COGNITIVE ASPECTS

Performance on an Everyday Life Activity in Persons Diagnosed with Alcohol Dependency Compared to Healthy Controls: Relations between a Computerized Shopping Task and Cognitive and Clinical Variables†

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(*Received* 27 *October* 2011; *accepted* 26 *January* 2012)

Abstract — **Aim:** Persons diagnosed with alcohol dependency often suffer from cognitive impairments. Little is known, however, concerning how these cognitive deficits impact complex, everyday life activities. We set out to better characterize the nature of everyday life difficulties in patients with alcohol dependency using a computerized shopping task. **Methods:** A computerized real-life activity task (shopping task) required participants to shop for a list of eight grocery store items. Twenty individuals diagnosed with alcohol dependency and 20 healthy controls were administered a battery of cognitive tests, clinical scales and the shopping task. **Results:** Performance on the shopping task significantly differentiated patients and healthy controls for several variables and, in particular, for total time. Total time to complete the task correlated significantly with poor performance on measures of processing speed, verbal episodic memory, cognitive flexibility and inhibition. Total time was significantly correlated with poorer everyday life functioning and longer duration of illness. **Conclusion:** This computerized task is a good proxy measure of the level of everyday life and cognitive functioning of persons diagnosed with alcohol dependency.

INTRODUCTION

Persons diagnosed with alcohol dependency often suffer from cognitive impairments such as deficits in processing speed, flexibility, selective attention (Ratti *et al.*, 2002), divided attention (Tedstone and Coyle, 2004), episodic memory (Pitel *et al.*, 2007) and executive functioning, including inhibition (Noël *et al.*, 2001; Ratti *et al.*, 2002), problem-solving (Ratti *et al.*, 2002), planning (Ihara *et al.*, 2000) and working memory (Noël *et al.*, 2001). Moreover, these impairments—and in particular executive functioning deficits—are major predictors of poor psychosocial functioning (Moriyama *et al.*, 2002; Zinn *et al.*, 2004). Executive dysfunction is also a good predictor of relapse as Morrison (2011) recently demonstrated. In this study, cognitive functioning (verbal and non-verbal episodic memory, working memory, flexibility and verbal fluency) was assessed in 34 inpatients a few days after their admission into a detoxification unit. Three months after withdrawal, verbal episodic memory, working memory and flexibility were significantly related to the number of days of drinking after discharge. Furthermore, only flexibility was a significant predictor (based on regression analysis) of the number of days of drinking. The author concluded that executive dysfunction at the end of detoxification is associated with an increased likelihood of relapse and thus that intact executive functioning is important in order to maintain abstinence. Similarly, in Noël *et al.* (2002), 20 detoxified inpatients were administered several cognitive tasks (i.e. working memory, inhibition, abstract reasoning and episodic memory task) and were scanned with single-photon emission computed tomography. Additionally, patients were contacted 2 months after the first testing. Results showed that those patients who relapsed after 2 months demonstrated a significantly lower score on

working memory and inhibition tasks compared with abstinent patients. Moreover, they presented lower cerebral blood flow in the inferior frontal gyrus. The authors concluded that these deficits may be related to difficulties in maintaining short-term abstinence. In the same vein, Teichner *et al.* (2001) investigated predictors of attainment of cognitive behavioral treatment objectives. They administered a cognitive screening battery and clinical scales after acute detoxification, but before daily group therapy. They found that working memory and level of depression were significant predictors of treatment success, and concluded that these domains have a significant impact on substance abuse treatment success.

Although there seems to be a link between cognitive deficits (in particular executive deficits) and clinical variables (such as relapse-rates) in persons suffering from alcohol dependency, the nature of this relationship is not entirely clear. One possible interpretation is that the transition from a relatively structured environment (i.e. such as one in a hospital setting during detoxification) to an everyday life setting is particularly difficult for patients with alcohol dependency, as this type of transition requires relatively intact executive functioning, resulting in relapse. According to Tiffany (1990), alcoholic consumption behaviors tend to become automatic (i.e. action schemata), effortless, stimulus-bound and initiated and completed without intention. On the other hand, maintaining abstinence behaviors is non-automatic, consciously controlled, effortful and directed against the execution of automatic alcohol consumption schemata. Furthermore, the identification of risk situations and the establishment of facing strategies all involve executive skills such as working memory, planning and the management of dual tasks. Moreover, control of alcohol-related thinking and behaviors involves inhibition and flexibility ability. Thus,

executive functioning appears to be a central feature of avoiding relapse (Noël *et al.*, 2008).

Studies have not, however, examined how these cognitive deficits may impact real-life activities and functioning in patients with alcohol dependency. This issue has been examined for other patients, such as those with schizophrenia and bipolar disorder. Semkovska *et al.* (2004) and Rempfer *et al.* (2003) directly observed patients with schizophrenia while they performed everyday life activities (preparing a meal and shopping, respectively) in real situations (a kitchen and grocery store, respectively). Results from these studies reported significant correlations between the everyday tasks and performance on standardized cognitive tests. Other studies have used performance-based measures of functional living skills, such as the short version of the University of California San Diego Performances-Based Skills Assessment (UPSA-B; Patterson *et al.*, 2001), where participants are required to perform brief and simple everyday tasks in areas of communication (call to reschedule a doctor's appointment, make an emergency call) and finances (count change, read a utility bill). Studies using the UPSA-B (e.g. Bowie *et al.*, 2010) have similarly observed relations between performance on these tasks and cognitive variables in patients with schizophrenia and bipolar disorder. Taken together, these studies confirm the close relationship between cognitive deficits and poor performance on simulations of everyday life activities.

There are, however, a number of limits associated with performance- and observation-based measures. In regard to performance-based measures, participants are asked to perform relatively simple tasks, which do not reflect the complex, multi-tasking activities often present in everyday life. Concerning observation-based assessment, it may prove highly difficult to carry out such assessments due to practical constraints (e.g. finding the time and opportunity to observe patients) and human resource limits (e.g. having the available personnel that can leave the clinical setting to perform this type of assessment). Furthermore, when observing patients perform specific activities, a series of variables cannot be controlled (e.g. in the case of a shopping task, variations in the number of shoppers, the amount of noise and other distractions). Moreover, it is difficult to obtain precise measures of performances when conducting qualitative observations and, additionally, only a limited number of variables can be encoded and calculated as there are constraints as to how much the observer can note down.

One way of addressing many of these limits is to develop computerized versions of more complex tasks (that more accurately reflect everyday life activities), and furthermore where the environment is the same for all participants and where a large number of variables can be calculated in a quantitative and precise manner. In this context, Larøi *et al.* (2010) developed a computerized real-life activity task (shopping task), where participants are required to shop for a list of grocery store items. Thirty individuals diagnosed with schizophrenia and 30 healthy controls were administered an extensive battery of cognitive tests and the computerized shopping task. Performances on the computerized shopping task significantly differentiated patients and healthy controls for several variables. Moreover, performance on these variables from the shopping task were significantly correlated with a number of cognitive (measuring verbal episodic

memory, cognitive flexibility, planning, processing speed and inhibition) and clinical (symptomatology, social and personal functioning) measures. Similarly, Laloyaux *et al.* (submitted) administered the same computerized shopping task to a group of 21 individuals diagnosed with bipolar disorder and 21 healthy controls. Comparable to Larøi *et al.* (2010), performance on the shopping task significantly differentiated patients and healthy controls for several variables, and these variables on the shopping task were significantly correlated with cognitive (verbal episodic memory, cognitive flexibility, planning, processing speed and inhibition) and clinical (duration of illness, personal and social functioning) measures. Findings from these studies suggest that computerized tasks, such as the shopping task, are good proxy measures of cognitive and functional functioning in patients with various psychopathologies, such as schizophrenia and bipolar disorder.

In the present study, we wished to contribute to a better characterization of the nature of everyday life difficulties in patients with alcohol dependency. To the best of our knowledge, this is the first time this issue has been examined in the scientific literature. In particular, we wished to examine relations between performances on the computerized shopping task, and cognitive and clinical variables, in patients compared with a group of healthy controls. It was hypothesized that the performance on the shopping task would differentiate the patients with alcohol dependency from the healthy controls. Furthermore, we hypothesized significant correlations between patients' performance on the shopping task and measures of cognitive testing (in particular, with tests assessing memory, processing speed, executive functions) and clinical variables (in particular, personal and social functioning).

MATERIALS AND METHODS

Subject groups

Twenty persons diagnosed with alcohol dependency according to DSM-IV criteria (American Psychiatric Association, 1994) were included. Patients with diagnosis other than alcohol dependence on Axis I of the DSM-IV were excluded (except caffeine and nicotine dependence). Other reasons for exclusion were the presence of neurological disorder, including Wernicke–Korsakoff syndrome and head injury. All patients were hospitalized for detoxification at the moment of testing. Before withdrawal, participants reported a mean alcohol consumption of 279.54 g (SD = 136.33) per day during a mean period of 15.7 (SD = 11.31) years. The detoxification regime consisted of vitamin B, acamprosate and diazepam (40 mg per day to begin with, followed by decreased doses until full stop during a period of 10 days). Testing took place after the detoxification program and none of the patients were taking diazepam for at least 7 days. Subjects were abstinent from alcohol for a minimum of 19 days and maximum of 151 days (mean = 54.80 days, SD = 35.72).

Twenty healthy controls were also included who were matched as closely as possible according to sex, age and educational level. They did not have any psychiatric or neurological disorders. All participants were also asked to indicate the frequency and their level of familiarity with video

games and with shopping in a supermarket. Participants provided written informed consent and the project was approved by the local ethics committee. Participant characteristics are presented in Table 1. Based on independent *t*-tests, there were no significant differences between the two groups for age, education, estimated premorbid IQ and familiarity with video games. However, there were significant group differences for level of depression ($t = 4.91$), familiarity with shopping ($t = -2.18$) and scores on an everyday activities scale ($t = 5.98$).

Measures

Computerized shopping task

All participants completed the computerized shopping task. The task was programmed in C# and DirectX 9. All participants first completed a learning phase and thereafter completed the shopping task.

Learning phase. The goal of this learning phase was to systematically familiarize all the participants with the basic actions and functions that are required in the shopping task, and to do so successfully (i.e. without committing any errors). The learning phase was based on the principles of errorless learning. In this context, the learning phase consisted of carrying out task-relevant actions (i.e. those that are required during the shopping task) in a progressive and error-limiting manner. That is, to begin with, participants were required to perform very simple actions followed by gradually more demanding and complex actions. Furthermore, when participants performed each action successfully, they proceeded to the next level of the learning phase. Instructions were given both visually (on the screen) and orally (via a computerized voice) throughout the learning phase. If the

participant committed an error at any time during the learning phase, the error was registered, the participant was alerted of this error, the instructions were repeated and the participant was asked to continue until the action was performed without committing an error.

To begin with, the functions of the gamepad were introduced to the participant. This consisted of explaining the functions on the left-hand side of the gamepad, that is, for movement of the computerized person (forward, backwards, left and right) and those on the right-hand side of the gamepad (i.e. buttons A and B), which allow participants to perform various actions (open doors, view lists, open choice-menus, etc.). Specifically, participants were first asked to move the computerized person forwards, backwards, left and right. Participants were then required to go to various boxes and to open and close them. Following this, participants were asked to go to a box, take an object and put the object in a specific place. Subsequently, the task entailed entering a house, going towards a bookshelf and choosing a specific book. The final phase consisted of asking participants to perform a task (paint a room) where they were asked to read a list of the required items (paint, gloves and paintbrush), to go to the shelf and to choose the correct items from the shelf.

The following variables were calculated for the learning phase: total number of correct actions, total number of incorrect actions and total time to complete the learning phase.

Shopping task. After the learning phase, participants were told that the shopping task was to begin. The same gamepad used in the learning phase was also used for the shopping task. The instructions were given orally by a computerized voice and were presented visually on the screen. When the instructions were understood, the participant was invited to

Table 1. Demographic characteristics of participants

	Patients (*n* = 20)		Healthy controls (*n* = 20)	
	Mean (SD)	Min.–max.	Mean (SD)	Min.–max.
Age	46.05 (10.72)	24–63	45.8 (10.63)	25–67
Education (years)	12.35 (3.19)	6–17	12.6 (3.05)	6–18
Sex (F/M)		3/17		3/17
Age of onset of illness	31.6 (9.41)	20–56		
Duration of illness (years)	15.7 (11.31)	4–42		
Daily alcohol consumption (grams per day)	279.54 (136.33)	63.36–512		
Number of alcohol withdrawals	4.05 (3.70)	1–14		
Duration of abstinence (days)	54.80 (35.72)	19–151		
SADQ[a]	31.10 (11.56)	48–10		
BDI[b]	9.15 (6.78)	1–20	1.45 (1.76)**	0–6
AUDIT[c]			4.05 (2.41)	0–7
PSP total[d]	33.15 (11.86)	17–55		
SEA total[e]	69.69 (16.55)	38–95	93.23 (5.97)**	81.32–100
Familiarity shopping	4.45 (2.01)	0–7	5.60 (1.23)*	4–8
Familiarity video games	2.05 (2.43)	0–8	3.40 (2.58)	0–8
IQ (NART[f])	105.29 (5.57)	95.71–116.86	106.70 (6.02)	95.71–116.86

[a]Severity of Alcohol Dependence Questionnaire.
[b]Beck Depression Inventory short-form.
[c]Alcohol Use Disorder Identification.
[d]Personal and Social Performance Scale.
[e]Scale of Everyday Activities.
[f]National Adult Reading Test.
*$P < 0.05$.
**$P < 0.001$.

press a button in order to view the shopping list consisting of eight items, representing different categories (e.g. beverages, meat, fruits and vegetables). The items were: a beverage, four bananas, a pack of washing powder, a magazine, 'Cococake' biscuit, a packet of pasta, a meat and bread. All items were the same for each participant, and there was no time limit. The name of the aisle where the item could be found was written in parentheses next to each article name. Participants were given 20 € in order to make their purchases and were asked not to exceed this sum. The participant pressed a button in order to start the task. During the task, by pressing button A, participants could perform actions including having a close-up of the aisle, putting an item into the shopping cart or putting an article back into the aisle. Furthermore, by pressing button B, participants could consult the list of items and the contents of the shopping cart. Movement of the computerized person was done by using the left-hand side of the gamepad. Music was played in the background throughout the shopping task, which consisted of light, Vivaldi-type, classical music. A certain number of distractors were also provided, which included both visual (non-pertinent articles on sale and the presence of other shoppers) and auditory (loud-speaker announcements) distractors. In particular, this included three people randomly moving around the grocery store, three people standing still in front of an aisle, seven stands with (non-pertinent) items on sale and six different loud-speaker announcements (announcing non-pertinent items for sale) that were presented randomly throughout the shopping task. The grocery store consisted of seven (double-sided) aisles in the center of the grocery store and included the following aisles: stationary, cleaning products, washing powder and toilette paper, perfume and hygienic products, coffee and tea, chocolate and biscuits, cereals and jellies, beverages, wine, meat and fish tins, fruit and vegetable tins, condiments and sauces, pasta and rice, and products on sale. There were also 11 aisles along the wall of the grocery store and included the following aisles: fruits and vegetables, bakery, delicatessen, meat, cheeses, dairy products and frozen food. There were also six stands containing (non-pertinent) items on sale that were located in the corners of the grocery store and at the ends of certain aisles. When the participant approaches the till, a message asking if they are ready to pay for the items appears. If the participant answers 'no', then she/he returns to the grocery store; if the participant replies 'yes', then the task is terminated.

The following variables were calculated for the shopping task: total time to complete the shopping task (in seconds), distance traveled in the supermarket (in meters), number of correct items, number of intrusions (non-target items), number of missed shelves (number of times a person went towards a pertinent aisle but did not approach the shelf despite it containing a pertinent item), number of corrected errors (wrong item put in the caddy then put back on the shelf), number of items from the list bought more than once, number of items omitted from the shopping list, aisle redundancy (number of times in the same grocery aisle), shelf redundancy (number of times the same shelf is visualized), number of times a non-pertinent shelf was visualized, number of times a pertinent shelf was visualized without picking up the pertinent item, number of times a participant consulted the shopping list, total time spent consulting the shopping list (in seconds), mean time spent consulting the shopping list (in seconds), number of times a participant consulted the shopping cart, total time spent consulting the shopping cart (in seconds), mean time spent consulting the shopping cart (in seconds), number of times the person went to the till and total amount of purchase (Euros).

Cognitive measures

Patients were also assessed with an extensive battery of well-known, standardized cognitive tests. The choice of tests was based on the major cognitive functions implicated in the shopping task: participants are required to create a plan of action (planning), to maintain this plan in mind throughout the task (memory), to efficiently explore the grocery store in an organized manner (planning), to try to remember as many items on the shopping list as possible (memory), to inhibit irrelevant stimuli during the task (inhibition), to look for and localize required items in the aisle (selective attention), and to continuously shift between internal (internal thoughts) and external (stimuli presented in the environment) modes (cognitive flexibility).

- Pre-morbid IQ: National Adult Reading Test (NART; Nelson and O'Connell, 1978; Mackinnon and Mulligan, 2005).
- Processing speed: WAIS Processing speed index (Wechsler, 2000; scores on Digit symbol and Symbol search).
- Working memory: Digit span (Wechsler, 2001; backward span).
- Selective attention: The D2 Test of Attention (Brickenkamp, 1966; total number of errors and omitted stimuli).
- Verbal episodic memory: California Verbal Learning Test (CVLT; Delis et al., 1988; Poitenaud et al., 2007; total recall 1–5).
- Executive functions: Planning: Zoo map (Behavioral Assessment of the Dysexecutive Syndrome test battery; Wilson et al., 1996; execution time in seconds); Cognitive flexibility: Trail Making Test (TMT; Army Individual Test Battery, 1944; time in seconds on Part B minus time on Part A); Inhibition: Stroop time interference factor (Golden, 1978; time interference in seconds minus color naming time).

Clinical measures

All patients were evaluated with the Severity of Alcohol Dependence Questionnaire (SADQ; Stockwell et al., 1994), the Personal and Social Performance Scale (PSP; Morosini et al., 2000), the Beck Depression Inventory short-form (BDI-SF; Beck and Steer, 1993) and the Scale of Everyday Activities (SEA). The control subjects were evaluated with the Alcohol Use Disorder Identification (AUDIT; Saunders et al., 1993), the BDI-SF and the SEA. The AUDIT is a self-assessment questionnaire that detects high-risk or damaging alcohol consumption habits. The cut-off score for the AUDIT is 8. None of the control subjects attained this score and the mean score on the AUDIT was 4.05 (see Table 1). The SADQ is a 20-item clinical screening tool designed by the World Health Organization to measure the presence and severity of alcohol dependence. It is divided into five sections (physical withdrawal symptoms, affective withdrawal

symptoms, craving and relief drinking, typical daily consumption, reinstatement of dependence after a period of abstinence). Each item is scored on a 4-point scale, giving a possible range of 0–60. The PSP is a global measure of personal and social functioning based on four domains of function (self-care, socially useful activities such as work and studies, personal and social relationships as well as disturbing and aggressive behavior). Scores may vary from 0 to 100, with a higher score indicating a higher level of social and personal functioning. The SEA was developed by the authors based on existing standard and validated measures of everyday life functioning while at the same time addressing some of their limits (e.g. lack of specificity, dichotomous answering, long administration time). This self-assessment questionnaire is divided into 16 domains: work, leisure activities, management of administrative tasks, management of financial tasks, management of dangerous situations, transportation, personal care, food management, social network, communication, orientation, housekeeping, household chores, shopping skills, use of electronic domestic devices and use of electronic media devices. Each domain contains five questions, and participants are asked to answer on a 5-point Likert scale concerning the past 2 months. If they are not concerned with an item, she/he may answer 'not applicable'. High scores represent high levels of independency.

All clinical ratings were made during the same period, that is—after administration of cognitive assessment and the computerized shopping task. The time between administration of the cognitive battery and the computerized shopping task never exceeded 8 days.

Statistical analysis

Demographic variables were analyzed with Student's *t*-test. As there was a significant difference between the two groups concerning the level of shopping familiarity (see Table 1), all analyses were carried out while controlling for this variable [analysis of covariance (ANCOVA)]. Alpha was set at 0.05 and due to the large number of variables for the shopping phase, Bonferroni correction was carried out. Correlations were made using Pearson analysis.

RESULTS

Patients and healthy controls were compared concerning their performances on the learning phase (Table 2). These analyses revealed that performances on the learning task significantly differentiated patients and healthy controls for the

number of incorrect actions and total time to complete the learning phase.

These variables from the learning phase that significantly differentiated between groups were then correlated with results from cognitive tests and clinical variables. In terms of cognitive tests (Table 3), there were significant correlations between number of incorrect actions and selective attention (D2) and inhibition (Stroop).

In terms of clinical variables (Table 4), there was a significant correlation between total time to complete the learning phase and age of onset of illness, and a statistical tendency for SEA total score. There was also a statistical tendency for the correlation between number of incorrect actions and daily alcohol consumption.

Patients and healthy controls were then compared (ANCOVA) in regard to their performances on the shopping task (Table 5). These analyses revealed that performances on the shopping task significantly differentiated patients and healthy controls for the following variables: total time, distance traveled, number of times a participant went to the till, number of intrusions, number of items bought more than once, number of omitted items and mean time spent consulting the shopping list. Owing to the number of comparisons, Bonferroni correction was carried out, resulting in total time significantly differentiating the two groups.

Correlational analyses between total time and cognitive tests (Table 6) revealed significant correlations with processing

Table 3. Correlations between cognitive variables and performance on the learning phase in the patient group

	Number of incorrect actions	Total time to complete the learning phase
WAIS Processing speed index	−0.07	−0.24
Digit span backward	0.03	−0.01
D2 omissions + errors	0.47*	−0.22
CVLT: total recall 1–5	0.26	0.04
Zoo time (s)	−0.35	0.33
TMT B-A (s)	−0.27	0.07
Stroop time interference factor (s)	0.52*	0.13

$*P < 0.05$.

Table 4. Correlations between clinical variables and performance on the learning phase in the patient group

	Number of incorrect actions	Total time to complete the learning phase
Age of onset of illness	0.16	0.46*
Duration of illness	0.09	0.15
Daily alcohol consumption	−0.40; $P = 0.079$	−0.23
Number of alcohol withdrawals	0.10	0.02
Duration of abstinence	0.04	−0.06
SADQ	0.24	−0.07
BDI	0.07	0.16
PSP total	−0.22	−0.09
SEA total	−0.01	−0.43; $P = 0.056$

$*P < 0.05$.

Table 2. Performance on the learning phase in the two groups

	Patients (SD)	Healthy controls (SD)	$F_{(2,37)}$ group
Number of incorrect actions	14.10 (6.63)	9.95 (3.92)	8.70**
Total time to complete the learning phase	s: 483.35 (149.27)	s: 386.25 (109.16)	5.61*
	Min: 8.06 (2.49)	Min: 6.44 (1.82)	
Number of correct actions	30.75 (0.63)	30.95 (0.22)	0.84

$*P < 0.05$
$**P < 0.01$.

Table 5. Performance on the shopping task in the two groups

	Patients (SD)	Healthy controls (SD)	F (2,37) Group
Total time	s: 1399.85 (446.73)	s: 872.85 (294.00)	13.81***
	Min: 23.33 (7.45)	Min: 14.55 (4.9)	
Number of times went to the till	2.05 (1.31)	1.15 (0.36)	9.61**
Number of intrusions	1.20 (0.95)	0.45 (0.51)	8.06**
Distance traveled (m)	286.80 (116.18)	186.72 (61.86)	7.26**
Number of items bought more than once	0.45 (0.60)	0.05 (0.22)	6.78*
Number of omitted items	1.25 (1.25)	0.50 (0.60)	6.52*
Mean time spent consulting the shopping list (s)	14.94 (6.37)	10.96 (3.42)	4.84*
Total time spent consulting the shopping list (s)	142.05 (81.35)	86.70 (46.17)	3.51
Total time spent consulting the shopping cart (s)	48.85 (44.79)	25.15 (33.47)	3.38
Mean time spent consulting the shopping cart (s)	19.58 (37.09)	8.60 (8.16)	2.92
Number of corrected errors	1.35 (1.66)	0.50 (0.94)	2.69
Number of times a pertinent shelf is visualized without picking up the pertinent item	4.80 (1.90)	5.80 (1.50)	2.55
Aisle redundancy	15.80 (9.51)	10.00 (5.99)	2.45
Number of correct items	7.35 (1.59)	7.60 (0.50)	1.25
Number of missed shelves	4.45 (3.80)	2.70 (2.34)	1.06
Number of times a participant consulted the shopping list	9.95 (5.14)	7.80 (3.00)	0.49
Number of times a participant consulted the shopping cart	3.35 (2.96)	2.30 (1.41)	0.45
Shelf redundancy	2.00 (1.58)	1.65 (1.66)	0.35
Number of times a non-pertinent shelf was visualized	1.90 (1.41)	1.70 (1.49)	0.23
Total amount of purchase (Euros)	20.17 (4.47)	19.50 (3.31)	0.01

*$P < 0.05$.
**$P < 0.01$.
***$P < 0.001$.

Table 6. Correlations between cognitive variables and performance on the shopping task in the patient group

	Total time
WAIS Processing speed index	−0.53*
Digit span backward	−0.37
D2 omissions + errors	0.24
CVLT: total recall 1–5	−0.62**
Zoo time (s)	0.12
TMT B-A (s)	0.44*
Stroop time interference factor (s)	0.55*

*$P < 0.05$.
**$P < 0.01$.

Table 7. Correlations between clinical variables and performance on the shopping task in the patient group

	Total time
Age of onset of illness	0.01
Duration of illness	0.39
Daily alcohol consumption	0.24
Number of alcohol withdrawals	0.04
Duration of abstinence	−0.02
SADQ	0.21
BDI	0.23
PSP total	0.06
SEA total	−0.46*

*$P < 0.05$.

speed (WAIS Processing speed index), verbal episodic memory (CVLT), flexibility (TMT B-A) and inhibition (Stroop).

Total time was then also correlated with clinical variables (Table 7), revealing a significant correlation with SEA total.

Since age of onset of illness was significantly and positively associated with total time to complete the learning phase ($r = 0.46$, $P < 0.05$), we carried out supplementary analyses controlling for the impact of age of onset of illness on other correlational analyses (partial correlations) between performance of the patient group in the learning phase, the shopping task and clinical variables. Results remained basically the same, with some exceptions. That is, concerning the learning phase, results showed a significant correlation between total time to complete the learning phase and duration of illness ($r = 0.50$, $P < 0.05$) (before partial correlation, this correlation was not significant, $r = 0.15$, $P > 0.05$). Concerning the shopping task, results demonstrated a significant correlation between total time and duration of illness ($r = 0.46$, $P < 0.05$) (before partial correlation, this correlation was not significant, $r = 0.39$, $P > 0.05$).

DISCUSSION

The present study examined relations between performances on a real-life computerized shopping task with cognitive and clinical variables in a group of individuals diagnosed with alcohol dependency compared with a group of healthy controls.

Performance in the learning phase significantly differentiated patients and healthy controls for number of incorrect actions and total time to complete the learning phase. Furthermore, these variables correlated significantly with cognitive (selective attention and inhibition) and clinical (age of onset of illness and duration of illness) measures.

Performance on the shopping task significantly differentiated patients and healthy controls for a considerable number of variables (total time, distance traveled, number of intrusions, number of omitted items, number of items bought more than once, mean time spent consulting the shopping list and number of times went to the till) but only total time was still significant after Bonferroni correction. Moreover, total time correlated significantly with cognitive measures,

including processing speed, verbal episodic memory, cognitive flexibility and inhibition. Finally, total time to complete the computerized shopping task was significantly correlated with everyday life activities (i.e. SEA total) and duration of illness.

As expected, groups were differentiated for a certain number of variables and, furthermore, this was the case for both phases (i.e. learning and shopping) of the task. The main objective of the learning phase is to teach participants how to interact with the virtual environment to prepare them for the shopping task. Results from the present study suggest, however, that this phase also provides important information concerning participants' level of everyday and cognitive functioning. In fact, not only did number of incorrect actions and total time significantly differentiate both groups, these variables also correlated significantly with cognitive and clinical variables.

Moreover, it is important to mention that the learning phase and the shopping task differed in terms of their patterns of correlations with both clinical and cognitive variables. This suggests that these two phases are relatively independent and therefore do not necessarily measure the same thing. Furthermore, we have observed similar differing patterns between the two phases with other clinical disorders (e.g. schizophrenia, bipolar disorders) in studies using the same computerized shopping task (unpublished data).

We hypothesized that patients' performance on the shopping task would correlate with measures of memory, processing speed and executive functions. Indeed, total time to perform the shopping task was significantly correlated with memory, processing speed and executive functioning (flexibility and inhibition). Although total time did not significantly correlate with planning ability, there was a significant correlation ($r = 0.55$, $P < 0.05$) between time spent on consulting the shopping list and performance on the planning measure (Zoo map).

Effective shopping behavior requires the involvement of the cognitive functions that were found to be related to the performance on the shopping task (i.e. processing speed, episodic memory, planning, flexibility and inhibition): a novel situation is presented to participants, who are then required to create a plan of action (planning), to maintain this plan in mind throughout the task (memory), to efficiently explore the grocery store in an organized manner (planning), to try to remember as many items on the shopping list as possible (memory), to inhibit irrelevant stimuli during the task (inhibition) and to continuously shift between internal (internal thoughts) and external (stimuli presented to the participant by the computer screen) modes (cognitive flexibility). Interesting to note is that cognitive functioning, and in particular executive functioning (such as cognitive flexibility, planning and inhibition), has been found to be a main predicator of poor psychosocial functioning in alcohol dependency (Moriyama *et al.*, 2002; Zinn *et al.*, 2004) and relapse (Noël *et al.*, 2002; Morrison, 2011).

Finally, performance on the computerized shopping task was significantly correlated with a measure of everyday life activities, suggesting that performance on the computerized shopping task is indeed tapping into patients' level of everyday activities functioning.

As this study is the first of its kind in alcohol dependence, it is not possible to compare the results with previous studies. Nonetheless, a study on patients with schizophrenia (Larøi *et al.*, 2010) and a study on patients with bipolar disorder (Laloyaux *et al.*, submitted) that administered the same computerized shopping task both found that performances on the task significantly distinguished the clinical group from a group of healthy control participants and, furthermore, that performance on the task was associated with cognitive and social functioning, and clinical variables. Interestingly, in both of these studies and in the present study, one variable, namely total time to complete the task, significantly differentiated patients from healthy control subjects and was significantly correlated with a number of cognitive and clinical variables. Therefore, taken together, total time is an important variable for a number of clinical groups, including schizophrenia, bipolar disorder and alcohol dependency.

The SEAs used in the present study has not been validated. However (as mentioned in Materials and Methods), items contained in the SEA were based on existing standard and validated measures of everyday life functioning, while at the same time addressing many of the limits of these questionnaires (e.g. lack of specificity, dichotomous answering, long administration time). Moreover, the SEA total score significantly differentiated patients and controls (Table 1), thus suggesting a certain degree of sensitivity.

CONCLUSION

A computerized shopping task can significantly differentiate patients with alcohol dependency from healthy controls for a number of variables and especially total time. Furthermore, this variable is significantly associated with cognitive and clinical variables, and everyday life functioning. While computerized versions of everyday tasks possess several advantages, clearly, there are differences between such a task and the same task in a natural setting. Thus, a necessary addition to the present study's methodology would be to administer both a real-life shopping task and the computerized shopping task in order to examine the external validity of the computerized shopping task. Such a study is currently underway.

REFERENCES

American Psychiatric Association (1994) *Diagnostic and Statistical Manual of Mental Disorders*, 4th edn. Washington, DC: American Psychiatric Association Press.
Army Individual Test Battery (1944) *Manual of Directions and Scoring*. Washington: War Department, Adjudant General's Office.
Beck AT, Steer RA. (1993) *Beck Depression Inventory Manual*. San Antonio, TX: Psychological Corporation.
Bowie CR, Depp C, McGrath JA *et al.* (2010) Prediction of real-world functional disability in chronic mental disorders: a

comparison of schizophrenia and bipolar disorder. *Am J Psychiatry* **167**:1116–24.

Brickenkamp R. (1966) *Le Test d2 d'attention concentrée*. Paris: Editest.

Delis D, Freeland J, Kramer J *et al*. (1988) Integrating clinical assessment with cognitive neuroscience: construct validation of California Verbal Learning Test. *J Consult Clin Psychol* **56**:123–30.

Golden CJ. (1978) *Stroop Color and Word Test: A Manual for Clinical and Experimental Uses*. Chicago: Skoelting.

Ihara H, Berrios GE, London M. (2000) Group and case study of the dysexecutive syndrome in alcoholism without amnesia. *J Neurol Neurosurg Psychiatry* **68**:731–7.

Larøi F, Canlaire J, Mourad H *et al*. (2010) Relations between a computerized shopping task and cognitive tests in a group of persons diagnosed with schizophrenia compared with healthy controls. *J Int Neuropsychol Soc* **16**:180–9.

Mackinnon A, Mulligan R. (2005) Estimation de l'intelligence prémorbide chez les francophones. *Encephale* **31**:31–43.

Moriyama Y, Mimura M, Kato M *et al*. (2002) Executive dysfunction and clinical outcome in chronic alcoholics. *Alcohol Clin Exp Res* **26**:1239–44.

Morosini PL, Magliano L, Brambilla L *et al*. (2000) Development, reliability and acceptability of a new version of the DSM-IV Social and Occupational Functioning Assessment Scale (SOFAS) to assess routine social functioning. *Acta Psychiatr Scand* **101**:323–9.

Morrison F. (2011) Cognitive impairment and relapse following in-patient detoxification in severe alcohol dependence. *Int J Ment Health Addict* **9**:151–61.

Nelson HE, O'Connell A. (1978) Dementia, the estimation of pre-morbid intelligence levels using the New Adult Reading Test. *Cortex* **14**:234–44.

Noël X, Paternot J, Van der Linden M *et al*. (2001) Correlations between inhibition, working memory and delimited frontal area blood flow measured by 99MT Tv-Bicisate SPECT in alcohol-dependent patients. *Alcohol Alcohol* **36**:556–63.

Noël X, Sferrazza R, Van der Linden M *et al*. (2002) Contribution of frontal cerebral blood flow measured by ^{99m}Tc-Bicisate SPECT and executive function deficits to predicting treatment outcome in alcohol-dependent patients. *Alcohol Alcohol* **37**:347–54.

Noël X, Van der Linden M, Verbanck P. (2008) Une approche cognitive des personnes mésusant de substances psychoactives. In Van der Linden M, Ceschi G (eds). *Traité de psychopathologie cognitive, tome II*. Marseille, France: Solal, 283–343.

Patterson TL, Goldman S, McKibbin CL *et al*. (2001) UCSD Performance-Based Skills Assessment: Development of a new measure of everyday functioning for severely mentally ill adults. *Schizophr Bull* **27**:235–45.

Pitel A-L, Beaunieux H, Witkowski T *et al*. (2007) Genuine episodic memory deficits and executive dysfunctions in alcoholics early in abstinence. *Alcohol Clin Exp Res* **21**:1169–78.

Poitenaud J, Deweer B, Kalafat M *et al*. (2007) *Adaptation en langue française du California Verbal Learning Test*. Paris: Les Editions du Centre de Psychologie Appliquée.

Ratti MT, Bo P, Giardini A *et al*. (2002) Chronic alcoholism and the frontal lobe: which executive functions are impaired? *Acta Neurol Scand* **105**:276–81.

Rempfer M, Hamera E, Brown C *et al*. (2003) The relations between cognition and the independent living skill of shopping in people with schizophrenia. *Psychiatry Res* **117**:103–12.

Saunders JB, Aasland OG, Babor TF *et al*. (1993) Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption. *Addiction* **88**:791–804.

Semkovska M, Bédard MA, Godbout L *et al*. (2004) Assessment of executive dysfunction during activities of daily living in schizophrenia. *Schizophr Res* **69**:289–300.

Stockwell T, Sitharthan T, McGrath D *et al*. (1994) The measurement of alcohol dependence and impaired control in community samples. *Addiction* **89**:167–74.

Tedstone D, Coyle K. (2004) Cognitive impairments in sober alcoholics: performance on selective and divided attention tasks. *Drug Alcohol Depend* **75**:177–286.

Teichner G, Horner MD, Harvey RT. (2001) Cognitive predictors of the attainment of treatment objectives in substance abuse patients. *Int J Neurosci* **106**:253–63.

Tiffany S. (1990) A cognitive model of drug urges and drug-use behavior: role of automatic and non-automatic processes. *Psychol Rev* **97**:147–68.

Wechsler D. (2000) *WAIS-III: Echelle d'Intelligence de Wechsler pour Adultes*, 3ème edn. Paris: Les éditions du Centre de Psychologie Appliquée.

Wechsler D. (2001) *MEM-III: Manuel de l'Echelle Clinique de Mémoire*, 3ème edn. Paris: Les éditions du Centre de Psychologie Appliquée.

Wilson BA, Alderman N, Burgess PW *et al*. (1996) *BADS: Behavioural Assessment of the Dysexecutive Syndrome*. Bury St Edmunds, UK: Thames Valley Test Company.

Zinn S, Stein R, Swartzwelder HS. (2004) Executive functioning early in abstinence from alcohol. *Alcohol Clin Exp Res* **28**:1338–46.