Executive Function in Alcohol Dependents when Remaining in the Recovery Stage

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Abstract

Aims: In this study, the executive function in alcohol dependent patients who are in recovery stage is examined. Additionally, we investigate whether or not varied time periods of abstinence affect cognitive function. **Methods:** To examine the executive function, two hundred alcohol dependent patients were recruited from inpatient recovery treatment facilities, covering four locations of the Thanyarak Institute from the north, south, west and centre of Thailand. Furthermore, cognition of recent cessation and long-term abstinence was divided and compared. This research also assesses prefrontal function and intelligence. **Results:** 81.8% of alcohol dependent patients presented with deficits in IQ levels, measured by the Wechsler Adult Intelligence Scale (WAIS-III). After evaluating the functions of the frontal regions, approximately 70% of alcoholics in the recovery stage demonstrated several impairments of the executive function; i.e. when compared to a referenced normal control group, the participants showed impairments in both simple and complex sequencing when performing a Comprehensive Trail Making Test (CTMT). This implies that poor attention and concentration, as well as decision making deficits, tend to be useful measures of frontal lobe function. **Conclusion:** executive deficits are a prominent characteristic of cognitive impairment in alcoholic patients, even if patients remain abstinent for long periods of time.

Introduction

Considerable evidence is steadily accumulating which suggests that prolonged, excessive alcohol consumption is associated with executive malfunction. From several detailed reviews, executive function is usually a response to those mental capacities which are necessary for formulating goals, planning how to achieve them and then carrying out those plans effectively (Lezak, 1982). Therefore, executive brain function can be seen as a combination of essential complex behaviours which are

necessary for daily living, and those include planning, decision making and even self-control. Executive functioning typically operates by combining past experience with present activity, and also takes benefit from previous learning in order to plan future behaviour. Therefore, 'function' is at the heart of all social interaction, both for personal enhancement as well as constructive and creative activities.

Several previous studies have attempted to investigate connections between the structures and physiology of the brain, including the relationship between frontal lobe deficits and executive malfunction. This has been carried out by efficiently using several paradigms, such as medical imaging techniques, Magnetic Resonance Imaging (MRI) and positron emission tomography (PET). It has also included neuropsychological methods, including: the Wechsler Memory Scale (WMS), the Wisconsin Card Sorting Test (WCST) and the Delis–Kaplan Executive Function System™ (D–KEFS™).

To fully answer the question of alcohol consumption affecting cognition, Adam et al. (1993) extensively investigated the correlation between neuropsychological performance and medial-frontal glucose hypo-metabolism, in 31 chronically alcohol-dependent patients. Their results fully asserted a correlation between both variables. Later studies conducted in long-term alcoholism seemed to present similar results to the above study. The paper clearly showed a correlation with neuropsychological tests measuring frontal lobe function, such as the Halstead Category Test (HCT), the Wisconsin Card Sorting Test (WCST) and frontal subdivisions, including the cingulate, the dorsolateral and the orbitomedial divisions (Adams, Gilman, Koeppe, & Kluin, 1995).

Cognitive deficits, with regard to executive function, still present in early withdrawal, or detoxification, and the recovery stage. Loeber *et al.* (2009) evaluated the cognitive abilities of patients who were receiving detoxification treatment. Significant worsening of attention and executive function was exhibited in early abstinence participants, when compared with a normal control group. To gain a better understanding of the pattern of executive malfunction, in early cessation, the operation of the brain functions, especially the memory and executive function, is also examined in this study. Zinn, Stein and Swartzwelder (2004) compared the cognitive functions of recovery stage alcoholics with normal age-matched outpatients, in reply to the research question. Their results clearly pointed to an impairment of memory in non-verbal fluency, but not in verbal fluency.

Thus, the first aim of this study is to investigate the executive function in alcohol dependent patients maintaining the recovery stage. The second aim is to analyse the influence of abstinence periods on the improvement of executive function. In our hypothesis, we assume that the alcoholic patient clearly presents with increased vulnerability to brain capacity, relevant to executive function, even though they have stopped drinking and still remain in the inpatient recovery treatment phase. Another assumption is that the short-term abstinence participants display poorer executive performance than the long-term.

Materials and Methods

Study population

Two hundred and two patients (180 males, 22 females) who were all alcohol dependent, according to Diagnosis and Statistical Manual of Mental Disorders (DSM-IV) criteria, and who sought extended inpatient rehabilitation treatment at the Thanyarak Institute, and its provincial centres located in the north (Chiang Mai), south (Songkhla) and east (Khon Kaen) of Thailand, were recruited for this study. All of the participants were inpatients, and still being treated in recovery stages. Almost all of them were treated by the Therapeutic Community (TC) model. The aims of this method are to increase levels of personal and social responsibility through four key activities, comprising community and clinical management activities, clinical groups, community meetings, and vocational and educational activities.

Exclusion criteria for the samples were: aged below 18, serious complications in detoxification, mental health disorder and severe somatic or neurological diseases. They were not to present with previous inhalant abuse or dependence, and they had to be able to read and write the Thai language. The exclusion criteria, assessed through structured and semi-structured interviews, were as a follows: a score below 25 in a Mini Mental Status Examination (Thai MMSE - 2002), not met any criteria in the Clinical Institute Withdrawal assessment Scale for Alcohol Revised (CIWA-Ar) and a score above 9 in the BECK depression scale. The study was approved by the Ethics Committee of the Thanyarak institute and the Department of Medical Services.

General procedures

After screening, a battery of comprehensive neuropsychological tests was administered to the 202 participants. To examine cognitive function, the participants were issued with battery tests which employed the following: the Wechsler Memory Scale (WMS-III), the Wechsler Adult Intelligence Scale (WAIS-III), the Rey Complex Figure Test and Recognition Trail (RCFT), the Stroop Colour and Word test, the Delis-Kaplan Executive Function System (D-KEFS), the Wisconsin Card Sorting Test (WCST), the Comprehensive Trail Making Test (CTMT) and the Hand Dynamometer and Grooved Pegboard Test. Then, general demographics and drinking histories were acquired via questionnaires.

Questionnaires and neuropsychological measures

Several questionnaire measures and structured interviews were employed to assess demographics and drinking related variables, using the following tests:

1) Wisconsin Card Sorting Test (WCST)

This test consists of four stimulus patterns, printed on 128 response cards, presenting several figures (circles, triangles, crosses and stars) in four colours (red, blue, yellow and green). Each card contains a different number (one, two, three, and four) of the figures. Original developments of the test aimed at measuring abstract reasoning ability, the ability to shift cognitive strategies in response to changes, which is a function of the executive. Thus, the test was grouped to be an instrument for measuring the executive performance.

2) Comprehensive Trail-Making Test (CTMT)

There were several weakness points in the original Trail Making Test, such as confusing and unreliable normative data which was difficult to interpret, as well as being too brief and too general. In order to decrease those weakness points CTMT was developed. The newer test still maintains the original Trail A, but includes increases to some disturbance cycles in Trails 2 and 3. Trail 4 has the addition of numbers and letters, so that participants have to use greater cognitive abilities than they have previously. These increases propose to detect brain compromise and track progress, in rehabilitation, on the part of frontal performance, especially with regards to: attention, impairment of set shifting, psychomotor speed, visual search and sequencing.

3) Stroop Colour and Word Test

Stroop testing consists of three pages of words. The words used are: 'red, green, yellow, blue and purple', and are printed in rows and columns. On the first page all of the words are printed in black, and on the next page each word is printed in its own colour. On the final page each word, which describes a colour, is printed in coloured ink, but the words of the colours never match the ink colour. For example the word 'red' could be printed in blue or purple, but never in red ink. The test client is required to quickly say the name of the colour and not the colour he sees, and vice versa. A lower score for each page represents a different pattern of cognitive function.

A client getting a poor score in the word score (page 1) may reflect a motor-speed problem or poorly developed reading skills. Additionally, impairment in the colour score (page 2) may imply an inability to identify colour names or the presence of colour blindness, but may also identify a metal health problem, in their being a person who may be easily aroused by colour. Finally, a participant exhibiting a low score in the colour/word task is possibly presenting with either pre-frontal pathology or emotion turmoil.

4) Delis- Kaplan Executive Function System – Tower Test (D-KEFS Tower Test)

To measure whole factors of executive performance being an important function of the frontal region, D-KEFS testing was developed in 2000, by Delis-Kaplan. This neuropsychological battery test comprises a variety of tasks, such as: the Tower Test, the Trail Making Test, the Verbal Fluency or Colour Word Interfere Test etc. Those tests measure all the components of executive function, such as: planning, problem solving and inhibition, and having the essential abilities to function on a daily basis. The D-KEFS test provides two methods of measuring both verbal and non-verbal performances of executive function.

The D-KEFS Tower Test is part of a fuller version which was originally created to measure the non-verbal part of executive function. Planning, inhibition, problem solving and working memory are the main categories to be carefully examined by the test. A D-KEFS test involves nine items which are to be arranged in order, from easy to difficult. The test client is requested to move wooden plates of different sizes, in order to reproduce a pattern which matches a given sample model. This task is to be completed in a limited time frame, whilst following several rules: for example, the client must move the

wooden plates with only one hand, and only move one wooden plate at each time. Then, the participant's performances will be scored and classified into five categories: taking the Mean First-Move Time score, Achievement score, Time-Per-Move Ratio and Rule Violation score, before a qualitative interpretation is carefully processed.

4) Wechsler Intelligence Scale – Third Edition (WAIS-III)

In the mid-1930s a series of intelligence tests, blending strong clinical skills and statistical training, were developed by David Wechsler. He divided the battery test into two main categories: a verbal part and a performance part. The original reason for creating WAIS was to support military duties, which had two areas of issue. Those were to place the men into the appropriate jobs and to determine the effects of brain damage upon personal performance, especially with regards to mental health issues. Currently, WAIS is used for a variety of purposes; taking measures of cognitive incapacities or neurological dysfunctions, and obtaining clinical information used for planning treatment, for example.

WAIS has continually launched new versions, but maintains the same Wechsler traditional structure. WAIS-III is still composed of two main parts, the verbal and performance scores as the original version, but now includes some improvements. For example, there are three new additional subtests, including Matrix Reasoning, Symbol Search and Letter-Number Sequencing. The major change in new Wechsler testing is the addition of index scoring, which consists of Verbal Comprehension, Perceptual Organisation, Working Memory and Processing Speed. Like IQ tests, the four factor index has a mean of 100 and a standard deviation of 15.

Result

Means and comparisons of the general demographic are presented in Tables 1 and 2. A total of 202 participants met the criteria of the study, and consisted of 187 (91.7%) males and 15 (7.4%) females. The age of participants ranged from 19 to 71 years old (M = 39.10, SD = 9.00). The statistics showed significant differences in age, units of drinking per day and lengths of the problem.

The distributions for the demographic data and the primary outcome measure (MMSE Total and WAIS full scale score) were examined. Most of the variables did not show a normal distribution, except for that of age. Therefore, non-parametric analysis was applied to distributions that were not normally distributed, and parametric analysis was used in relation to normally distributed variables. From Table 2, on the part of demographic variables, the results showed no significant difference in education and MMSE total score. On the contrary; age, units of alcohol per day and lengths of time enduring the drinking problem, when examined, all indicated a significant
difference between both.

From Table 3, we see that WAIS scores indicate that 69.1% of alcoholic participants had intelligence quotient (IQ) levels lower than the referenced normal group. 12.3% of these participants displayed extremely low levels of IQ.

Table 1: Demographic Characteristics of Participants

	Alcoholic	
	Male	Female
Age	39.66 (8.95)	31.80 (6.98)
Education	11.59 (3.37)	10.29 (3.89)
Drinking duration	14.12 (8.79)	7.13 (5.85)
Units of drink per day	37.49 (25.53)	15.40 (12.65)
MMSE Score	26.78 (2.99)	27.00 (1.66)

TABLE 2: Comparisons of age, gender, education, units of drink and length of time drinking

Types of Accommodation	Kruskal-Wallis tests		T- Test	
	X^2	*p*	T	*p*
Age (mean and range of age)			3.32	0.001*
Education (Years)	1.47	0.225		
Units of alcohol drunk per day (Daily)	15.98	0.000***		
Length of problem (Years)	9.98	0.002**		
MMSE Score	0.01	0.930		

Note: significant results (*P <0.05, ** P <0.01, ***P ‹ 0.001)

Table 3: Means and standard deviations of neuropsychological measures

Measure	Alcoholic (*n = 204*)				Mann-Whitney U	
	Male		Female			
	Mean	SD	Mean	SD	Z	*p*
WAIS Full Scale Score	79.91	12.61	81.78	11.27	-0.248	0.804
Comprehensive Trail making Test (CTMT)						
Trail 1	61.71	27.51	53.08	19.45	-1.523	0.128
Trail 2	60.98	25.57	57.65	24.04	-0.854	0.393
Trail 3	66.67	29.53	61.04	31.27	-1.533	0.125
Trail 4	59.09	27.34	54.26	24.46	-1.098	0.272
Trail 5	122.85	69.35	117.48	88.36	-1.334	0.182
Wisconsin Card Sorting Test (WCST)						
Perseverative response	35.41	23.87	30.57	29.50	-1.359	0.174
Perseverative errors	30.13	17.94	26.14	21.98	-1.230	0.219
Non-perseverative errors	22.49	12.57	23.29	11.79	-0.122	0.903
Number of categories completed	3.01	1.86	3.14	1.99	-0.172	0.864
Trails to complete first category	27.43	31.04	21.50	26.60	-1.464	0.143
Failure to maintain set	1.34	1.44	0.86	1.02	-1.052	0.293
Learning to learn	-5.54	8.59	-3.86	10.48	-1.295	0.195
D-KEFS Tower Test						
Mean first move time	5.73	3.59	4.06	3.02	-2.384	0.804
Time per move ratio	*5.02*	*3.48*	*3.76*	*1.70*	*-1.844*	*0.017**
Move accuracy ratio	1.52	0.58	1.68	0.63	-1.150	0.250
Total rule violation	0.48	0.97	0.32	0.34	-0.582	0.561
STROOP						
Word	89.68	21.05	93.07	29.01	-1.423	0.155
Colour	59.96	16.69	61.20	22.08	-0.711	0.477

Colour – Word	28.76	11.33	29.73	12.81	-0.515	0.607
Note: significant results (*P <0.05)						

From Table 3, most of the variables did not show a significant difference between male and female groups, except for the Time per move ratio in D-KEFS Tower test (U = 990, p = 0.065)

Performance in each of the four tests that are sensitive to frontal system dysfunction (CTMT, WCST, D-KEFS tower test and Stroop; Table 3) will be addressed in turn. As noted previously, of particular interest we follow four measures: time to complete CTMT 5, perseverative errors in WCST, Total rule violation in D-KEFS Tower test and STROOP colour – word test.

A Pearson product-moment correlation coefficient was computed to assess the relationship between years of education and the four measures which are sensitive to any impairment in frontal lobe region. There was a significant positive correlation between years of education and WAIS Full Scale Score: where r = 0.336, n = 196, p = 0.000; move accuracy in Tower Testing: where r = 0.195, n = 196, p = 0.050; and color word score in Stroop testing: where r = 0.160, n = 196, p = 0.025. An obvious negative correlation was also present between years of education and Trail 5: where r = -0.243, n = 195, p = 0.001.

Discussion

The main objective of this study was to analyse the executive function of alcohol dependents remaining in the recovery stage. The sample consisted of alcohol free participants who had been abstinent for more than 30 days, and did not present with detoxification or depression symptoms.

Regarding the objectives, the data shows that in comparison between genders, in this research, females obviously drank less alcohol and presented shorter time periods of problem endurance than males. However, the analysis indicates that there were no differences in any of the measurements which are sensitive to the frontal lobe lesions between males and females.

When comparing with standard scores, the results show that 81.8% of alcoholics had lower intelligence than normal. On the part of executive function, measured from WCST, CTMT, Stroop and D-KEFS Tower

tests, the results indicated that 72.4% of the participants found difficulty in adapting themselves according to changes in environment, and 78.9% of abstinents had poor set shifting, especially in comprehensive Trail Making Tests (CTMT). This implied that poor attention and concentration, as well as decision-making deficits, tend to be useful measures of frontal lobe function. Contrary to that, Stroop tests found that only 26% of the participants showed any prefrontal disorder. This evidence may assume that poor performance in CTMT and WCST tests may be affected by malfunctions in other areas of the brain.

In conclusion, impairment of the brain still occurs even though the participants had stopped drinking, and this deficiency could be an important factor which encourages patients to start drinking again.

However, this research has several limitations. The standard scores used in this research were created from foreign data, which may not match with Thai culture. Consequently, the results from the tests might be deviated. Therefore, in future studies standard scores conforming to the culture of Thailand should be developed.

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