess the BEARNI's validity and its psychometric properties in order to determine whether it  
10 is an appropriate tool for identifying cognitive and motor impairments in ALs. A value of  
11 80% or above indicates high psychometric quality (Blazer and Hays, 1998), and we expected  
12 the BEARNI's psychometric properties to meet this criterion.

13

## 14 **MATERIALS AND METHODS**

### 15 *Participants*

16 A total of 254 HCs completed the BEARNI, and 58 of them also performed an extensive  
17 neuropsychological battery. We administered both the BEARNI and the extensive battery to  
18 73 ALs. None of the participants had a history of neurological pathologies, endocrine or  
19 infectious diseases, mental illness (psychiatric disorders assessed by the MINI 500;  
20 (American Psychiatric Association, 2004), depression (Beck Depression Inventory, BDI-II;  
21 (Beck et al., 1961), or other forms of substance misuse or dependence (except tobacco) over  
22 the lifetime. None were under psychotropic medication that might have had an effect on their  
23 cognitive functioning. All the participants were informed about the study (approved by the  
24 local ethics committee) and provided their written informed consent before their inclusion.  
25 Their demographic characteristics (age, sex ratio and education) with their scores on the Mini

1 Mental State Examination (MMSE; Folstein et al., 1975) and the Mattis Dementia Rating  
2 Scale (DRS; Mattis and Inc, 1988) are reported in Table 1.

3 The ALs were recruited by clinicians while they were receiving withdrawal treatment as  
4 inpatients at Caen University Hospital. All the patients met the DSM-IV criteria for alcohol-  
5 dependence (American Psychiatric Association, 2004). None of them had severe, enduring  
6 and global amnesia defining the Korsakoff's syndrome nor alcoholic dementia, **Marchiafava-**  
7 **Bignami** or **central pontine myelinolysis**. Although the patients were early in abstinence, none  
8 of them presented physical symptoms of alcohol withdrawal at inclusion. They were  
9 interviewed with the Alcohol Use Disorders Identification Test (AUDIT; (Gache et al., 2005)  
10 and a modified version of the semistructured Lifetime Drinking History questionnaire.  
11 Measures included the duration of alcohol use (in years), alcohol misuse (in years), number of  
12 withdrawals, and daily alcohol consumption prior to treatment (in standard drinks, a standard  
13 drink corresponding to a beverage containing about 10 g of pure alcohol) (Table 1).

14 All the HCs were interviewed with the AUDIT (Gache et al., 2005) to ensure that they did not  
15 meet the criteria for alcohol abuse or dependence over the lifetime (AUDIT <7 for men and  
16 <6 for women) (Table 1). None of the HCs had a MMSE (Folstein et al., 1975) or a Mattis  
17 DRS (Mattis and Inc, 1988) scores below the cut-off score of 24 and 127 respectively.

18

### 19 ***Material***

20 Participants completed the BEARNI and the extensive battery of neuropsychological tests  
21 over 2-3 days to minimize fatigue and interference. Only 58 of the HCs completed the  
22 neuropsychological battery (demographic characteristics in Table 1) in addition to the  
23 BEARNI. The latter was administered on the first day to avoid the possible influence of the  
24 extensive battery on performances. The order of the test administration was fixed because  
25 some of the BEARNI subtests were inspired by neuropsychological tests administered to

1 participants (see below the description of the BEARNI subtests). Thus, in administering the  
2 BEARNI before the extensive neuropsychological battery, all the subjects in our study were  
3 in the same situation than patients in clinical settings who would first undergo the BEARNI  
4 and then, an extensive neuropsychological examination. Raw scores of the BEARNI and the  
5 extensive neuropsychological battery are provided in Supporting Information B table 4.

6

### 7 **Brief Examination of Alcohol-Related Neuropsychological Impairments** 8 **(BEARNI)**

9 The BEARNI is designed to assess the cognitive and motor functions that are impaired in  
10 ALs, namely episodic memory, working memory, executive functions, visuospatial abilities,  
11 and ataxia (Table 2). It takes approximatively 15-20 minutes to administer the BEARNI. In  
12 order to avoid errors, instructions for administration and scoring are provided in Supporting  
13 Information A. Examples of the working memory, flexibility, visuospatial and ataxia subtests  
14 are provided to participants prior to data collection. The BEARNI is provided in Supporting  
15 Information A.

16 The *episodic memory* subtest was inspired by the California Verbal Learning Test (Delis et  
17 al., 1988). It consists of two learning trials of a 12-word list (4 words x 3 semantic  
18 categories). The list is read aloud by the examiner. After each trial, the patient is instructed to  
19 freely recall as many words as possible, in any order (1 minute per trial, no points scored).

20 **Once the remaining tests from the BEARNI have been administered**, delayed free recall is  
21 performed (one trial lasting 1 minute). The episodic measure is the number of correct  
22 responses (0.5 point per response) minus the number of errors (intrusions and perseverations;  
23 0.5 point per error) during the delayed free recall task (maximum score: 6 points).

24 *Working memory* is assessed with an alphabetical span subtest adapted from the alpha-span  
25 task (Belleville et al., 1998). This task probes the ability to manipulate information stored in

1 verbal working memory. Increasingly long letter sequences are read out loud, and for each  
2 sequence the patient has to repeat the letters in alphabetical order. Two trials are performed  
3 for each sequence. The task ends when the participant fails both two trials of a sequence (0.5  
4 point per trial; maximum score: 5 points).

5 **Flexibility abilities** are assessed with the alternating verbal fluency subtest. Patients are given  
6 120 seconds to generate as many words as possible from two alternating categories (“color  
7 name” and “city name”). Depending on the number of correct responses, points range from 0  
8 to 6 (for scoring details, see Supporting Information A).

9 **Visuospatial abilities** are assessed with an adapted version of the Hidden Figures Test  
10 (Corkin, 1979; Thurstone, 1944). This subtest includes five complex figures, each containing  
11 two separate hidden figures that the patient has to find. An example is provided and explained  
12 to the patient by the examiner. For each complex figure, one point is provided when the  
13 patient finds both hidden figures within 1 minute (maximum score: 5 points).

14 Finally, the **ataxia** subtest, drawn from the Walk-a-Line Ataxia Battery (Fregly, 1971),  
15 requires patients to stand on each foot in turn for 30 seconds, first with eyes open, then with  
16 eyes closed. There are up to two trials per condition. For each condition, 2 points are awarded  
17 when patients successfully perform the task at the first trial, 1 point when they successfully  
18 perform the task at the second trial, and 0 point when they fail both trials (maximum score: 8  
19 points).

20 The BEARNI yields seven scores: five subscores (one for each of the subtests), a total score  
21 (maximum score: 30 points) and a total *cognitive* score (excluding the ataxia subtest;  
22 maximum score: 22 points).

23

24 **Neuropsychological examination**

1 The extensive neuropsychological battery we administered targeted a broad range of cognitive  
2 and motor functions: *verbal episodic memory* (French adaptation of the CVLT (Delis et al.,  
3 1988)); *working memory* (verbal and visuospatial spans of the MEM-III (Wechsler, 2001a)  
4 and the Letter-Number Sequencing subtest of the WAIS-III (Wechsler, 2001b)); *executive*  
5 *functions* (the Trail Making Test (Reitan, 1955), the Ruff Figural Fluency Test (RFFT;  
6 (Foster et al., 2005), the Stroop test (Stroop, 1935), and fluency tasks (Cardebat et al., 1990);  
7 *visuospatial abilities* (the Rey-Osterrieth Complex Figure (ROCF; (Osterrieth, 1944)) and  
8 *ataxia* (the Walk-a-Line Ataxia Battery). The data collected for each test are summarized in  
9 Table 2.

10

### 11 ***Data analysis***

#### 12 **Validation of the BEARNI's internal structure**

13 The first step consisted of an exploratory factor analysis (EFA) to determine the BEARNI's  
14 factorial structure, the explained variance for each factor and the total variance. An orthogonal  
15 rotation (normalized varimax rotation) was used because the latent factors were not correlated  
16 with each other (data not shown). The number of factors was determined by three criteria: a)  
17 eigenvalues above 1 (Kaiser criterion; (Kaiser, 1960); b) proportion of variance explained by  
18 the factor above 5%; and c) number of theoretical variables in the integrated model. Given the  
19 number of cognitive and motor functions targeted by the BEARNI (delayed verbal memory,  
20 verbal working memory, flexibility, visuospatial abilities and ataxia), we expected to extract  
21 five factors reflecting these five domains. A threshold  $\geq 0.50$  was used to determine the factors  
22 on which each variable loaded. Any factor below the threshold of 0.50 was assigned to the  
23 factor on which it most highly loaded. The EFA was conducted with the 58 HCs and 73 ALs  
24 who had completed both the BEARNI and the extensive battery.

1 In addition, we compared the performance profiles of the ALs and HCs on each of the  
2 BEARNI subtests. The objective was to determine whether the BEARNI's  
3 neuropsychological profile was consistent with that described in the literature. To do so, we  
4 carried out multivariate analyses of variance (MANOVAs; 2 groups x 5 subtests x 2 sexes;  
5 age and education entered as covariates) and Tukey's tests for post-hoc comparisons.

6

### 7 **Standardization of the BEARNI**

#### 8 ***Total scores***

9 For the BEARNI's two total scores (total score and total cognitive score), the standardization  
10 was performed for the 58 HCs who had completed the neuropsychological battery. We used  
11 the method described in (Godefroy et al., 2014) and reported in Supporting Information B.

12

#### 13 ***Psychometric properties of the BEARNI total scores***

14 Sensitivity, specificity, positive and negative predictive values, diagnostic accuracy (% of  
15 patients well classified; i.e., reliability of the screening test) and Yule's Q coefficient  
16 (coefficient measuring the association between two attributes, ranging from 0 to 1, where a Q  
17 coefficient of 0.70-1 is deemed to represent a very strong association) were computed using  
18 the ALs' results on the BEARNI.

19 The psychometric properties of the BEARNI were then compared with those of the MMSE  
20 (Folstein et al., 1975; Kalafat et al., 2003; cut-off scores in Supporting Information B Table 1)  
21 and the Mattis DRS (cut-off score for persons aged under 69 years  $\leq 127$ ; Lucas et al., 1998;  
22 Mattis and Inc, 1988).

23

#### 24 ***BEARNI subtests***

25 For each subtest, we determined cut-off scores using the data collected from the 254 HCs who  
26 had completed the BEARNI with the method described in (Godefroy et al., 2014) and in  
27 Supporting Information B. We then investigated the predictive value of these cut-off scores

1 for detecting ALs with impaired performances on the neuropsychological battery. Based on  
2 the cut-off scores, patients were classified as either impaired or preserved on each BEARNI  
3 subtest. Performances on the tasks in the extensive neuropsychological battery were thus  
4 compared across three groups (HCs ( $n=58$ ), ALs with impaired BEARNI performances, and  
5 ALs with preserved BEARNI performances) using an ANOVA. Tukey's tests were then  
6 carried out for post-hoc comparisons. For each subtest, we regarded the BEARNI cut-off  
7 score as predictive when ALs classified as impaired on a specific BEARNI subtest performed  
8 more poorly on the corresponding domain of the neuropsychological battery than ALs with  
9 preserved results on that subtest and HCs.

10

11 Statistical analyses were performed using Statistica and MedCalc software and the probability  
12 significance threshold was set at  $p \leq 0.05$ . Where necessary, Bonferroni corrections were  
13 applied to prevent Type-I errors.

14

## 15 **RESULTS**

### 16 *Validation of the BEARNI's internal structure*

17 The results of the EFA analysis are reported in Table 3. All the factors met the criteria of an  
18 eigenvalue above 1 (Kaiser, 1960) and more than 5% of variance explained by the factor.  
19 Consistent with our hypothesis, five factors were extracted. Factor 1 was deemed to reflect  
20 executive and visuospatial abilities, factor 2 was represented by ataxia, factor 3 included  
21 variables related to verbal episodic memory, factor 4 was represented by fluency tasks and  
22 factor 5 included variables related to verbal working memory. Taken together, these five  
23 factors accounted for 60.08% of the total variance. When restricted to HCs ( $n=58$ ), the EFA  
24 yielded the same results.



1 The two (group: ALs vs. HCs) x two (sexes) x five (BEARNI subtests) MANOVA on  
2 BEARNI performances revealed significant effects of group,  $F_{(1, 324)} = 53.53, p < 0.001$ , age,  
3  $F_{(1, 327)} = 11.28, p < 0.001$ , and education,  $F_{(1, 327)} = 69.72, p < 0.001$ , the Subtest x Group  
4 interaction,  $F_{(4, 1308)} = 16.02, p < 0.001$ , and the Subtest x Education interaction,  $F_{(4, 1308)} = 3.55,$   
5  $p = 0.007$ , but no other significant effects. Tukey's post-hoc tests revealed that ALs performed  
6 more poorly than HCs (effect of group), and this effect was found for each of the BEARNI  
7 subtests (Subtest x Group interaction) except for delayed verbal memory (Figure 1).

8

### 9 ***Standardization of the BEARNI***

10 Most of the raw scores (both for the BEARNI and for the extensive neuropsychological  
11 battery) deviated from normality and were influenced by age, education, sex, or all three.

12

### 13 **Standardization of the BEARNI's total scores**

14 On the extensive neuropsychological battery, 86% of ALs were classified as having at least a  
15 mild impairment, 53% as having a moderate-to-severe impairment, and 14% having no  
16 impairment. Regarding the neuropsychological battery with only cognitive functions (i.e.,  
17 excluding performances on the Walk-a-Line Ataxia Battery), 84% of ALs were classified as  
18 having at least a mild impairment, 45% as having a moderate-to-severe impairment and 16%  
19 as having no impairment.

20 The ROC curve analysis performed to standardize the total BEARNI score (cognitive  
21 functions plus ataxia) showed that a cut-off score of  $\leq 19$  yielded the best balance between  
22 sensitivity and specificity for detecting mild impairment in the neuropsychological battery  
23 (Supporting Information B Table 2, Figure 2A). For moderate-to-severe impairment, a cut-off  
24 score of  $\leq 16$  yielded the best balance between sensitivity and specificity (Supporting  
25 Information B Table 2, Figure 2B).

1 Regarding the total cognitive score (excluding the ataxia BEARNI subtest), a cut-off score of  
2  $\leq 15$  yielded the best balance between sensitivity and specificity for detecting mild impairment  
3 in the neuropsychological battery (Supporting Information B Table 2, Figure 2C). For  
4 moderate-to-severe impairment, a cut-off score of  $\leq 11.5$  yielded the best balance between  
5 sensitivity and specificity (Supporting Information B Table 2, Figure 2D).

6 Linear regression analysis (forward stepwise) conducted in HCs and ALs showed a significant  
7 effect of education on these two total BEARNI scores, indicating that participants with more  
8 than 12 years of schooling had better performances. Thus, in order to correct for this  
9 education effect, we adjusted the cut-off scores for participants with more than 12 years of  
10 schooling. This adjustment of the cut-off scores was determined by the best balance between  
11 true positive and true negative on the extensive neuropsychological battery. All total cut-off  
12 scores are summarized in **Table 5**.

13

#### 14 ***Psychometric properties of the BEARNI***

15 The psychometric properties of the BEARNI total scores are reported in Table 5. The  
16 sensitivity, positive and negative predictive values, Yule's Q coefficient and diagnostic  
17 accuracy to identify ALs showing mild or moderate-to-severe impairments on the extensive  
18 neuropsychological battery range from acceptable to excellent. However, the specificity of the  
19 BEARNI total scores for identifying ALs with mild impairments was low.

20 Only 9.59% and 8.22% of alcoholic patients were impaired on the MMSE and Mattis DRS  
21 respectively. Although the specificity and the positive predictive value were excellent for the  
22 MMSE (Folstein et al., 1975) and the Mattis DRS (Mattis and Inc, 1988) in identifying  
23 alcoholic patients with mild impairment, the positive predictive value for moderate-to-severe  
24 impairment as well as the sensitivity, negative predictive value, Yule's Q coefficient and  
25 diagnostic accuracy were poor for mild and moderate-to severe impairments (Table 5).

1

2

### **Standardization of the BEARNI subtests and predictability**

3 Each of the subtest scores yielded sensitivity values of 100%, specificity values ranging from  
4 75.21% to 99.59%, and AUC values ranging from 0.950 to 0.998 (Supporting Information B  
5 Table 3). ROC analyses provided cut-off scores for the following BEARNI subtests: delayed  
6 verbal memory  $\leq 2$ ; alphabetical span  $\leq 2.5$ ; alternating fluency  $\leq 2$ ; visuospatial  $\leq 1$ ; and ataxia  
7  $\leq 3$ .

8 These cut-off scores indicated that 16% of the ALs were impaired on the episodic memory  
9 subtest, 32.91% on the alphabetical span subtest, 21.52% on the alternating fluency subtest,  
10 45.57% on the visuospatial subtest, and 49.36% on the ataxia subtest.

11 We then compared the HCs, ALs with impaired BEARNI results, and patients with preserved  
12 BEARNI results on cognitive performances. Using the cut-off scores of each BEARNI  
13 subtest, we compared these three groups on the corresponding domain of the  
14 neuropsychological battery. As the raw scores on the neuropsychological battery were  
15 influenced by demographic factors, each comparison was conducted using standard residuals.

16 All ANOVA results are provided in Table 6. The cut-off score of  $\leq 2$  for the delayed verbal  
17 memory BEARNI subtest was predictive of performances on CVLT. Regarding the  
18 alphabetical span BEARNI subtest, the cut-off score of  $\leq 2.5$  was predictive of performances  
19 on verbal forward span and Letter-Number Sequencing. The cut-off of  $\leq 2$  for the flexibility  
20 subtest was predictive of performances on the verbal fluency tasks and the TMT (Part B  
21 minus Part A;  $F_{(1, 128)} = 9.25$ ,  $p < 0.001$ , Tukey's post-hoc: impaired ALs < (preserved ALs  
22 =HCs)). Regarding the visuospatial BEARNI subtest, the cut-off score of  $\leq 1$  was predictive of  
23 performances on visuospatial backward span, Stroop, TMT and RFFT (total design but not  
24 total strategies). For the ROCF and visuospatial forward span, although impaired ALs had  
25 lower performances than preserved ALs and HCs (who did not differ between each other), no

1 statistical differences were found between the two patient groups. Finally, the cut-off of  $\leq 3$   
2 for the ataxia subtest was predictive of performances on the Walk-a-Line Ataxia Battery.

3

#### 4 **DISCUSSION**

5 The goal of the present study was to assess the validity and psychometric properties of the  
6 BEARNI, a new screening tool especially designed for the rapid assessment of alcohol-related  
7 neuropsychological deficits. An extensive neuropsychological battery of proven classification  
8 accuracy (Godefroy et al., 2014) served as the reference (i.e., gold standard) for determining  
9 the ALs' cognitive status.

10 In agreement with our theoretical hypothesis, the EFA validated the BEARNI's underlying  
11 structure, as it highlighted five factors that accounted for 60% of the total variance: a first  
12 factor including visuospatial and visual executive abilities, a second one reflecting ataxia, a  
13 third one verbal episodic memory, a fourth one spontaneous cognitive flexibility, and a fifth  
14 one verbal working memory. Three of these factors involved executive functions and  
15 visuospatial abilities, which are impaired in two thirds of ALs (Ihara et al., 2000), and more  
16 severely so than other cognitive deficits (Sullivan et al., 2000). The second factor, which  
17 pertained to ataxia, was in agreement with deficits in gait and balance described in previous  
18 studies (Fein and Greenstein, 2013) as being just as severe as the visuospatial impairments  
19 (Sullivan et al., 2000). The delayed verbal memory factor represented a smaller proportion of  
20 the explained variance in the present study, in accordance with a less severe and consistent  
21 impairment of this function in ALs compared with other deficits (Ihara et al., 2000; Sullivan  
22 et al., 2000). Thus, these results suggest that the BEARNI has satisfactory content validity.

23 Even though the BEARNI includes most of the cognitive domains known to be impaired in  
24 ALs, such a brief screening tool cannot allow for the assessment of all cognitive functions.  
25 For example, there is no evaluation of inhibition abilities, even though inhibition deficits have

1 repeatedly been reported in alcoholism (Ihara et al., 2000; Lusher et al., 2004) and have been  
2 linked to poorer delayed recall in episodic memory (Noël et al., 2012) and motivation to  
3 change (Blume et al., 2005). The EFA revealed that inhibition abilities contributed to the  
4 variability of the visuospatial BEARNI subtest, which requires participants to find two figures  
5 hidden in a complex figure. Impaired visuospatial global-local processing in alcoholism has  
6 also been found to reflect difficulty inhibiting local information (Müller-Oehring et al., 2009).  
7 Thus, performances on the visuospatial BEARNI subtest seem to be cognitively multi-  
8 determined and may also reflect inhibition abilities.

9 This interpretation is confirmed by the high concurrent validity we observed when we  
10 standardized the BEARNI subtests. ALs classified as impaired on the BEARNI subtests using  
11 the cut-off scores were also impaired on the corresponding cognitive and motor domains of  
12 the extensive battery. Those classified as preserved did not differ from HCs. Performances on  
13 the visuospatial BEARNI subtest were predictive of results for the visuospatial abilities  
14 assessed by the extensive neuropsychological battery, as well as for visuospatial working  
15 memory, inhibition and flexibility. The episodic memory, verbal working memory, flexibility  
16 and ataxia subtests were similarly predictive. Thus, the cut-off scores computed for each  
17 BEARNI subtest had high diagnostic efficiency in terms of accurately detecting the cognitive  
18 impairments observed on the extensive neuropsychological battery. In addition, performances  
19 on each BEARNI subtest were only predictive of results on the corresponding cognitive  
20 domains, and not of all the domains evaluated by the extensive battery. Taken together, these  
21 findings indicate that the BEARNI could be used in clinical settings to obtain a reliable  
22 estimation of neuropsychological performances, including episodic memory, executive  
23 functions, working memory, visuospatial abilities and ataxia. Compared to other screening  
24 tools, such as the MOCA (Alarcon et al., 2015; Wester et al., 2013), the BEARNI provides

1 larger scales of cut-off score for each subtest, that may lead to a more accurate assessment of  
2 the severity and the improvement of neuropsychological deficits with abstinence.

3 Analysis of the BEARNI's psychometric properties showed that the two total scores made it  
4 possible to distinguish between ALs with no impairment, mild deficits or moderate-to-severe  
5 impairments, with satisfactory sensitivity, predictive validity and diagnostic accuracy (Blazer  
6 and Hays, 1998). This finding suggests that 1) even ALs with mild impairments can be  
7 detected with the BEARNI, and 2) the BEARNI identifies alcohol-related cognitive and  
8 motor impairments with a high degree of accuracy. Yule's Q coefficients highlighted a strong  
9 association between the cognitive profiles identified by the extensive neuropsychological  
10 battery and by the BEARNI, suggesting a high reliability of our screening tool. Whereas it  
11 takes 20 minutes at most to administer the BEARNI, an extensive neuropsychological battery  
12 takes at least 90, if not 120 minutes, to complete, hand-score and interpret. Moreover, the  
13 latter is not accessible to non-psychologists, making its routine use impracticable in clinical  
14 settings. When an extensive neuropsychological battery cannot be readily conducted, the  
15 BEARNI is therefore a useful and reliable screening tool for detecting cognitive and motor  
16 impairments in ALs.

17 Compared to the BEARNI, the MMSE and DRS Mattis were found in our study to have poor  
18 sensitivity, negative predictive value and diagnostic accuracy. 50% and more of the alcoholic  
19 patients were not well identified by these screening tools. This finding could be explained by  
20 the fact that these screening tools were initially designed to detect cognitive decline  
21 associated with dementia. They are therefore neither relevant nor sensitive to assess cognitive  
22 functioning in alcoholic patients. However, the use of the MMSE, the DRS Mattis as well as  
23 the MOCA should not be disregarded in older alcoholic patients and/or in a context of  
24 differential diagnosis. Our findings do not aim at convincing the readers they should not use

1 these tools any more. We believe that BEARNI is more relevant to detect alcohol-related  
2 neuropsychological deficits but that these tools would be useful, as a complement.

3 The main limitation of the BEARNI is its relatively low specificity, especially for detecting  
4 patients with mild impairment. Between 7 and 14% of patients were classified as impaired on  
5 the BEARNI, whereas they had preserved results on the extensive neuropsychological battery.

6 This result cannot be attributed to incorrect sampling, as the prevalence of no, mild, and  
7 moderate-to-severe impairments among the patients included in the present investigation,  
8 according to the neuropsychological battery, matched that reported in previous study (Ihara et  
9 al., 2000). The BEARNI therefore tends to overestimate motor and cognitive impairments in  
10 ALs. As this screening tool has been developed to identify patients who should be referred to  
11 a psychologist for a more comprehensive neuropsychological evaluation, the BEARNI seems  
12 unlikely to miss impaired patients, instead referring some who may actually have a preserved  
13 cognitive profile. It is important to stress that the BEARNI is not intended as a substitute for  
14 an extensive neuropsychological examination, as it does not cover all the cognitive domains  
15 and does not assess specific processes within a given domain. An extensive  
16 neuropsychological examination will still be crucial when a differential diagnosis is required  
17 or when a detailed profile is needed to ensure adequate treatment in relation to cognitive  
18 rehabilitation.

19 In the light of these findings, we can make several recommendations for the clinical use of the  
20 BEARNI (Figure 3). In this study, all alcoholics underwent both the BEARNI and the  
21 neuropsychological battery while they were inpatients at treatment entry immediately after  
22 withdrawal from alcohol. In this clinical context, ALs diagnosed as having preserved abilities  
23 on the BEARNI can attend and benefit from standard alcohol treatment. For patients  
24 identified by the BEARNI as having mild impairments, several clinical and medical factors  
25 need to be considered to determine whether the treatment needs to be adjusted. Alcohol

1 history, including repeated withdrawals (Duka et al., 2003), bouts of thiamine deficiency  
2 (Thomson, 2000), liver complications (Arria et al., 2007) and level of motivation (Blume et  
3 al., 2005) have all been reported to be related to neuropsychological impairments in ALs.  
4 Finally, ALs identified by the BEARNI as having moderate-to-severe impairments are  
5 unlikely to benefit fully from treatment and should be referred for an extensive  
6 neuropsychological examination. As the neuropsychological impairments present at treatment  
7 entry are partially reversible, even after a short time of abstinence (Mann et al., 1999), a safe  
8 and enriched environment (withdrawal from alcohol and nutrition treatment) may prove  
9 beneficial for these impaired patients before they undergo standard alcohol treatment. A re-  
10 test after this recovery period would determine whether their cognitive abilities were  
11 sufficient for them to benefit from the standard treatment. A parallel version of the BEARNI,  
12 allowing for this second assessment, is therefore required. More generally, the BEARNI aims  
13 at determining the neuropsychological profile of ALs and whether a patient is able to attend  
14 and gain from standard alcohol treatment or whether some adjustments are required.  
15 Depending on the clinical context or the time when the BEARNI is administered, it will  
16 enable to adjust alcohol treatment to the neuropsychological profile or to assess the  
17 modification of neuropsychological performance with abstinence, reduction of alcohol  
18 consumption or relapse.

19 To conclude, the present study suggests that the BEARNI has high content validity, as it  
20 assesses the cognitive functions known to be impaired in chronic alcoholism, and reliable  
21 diagnostic accuracy in detecting ALs with cognitive and motor impairments. It provides a  
22 cognitive and motor profile that can guide the adjustment of alcohol treatment and further  
23 cognitive assessments. As such, the BEARNI seems to be a useful screening tool in clinical  
24 settings for detecting motor and cognitive impairments present at alcohol treatment entry. An



- 1 English/US version is ongoing to make available the BEARNI to native English speaker
- 2 patients.

For Review Only

1 **CONFLICT OF INTEREST**

2 Authors declare no conflict of interest.

For Review Only

1       **REFERENCES**

- 2       Alarcon R, Nalpas B, Pelletier S, Perney P (2015) MoCA as a Screening Tool of  
3       Neuropsychological Deficits in Alcohol-Dependent Patients. *Alcohol Clin Exp Res*.  
4       American Psychiatric Association AP (2004) DSM-IV-TR Manuel diagnostique et  
5       statistique des troubles mentaux: Texte révisié Elsevier Masson.  
6       Arria AM, Tarter RE, Kabene MA, Laird SB, Moss H, Thiel DV (2007) The role of  
7       cirrhosis in memory functioning of alcoholics. *Alcohol Clin Exp Res* 15:932–937.  
8       Bates ME, Pawlak AP, Tonigan JS, Buckman JF (2006) Cognitive impairment influences  
9       drinking outcome by altering therapeutic mechanisms of change. *Psychol Addict Behav*  
10      20:241–253.  
11      Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J (1961) An inventory for measuring  
12      depression. *Arch Gen Psychiatry* 4:561–571.  
13      Belleville S, Rouleau N, Caza N (1998) Effect of normal aging on the manipulation of  
14      information in working memory. *Mem Cognit* 26:572–583.  
15      Blazer DG, Hays JC (1998) *An Introduction to Clinical Research in Psychiatry*. 1 edition.  
16      ed New York: Oxford University Press.  
17      Blume AW, Schmalting KB, Marlatt GA (2005) Memory, executive cognitive function, and  
18      readiness to change drinking behavior. *Addict Behav* 30:301–314.  
19      Cardebat D, Doyon B, Puel M, Goulet P, Joannette Y (1990) [Formal and semantic lexical  
20      evocation in normal subjects. Performance and dynamics of production as a function of sex,  
21      age and educational level]. *Acta Neurol Belg* 90:207–217.  
22      Copersino ML, Fals-Stewart W, Fitzmaurice G, Schretlen DJ, Sokoloff J, Weiss RD  
23      (2009) Rapid cognitive screening of patients with substance use disorders. *Exp Clin*  
24      *Psychopharmacol* 17:337.  
25      Corkin S (1979) Hidden-figures-test performance: lasting effects of unilateral penetrating  
26      head injury and transient effects of bilateral cingulotomy. *Neuropsychologia* 17:585–605.  
27      Delis DC, Freeland J, Kramer JH, Kaplan E (1988) Integrating clinical assessment with  
28      cognitive neuroscience: construct validation of the California Verbal Learning Test. *J Consult*  
29      *Clin Psychol* 56:123–130.  
30      Duka T, Townshend JM, Collier K, Stephens DN (2003) Impairment in Cognitive  
31      Functions After Multiple Detoxifications in Alcoholic Inpatients. *Alcohol Clin Exp Res*  
32      27:1563–1572.  
33      Fals-Stewart W (1996) Intermediate length neuropsychological screening of impairment  
34      among psychoactive substance-abusing patients: A comparison of two batteries. *J Subst*  
35      *Abuse* 8:1–17.  
36      Fals-Stewart W (1997) Detection of neuropsychological impairment among substance-  
37      abusing patients: Accuracy of the Neurobehavioral Cognitive Status Examination. *Exp Clin*  
38      *Psychopharmacol* 5:269.  
39      Fama R, Pfefferbaum A, Sullivan EV (2004) Perceptual Learning in Detoxified Alcoholic  
40      Men: Contributions From Explicit Memory, Executive Function, and Age. *Alcohol Clin Exp*  
41      *Res* 28:1657–1665.  
42      Folstein MF, Folstein SE, McHugh PR (1975) “Mini-mental state”. A practical method for  
43      grading the cognitive state of patients for the clinician. *J Psychiatr Res* 12:189–198.  
44      Foster PS, Williamson JB, Harrison DW (2005) The Ruff Figural Fluency Test: heightened  
45      right frontal lobe delta activity as a function of performance. *Arch Clin Neuropsychol Off J*  
46      *Natl Acad Neuropsychol* 20:427–434.  
47      Fregly AR (1971) Walk on floor eyes closed (WOFEC): a new addition to an ataxia test  
48      battery DTIC Document.  
49      Gache P, Michaud P, Landry U, Accietto C, Arfaoui S, Wenger O, Daepfen J-B (2005)

- 1 The Alcohol Use Disorders Identification Test (AUDIT) as a Screening Tool for Excessive  
2 Drinking in Primary Care: Reliability and Validity of a French Version. *Alcohol Clin Exp Res*  
3 29:2001–2007.
- 4 Godefroy O, Gibbons L, Diouf M, Nyenhuis D, Roussel M, Black S, Bugnicourt JM,  
5 GREFEX study group (2014) Validation of an integrated method for determining cognitive  
6 ability: Implications for routine assessments and clinical trials. *Cortex J Devoted Study Nerv*  
7 *Syst Behav* 54:51–62.
- 8 Goldstein RZ, Leskovjan AC, Hoff AL, Hitzemann R, Bashan F, Khalsa SS, Wang GJ,  
9 Fowler JS, Volkow ND (2004) Severity of neuropsychological impairment in cocaine and  
10 alcohol addiction: association with metabolism in the prefrontal cortex. *Neuropsychologia*  
11 42:1447–1458.
- 12 Green A, Garrick T, Sheedy D, Blake H, Shores EA, Harper C (2010) The Effect of  
13 Moderate to Heavy Alcohol Consumption on Neuropsychological Performance as Measured  
14 by the Repeatable Battery for the Assessment of Neuropsychological Status. *Alcohol Clin*  
15 *Exp Res* 34:443–450.
- 16 Grohman K, Fals-Stewart W (2004) The detection of cognitive impairment among  
17 substance-abusing patients: the accuracy of the neuropsychological assessment battery-  
18 screening module. *Exp Clin Psychopharmacol* 12:200–207.
- 19 Heaton RK, Thompson LL, Nelson LM, Filley CM, Franklin GM (1990) Brief and  
20 intermediate length screening of neuropsychological impairment in multiple sclerosis. In:  
21 *Neurobehavioral Aspects of Multiple Sclerosis* New York: Oxford University Press. p. 149–  
22 160.
- 23 Ihara H, Berrios GE, London M (2000) Group and case study of the dysexecutive  
24 syndrome in alcoholism without amnesia. *J Neurol Neurosurg Psychiatry* 68:731–737.
- 25 Kaiser HF (1960) The application of electronic computers to factor analysis. *Educ Psychol*  
26 *Meas* 20:245–276.
- 27 Kalafat M, Hugonot-Diener L, Poitrenaud J (2003) Standardisation et étalonnage français  
28 du Mini Mental State (MMS) version GRÉCO. *Rev Neuropsychol* 13:209–236.
- 29 Kiernan RJ, Mueller J, Langston JW, Van Dyke C (1987) The Neurobehavioral Cognitive  
30 Status Examination: a brief but quantitative approach to cognitive assessment. *Ann Intern*  
31 *Med* 107:481–485.
- 32 Kopelman MD, Thomson AD, Guerrini I, Marshall EJ (2009) The Korsakoff syndrome:  
33 clinical aspects, psychology and treatment. *Alcohol Alcohol* 44:148.
- 34 Le Berre A-P, Pinon K, Vabret F, Pitel A-L, Allain P, Eustache F, Beaudieux H (2010)  
35 Study of Metamemory in Patients With Chronic Alcoholism Using a Feeling-of-Knowing  
36 Episodic Memory Task. *Alcohol Clin Exp Res* 34:1888–1898.
- 37 Lucas JA, Ivnik RJ, Smith GE, Bohac DL, Tangalos EG, Kokmen E, Graff-Radford NR,  
38 Petersen RC (1998) Normative data for the Mattis Dementia Rating Scale. *J Clin Exp*  
39 *Neuropsychol* 20:536–547.
- 40 Lusher J, Chandler C, Ball D (2004) Alcohol dependence and the alcohol Stroop paradigm:  
41 evidence and issues. *Drug Alcohol Depend* 75:225–231.
- 42 Mann K, Günther A, Stetter F, Ackermann K (1999) Rapid recovery from cognitive  
43 deficits in abstinent alcoholics: a controlled test-retest study. *Alcohol Alcohol Oxf Oxf*  
44 *34:567–574*.
- 45 Mattis S, Inc PAR (1988) DRS, Dementia Rating Scale Psychological Assessment  
46 Resources, Incorporated.
- 47 Müller-Oehring EM, Schulte T, Fama R, Pfefferbaum A, Sullivan EV (2009) Global-local  
48 interference is related to callosal compromise in alcoholism: a behavior-DTI association  
49 study. *Alcohol Clin Exp Res* 33:477–489.
- 50 Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I,

- 1 Cummings JL, Chertkow H (2005) The Montreal Cognitive Assessment, MoCA: a brief  
2 screening tool for mild cognitive impairment. *J Am Geriatr Soc* 53:695–699.
- 3 Noël X, Bechara A, Dan B, Hanak C, Verbanck P (2007) Response inhibition deficit is  
4 involved in poor decision making under risk in nonamnesic individuals with alcoholism.  
5 *Neuropsychology* 21:778.
- 6 Noël X, Van der Linden M, Brevers D, Campanella S, Hanak C, Kornreich C, Verbanck P  
7 (2012) The contribution of executive functions deficits to impaired episodic memory in  
8 individuals with alcoholism. *Psychiatry Res*.
- 9 Osterrieth PA (1944) Le test de copie d'une figure complexe; contribution à l'étude de la  
10 perception et de la mémoire. [Test of copying a complex figure; contribution to the study of  
11 perception and memory.]. *Arch Psychol* 30:206–356.
- 12 Pitel AL, Witkowski T, Vabret F, Guillery-Girard B, Desgranges B, Eustache F,  
13 Beaunieux H (2007) Effect of Episodic and Working Memory Impairments on Semantic and  
14 Cognitive Procedural Learning at Alcohol Treatment Entry. *Alcohol Clin Exp Res* 31:238–  
15 248.
- 16 Pitel A-L, Zahr NM, Jackson K, Sassoon SA, Rosenbloom MJ, Pfefferbaum A, Sullivan  
17 EV (2011) Signs of preclinical Wernicke's encephalopathy and thiamine levels as predictors  
18 of neuropsychological deficits in alcoholism without Korsakoff's syndrome.  
19 *Neuropsychopharmacol Off Publ Am Coll Neuropsychopharmacol* 36:580–588.
- 20 Randolph C, Tierney MC, Mohr E, Chase TN (1998) The Repeatable Battery for the  
21 Assessment of Neuropsychological Status (RBANS): preliminary clinical validity. *J Clin Exp*  
22 *Neuropsychol* 20:310–319.
- 23 Reitan RM (1955) The relation of the trail making test to organic brain damage. *J Consult*  
24 *Psychol* 19:393–394.
- 25 Rosenbloom MJ, Rohlifing T, O'Reilly AW, Sassoon SA, Pfefferbaum A, Sullivan EV  
26 (2007) Improvement in memory and static balance with abstinence in alcoholic men and  
27 women: selective relations with change in brain structure. *Psychiatry Res* 155:91–102.
- 28 Shulman KI (2000) Clock-drawing: is it the ideal cognitive screening test? *Int J Geriatr*  
29 *Psychiatry* 15:548–561.
- 30 Stroop JR (1935) Studies of interference in serial verbal reactions. *J Exp Psychol* 18:643–  
31 662.
- 32 Sullivan EV, Rosenbloom MJ, Pfefferbaum A (2000) Pattern of motor and cognitive  
33 deficits in detoxified alcoholic men. *Alcohol Clin Exp Res* 24:611–621.
- 34 Thomson AD (2000) Mechanisms of vitamin deficiency in chronic alcohol misusers and  
35 the development of the Wernicke-Korsakoff syndrome. *Alcohol Alcohol Oxf Oxf Suppl*  
36 35:2–7.
- 37 Thurstone L (1944) A factorial study of perception Chicago, IL, US: University of  
38 Chicago Press.
- 39 Uekermann J, Channon S, Winkel K, Schlebusch P, Daum I (2007) Theory of mind,  
40 humour processing and executive functioning in alcoholism. *Addiction* 102:232–240.
- 41 Wechsler D (2001a) MEM-III, Échelle clinique de mémoire de Wechsler: manuel les Éd.  
42 du Centre de psychologie appliquée.
- 43 Wechsler D (2001b) WAIS-III: Wechsler Adult Intelligence Scale, Third Edition :  
44 Canadian Technical Manual Harcourt Canada.
- 45 Wester AJ, Roy J, Kessels RPC, Egger JIM (2013) The Montreal Cognitive Assessment  
46 (MoCA) as a measure of severity of amnesia in patients with alcohol-related cognitive  
47 impairments and Korsakoff syndrome. *Clin Neuropsychiatry* 10:134.
- 48 White T, Stern R (2003) NAB Neuropsychological Assessment battery Psychological  
49 Assessment Resources, Incorporated.
- 50

1 **TABLES**

2

Table 1: Participants' Demographic Characteristics

	Alcoholic patients	Control participants		p-values
Number	73	254	58 <sup>1</sup>	
Men/women	53/20	154/100	27/31	0.06; 0.002*
Age (years)	45.47 ± 8.85	43.22 ± 9.32	42.81 ± 10.86	0.07; 0.13
Range	26-67	20-66	31-60	
Education (years of schooling)	11.18 ± 1.69	12.83 ± 2.61	12.76 ± 2.47	<0.001*; <0.001
Range	8-15	6-21	5-18	
MMSE	27.90 ± 1.90	-	28.79 ± 1.13	0.002*
Range	21-30		26-30	
DRS Mattis	136.96 ± 6.07	-	141.76 ± 2.31	<0.001*
Range	115-144		134-144	
AUDIT	29.90 ± 6.33	3.07 ± 1.68	2.84 ± 1.68	<0.001*; <0.001
Range	9-40	0-6	0-6	
Days of sobriety before inclusion	13.17 ± 6.73	-	-	
Range	4-50			
Alcohol use (years)	30.25 ± 9.07	-	-	
Range	10-51			
Alcohol misuse (years)	17.49 ± 9.23	-	-	
Range	5-43			
Daily alcohol consumption (units)	23.48 ± 35.36	-	-	
Range	0-300			
Number of withdrawals	3.52 ± 6.05	-	-	
Range	0-52			

3 Data are shown as means ± standard deviation. Only 58 of the control participants underwent the extensive  
 4 neuropsychological battery. AUDIT = Alcohol Use Disorders Identification Test.

5 \* Significant difference between alcoholic patients and control participants (n=254 ; n=58) at p<0.05 (t-tests)

6

1 Table 2: Cognitive and Motor Domains Assessed by the Brief Evaluation of Alcohol-Related  
 2 Neuropsychological Impairments (BEARNI) and the Extensive Neuropsychological Battery

Domains	BEARNI subtests	Neuropsychological battery tests
<i>Verbal episodic memory</i>	Learning	CVLT Learning (sum of correct responses across 5 trials)
	Delayed free recall	CVLT Delayed free recall (number of correct responses)
		CVLT Delayed free recall (number of errors)
<i>Working memory</i>	Alphabetical span	Verbal Span (forward span)
		Verbal Span (backward span)
		Letter-Number Sequencing (standard score)
		Visuospatial Span (forward span)
		Visuospatial Span (backward span)
<i>Executive function</i>	Alternating fluency	TMT Part B - Part A (time)
		Fluency task (letter <i>p</i> ; number of correct responses)
		Fluency task (animal category; number of correct responses)
		Stroop Interference-Naming (time)
		RFFT (total design)
		RFFT (total strategies)
<i>Visuospatial abilities</i>	Visuospatial	ROCF (copy accuracy /36)
	(hidden figures)	
<i>Ataxia</i>	Ataxia (balance)	Stand in Romberg position (one foot in front of the other placed heel to toe) (two 60-s trials; eyes open)
		Stand in Romberg position (one foot in front of the other placed heel to toe) (two 60-s trials; eyes closed)
		Walk heel-to-toe (two 10-step trials, eyes open)
		Walk heel-to-toe (two 10-step trials, eyes closed)

3 CVLT = California Verbal Learning Test; TMT B-A = Trail Making Test Part A minus Part B; RFFT = Ruff

4 Figural Fluency Test; ROCF = Rey Osterrieth Complex Figure.

5

1

Table 3 Results of the Exploratory Factor Analysis (EFA)

Variables	Factors				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
<b>Eigenvalues</b>	6.70	2.24	1.65	1.31	1.10
<b>Explained variance</b>	30.45%	10.18%	7.48%	5.97%	5.00%
BEARNI Delayed free recall			0.49*		
BEARNI Alphabetical span					0.69
BEARNI Fluency				0.57	
BEARNI Visuospatial	0.67				
BEARNI Ataxia		0.63			
Feet placed heel-to-toe (eyes open)		0.74			
Feet placed heel-to-toe (eyes closed)		0.77			
Walk heel-to-toe (eyes open)		0.78			
Walk heel-to-toe (eyes closed)		0.68			
CVLT Learning			0.85		
CVLT Delayed free recall (correct responses)			0.80		
CVLT Delayed free recall (errors)			-0.75		
Letter ( <i>p</i> ) fluency				0.67	
Categorical (animals) fluency				0.78	
Verbal forward span					0.69
Verbal backward span					0.73
Letter-Number Sequencing					0.77
ROCF (copy accuracy)	0.30*				
Visuospatial forward span	0.69				
Visuospatial backward span	0.72				
Stroop Interference-Naming (time)	-0.61				
TMT B-A (time)	-0.47*				
RFFT (total strategies)	0.59				
RFFT( total design)	0.62				

2 Marked factor loadings with significance threshold set at 0.5. \* Variable not significant at established threshold of 0.5, but  
3 assigned to the factor on which it most highly loaded. CVLT = California Verbal Learning Test; ROCF = Rey Osterrieth  
4 Complex Figure; TMT B-A = Trail Making Test Part A minus Part B; RFFT = Ruff Figural Fluency Test.

5



1 Table 4: Summary of Total BEARNI Cut-Off Scores Adjusted for Education Level

BEARNI total score	Criteria	Education (years of schooling)	
		≤ 12	> 12
Total score /30 (cognitive functions plus ataxia)	Mild impairment	≤ 19	≤ 21
	Moderate-to-severe impairment	≤ 16	≤ 17
Total cognitive score /22 (excluding the Ataxia subtest)	Mild impairment	≤ 15	≤ 16
	Moderate-to-severe impairment	≤ 11.5	≤ 12.5

2

3

For Review Only

1 Table 5: Psychometric properties of the BEARNI, MMSE (Folstein et al., 1975; Kalafat et al.,  
2 2003) and Mattis DRS (Lucas et al., 1998; Mattis and Inc, 1988)

Psychometric properties	BEARNI (total score)	BEARNI (total "cognitive" score)	MMSE	Mattis DRS
<b><i>Mild impairment</i></b>				
Sensitivity	98.41 %	93.44 %	9.52 %	7.94 %
Specificity	50.00 %	50.00 %	90.00 %	90.00 %
Positive predictive value	92.54 %	90.48 %	85.71 %	83.93 %
Negative predictive value	83.33 %	60.00 %	13.64 %	13.43 %
Yule's Q coefficient	0.97	0.87	0.03	0.13
Diagnostic accuracy	91.78 %	86.30 %	20.54 %	19.17 %
<b><i>Moderate-to-severe impairments</i></b>				
Sensitivity	94.87 %	81.82 %	7.69 %	7.69 %
Specificity	70.59 %	85.00 %	88.24 %	91.18 %
Positive predictive value	78.72 %	81.82 %	42.86 %	50.00 %
Negative predictive value	92.31 %	85.00 %	45.45 %	46.27 %
Yule's Q coefficient	0.96	0.92	0.23	0.07
Diagnostic accuracy	83.56 %	83.56 %	24.09	46.57 %

3

4

1 Table 6: Predictive Value of the Cut-Off Scores of Each BEARNI Subtest for Detecting the  
 2 Neuropsychological Impairments Identified by the Extensive Battery

NP battery tasks	Alcoholic patients		Controls	Statistics	Tukey post hoc
	AL <sup>-</sup>	AL <sup>+</sup>	(n = 58) HC		
<i>Episodic memory (BEARNI cut-off score ≤ 2)</i>					
CVLT Learning	-1.41 ± 1.23	-0.24 ± 1.14	0.00 ± 1.00	$F_{(2,128)} = 9.02$ ; $p < 0.001^*$	AL <sup>-</sup> < AL <sup>+</sup> = NC
CVLT Delayed recall (correct response)	-1.64 ± 1.20	-0.55 ± 1.56	0.00 ± 0.98	$F_{(2,128)} = 9.12$ ; $p < 0.001^*$	AL <sup>-</sup> < AL <sup>+</sup> = NC
CVLT Delayed recall (error)	-1.36 ± 2.02	-0.24 ± 1.53	0.00 ± 0.99	$F_{(2,128)} = 5.15$ ; $p = 0.007^*$	AL <sup>-</sup> < AL <sup>+</sup> = NC
<i>Verbal working memory (BEARNI cut-off score ≤ 2.5)</i>					
Verbal forward span	-1.01 ± 0.94	-0.23 ± 0.88	0.00 ± 1.00	$F_{(2,128)} = 9.25$ ; $p < 0.001^*$	AL <sup>-</sup> < AL <sup>+</sup> = NC
Verbal backward span	-1.41 ± 0.64	-0.50 ± 0.90	0.00 ± 1.00	$F_{(2,128)} = 19.68$ ; $p < 0.001^*$	AL <sup>-</sup> < AL <sup>+</sup> < NC
Letter-Number Sequencing	-1.69 ± 0.78	-0.21 ± 0.80	0.00 ± 1.00	$F_{(2,128)} = 29.73$ ; $p < 0.001^*$	AL <sup>-</sup> < AL <sup>+</sup> = NC
<i>Flexibility (BEARNI cut-off score ≤ 2)</i>					
Letter (p) fluency	-0.66 ± 0.93	0.00 ± 0.93	0.00 ± 1.00	$F_{(2,128)} = 3.30$ ; $p = 0.04$	AL <sup>-</sup> < AL <sup>+</sup> = NC
Categorical (animals) fluency	-0.96 ± 1.20	-0.32 ± 1.20	0.00 ± 1.00	$F_{(2,128)} = 5.20$ ; $p = 0.007^*$	AL <sup>-</sup> < AL <sup>+</sup> = NC
<i>Visuospatial abilities (BEARNI cut-off score ≤ 1)</i>					
ROCF (copy accuracy)	-0.61 ± 1.11	-0.22 ± .092	0.00 ± 1.00	$F_{(2,128)} = 3.86$ ; $p = 0.02$	AL <sup>-</sup> < NC AL <sup>+</sup> = NC
Visuospatial forward	-0.83 ± 0.67	-0.38 ± 0.93	0.00 ± 1.00	$F_{(2,128)} = 9.12$ ;	AL <sup>-</sup> < AL <sup>+</sup>

span				$p < 0.001^*$	$AL^+ = NC$
Visuospatial	$-0.74 \pm 0.80$	$-0.18 \pm 0.79$	$0.00 \pm 1.00$	$F_{(2,128)} = 7.34;$	$AL^- < AL^+ = NC$
backward span				$p < 0.001^*$	
Stroop Interference-	$-1.97 \pm 3.10$	$-0.50 \pm 1.94$	$0.00 \pm 1.00$	$F_{(2,128)} = 10.42;$	$AL^- < AL^+ = NC$
Naming (time)				$p < 0.001^*$	
TMT Part A-Part B	$-2.77 \pm 6.57$	$-0.45 \pm 1.40$	$0.00 \pm 1.00$	$F_{(2,128)} = 7.20;$	$AL^- < AL^+ = NC$
(time)				$p = 0.001^*$	
RFFT	$-0.73 \pm 0.74$	$-0.44 \pm 0.89$	$0.00 \pm 1.00$	$F_{(2,128)} = 2.59;$	<i>ns</i>
(total strategies)				$p = 0.07$	
RFFT( total design)	$-1.10 \pm 1.02$	$-0.18 \pm 1.21$	$0.00 \pm 1.00$	$F_{(2,128)} = 11.64;$	$AL^- < AL^+ = NC$
				$p < 0.001^*$	
<b><i>Ataxia (BEARNI cut-off score <math>\leq 3</math>)</i></b>					
Heel-to-toe	$-1.68 \pm 2.15$	$-0.06 \pm 0.89$	$0.00 \pm 1.00$	$F_{(2,128)} = 18.68;$	$AL^- < AL^+ = NC$
(eyes open)				$p < 0.001^*$	
Heel-to-toe	$-0.92 \pm 0.94$	$-0.37 \pm 0.92$	$0.00 \pm 1.00$	$F_{(2,128)} = 10.19;$	$AL^- < AL^+ < NC$
(eyes closed)				$p < 0.001^*$	
Walk heel-to-toe	$-1.56 \pm 2.05$	$-0.21 \pm 1.21$	$0.00 \pm 1.00$	$F_{(2,128)} = 14.57;$	$AL^- < AL^+ = NC$
(eyes open)				$p < 0.001^*$	
Walk heel-to-toe	$-0.92 \pm 0.82$	$0.01 \pm 1.12$	$0.00 \pm 1.00$	$F_{(2,128)} = 11.61;$	$AL^- < AL^+ = NC$
(eyes closed)				$p < 0.001^*$	

- 1 Data are shown as standard residuals (i.e., *z* scores) mean  $\pm$  standard deviation.
- 2 NP = neuropsychological; CVLT = California Verbal Learning Test; ROCF = Rey Osterrieth Complex Figure;
- 3 TMT B-A = Trail Making Test Part A minus Part B; RFFT = Ruff Figural Fluency Test;
- 4  $AL^+$  = preserved alcoholic patients;  $AL^-$  = impaired alcoholic patients; HC = healthy controls.
- 5 \* still significant after Bonferroni correction.
- 6 *ns* = not significant ( $p > 0.05$ ).
- 7

1        **FIGURE LEGENDS**

2        Figure 1: Results of the comparison between ALs (in red) and HCs (in black) on each  
3        BEARNI subtest. Data are shown as mean  $\pm$  standard error of mean, taking the significant  
4        effects of age and education into account.  
5        (*ns*: nonsignificant).

6

7        Figure 2: ROC curve analyses for determining the total BEARNI (A and B) and total  
8        cognitive BEARNI (C and D) cut-off scores reflecting mild impairment (A and C) and  
9        moderate-to-severe impairment (B and D).

10

11        Figure 3: Clinical recommendations according to the cognitive status of alcoholic patients at  
12        treatment entry as diagnosed by the BEARNI.

13