Neurocognitive, psychosocial and functional status of individuals with alcohol-related brain damage (ARBD) on admission to specialist residential care

Running head: Functioning of individuals with ARBD

Lindsay Horton[1,2]

Tim Duffy[1]

and

Colin R. Martin[3,4]

[1]School of Health, Nursing and Midwifery, University of the West of Scotland, Ayr UK, [2]Loretto Care, Glasgow, Scotland,[3]Faculty of Society and Health, Buckinghamshire New University, Uxbridge, Middlesex, UK, and [4]West London Mental Health NHS Trust, London, UK.

Address for correspondence:

Professor Colin R Martin

Room 2.11

Faculty of Society and Health

Buckinghamshire New University

Uxbridge Campus

106 Oxford Road, Uxbridge, Middlesex, UB8 1NA, UK.

Tel: 01494 522141 Extension 2349

Fax: 01494 603179 Email: colin.martin@bucks.ac.uk

Abstract

Alcohol-related brain damage (ARBD) is a complex neuropsychiatric condition with a multifaceted impact on functioning and the ability to live independently. A comprehensive approach to assessing ARBD is therefore necessary. This study aimed to investigate the neurocognitive, psychosocial and everyday functioning of a group of individuals with ARBD on admission to specialist residential care. A comprehensive assessment framework was used to investigate the baseline functioning of 20 individuals with ARBD. The following assessment tools were administered: the National Adult Reading Test (NART); a selection of Cambridge Neuropsychological Test Automated Battery (CANTAB) tasks; the EuroQoL EQ-5D-5L; the Medical Outcomes Study 36-item Short Form Version 2, acute version (SF-36v2); the Profile of Mood States; the Hospital Anxiety and Depression Scale (HADS); the Depression, Anxiety and Stress Scales (DASS); and the Assessment of Motor and Process Skills (AMPS). The results demonstrate the heterogeneity of individuals with ARBD. There was variability across the group. However, the results indicate a broad pattern of deficits across neurocognitive domains. The majority of participants scored within the normal range for depression, anxiety and stress, although there was evidence for mild to extreme levels of depression and anxiety, as well as elevated levels of confusion and relatively low levels of vigour. Scores on the AMPS also showed variability and most participants demonstrated increased clumsiness and physical effort, and decreased efficiency while performing activities of daily living. Larger scale, longitudinal research is now required to investigate changes in the functioning of people with ARBD over time.

Introduction

Alcohol-related brain damage (ARBD) is a complex neuropsychiatric condition that can have a profound and multifaceted impact on everyday functioning and the ability to live independently. It is primarily associated with impaired memory function, although an emerging body of evidence suggests that it also results in problems with executive functioning (Brion et al, 2014). ARBD is also associated with mental health problems such as anxiety and depression, as well as everyday functional problems (Cox et al, 2004; Thomson et al, 2012). To date, researchers have used a wide range of assessment tools for investigating the impact of ARBD. However, the existing evidence base focuses mainly on neuropsychological assessment, while there is a scarcity of research into the mental health status, quality of life (QoL) and functional ability of individuals with ARBD (Horton et al, 2014a,b). No comprehensive assessment battery has been validated for use specifically within an ARBD context. There is consequently a need for research into the holistic assessment of ARBD, comprising appropriate methods of measuring neurocognitive, psychosocial and everyday functioning. These three functional domains will be considered below.

Neurocognitive functioning

A wide range of neurocognitive tests have been used in ARBD research. These tests generally measure three main neurocognitive domains, including general cognitive and intellectual functioning, memory impairment and executive functioning (Horton et al, 2014a). Nevertheless, the current approach to neurocognitive assessment in ARBD research is inconsistent and diffuse, suggesting that an integrated and comprehensive means of measuring neurocognitive functioning in ARBD should be sought. The Cambridge Automated Neuropsychological Test Battery (CANTAB) has a robust evidence base and offers an integrated, user friendly means of assessing multiple domains of neurocognitive functioning including memory, attention and executive functioning (Smith et al, 2013). The CANTAB tests are administered using a specialist touch-screen computer, and a standardized assessment procedure is used to ensure consistency across testing sessions (Cambridge Cognition, 2013). Normative comparisons can be made for some of the CANTAB tests. Moreover, the

assessment battery can be administered with minimal training, making CANTAB suitable for use in research, as well as a range of practice contexts. The graded nature of the CANTAB tests helps to reduce floor and ceiling effects, whilst parallel versions of the tests reduce the likelihood of practice effects and enable the assessments to be repeated over time (Levaux et al, 2007). Thomson et al (2012) recommend incorporating a measure of general intellectual functioning into the cognitive assessment of ARBD. Therefore, a reliable and valid measure of premorbid intelligence, such as the National Adult Reading Test (NART; Nelson & Willison 1991), should be used in combination with the CANTAB.

Psychosocial Functioning

Research into the psychosocial functioning of people with ARBD is currently limited, with existing studies using self-report instruments such as the Center for Epidemiological Studies Depression Scale (Irvine & Mawhinney, 2008); Profile of Mood States (Douglas & Wilkinson, 1993); Geriatric Depression Scale (Douglas & Wilkinson, 1993); Hamilton Depression Scale (Oscar-Berman et al, 2004) and the Brief Psychiatric Rating Scale (Blansjaar et al, 1992). These instruments have not, however, been validated for use in ARBD context, and they have variable reliability and validity when used in wider research contexts (Horton et al, 2014a). One instrument that may be useful for assessing people with ARBD is the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983). McPherson and Martin (2010) reviewed the psychometric properties of the HADS in a diverse range of clinical populations and concluded that it was also suitable for use with alcohol-dependent populations. A key advantage of the HADS is its brevity. Furthermore, as the items on the HADS do not relate to somatic symptoms, the likelihood of respondents confusing the symptoms of physical illness with anxiety or depression is reduced.

Another widely used instrument for assessing mental health status is the Depression, Anxiety and Stress Scales (DASS; Lovibond & Lovibond, 1993). The

DASS was developed more recently than the HADS and measures depression and anxiety, as well as physiological stress. The DASS has been shown to be psychometrically sound when used with both clinical and non-clinical populations (Brown et al, 1997; Lovibond & Lovibond, 1993). Thus, it may also be a useful instrument for assessing psychiatric status in people with ARBD. The recall period for the HADS and the DASS is one-week. Therefore, respondents are required to draw on memory resources when completing both of these instruments. A third instrument, the Profile of Mood States (POMS; McNair, Lorr & Droppleman, 1971) may offer a valuable additional assessment for people with ARBD because it can be used to assess mood status on the day of administration only, without relying on intact memory function. The POMS is a widely validated, norm referenced instrument that measures a range of mood states including anxiety, depression, anger, vigour, fatigue, confusion, and total mood disturbance. It therefore provides a means of measuring additional states, such as confusion, that may be elevated in people with ARBD due to the presence of cognitive impairment.

Another important aspect of psychosocial functioning is quality of life. The measurement of QoL has become increasingly prevalent in health outcomes research in recent years (Garratt et al, 2002). Nevertheless, QoL has received little attention in alcohol research and has not been given sufficient attention in ARBD outcomes research (Horton et al, 2014b; Levola et al, 2014). There are currently only two published studies focusing specifically on QoL in ARBD (Oudman & Zwart, 2012; Oudman & Wijnia, 2014). Both of these studies used the QUALIDEM scale (Ettema et al, 2005) to provide a proxy-based assessment of QoL in individuals with Korsakoff's syndrome. The QUALIDEM is a dementia-specific instrument that was developed for use with individuals who are unable to self-report accurately due to cognitive impairment. To date, no studies have been published using self-report methods to measure ARBD patients' perceived QoL. However, in the wider context of alcohol dependence, a review by Luquiens et al (2012) revealed that the Medical Outcomes Study 36-Item Short-form Health Survey (SF-36; Ware & Sherbourne, 1992) is the most frequently used QoL questionnaire, followed by the EQ-5D (EuroQol group, 1990). The acute version of the SF-36 uses a one-week recall

period, whilst the EQ-5D has a one-day recall period. Both of these instruments have strong psychometric properties and offer a potentially useful means of assessing ARBD patients' perceived QoL.

Everyday Functioning

The neurocognitive and psychosocial problems associated with ARBD can have consequences in terms of everyday functioning. For example, the ability to perform instrumental activities of daily living (IADL), such as housework tasks, may be particularly affected due to underlying cognitive impairment (Oudman et al, 2013). The restoration of functional ability and independence is a key aim of ARBD services (Thomson et al, 2012). However, there are currently no published studies that focus specifically on standardised assessment of everyday functioning in people with ARBD. The Assessment of Motor and Process Skills (AMPS; Fisher & Jones, 2012) is a standardised, norm-referenced occupational therapy assessment tool that uses observation to rate the quality of an individual's performance during IADL tasks. The AMPS has been used in traumatic brain injury and dementia research to provide insight into the functional difficulties individuals display as a result of cognitive impairment (Bouwens et al, 2008; Linden et al, 2005). The inclusion of the AMPS may therefore be advantageous in the comprehensive assessment of ARBD.

The purpose of this study was to investigate the neurocognitive, psychosocial and everyday functioning of people with ARBD. In particular, this study aimed to gather comprehensive baseline information about the functional status of a group of individuals on admission to a purpose-built residential rehabilitation facility for people with ARBD. It is anticipated that the findings from this study will provide rich information that can be used to inform care plans for people living in this ARBD service. Moreover, it is hoped that the findings will have wider implications in terms of the types of assessment tools used by practitioners working in ARBD services in the UK and beyond.

Method

Setting

Participants were recruited within a newly opened, abstinence-based ARBD residential rehabilitation service in the social care sector. Prior to entering the facility, participants had been diagnosed with ARBD. The service was deemed to be appropriate to the needs of each individual by a panel of health and social care professionals who were responsible for managing referrals to the service. The facility is staffed by a team of nurses and social care staff. The building comprises 22 studio flats with private kitchen facilities, as well as communal lounge, dining and internal courtyard areas. The service aims to promote independent living within a supported environment, and the expected length of stay is approximately 6 months to 2 years, depending on the needs of the service user. Participants were admitted to the facility successively over a period of 9 months from a range of health and social care settings, including hospital care and other ARBD supported accommodation services, as well as non-specialist services, such as traditional care homes for older adults. On admission to the service, all individuals had undergone detoxification from alcohol and had been abstinent from alcohol for at least 3 months.

Design

The study used a descriptive design to present the baseline functioning of one group of individuals 3 weeks after they were admitted to the ARBD facility. Standardised T scores and Z scores were used where available to compare participants' performance to existing normative data.

Participants

A total of 24 individuals were invited to participate in the study. Four of these individuals declined, leaving a total of 20 participants. The 20 participants were admitted to the facility over a period of 9 months and were assessed 3 weeks after moving into the ARBD facility to provide an overview of baseline functioning. Ethical

approval was obtained prior to the commencement of the study and participants gave informed consent before they took part in the assessments.

Measures

Three types of assessment were used in this study, including neurocognitive assessment, standardised self-report questionnaires and functional assessment. Each of these is detailed below.

Neurocognitive Assessment

Participants completed the National Adult Reading Test (NART, Nelson & Willison, 1991) prior to undergoing the neurocognitive assessments. The NART was administered as a means of predicting premorbid intelligence and took around 10 minutes to complete. Participants' NART scores were compared to the scores obtained for the NART re-standardisation study (n = 182), where the majority of scores (n=119) ranged between 81 and 119 (Nelson & Willison, 1991).

The Cambridge Neuropsychological Test Automated Battery (CANTAB) was used to assess participants' performance on a range of neurocognitive tests. A total of 7 CANTAB tests were administered in the order detailed in Table 1. Normative data was available for 5 of the 7 tests, enabling participants' performance to be compared to a normative reference database of adults using standardised Z scores. The CANTAB tests were administered by a certified CANTAB tester using a touch screen Windows PC; CANTABeclipse 6 Test Administration Guide; CANTABeclipse 6 software and a two-button press pad.

TABLE 1. ABOUT HERE

Standardised Self-Report Measures

5 standardised questionnaires were used to assess quality of life (QoL), mental health status and mood disturbance. The questionnaires included the EuroQoL EQ-5D-5L, Version 2.0 (Oemar & Janssen, 2013); the Medical Outcomes Study 36-Item Short Form Version 2, 1-week recall (SF-36v2; Maruish, 2011); the Profile of Mood States (POMS, McNair, Lorr & Droppleman, 1971); the Hospital Anxiety and Depression Scales (HADS, Snaith & Zigmond, 1994); and the Depression, Anxiety and Stress Scales (DASS, Lovibond & Lovibond, 1995). These instruments are detailed in Table 2. The recall period for the SF-36v2, HADS and DASS was 1-week, whilst the EQ-5D-5L and POMS required participants to report how they were feeling on the day of the assessment. As ARBD is primarily associated with memory impairment, the acute 1-week recall version of the SF-36v2 was used instead of the standard 4-week recall version. The EQ-5D-5L and POMS were chosen because they require participants to report how they are feeling 'today,' thereby reducing the burden on memory.

TABLE 2. ABOUT HERE

Functional Assessment

The Assessment of Motor and Process Skills (AMPS) was used to assess the quality of participants' performance during Instrumental Activities of Daily Living (IADL), such as meal preparation and housework tasks. The AMPS was administered by a registered occupational therapist and trained AMPS rater. The AMPS is a standardised, observational assessment tool comprising a set of universal motor and process performance skills that can be observed during any activity. The performance skills are rated on a 4-point scale according to how effectively everyday tasks are performed. The AMPS uses criterion-referenced scoring and cut-off measures indicate a minimal level of competent task performance beyond which increased clumsiness, physical effort and inefficiency during task performance is likely to be observed. There is a "risk zone" ranging from 0.3 points above and

below each cut-off score, representing the range where individuals may display difficulty with IADL task performance. Standardised Z scores indicate how participants performed in relation to a norm-based interpretation of IADL ability. The 2 AMPS scales, competence cut-offs and risk zones for each scale are presented in Table 3.

TABLE 3. ABOUT HERE

Procedure

Each participant was introduced to the study within 2 weeks of admission to the residential rehabilitation facility, with the intention of completing the assessments the following week. Participants were encouraged to read the information sheet, ask questions and discuss the study with the researcher, as well as staff within the ARBD facility, and friends and relatives, before deciding whether to take part in the study. A total of 24 individuals were approached (16 male, 8 female). Twenty people agreed to take part in the study (15 male, 5 female) and 4 people declined (1 male, 3 female). Each of the 24 individuals was revisited a few days after receiving the information sheet and invited to complete the consent form. Appointments were scheduled for administering the assessments with the 20 individuals who agreed to take part in the study. The timing of the assessments and the order in which they were presented varied, depending on each individual's preferences and other daily commitments. The consent form detailed all 3 elements of the study, and gave participants the opportunity to choose whether they wished to complete all 3 types of assessment. Assessments were scheduled to run over 2 consecutive days, 3 weeks after admission to the ARBD facility, when individuals had settled into their new environment.

Neurocognitive Assessment

The neurocognitive assessments were conducted in a private office within the ARBD service. Participants completed the NART prior to the neurocognitive assessments and were seated in a comfortable chair in front of the touch screen computer for the duration of the session. The automated nature of the CANTAB testing software ensured consistency between testing sessions and the CANTAB eclipse 6 Test Administration Guide was used to provide participants with standardised instructions throughout the testing session. Each neurocognitive assessment session lasted for approximately 1.5 to 2 hours. Participants were encouraged to take short breaks where necessary to avoid and alleviate fatigue.

Self-Report Measures

Structured interviews were conducted using the 5 standardised questionnaires, which were administered in the following order: EQ-5D-5L; SF-36v2; POMS; HADS and DASS. The interviews lasted for approximately 45 minutes and were conducted in residents' studio flats within the ARBD facility. As the EQ-5D-5L and POMS required participants to report how they had been feeling that day, the interviews were conducted late in the afternoon.

Assessment of Motor and Process Skills

Each participant was observed performing 2 standardised IADL tasks in their own studio flat within the ARBD facility. The tasks used for the AMPS assessments included one snack/meal preparation task and one housework task, such as sandwich preparation and changing a bed. All tasks were chosen from the "average" and "harder than average" options in the AMPS task hierarchy (Fisher & Jones, 2012). The total time taken to complete the 2 IADL tasks was approximately 30 minutes per participant. The raw AMPS test scores from each assessment were entered into Occupational Therapy Assessment Package (OTAP) software to calculate linearized measures of each participant's IADL motor and process ability.

Statistical Analysis

SPSS software (Version 20) was used to calculate descriptive statistics for each of the measures outlined above.

Results

Demographics

Twenty individuals participated in the study. Ages ranged from 36 to 68 years old (mean age = 53 years old). Fifteen of the participants were male (mean age = 51.1), while 5 were female (mean age = 57.4). The gender ratio of the sample reflects the over-representation of males within the service as a whole. However, while two-thirds of the individuals invited to participate in the study were male, a greater proportion of males (75%) agreed to take part. Females were therefore slightly under-represented in the study sample. Nineteen of the participants took part in the neurocognitive assessments, while all 20 completed the self-report questionnaires, and 18 completed the functional assessment. The results from these assessments are presented below.

Descriptive Statistics

Premorbid Intelligence Quotient

NART predicted full scale premorbid IQ scores for the 20 participants ranged from 77 to 123 (mean = 104.65, SD = 11.73). A minority of scores (n = 4) were within +/-4 points outside of the normal range of 81 to 119 reported by Nelson and Willison (1990).

Neurocognitive Assessment

Of the 19 participants taking part in the neurocognitive assessments, 16 completed all 7 of the CANTAB neuropsychological assessment battery tests. Three

participants chose to withdraw partway through the neuropsychological assessments. One of these participants completed the first 2 tests, whilst another participant completed 3 tests and a third participant completed 4 of the tests before choosing to withdraw. The mean and standard deviation (SD) scores for each of the CANTAB neuropsychological tests are shown in Table 4. Standardised Z scores are also presented for the 5 CANTAB tests which have normative comparison data. Z scores of up to 2 SD below the mean (Z = 0 to -2) are considered to be within the normal range (p = 0.95), while Z scores of greater than 2 SD below the normative mean (Z = >-2) are outside the normal range (Field, 2013). The normal range (Z = -2 to 2) was split into high normal (Z = 0 to 2) and low normal (Z = -2 to 0), to distinguish between participants scoring above and below the normative mean.

Table 4. demonstrates that participants performed below the normative mean on all 5 of the tests with normative comparison data. Participants made a large number of errors on the PAL test in comparison to the normative population and scored outside the normal range on the “total errors (adjusted)” outcome measure (Z = -2.54). Performance was also below average on the SOC test, as participants only solved 5 problems out of a possible 12 in the minimum possible number of moves (Z = -1.54). Participants also had difficulty during the IED test, as they completed only 7 of the 9 possible stages (Z = -1.14) and made a relatively large number of errors in comparison to normative data (Z = -1.04).

Performance was particularly impaired on the RVP test “total false alarms” outcome measure (Z = -14.09), as participants made an extremely large number of errors in comparison to the normative population. Performance was least impaired on the SWM test (BE = -1.07; SU = -0.86).

Scores on the CGT demonstrate that participants chose to risk around half of their total points on each test trial (OPB = 0.52; RT = 0.53). The QDM score on the CGT was 0.75, indicating that participants chose to bet on the more likely outcome 75% of time; while they bet on the less likely outcome 25% of the time. The SST scores show that participants were able to inhibit the pre-potent response 50% of the time

(PSS = 0.50), whereas they were unable to withhold it 50% of the time. As there is no normative data available for these 2 tests, normative comparisons cannot be made.

TABLE 4. ABOUT HERE

Table 5. shows the proportion of participants who scored within the normal and impaired ranges on the 5 CANTAB tests with available normative comparison data. The percentages demonstrate that at least 50% of participants scored within the impaired range on the PAL test, RVP test, and PSMM and MM3 outcomes of the SOC test. Furthermore, 50% of participants scored beyond -7SD below the normative mean on the TFA outcome measure of the RVP test, indicating performance that was extremely impaired. The majority of participants scored within the low normal range on the most difficult stages of the SOC (MM4 = 70%; MM5 = 65%), while 90% of participants performed within the low normal range on the SWM test, and around half of the participants performed in the low normal range on the IED test. A total of 85% of participants scored in the high normal range on the MM2 stage of the SOC test, indicating that they performed the easiest stage of this test without difficulty. A minority of participants (0% to 35%) scored above the normative mean on all other outcome measures across the CANTAB test battery, indicating that a small proportion of scores were either at or above average on these tests.

TABLE 5. ABOUT HERE

Standardised Self-Report Measures

Nineteen participants completed the self-report questionnaires. The mean (SD) scores for each of the 5 self-report instruments are shown in Table 6. Tables 7 to 11 display the proportion of participants falling into each descriptive category on the self-report questionnaires.

TABLE 6 ABOUT HERE

Table 7. demonstrates that self-care (85% of participants), and usual activities (75% of participants) received the largest proportion of “no problems” ratings on the EQ-5D-5L, while anxiety/depression (45% of participants) and pain/discomfort (45% of participants) received the smallest proportion of “no problems” ratings. None of the participants reported extreme problems on the EQ-5D-5L, while a minority of participants reported severe problems on all health domains, apart from Self-Care. The largest proportion of “severe problems” ratings were reported for anxiety/depression (25% of participants), followed by pain/discomfort (15% of participants). The EQ-5D-5L Visual Analogue Scale (VAS) mean score was 67, indicating that on average, participants perceived their overall health to be relatively good.

TABLE 7. ABOUT HERE

Mean scores on the mental component summary (MSC) and physical component summary (PCS) for the SF-36v2 indicate that participants reported their mental health and physical health to be below average in comparison to the normative population. The MCS (46) and PSC (45.25) mean scores were in the low normal range (45-55). Mean scores on the 8 individual health domains of the SF-36v2 were found to be above the normative average and outside the normal range. The individual health domain scores had large standard deviations, indicating a wide range of scores among the participants.

Table 8. shows the proportion of participants scoring within the normal range (45-55), as well as above (>55) and below (<45) the normal range on each of the SF-36v2 domains. A minority of individual scores fell within the normal range on each of the domains, with only 25% of participants scoring in the normal range on the MCS, and 20% of participants scoring in the normal range on the PCS. A total of 45% of participants scored below the normal range on the MCS measure, while 30% scored above the normal range. On the PCS measure, 55% of participants scored below the normal range, and 25% scored above the normal range.

TABLE 8. ABOUT HERE

All POMS mean scores were within the normal range (40-60). The 6 mean mood domain scores indicate that tension-anxiety (51.75) and depression-dejection (52.15) were slightly above the normative mean, whilst anger-hostility (46.25) and fatigue-inertia (48.90) were slightly below the average score of 50. Vigour-activity was the lowest mean score at 43, indicating that participants reported having less vitality, or energy, than the normative population. The highest mean score was for confusion-bewilderment (56.90), indicating that participants reported a higher level of confusion than the normative average. The mean Total Mood Disturbance (TMD) score was slightly above average (52.85).

Table 9. shows the proportion of individual POMS scores falling within the normal range, as well as above (>60) and below (<40) the normal range, on each of the mood domains. The largest proportion of “normal range” scores were on the anger-hostility domain (90%), followed by the depression-dejection domain (80%). A minority of scores were above the normal range, with 40% of participants reporting higher than average confusion-bewilderment (40%), while 25% of participants reported elevated levels of tension-anxiety and total mood disturbance. Vigour-activity was the only domain where a substantial proportion (50%) of participants scored below the normal range, indicating that half of the participants reported reduced levels of energy in comparison to the normative population.

TABLE 9. ABOUT HERE

The HADS anxiety and depression mean scores were within the normal range, whilst the mean anxiety and depression scores on the DASS were in the mild range and stress was in the normal range. There was a strong correlation between the anxiety scores on the HADS and DASS ($r = 0.83$, $p < 0.01$), whist the correlation between the depression scores on the HADS and DASS was moderately high ($r = 0.65$, $p < 0.01$).

Table 10. and Table 11. show the proportion of individual scores falling within each range on the HADS and DASS. The majority of participants (75%) scored within the

normal range for depression on the HADS, while 50% of scores were in the normal range for depression on the DASS. An equal proportion of participants (60%) scored within the normal range for anxiety on the HADS and the DASS. A minority of scores were in the mild, moderate, severe, and extreme ranges: 20% of HADS anxiety scores were severe, while 25% of DASS anxiety scores were severe or extreme. The majority of DASS stress scores were in the normal range (65%), while 10% of DASS stress scores were mild or moderate, and 15% were in the severe range.

TABLE 10. ABOUT HERE

TABLE 11. ABOUT HERE

Functional Assessment

The mean and standard deviation AMPS Motor and Process scores for the 17 participants completing the functional assessments are displayed in Table 12. Standardised Z scores are also presented in Table 5 to enable comparisons to be made with normative IADL ability.

Table 12. demonstrates that the raw mean score for Motor Ability was below the competence cut-off of 2 (1.74), whilst the raw score for Process Ability was at the competence cut-off of 1 (1.03). These raw scores indicate that both motor performance and process performance were within the risk zone (+/- 0.3 from the cut-off) for compromised task performance. The negative Z Scores indicate that participants demonstrated increased clumsiness or physical effort (Motor Ability = -1.28), as well as reduced efficiency (Process Ability = -1.38) whilst performing tasks.

TABLE 12. ABOUT HERE

Table 13. shows the proportion of participants scoring within the impaired range (Z = >-2), low normal range (Z = -2 to 0), and high normal range (Z = 0 to 2) on the AMPS

assessment (Field, 2013). The largest proportion of participants scored within the low normal range (Motor Skills = 65%; Process Skills = 85%), while a minority of participants scored within the impaired and high normal ranges. A total of 17.5% of Motor Skills scores were above the normative mean, whilst only 5% of Process Skills scores were above the normative mean. Furthermore, 17.5% of Motor Skills scores were in the impaired range, while 10% of Process Skills scores were impaired.

TABLE 13. ABOUT HERE

Discussion

The findings from this study present a comprehensive picture of the functional status of a group of individuals with ARBD on admission to a specialist residential rehabilitation facility. The results indicate that general intellectual functioning on the NART was intact; a finding that is consistent with existing evidence (Thomson et al, 2012). Four participants scored outside the normal range on the NART: Two were slightly below the normal range, while the other two were slightly above. Due to the small sample size in this study, it is not possible to use statistical analysis to determine whether these individuals performed differently to the rest of the group. However, future larger scale research may provide insight into the functional characteristics of ARBD patients who fall outside the normal premorbid IQ range.

As a group, participants were found to perform below the normative average on all five CANTAB tests with available normative comparison data, suggesting compromised neurocognitive performance in the domains of memory, attention and executive functioning. Performance was generally within the low normal range on the SOC, SWM and IED tests, while the majority of participants displayed impaired performance on the PAL test, due to relatively poor scores on the “total errors (adjusted)” outcome measure. Performance was severely impaired on the “total false alarms” outcome measure of the RVP test, with the majority of participants

performing well below the normative average. The majority of participants performed well on the 2 moves stage of the SOC test, indicating competent spatial planning ability at a relatively simple level. However, performance was generally in the low normal range on the most difficult stages of the SOC test, suggesting that most participants had difficulty when more complex spatial planning ability was required.

No normative data exist for the CGT and SST and there are currently no published studies that focus specifically on ARBD patients' performance on these two CANTAB tests. Nevertheless, there is evidence to suggest that abstinent alcohol-dependent individuals have slower reaction times on the SST in comparison to healthy controls, while they perform similarly to healthy controls in terms of their ability to successfully inhibit the unwanted response on the SST (Lawrence et al, 2009b). Alcohol-dependent individuals have also been found to have increased risk-taking on the CGT (Lawrence et al, 2009a), but perform similarly to healthy controls on the quality of decision-making outcome measure on the CGT (Czapla et al, 2015). The results from the current study are partially consistent with Lawrence et al's (2009a & 2009b) findings, in that participants were able to inhibit the unwanted response around half of the time on the SST, and showed a moderate level of risk taking on the CGT. Nevertheless, the results from the current study suggest that individuals with ARBD may show decision-making deficits on the CGT, as they chose to gamble on the most likely outcome 75% of the time, in comparison to Lawrence et al's (2009b) alcohol-dependent group who made rational decisions 94% of the time. Participants in the current study also had slower reaction times (SSRT = 306ms) than Lawrence et al's (2009b) alcohol-dependent group (SSRT = 212ms), suggesting that ARBD may result in further psychomotor slowing in comparison to alcohol-dependent individuals with no ARBD diagnosis.

Taken together, the CANTAB results are indicative of episodic memory impairment (PAL), coupled with relatively preserved, but below average, spatial planning ability (SOC), spatial working memory (SWM) and cognitive flexibility (IED). Participants also demonstrated a degree of impulsivity and psychomotor slowing on the CGT and

SST, although the absence of normative data for these two tests, and limited evidence within the alcohol dependence literature, means that the degree of impairment on these tasks cannot easily be ascertained. The observed pattern of neurocognitive functioning in this study is consistent with classic conceptualisations of alcoholic Korsakoff syndrome as being primarily associated with episodic memory impairment (Pitel et al, 2008). Spatial planning ability, spatial working memory performance and cognitive flexibility were found to be below the normative average. Therefore, the findings also provide evidence for executive dysfunction in ARBD, which is in line with recent postulations that ARBD is not solely associated with anterograde amnesia (Van Oort and Kessels, 2009; Maharasingam et al, 2013; Brion et al, 2014). The neurocognitive profile observed in this study reflects current knowledge about the structural brain abnormalities that are associated with ARBD, including damage to the brain regions underpinning memory, such as the mammillary bodies, anterior thalamus, mammilothalamic tract and hippocampus, as well as damage to the prefrontal brain circuitry involved in executive functions such as behavioural inhibition (Kril & Harper, 2012; Oscar-Berman, 2012; Zahr, Kaufman & Harper, 2011).

A floor effect was found on the RVP test of the CANTAB, suggesting that this test may be an insensitive means of tapping into sustained visual attention in some individuals with ARBD. Half of the participants scored well below the normative average on the "total false alarms" outcome measure on the RVP test. It is unclear whether the observed findings on the RVP reflect attentional deficits, or deficits in other cognitive domains. The results from the SST suggest that participants had some difficulty with impulse control. However, it cannot be assumed that the large number of "false alarms" during the RVP was also indicative of behavioural disinhibition. The disproportionate deficit observed on the RVP test can neither be adequately explained in terms of problems with encoding or working memory impairment: Although performance was found to be compromised on the PAL and SWM tests, participants generally performed within, or close to, the low normal range on these tests. There is evidence to suggest that individuals with ARBD show deficits on speed of information processing tests (Maharasingam et al, 2013). Thus, a

possible explanation for the observed findings on the RVP test may be compromised speed of information processing. The RVP stimuli are presented on-screen automatically, at a fixed speed. Therefore, a proportion of participants may have struggled to process the information quickly enough to accurately respond to the target stimuli, and may have attempted to over-compensate for this deficit by pressing the response pad excessively in an attempt to avoid missing the target sequences.

Research into the psychosocial functioning of individuals with ARBD is currently scarce (Horton et al, 2014a). Nevertheless, anxiety and depression are recognised to be common comorbidities in this population (MacRae & Cox, 2003; Wilson et al, 2012). The findings from the self-report questionnaires provide evidence for relatively low levels of vigour, as well as elevated levels of confusion in individuals with ARBD. The majority of participants scored within the normal range on the POMS, HADS and DASS, although a proportion of individuals also reported elevated levels of depression, anxiety and stress on these instruments. At least half of the participants reported problems with anxiety/depression, pain/discomfort and mobility on the EQ-5D-5L. As a group, the SF-36v2 mental and physical health scores were found to be in the low normal range. Nevertheless, around half of the participants scored below the normal range on the mental and physical health components of the Sf-36v2, indicating that a proportion of individuals perceived their health-related QoL to be below average.

The results from the self-report questionnaires suggest that although a considerable proportion of participants scored relatively low in comparison to normative comparison data, at least half of the participants' perceived QoL was within the normal range. These findings are perhaps surprising, and it is possible that participants in the current study perceived their current situation to be relatively good in comparison to their past circumstances, resulting in a positively skewed perception of current QoL. Nevertheless, the current findings are consistent with evidence from Oudman and Wijnia's (2014) recent study, in which moderate to good

QoL was found in patients with ARBD living in long-term care. A strong correlation was found between the scores on the HADS and the DASS, reflecting consistency in responding across these two measures. Nevertheless, while the group scored within the mild range on the DASS, group scores on the HADS were found to be in the normal range. The discrepancy between scores on the HADS and DASS raises the possibility that the HADS may not be sensitive to anxiety and depression in individuals with ARBD. However, larger scale research is required to determine the psychometric properties of these instruments within an ARBD context.

Scores on the AMPS indicate that participants demonstrated evidence of increased clumsiness/physical effort and reduced efficiency during IADL task performance. Research into the everyday functional performance of individuals with ARBD is scarce. Moreover, this is believed to be the first study to use the AMPS within an ARBD context. A recent study by Oudman et al (2013) compared the effect of errorless learning and trial and error learning on IADL task performance in patients with Korsakoff's syndrome during a laundry task. Nevertheless, the assessment procedure used by Oudman et al was unique to the study, precluding comparisons with normative IADL ability. The AMPS offers a valuable alternative means of assessing IADL ability in ARBD, as it is widely used in occupational therapy practice and allows normative comparisons to be made. Evidence in the context of acquired brain injury and dementia suggests that the AMPS may predict an individual's capacity for independent living better than neuropsychological testing alone (Bouwens et al, 2008; Linden et al, 2005). Further research using the AMPS as an outcome measure for everyday functioning in ARBD is therefore recommended.

The results from this study provide evidence for the multifaceted impact of ARBD in a cohort of individuals upon admission to a residential rehabilitation facility. The participants not only displayed neurocognitive deficits, but also demonstrated evidence for reduced psychosocial and everyday functioning. The results from this study confirm expectations and are consistent with existing research into the functioning of people with ARBD. The variability among individual scores highlights

the heterogeneity of the group and highlights the importance of taking an individualised, person centred approach when formulating care plans for people with ARBD (Arbias, 2011).

Future larger scale research should seek to delineate differences in the functional profile of subgroups of individuals with ARBD, for example by examining demographic factors such as age, gender and premorbid IQ. Another potentially fruitful avenue for future research would be to investigate the extent to which neurocognitive impairment has an impact upon psychosocial and everyday functioning. As impulsivity and faulty decision-making are associated with increased risk of relapse in individuals with a history of alcohol dependence (Czapla et al, 2015), future research should also be conducted to determine the extent to which impulsivity may be a predictor of relapse in individuals with ARBD. There is also the potential for further research to address the effectiveness of specific intervention strategies on functioning on an individual case study basis (Svanberg & Evans, 2013).

This study has a number of methodological limitations. Firstly, the small sample size may limit the generalizability of the findings to the wider ARBD population. Secondly, the obtained scores were not compared to a control group, although they were compared to normative data sets where possible to facilitate normative comparisons. Thirdly, while some individuals had been abstinent from alcohol for 3 months on admission to the residential facility, others had been abstinent for up to two years and were therefore further into their recovery. Fourthly, the use of the NART provides an index of premorbid IQ only. Given that the participants represent a group of individuals with acquired brain injury, it is conceivable that premorbid IQ may be inconsistent with actual IQ in this clinical presentation. Additional limitations include the use of self-report instruments that have not been specifically evaluated for use with ARBD, and the possibility that participants had some difficulty with the one-week recall period used within the SF36v2, HADS and DASS, due to the demands placed upon memory. In the wider research literature, the SF36 has been

shown to be a valid and reliable measure of general health status in individuals with cognitive impairment (Riemsma et al, 2001). However, there is inconsistent evidence for the validity of the HADS and the DASS in traumatic brain injury (Ownsworth et al, 2008; Whelan-Goodinson et al, 2009; Schonberger & Ponsford, 2010; Dahm et al, 2013). Future research should seek to validate these instruments when used with ARBD.

Conclusion

The comprehensive assessment framework used in this study is line with existing recommendations for the assessment of ARBD (Cox et al, 2004), and provides an integrated overview of the neurocognitive, psychosocial and everyday functioning of a cohort of individuals with ARBD on admission to specialist residential care. This study suggests that CANTAB can be used to provide an integrated, norm-referenced cognitive profile of people with ARBD. There are, however, two caveats to this: Firstly, the findings suggest that the RVP test may be unsuitable for measuring sustained visual attention in some people with ARBD. Secondly, the lack of existing normative comparison data on the CGT and SST is problematic in terms of ascertaining the degree to which people with ARBD display impulsivity. To date, there has been very limited research concerning the psychosocial and everyday functioning of people with ARBD. Moreover, as recent studies have used proxy measures to investigate QoL in people with ARBD (Oudman & Zwart, 2012; Oudman et al, 2013), research into individuals' perceived QoL has been absent from the ARBD literature. This study makes a valuable contribution to ARBD research as it provides insight into subjective evaluations of QoL, as well as self-reported mental health status, and the quality of IADL performance. This study was conducted within a supported accommodation facility, which aims to promote service users' wellbeing and independence through the provision of person-centred support. Future research in this setting will illustrate changes in service users' functioning over time, whilst providing evidence for the impact of specialist residential care on the recovery of individuals with ARBD. Larger scale research is also needed to validate this assessment framework in an ARBD context.

Acknowledgements

This review was funded in part by a grant from the West of Scotland Knowledge Transfer Partnership Centre, Glasgow, Scotland, UK.

Conflict of interest

The authors report no conflicts of interest.

References

Arbias (2011). *Looking forward: Information & specialised advice on alcohol-related brain impairment.* Australia: Arbias.

Blansjaar, B.A., Takens, H. & Zwinderman, A.H. (1992). The course of alcohol amnestic disorder: a three-year follow-up study of clinical signs and social disabilities. *Acta Psychiatrica Scandinavica,* 86, 240-246.

Bouwens, S.F.M., van Heugten, C.M., Aalten, P., Wolfs, C.A.G., Baarends, E.M., van Menxel, D.A.J. & Verhey, F.R.J. (2008). Relationship between Measures of Dementia Severity and Observation of Daily Life Functioning as Measured with the Assessment of Motor and Process Skills (AMPS), *Dementia and Geriatric Cognitive Disorders*, 25, 81-87.

Brion, M., Pitel, A.L., Beaunieux, H. & Maurage, P. (2014). Revisiting the continuum hypothesis: toward an in-depth exploration of executive functions in Korsakoff syndrome, *Frontiers in Human Neuroscience*, 8, 1-7.

Brown, T.A., Chorpita, B.F., Korotitscw, W. & Barlow, D.H. (1997). Psychometric properties of the Depression Anxiety Stress Scales (DASS) in clinical samples, *Behaviour Research and Therapy*, 35, 79-89.

Cambridge Cognition (2013). *CANTABeclipse 6: Test Administration Guide*, Cambridge Cognition Ltd, Cambridge, UK.

Cox, S., Anderson, I. & McCabe, L. (2004). *A Fuller Life: Report of the Expert Group on Alcohol Related Brain Damage*. University of Stirling: Dementia Services Development Centre, Stirling.

Czapla, M., Simon, J.J., Richter, B., Kluge, M., Friederich, H.C., Herpertz, S., Mann, K., Herpertz, C. & Loeber, S. (2015). The impact of cognitive impairment and impulsivity on relapse of alcohol-dependent patients: implications for

psychotherapeutic treatment. *Addiction Biology*, Early View, Published online: 11 Feb 2015.

Dahm J., Wong, D. & Ponsford, J. (2013). Validity of the Depression Anxiety Stress Scales in assessing depression and anxiety following traumatic brain injury. *Journal of Affective Disorders,* 151, 392–396.

Douglas J. & Wilkinson D.A. (1993) Evidence for normal emotional responsiveness in alcoholic Korsakoff's syndrome in the presence of profound memory impairment. *Addiction*, 88, 1637–1645.

EuroQol Group (1990). EuroQol: A new facility for the measurement of health-related quality of life. *Health Policy*, 16, 199-208.

Ettema T.P., Droes R.M., de Lange J., et al. (2007) QUALIDEM: development and evaluation of a dementia specific quality of life instrument. Scalability, reliability and internal structure. *International Journal of Geriatric Psychiatry*, 22, 549–556.

Field, A. (2013). Discovering Statistics Using IBM SPSS Statistics 4th Edition, SAGE Publications LTD, London.

Fisher, A.G. & Jones, K.B. (2012). *Assessment of Motor and Process Skills*, 7th Edition, Volume 2: *User Manual*, Three Star Press, Inc.

Garratt, A., Schmidt, L., Mackintosh, A. & Fitzpatrick, R. (2002). Quality of life measurement: bibliographic study of patient assessed health outcome measures, *British Medical Journal*, 324: 1417.

Horton, L., Duffy, T., Hollins-Martin, C. & Martin, C.R. (2014a). Comprehensive assessment of alcohol-related brain damage (ARBD): Gap or chasm in the evidence? *Journal of Psychiatric and Mental Health Nursing*, Published online 21 May 2014.

Horton, L., Duffy, T. & Martin, C.R. (2014b). Assessing outcomes of alcohol-related brain damage (ARBD): What should we be measuring? *Drugs: Education, Prevention, and Policy*, Early Online.

Irvine, C. & Mawhinney, S. (2008). Functioning of individuals with Korsakoff's syndrome: a pilot study of supported group living in Northern Ireland. *Mental Health Review Journal*, 13, 16-23.

Kril, J.J., & Harper, C.G. (2012). Neuroanatomy and neuropathology associated with Korsakoff's syndrome. *Neuropsychological Review*, 22, 72-80.

Lawrence, A.J., Luty, J., Bogdam, N.A., Sahakian, B.J. & Clark, L. (2009a). Problem gamblers share deficits in impulsive decision-making with alcohol-dependent individuals. *Addiction*, 104, 1006-1015.

Lawrence, A.J., Luty, J., Bogdam, N.A., Sahakian, B.J. & Clark, L. (2009b). Impulsivity and response inhibition in alcohol dependence and problem gambling, *Psychopharmacology*, 207, 163-172.

Levaux, M.N., Potvina, S., Sepehrya, A.A., Sabliera, J., Mendreka, A. & Stipa, E. (2007). Computerized assessment of cognition in schizophrenia: Promises and pitfalls of CANTAB, *European Psychiatry*, 22, 104–115.

Levola, J., Aalto, M., Holopainen, A., Cieza, A. & Pitkänen. T. (2014). Health-related quality of life in alcohol dependence: A systematic literature review with a specific focus on the role of depression and other psychopathology, *Nordic Journal of Psychiatry*, 68, 369-384.

Linden, A., Boschian, K., Eker, C., Schalen, W. & Nordstrom, C.H. (2005). Assessment of motor and process skills reflects brain-injured patients' ability to resume independent living better than neuropsychological tests, *Acta Neurologica Scandinavica,* 111, 48-53.

Lovibond, S. H. & Lovibond, P. F. (1993). *Manual for the Depression Anxiety Stress Scales (DASS).* Psychology Foundation, University of New South Wales, Australia.

Luquiens A., Reynaud, M., Falissard, B. & Aubin H.J. (2012) Quality of life among alcohol-dependent patients: How satisfactory are the available instruments? A systematic review. *Drug and Alcohol Dependence*, 3, 192–202.

MacRae, S. & Cox, S. (2003). *Meeting the needs of people with alcohol-related brain damage: A literature review on the existing and recommended service provision and models of care*. University of Stirling, Stirling.

Maharasingam M., MacNiven J.A.B. & Mason J. (2013) Executive functioning in chronic alcoholism and Korsakoff syndrome. *Journal of Clinical and Experimental Neuropsychology,* 35, 501–508.

Maruish, M. E. (Ed.). (2011). *User's Manual* for the SF-36v2 Health Survey, 3rd Edition, Lincoln, RI: QualityMetric Incorporated.

McNair, D.M., Lorr, M. & Droppleman, L.F. (1971). *Manual: Profile of Mood States*. San Diego, CA: Educational and Industrial Testing Service.

McPherson, A. & Martin, C.R. (2010). Is the Hospital Anxiety and Depression Scale (HADS) an appropriate screening tool for use in an alcohol-dependent population? *Journal of Clinical Nursing*, 20, 1507–1517.

Nelson H.E. & Willison J.R. (1991) *The Revised National Adult Reading Test-Test Manual.* Windsor, UK: NFER-Nelson.

Oemar, M. & Janssen, B. (2013). *EQ-5D-5L User Guide: Basic information on how to use the EQ-5D-5L instrument*, *Version 2.0,* EuroQol Group, Rotterdam.

Oscar-Berman M., Kirkley S.M., Gansler D.A., et al. (2004) Comparisons of Korsakoff and non-Korsakoff alcoholics on neuropsychological tests of prefrontal brain functioning. *Alcoholism, Clinical and Experimental Research,* 28, 667–675.

Oscar-Berman, M. (2012). Function and dysfunction in prefrontal brain circuitry in Korsakoff's syndrome. *Neuropsychological Review*, 22, 154-169.

Oudman, E., Nijboer, T.C.W., Postma, A., wijnia, J.W., Kerklaan, S., Lindsen, K. & Van der Stigchel, S. (2013) Acquisition of an instrumental activity of daily living in patients with Korsakoff's syndrome: A comparison of trial and error and errorless learning, *Neuropsychological Rehabilitation: An international Journal*, 23, 888-913.

Oudman, E. & Wijnia, J.W. (2014). Evolution of quality of life in patients with Korsakoff's syndrome in a long-term care facility, *International Psychogeriatrics*, 26, 2073-2079.

Oudman E. & Zwart E. (2012) Quality of life of patients with Korsakoff's syndrome and patients with dementia: a cross sectional study. *Journal of the American Medical Directors Association*, 13, 778–781.

Ownsworth, T., Little, T., Turner, B., Hawkes, A. & Shumi, D. (2008). Assessing emotional status following acquired brain injury: The clinical potential of the depression, anxiety and stress scales, *Brain Injury*, 22, 858–869.

Pitel A.L., Beaunieux H., Witkowski T., et al. (2008) Episodic and working memory deficits in alcoholic Korsakoff patients: the continuity theory revisited. *Alcoholism, Clinical and Experimental Research*, 32, 1229–1241.

Riemsma, R.P., Forbes, C.A., Glanville, J.M., Eastwood, A.J. & Kleijnen, J. (2001). General health status measures for people with cognitive impairment: learning disability and acquired brain injury, *Health Technology Assessment*, 5(6).

Schonberger, M. & Ponsford, J. (2010). The factor structure of the Hospital Anxiety and Depression Scale in individuals with traumatic brain injury, *Psychiatry Research,* 179, 342–349.

Smith, P. J., Need, A.C., Cirulli, E.T., Chiba-Falek. O. & Attix, D.K. (2013). A comparison of the Cambridge Automated Neuropsychological Test Battery (CANTAB) with "traditional" neuropsychological testing instruments, *Journal of Clinical and Experimental Neuropsychology,* 35, 319-328.

Snaith, R.P. & Zigmond, A.S. (1994). *The Hospital Anxiety and Depression Scale Manual*, GL Assessment Limited, London, UK.

Thomson, A.D. Marshall, J.E. & Bell, D. (2012). Time to Act on the Inadequate Management of Wernicke's Encephalopathy in the UK. *Alcohol and Alcoholism*, 48, 1, 4-8.

Van Oort, R. & Kessels, R.P.C. (2009) Executive dysfunction in Korsakoff's syndrome: Time to revise the DSM criteria for alcohol-induced persisting amnestic disorder? *International Journal of Psychiatry in Clinical Practice*, 13, 78-81.

Ware Jr, J.E. & Sherbourne, C.D. (1992). The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Medical Care*, 30, 473-483.

Wilson, K., Halsey, A., Macpherson, H., Billington, J., Hill, S., Johnson, G., Raju, K. & Abbott, P. (2012). The Psycho-Social Rehabilitation of Patients with Alcohol-Related Brain Damage in the Community, *Alcohol & Alcoholism*, 47, 3, 304-311.

Whelan-Goodinson, R. Ponsford, J. & Schönberger, M. (2009). Validity of the Hospital Anxiety and Depression Scale to assess depression and anxiety following traumatic brain injury as compared with the Structured Clinical Interview for DSM-IV, *Journal of Affective Disorders,* 114, 94–102.

Zahr, N.M., Kaufman, K.L., Harper, C.G. (2011). Clinical and pathological features of alcohol-related brain damage. *Nature Reviews Neurology*, 7, 284-294.

Zigmond, A.S. & Snaith, R.P. (1983). The Hospital Anxiety and Depression Scale, *Acta Psychiatrica Scandinavica*, 67, 361–370.

Table 1: CANTAB tests and their respective neurocognitive domains of assessment and associated outcome measures.

Test	**Neurocognitive Domain**	**Outcome Measures**	**Normative comparison available?**
Cambridge Gambling Task (CGT)	Impulse control and risk-taking in decision-making	Overall Proportional Bet (OPB) Quality of Decision Making (QDM) Risk Taking (RT)	No
Paired Associates Learning (PAL)	Episodic memory	Total Errors (adjusted) Total Errors (6 shapes adjusted)	Yes
Rapid Visual Information Processing (RVP)	Sustained visual attention	Sensitivity to target (S) Probability of hit (PoH) Total false alarms (TFA) Mean latency (ML)	Yes
Stockings of Cambridge (SOC)	Spatial planning	Problems solved in minimum moves (PSMM) Mean moves (2 moves) (MM2) Mean moves (3 moves) (MM3) Mean moves (4 moves) (MM4) Mean moves (5 moves) (MM5)	Yes
Spatial Working Memory (SWM)	Working memory and strategy use	Between Errors (BE) Strategy Use (SU)	Yes
Stop Signal Task (SST)	Response inhibition	Direction Errors (DE) Proportion of successful stops (PSS) Stop signal reaction time (SSRT)	No
Intra-Extra Dimensional Set Shift (IED)	Rule acquisition and attentional set shifting	Total Errors (TE) Stages Completed (SC)	Yes

Table 2: Self-report measures including description of each test, domain assessed and scoring approach.

Instrument	Description, domains measured and scoring	Recall Period Used
EQ-5D-5L	5-item measure of health status assessing self-reported problems with mobility, self-care, usual activities, pain/discomfort and anxiety/depression, as well as the respondent's self-rated health on a Visual Analogue Scale ranging from 0 (worst health imaginable) to 100 (best health imaginable).	Today
SF-36v2	36-item instrument used to measure 8 domains of health-related quality of life (physical functioning; role-physical; bodily pain; general health; vitality; social functioning; role-emotional; and mental health), which are collapsed into the Physical Component Summary (PCS) and Mental Component Summary (MCS). Standardised T-scores, based on U.S.A general population norms in 2009, have a mean of 50 and a standard deviation of 10 (normal range = 45-55).	1 week
POMS	65-item measure of mood state comprising tension-anxiety; depression-dejection; anger-hostility; vigour-activity; fatigue-inertia; confusion-bewilderment; and total mood disturbance. Standardised T-scores for adult norms have a mean of 50 and standard deviation of 10 (normal range = 40-60). T scores of 65 and 35 are cut-off points for extreme cases requiring attention.	Today
HADS	14-item instrument measuring self-assessed anxiety and depression on 2 separately scored subscales. Scores: 0-7 (normal); 8-10 (mild depression/anxiety); 11-14 (moderate depression/anxiety); 15-21 (severe depression/anxiety)	1 week
DASS	42-item measure of self-assessed depression, anxiety and stress comprising separate severity ratings for each of the 3 scales: Depression: 0-9 (normal); 10-13 (mild); 14-20 (moderate); 21-27 (severe); 28+ (extremely severe) Anxiety: 0-7 (normal); 8-9 (mild); 10-14 (moderate); 15-19 (severe); 20+ (extremely severe) Stress: 0-14 (normal); 15-18 (mild); 19-25 (moderate); 26-33 (severe); 34+ (extremely severe)	1 week

Table 3: The AMPS assessment scales and description and scoring of each component scale.

Scale	**Description and scoring**
Motor Skills	Measures the degree of clumsiness or physical effort during task performance using 16 performance skill items Competence cut-off = 2, risk zone = 1.7 to 2.3
Process Skills	Measures how efficiently tasks are performed using 20 performance skill items Competence cut-off = 1, risk zone = 0.7 to 1.3

Table 4: CANTAB mean (SD) Scores as a function of each test.

Test	Outcome measures	n	Raw Scores	Z Scores
Cambridge Gambling Task (CGT)	Overall Proportional Bet (OPB)	19	0.52 (0.18)	n/a
	Quality of Decision Making (QDM)	19	0.75 (0.20)	n/a
	Risk Taking (RT)	19	0.53 (0.19)	n/a
Paired Associates Learning (PAL)	Total Errors (adjusted)	19	88 (45.27)	-2.54 (1.88)
	Total Errors (6 shapes adjusted)	19	27.89 (18.32)	-1.68 (1.61)
Rapid Visual Information Processing (RVP)	Sensitivity to target (S)	18	0.81 ((0.07)	-2.29 (1.57)
	Probability of hit (PoH)	18	0.50 (0.25)	-1.02 (1.41)
	Total false alarms (TFA)	18	33.56 (49.48)	-14.09 (21.10)
	Mean latency (ML)	18	715.78 (277.08)	-2.20 (2.80)
Stockings of Cambridge (SOC)	Problems solved in minimum moves (PSMM)	18	5 (2.79)	-1.54 (1.38)
	Mean moves (2 moves) (MM2)	17	2.26 (0.75)	-0.93 (3.14)
	Mean moves (3 moves) (MM3)	17	4.24 (1.06)	-1.78 (1.81)
	Mean moves (4 moves) (MM4)	17	6.31 (1.15)	-0.86 (1.05)
	Mean moves (5 moves) (MM5)	15	8.58 (1.92)	-1.14 (1.19)
Spatial Working Memory (SWM)	Between Errors (BE)	16	62.44 (23.43)	-1.07 (0.97)
	Strategy Use (SU)	16	39 (6.18)	-0.86 (1.03)

Stop Signal Task (SST)	Direction Errors (DE)	16	5.50 (5.85)	n/a
	Proportion of successful stops (PSS)	16	0.50 (0.09)	n/a
	Stop signal reaction time (SSRT)	16	305.59 (164.23)	n/a
Intra-Extra Dimensional Set Shift (IED)	Total Errors (TE)	16	68.68 (59.14)	-1.14 (1.84)
	Stages Completed (SC)	16	7 (2.45)	-1.04 (1.83)

Table 5: CANTAB Percentage of Individual Scores in Each Z Score Category

Test	Outcome measures	n	Impaired (Z = > -2)	Low normal range (Z = -2 to 0)	High normal range (Z = 0 to 2)
Paired Associates Learning (PAL)	Total Errors (adjusted)	19	65%	25%	10%
	Total Errors (6 shapes adjusted)	19	50%	30%	20%
Rapid Visual Information Processing (RVP)	Sensitivity to target (S)	18	55%	45%	0%
	Probability of hit (PoH)	18	30%	50%	20%
	Total false alarms (TFA)	18	60%	5%	35%
	Mean latency (ML)	18	50%	15%	35%
Stockings of Cambridge (SOC)	Problems solved in minimum moves (PSMM)	18	50%	35%	15%
	Mean moves (2 moves) (MM2)	17	10%	5%	85%
	Mean moves (3 moves) (MM3)	17	50%	20%	30%
	Mean moves (4 moves) (MM4)	17	5%	70%	25%
	Mean moves (5 moves) (MM5)	15	20%	65%	15%
Spatial Working Memory (SWM)	Between Errors (BE)	16	5%	90%	5%
	Strategy Use (SU)	16	5%	90%	5%
Intra-Extra Dimensional Set Shift (IED)	Total Errors (TE)	16	20%	55%	25%
	Stages Completed (SC)	16	20%	45%	35%

Table 6: Self-report measures score as a function of each domain assessed (n = 20).

Instrument	Domain	Mean (SD)	Range
EQ-5D-5L	Visual Analogue Scale	67 (18.52)	n/a
SF-36v2 (T scores)	Physical functioning	61.5 (29.56)	Better than average
	Role-Physical	63.25 (28.32)	Better than average
	Bodily Pain	57.8 (32.16)	Better than average
	General Health	57.75 (27.28)	Better than average
	Vitality	52.05 (31.15)	Slightly better than average
	Social Functioning	77.55 (29.08)	Better than average
	Role-Emotional	75.45 (28.62)	Better than average
	Mental Health	61.50 (27.00)	Better than average
	Physical Component Summary	45.25 (10.55)	Below average
	Mental Component Summary	46.00 (12.26)	Below average
POMS (T scores)	Tension-Anxiety	51.75 (14.90)	Slightly above average
	Depression-Dejection	52.15 (12.24)	Slightly above average
	Anger-Hostility	46.25 (7.53)	Below average
	Vigour-Activity	43.00 (12.20)	Below average
	Fatigue-Inertia	48.90 (12.13)	Slightly below average
	Confusion-Bewilderment	56.90 (14.64)	Above average
	Total Mood Disturbance	52.85 (12.19)	Slightly above average
HADS	Anxiety	6.80 (6.07)	Normal
	Depression	4.9 (4.18)	Normal
DASS	Depression	11.35 (10.40)	Mild
	Anxiety	8.10 (9.76)	Mild
	Stress	10.80 (11.03)	Normal

Table 7: EQ-5D-5L Percentage of Individual scores in each category (n = 20).

	Mobility	Self-Care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
No Problems	50%	85%	75%	45%	45%
Slight Problems	15%	10%	5%	10%	15%
Moderate Problems	30%	5%	15%	30%	15%
Severe Problems	5%	0%	5%	15%	25%
Extreme Problems	0%	0%	0%	0%	0%

Table 8: SF-36v2 Percentage of individual scores in each range (n = 20).

	PF	RP	BP	GH	VT	SF	RE	MCS	PCS
Below Average (<45)	30%	35%	50%	25%	15%	25%	25%	45%	55%
Normal Range (45-55)	5%	5%	5%	25%	10%	0%	0%	25%	20%
Above Average (>55)	65%	60%	45%	50%	75%	75%	75%	30%	25%

Table 9: POMS Percentage of individual scores in each range (n = 20).

	Tension	Depression	Anger	Vigour	Fatigue	Confusion	TMD
Below Average (<40)	25%	5%	5%	50%	25%	20%	20%
Normal Range (40-60)	50%	80%	90%	45%	70%	40%	55%
Above Average (>60)	25%	15%	5%	5%	5%	40%	25%

Table 10: HADS Percentage of individual scores in each range (n = 20).

	Depression	**Anxiety**
Normal	75%	60%
Mild	10%	10%
Moderate	10%	10%
Severe	5%	20%

Table 11: DASS Percentage of individual scores in each range (n = 20).

	Depression	Anxiety	Stress
Normal	50%	60%	65%
Mild	15%	5%	10%
Moderate	20%	10%	10%
Severe	5%	5%	15%
Extreme	10%	20%	0%

Table 12: AMPS mean (SD) scores (n = 18)

Performance Skill	Raw Scores	Z Scores
Motor Ability	1.74 (0.55)	-1.28 (1.01)
Process Ability	1.03 (0.32)	-1.38 (0.77)

Table 13: AMPS Percentage of individual scores in each range (n = 18)

	Motor Skills	**Process Skills**
Impaired (Z = > -2)	17.5%	10%
Low Normal Range (Z = 0 to -2)	65%	85%
High Normal Range (Z = 0 to 2)	17.5%	5%