An Investigation into the Ecological Validity of Virtual Reality Measures of Planning and Prospective Memory in Adults with Acquired Brain Injury

and

Clinical Research Portfolio

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Fiona Scott

Academic Unit of Mental Health & Wellbeing

Institute of Health & Wellbeing

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Faculty of Medicine Graduate School

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Chapter 1: Systematic Literature Review

Development of Prospective Memory: A Review of Age-Related Changes between Childhood and Young Adulthood

Fiona Scott[1]*

Written according to guidelines for submission to the *Journal of the International Neuropsychological Society*
(Author's Instructions – see Appendix 1.1)

[1] Academic Unit of Mental Health & Wellbeing, University of Glasgow

* Address for correspondence:
Academic Unit of Mental Health & Wellbeing
Institute of Health & Wellbeing
University of Glasgow
Gartnavel Royal Hospital
Administration Building
Trust HQ, 1st floor
1055 Great Western Road
Glasgow, G12 0XH
Email: fiona.scott7@nhs.net

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Abstract

Background: Little is known regarding the development and underpinning processes that lead to successful prospective memory performance in childhood and adolescence. This review systematically examines the nature of normative developmental change in event- and time-based prospective memory between childhood and young adulthood and evaluates the impact that methodological design has on the age differences reported in the literature. ***Methods:*** Electronic database searches of published studies ranging from 1980-2011 were undertaken. Hand searches of reference lists and selected journals were also completed. Identified studies that fulfilled the inclusion criteria were reviewed using a tailored, methodological quality rating checklist and relevant data was extracted. ***Results:*** Twenty-eight studies were included in the review. Evidence from event-based PM studies indicated improvement in PM abilities across all age ranges considered. Time-based PM studies were less abundant, although indicated developmental gains between early school age and adolescence. Key methodological considerations for PM task design are discussed and suggestions for future research outlined. ***Conclusions:*** There is growing evidence for developmental changes in PM spanning the preschool to young adulthood age range. Methodological variation in developmental research paradigms influence the age effects reported. Findings have potential theoretical and practical implications in educational and neuropsychological settings.

Keywords: Prospective memory; development; children; adolescents; young adults

Introduction

The ability to remember to perform an intended action in the future is critical to daily independent functioning (Shallice & Burgess, 1991). This form of remembering has been termed *prospective memory* (PM) (Ellis, 1996; Ellis & Freeman, 2008) and has been conceptualised as a multi-phase process involving the formation, retention, delayed initiation and execution of intentions (Kliegel et al., 2008a). In the experimental literature, a further distinction has been made between time- and event-based PM, with the former referring to the task of remembering to do something at a specified time point in the future, whilst event based PM is prompted by an external cue (Einstein et al., 1995). Furthermore, PM has been considered to have both a prospective and retrospective memory (RM) component, with the self-initiated execution of a delayed intention (i.e. remembering that there is *something* to do) forming the prospective component, whilst the memory for the specific content of the intention (i.e. remembering *what* to do and *when* to do it) forms the retrospective component (Einstein & McDaniel, 1996). Since PM is highly dependent on self-initiated retrieval processes, it is unsurprising that one of the most frequent memory failures in everyday life is forgetting to carry out a delayed intention (Winograd, 1988).

Interest in age-related change in PM has increased over the last two decades, though the majority of research has centered on group differences using adult and older adult populations (see Henry et al., 2004 and Uttl, 2008 for meta-analyses). In contrast, there have been fewer studies investigating the development of successful PM performance at the younger end of the lifespan (Kvavilashvili et al., 2008). This is surprising given that PM demands are placed upon children from a young age and the acquisition of prospective remembering skills is likely to impact upon successful attainment of autonomy, academic accomplishments and social relationships (McCauley & Levine, 2004; Meacham & Columbo, 1980). Furthermore, deficits in PM frequently occur after neurological injury or disease in childhood causing disruption to normative development (McCauley et al., 2010; Ward et al., 2007).

The current evidence-base indicates that event-based PM skills first emerge in early childhood

(Guajardo & Best, 2000; Kliegel & Jäger, 2007; Somerville et al., 1983; Wang et al., 2008) and become progressively drawn upon in the school environment, reflecting children's increasing reliance on using external reminders to cue prospective remembering when undertaking goal-directed behaviours (Beal, 1988; Meacham & Colombo, 1980; Passolunghi et al., 1995). However, there appear to be inconsistencies between studies in the developmental trajectories reported, with some studies reporting no age-related changes over the preschool and early school-age range (Kliegel et al., 2010; Meacham & Columbo, 1980; Somerville et al., 1983), whilst other studies document significant age effects on PM performance (Atance & Jackson, 2009; Kliegel et al., 2007; Kvavilashvili et al., 2001). The empirical evidence from event-based PM studies across adolescence is also somewhat inconsistent, with some studies reporting that PM continues to develop in adolescence (e.g. Wang et al., 2006), whilst others have found no difference in task performance between adolescents and young adults (e.g. Ward et al., 2005). Time-based PM is considered to develop later than event-based PM due to greater demands being placed on executive control processes, evidenced through the use of increasingly sophisticated strategies such as continuous time-monitoring (Kerns, 2000; Mackinlay et al., 2009; Mäntylä et al., 2007), although again mixed findings have been reported across the literature and some studies have focused on the time-monitoring behaviours exhibited by children as opposed to PM task completion (e.g. Ceci & Bronfenbrenner, 1985)

One reason for the relative lack of research on early PM development may be the difficulty in devising well-controlled experimental procedures for investigating this cognitive skill, particularly within a developmental framework. It has been argued that experimental PM tasks should have the following core attributes: the presence of a delay between the formation and opportunity to execute an intention; the absence of an explicit prompt to carry out the intended task at the appropriate moment; and the need for participants to interrupt an ongoing activity in order to carry out the intention (Ellis & Kvavilashvili, 2000). Thus, the gold-standard experimental paradigm is deemed to be the controlled dual-task paradigm such as that developed by Einstein & McDaniel (1990), whereby participants engage in an ongoing (OG) task, and at a designated time (time-based), or in response to a particular event (event-based), are asked to carry out an additional task (PM task). Furthermore, as successful performance on PM tasks is reliant on both prospective and retrospective components of PM, it is recommended that performance on both components is measured to determine their respective influence (Einstein & McDaniel, 1996). When considering research paradigms that compare age groups, an adjustment of OG task difficulty has been advocated to isolate age-effects on PM task performance and reduce the influence of age differences in cognitive resources (Einstein et al., 1997; Kvavilashvili et al., 2008). Therefore, measuring OG task performance and considering the differential impact of OG task difficulty across age groups can be considered essential. This is consistent with evidence from the adult to older adult literature, where age effects are more likely to occur when the OG activity is demanding and when the PM load is high (Henry et al., 2004).

Despite evidence for maturational trends in PM, the distinct developmental patterns are unclear. It appears that little is known about the factors underpinning the reported age differences in event-based and time-based PM across childhood and adolescence, due to studies having used different age groups, investigated different variables and dynamics of PM with diverse assessment measures, as well as having utilised a variety of research paradigms with seemingly inconsistent control over potential age-related confounders. As such, significant differences between age groups on PM tasks alone does not necessarily explain how PM develops in children and adolescents, nor does it elucidate what factors in methodological design impact upon these differences. Factors such as the length of delay between intention formation and execution (Guajardo & Best, 2000), the level of motivation attached to the PM task (Kliegel et al., 2010), the presence of task interruption (Kvavilashvili et al., 2001), the level of OG task difficulty and the nature of cue presentation (i.e. focal versus non-focal)[1] (Wang et al., 2011) have been reported to influence PM performance in children and adolescents.

Within the adult and older-adult literature, several other factors have been implicated to impact upon age-related PM changes, including: the experimental setting; the frequency of PM cue presentation;

[1] Focal cues are cues that must be processed by participants as part of the OG task, and as such will be sufficiently processed during the OG task to allow involuntary retrieval of the intended action. Whereas non-focal cues are cues that need not be processed during the OG task, and thus successful PM performance would require additional executive resources to monitor for cue occurrence to signal the appropriate moment to perform the intended action (Einstein & McDaniel, 2005)

the nature of PM task measurement (i.e. dichotomous or continuous); and the presence of age-related confounders - such as age-differences in OG task difficulty, RM performance or cognitive ability (Uttl, 2008). PM performance has also been shown to vary with respect to verbal ability, education and social economic status of participants (Cherry & LeCompte, 1999; Henry et al., 2004), as well as with respect to gender (Maylor & Logie, 2010). Therefore, it would be pertinent to consider the impact of these variables within the preschool to young adult literature-base.

The age-range considered in this review spans from birth to aged 29, with this upper age-limit being selected due to it being recognized that many higher-order cognitive functions, such as PM or working memory, continue to develop until the late 20s (Blakemore & Choudhury, 2006; Luna et al., 2010; Zelazo et al., 2004). Additionally, as time-based PM has been typically evaluated in terms of task accuracy and time-monitoring behavior[2], performance on both aspects are considered in this review.

Thus, considering the variation in study findings, the range of different experimental paradigms used and the inconsistent consideration of the methodological factors potentially impacting upon the developmental trends reported, it appears that a systematic and objective review on this subject area is warranted to determine the status of the field and provide guidance for future research. Therefore, this review will evaluate the literature on the development of event-based and time-based PM with the following objectives:

1. To determine the nature of developmental change in both event- and time-based prospective memory between childhood and young adulthood

2. To explore the extent to which variations in experimental methodology influence the developmental changes reported.

[2] Task accuracy refers to whether the delayed intention is carried out under one's own initiative, whilst time-monitoring behavior is how time is monitored to enable action at the appropriate point. Thus time-monitoring can often serve as an indicator of the PM component of prospective remembering (i.e. indicates that children are remembering that *something* needs to be done)

Methodology

Search Strategy

Database Searches

The following electronic databases were searched: PsycINFO, CINAHL, MEDLINE, EMBASE, and all Evidence Based Medicine (EBM) Reviews. Search mesh terms were used including [prospective memory] combined with [development], [early childhood development], [childhood development], [adolescent development], [cognitive development], [brain development], [lifespan], [developmental psychology], [developmental age groups] or [age differences]. Keyword terms used as search parameters included [prospective memor*] OR [intention* ADJ2 memor*] OR [future memor*] combined with [child* or adolescen* or memory or cognitive or psycholog* ADJ2 development] OR [ageing] OR [aging]. Where possible, studies were limited to child (aged 0-12), adolescent (13-18) and young adult populations, with this latter category spanning ages 19-24 (MEDLINE) and 18-29 (PsycINFO) respectively.

Inclusion and Exclusion Criteria

Articles were screened against the inclusion and exclusion criteria outlined below. Half the articles were randomly reviewed for eligibility by a second-rater resulting in 100% agreement, indicating high inter-rater reliability for study inclusion.

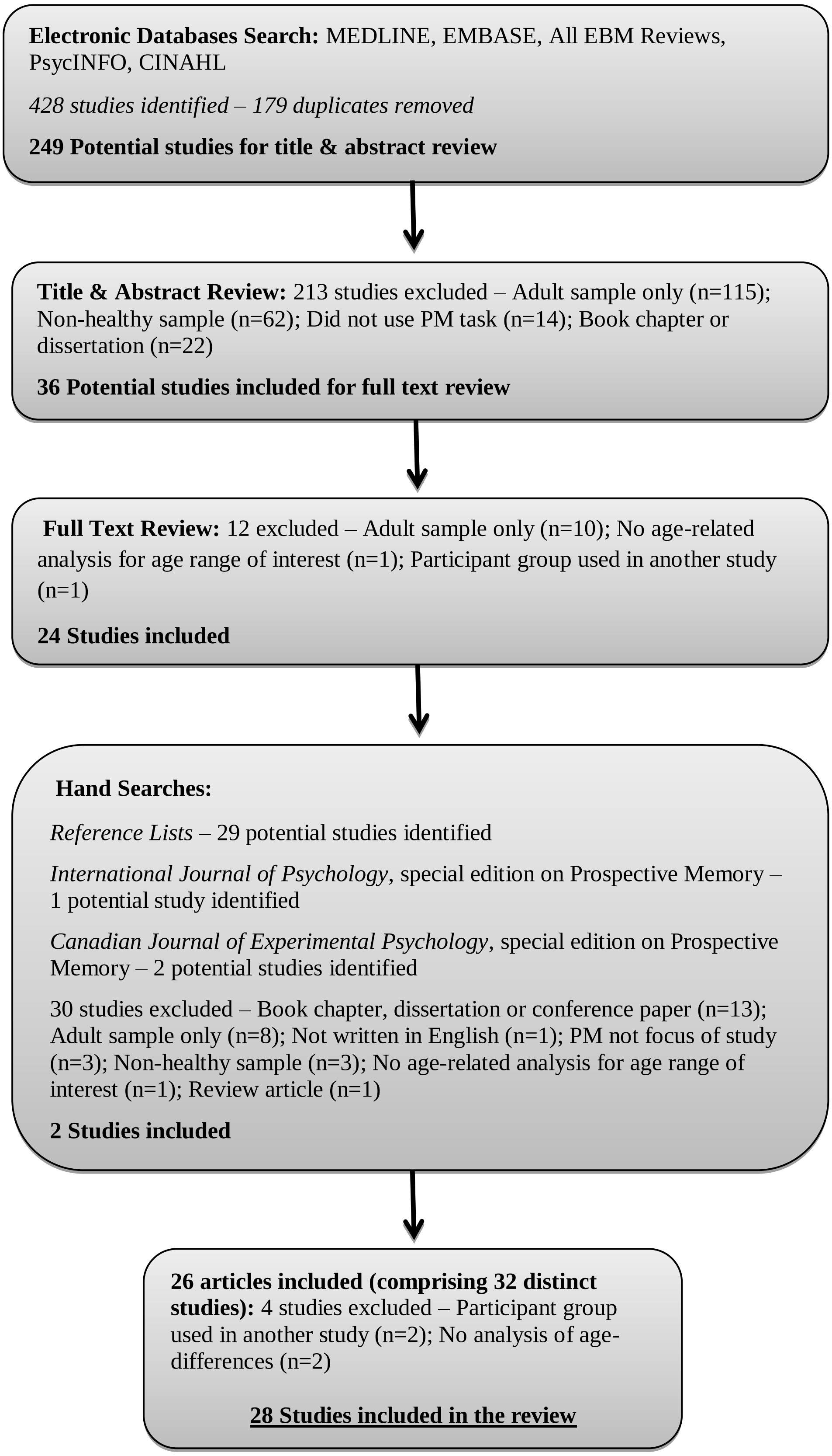
Inclusion Criteria: All studies published between 1980 and April 2011 that investigated age-related changes in performance on either time-based or event-based PM tasks using healthy child or adolescent populations were included. This time-frame was selected to maintain integrity between the various databases searched, with 1980 being the earliest date available for all databases. The definition of PM tasks was kept quite broad due to the range of experimental methodologies applied, although tasks had to involve participants performing an intended action in the future without experimenter prompting, and performance had to be measured in terms of successful remembering (as opposed to solely measuring time-monitoring behavior). In cases where more than one study had used the same participant sample (both across and within articles), only the initial study (or experiment within a study) was included to reduce risk of multiple publication bias.

Exclusion Criteria: Studies using only non-healthy populations, including the presence of co-morbid conditions such as learning disability or ADHD, or studies using only adult populations were excluded. Case studies, qualitative studies and studies not written in English were also excluded as well as book chapters, dissertations, conference papers and review articles.

Search Selection

Database searches identified 249 papers excluding duplicates. Of these, 213 were excluded after review of the title and abstract with respect to inclusion and exclusion criteria. The remaining 36 articles were retrieved in full-text format. After application of the inclusion and exclusion criteria to full papers, 12 articles were excluded. Hand searches of relevant journals were carried out including *International Journal of Psychology*, special edition on prospective memory (2003, vol. 38 part 4) and the *Canadian Journal of Psychology,* special edition on prospective memory (2011, vol. 65 part 1). Reference lists of included studies were also checked to identify potentially relevant papers. Thirty-two further potential articles were identified, of which 30 were excluded after review of the title and/or abstract. When considering articles containing more than one study, a further four studies were excluded either due to not clearly stating whether the participant group had been used in a previous study (n=2) or due to an analysis of age differences not being undertaken (n=2). This resulted in 28 distinct studies being included in this review, 22 of which examined event-based PM, five time-based PM and one which considered both types of PM cue. Figure 1 depicts a flow diagram outlining the systematic search strategy used.

Figure 1: Flowchart of Search Strategy and Results



Recorded Variables

For each eligible study, the first author, year of publication, country research was undertaken and summary of main findings was recorded. Subject-related variables that were recorded included: mean age of participants (and standard deviation (SD); age range if reported); number of participants in each age group (and number of males); and, if reported, mean IQ and socio-economic status (SES) of participant groups. Recorded measure-related variables included: nature of OG task; nature of PM task (and variation by experimental condition if applicable); nature of measure of PM performance; modality of PM cue (i.e. visual, auditory or temporal); nature of PM cue (i.e. focal or non-focal) and frequency of PM cue exposure. Recorded methodological design-related variables included: experimental setting (i.e. laboratory or naturalistic); the presence of interval task between intention formation and execution (and time delay if reported); and presence of age-related confounds (i.e. whether age-differences in OG task performance were measured or considered in experimental design &/or whether RM performance is measured, and if appropriate what percentage of participants are excluded from PM analyses). When possible, the magnitude of reported effect sizes was summarized following Cohen's (1988) guidance, whereby η^2 values of 0.01, 0.059 and 0.138 (and *r* values of 0.10, 0.30, and 0.50), correspond to small, medium and large effect sizes, respectively. Extracted data is presented in tabular format in Appendix 1.2.

Assessing Methodological Quality

On the basis of preliminary searches it was evident that a wide variation in methodologies and applied measures exist within this field, precluding a meta-analysis. Therefore the methodological quality of studies was determined via a specially developed methodological quality rating checklist based on the Scottish Intercollegiate Guidelines Network (SIGN) Methodology Checklist 3 for cohort studies (SIGN, 2007) and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cross-sectional studies (Vandenbroucke et al., 2007). Additional items relating to the developmental PM literature were incorporated or augmented to ensure relevant aspects of quality were measured. The checklist comprised 27 items with a maximum score of 56 points (see

Appendix 1.3). Scores were then calculated as a percentage to provide an overall quality rating, with higher values indicating higher methodological quality. All papers were rated by the author, and a second-rater assessed 80% of studies as a means of examining the inter-rater reliability of the checklist. Across all the individual checklist items for all papers that were subject to inter-rater assessment there was 86% agreement between raters, with divergence on scores not being concentrated on any one of the criteria items. Discrepancies between raters were resolved by discussion (see Appendix 1.4 for detailed scoring per study). Final methodological quality scores are displayed in Figures 2 and 3.

Study Categorisation

To review the age-related literature-base, studies were categorised into age-range bandings including: preschool to school age, school age to adolescence and adolescence to young adulthood. Allocation was primarily based on the age of the youngest sample used in each study, with 2-5 year olds being classified as preschool, 6-12 as school-age and 13-17 as adolescent[3]. If studies contained three or more age groups that could be allocated to more than one age-range category the separate age-comparisons pertaining to each category will be discussed under separate category headings.

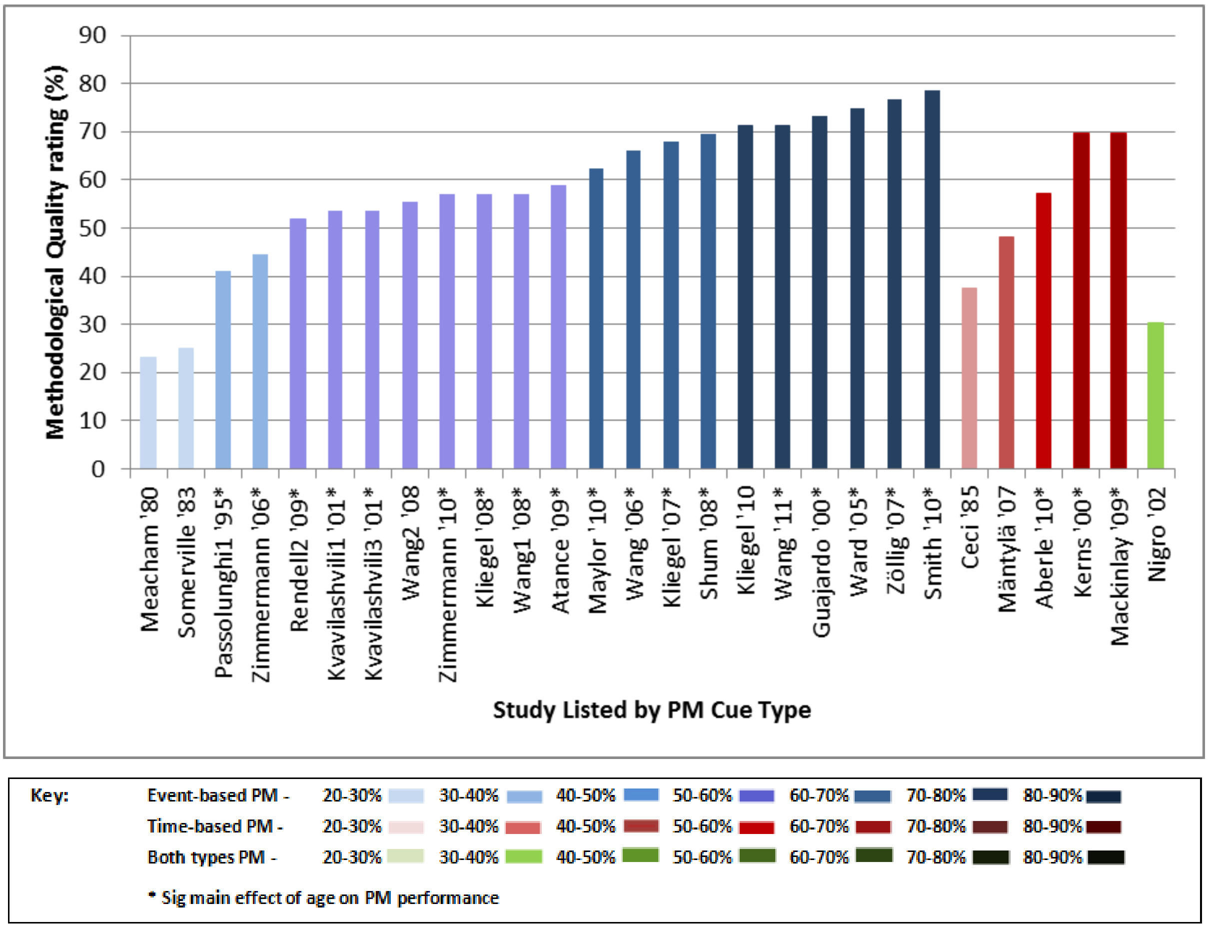
This review will summarise main findings according to age-group categories for both event- and time-based PM, prior to discussing pertinent methodological issues impacting upon the quality of this literature-base. Overall conclusions regarding the nature of developmental change in PM will be discussed, as well as potential implications of findings.

[3]. For three studies the age groups being compared spanned more than one age-range category. Thus these were allocated to the category most appropriate for the purposes of discussion. In Zimmermann & Meier (2006) 4-6 year olds' performance was compared to 13-14 year olds' and this was allocated to "school age to adolescence". Kliegel et al. (2008) compared 10 year olds with 25 year olds, which was allocated to the "adolescent to young adulthood" category. In Mäntylä et al. (2008) 8-12 year olds were compared to 20-29 year olds and this study was allocated to "adolescence – young adult" group.

Results

A comprehensive summary of extracted data and main findings per study can be found in Appendix 1.2. Methodological quality ratings are illustrated in Figures 2 and 3, with the latter Figure incorporating information on the age-ranges being compared. Ratings for event-based studies ranged from 23.2% to 78.6% (*M* = 57.5 ± 15.9) whilst time-based studies ranged from 30.4 to 69.6% (*M* = 52.1 ± 16.4).

Figure 2: Methodological Quality Ratings per Study



Of the 28 studies reviewed, eleven related specifically to PM development from preschool to school age (one time-based), six considered school age to adolescence (three time-based and one investigating both PM types) and five investigated adolescence to young adulthood (one time-based). A further six studies considered PM development across more than one age-range category (all event-based), with these predominately spanning school age to young adulthood.

Figure 3: Methodological Ratings of Studies by Deciles across Age Ranges

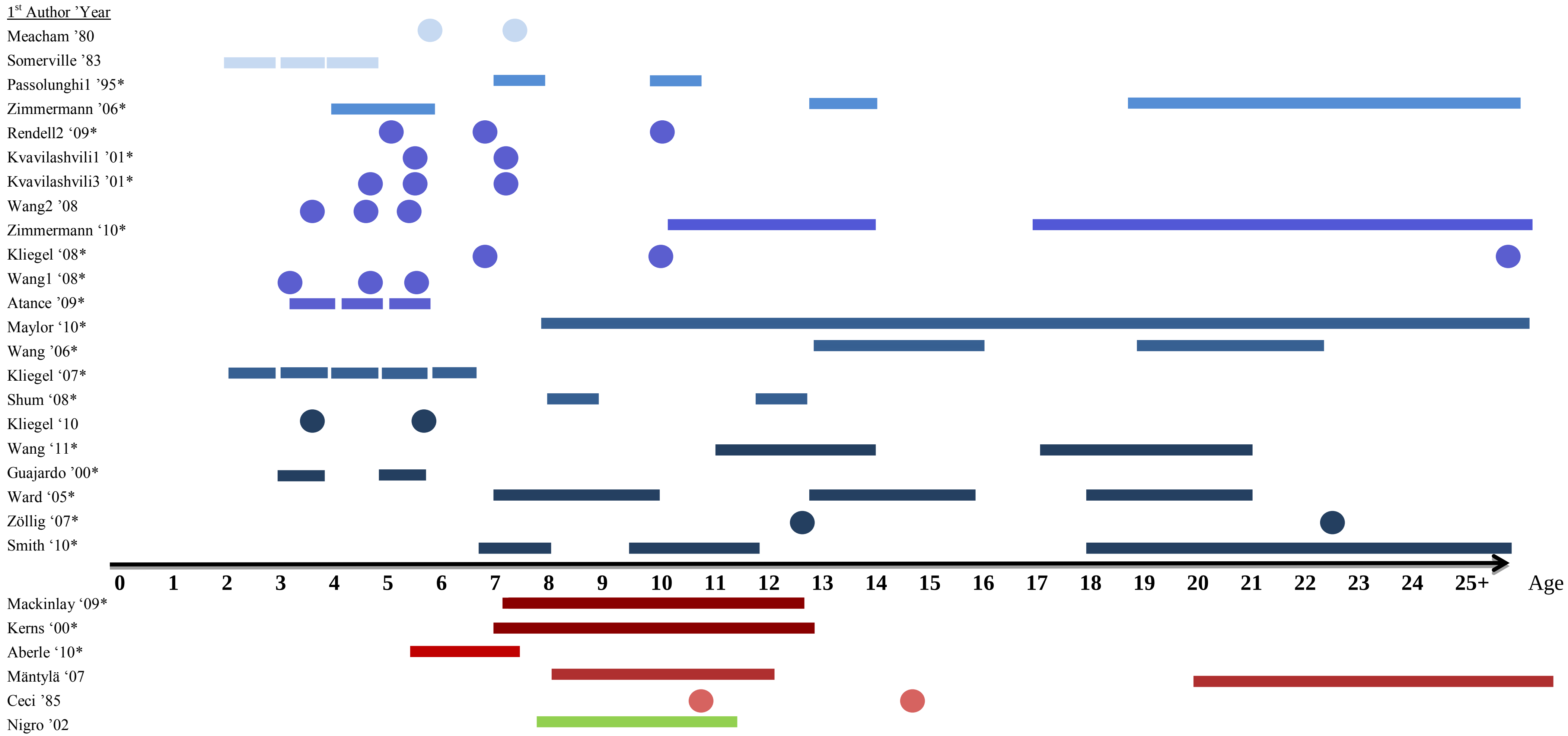


Figure 3: Studies presented in ranked methodological quality order, separated into those that considered event-based (blue), time-based (red) and both PM types (green). Degree of methodological quality indicated by coloured decile bandings, with darker colours indicating higher methodological quality (see Key in Figure 2). Age-ranges investigated (▬) or age-group means (●) are depicted for each study to allow age-specific comparison of quality. * Sig age effect on PM performance.

Twenty-one studies (18 event-based) reported significant main effects of age on PM performance, all indicating improvement in PM ability with increasing age. However results from post-hoc analyses comparing wider age-ranging studies (comprising 12 age-group comparisons from six papers), revealed three further non-significant age-group comparisons; relating to the school age-adolescent category and the adolescent-young adulthood category. Therefore, 35 distinct age-group analyses were reviewed, of which 24 reported significant age differences in PM performance. Table 1 summarises collective main findings of these analyses according to age-range category. Thus studies which spanned more than one age-range (or considered both event- and time-based PM) are reported more than once across age categories.

Event-Based PM Development

Preschool-School Age

Seven of the eleven studies which investigated this age-range report significant age effects on PM performance (Atance & Jackson, 2009; Guajardo & Best, 2000; Kliegel & Jäger, 2007; Kvavilashvili et al., 2001 (studies 1 and 3); Rendell et al., 2009 (study 2); Wang et al., 2008 (study 1)).

Somerville and colleagues' (1983) study suggested children as young as 2 years old possess competence in real-life PM situations. Moreover no substantial development in PM abilities between the ages of 2 and 4 was indicated; although on tasks considered low interest, 2 year olds displayed reduced performance compared to 3 and 4 year olds. However, generalisability of findings are questionable due to several methodological shortcomings, including lack of experimenter control, small sample size and reliance on subjective self-report. In contrast, Kliegel & Jäger (2007) employed more stringent methodology and found a significant age effect in a laboratory PM task using five age-groups aged between 2 and 6, where 2 and 3 year olds performed significantly lower than 4-6 year olds. However, when restricting analyses to individuals with intact RM performance, 2 year olds were excluded as only 6/20 could recall instructions, but other age-effects remained. Consistent with this finding, three further studies report significant age effects between the ages of 3

Table 1: Summary of Age-Related Findings by Age Range

Age Range	N (sig) analyses	Authors*	Quality Rating M (SD) & Range (%)	Collated Main Findings
EVENT-BASED				
Preschool – School age	11 (7)	Atance & Jackson (2009)*, Guajardo & Best (2000)*, Kliegel & Jäger (2007)*, Kliegel et al (2010), Kvavilashvili et al (2001) – study 1* & 3*, Meacham & Columbo (1980), Rendell et al (2009) – study 2*, Somerville et al (1983), Wang et al, (2008) – study 1* & 2	53.7% (16.4) 23.2 – 73.2	2-3 year olds sig differ from 4-5 year olds (n=4) (non-sig: n=3). Mixed findings for 2 year olds. 4-5 year olds differ from 7-8 year olds (n=3) (non-sig: n=1 & Kliegel & Jäger (2007) post-hoc) Sig interactions between age x motivation of PM task, age x task delay & age x task interruption
School age – Adolescent	9 (7)	Kliegel et al (2008b)*, Maylor & Logie (2010)*, Nigro et al (2002), Passolunghi et al (1995) – study 1*, Rendell et al (2009) – study 2, Shum et al (2008)*, Smith et al (2010)*, Ward et al (2005)*, Zimmermann & Meier (2006)*	56.7% (16.3) 30.4 – 78.6	4-6 year olds sig differ from 13-14 year olds (n=1) 7-8 year olds sig differ from 10-12 year olds (n=4) (non-sig: n=2) 8-10 year olds sig differ from 13-16 year olds (n=1). All age groups from 8-9 to 16-17 sig. differ from each other (n=1) Sig interactions between age x task interruption & age x encoding modality
Adolescent – Young adult	9 (7)	Kliegel et al (2008b)*, Maylor & Logie (2010)*, Smith et al (2010)*, Wang et al (2006)*, Wang et al (2011)*, Ward et al (2005), Zimmermann & Meier (2006), Zimmermann & Meier (2010)*, Zöllig et al (2007)*	65.5% (11.2) 44.6-78.6	10-14 year olds sig differ from 17-29 year olds (n=5) 13-17 year olds sig differ from 18+ year olds (n=2) (non-sig: n=2) Sig interactions between age x focality & age x task importance
TIME-BASED				
Preschool – School age	1 (1)	Aberle & Kliegel (2010)*	[57.1%]	Sig age effect over 5 to 7 age range (n=1)
School age – Adolescent	4 (2)	Ceci & Bronfenbrenner (1985), Kerns (2000)*, Mackinlay et al (2009)*, Nigro et al (2002)	51.8% (20.8) 30.4-69.6	Sig age effect over 7 to 12 age range (n=2) (non-sig: n=2) Sig age x time period interaction for time monitoring
Adolescent – Young adult	1 (0)	Mäntylä et al (2007)	[48.2%]	Non-sig age effect for 8-12 vs. 20-29 year olds for PM performance. Sig age effect for clock checking (n=1)
OVERALL	**35 (24) [a]**		**57.3 % (15.3) 23.2-78.6**	

* Study reports significant main effect of age on PM performance ($p<0.05$)
[a] Total of 35 includes the study by Nigro et al (2002) being counted twice under separate PM types

and 5 (Atance & Jackson, 2009; Guajardo & Best, 2000; Wang et al., 2008 – study 1). Various methodologies were employed in these studies; whilst Atance & Jackson (2009) and Wang et al. (2008) used more "naturalistic" methodologies to demonstrate lower PM performance in 3 year olds compared to 4 and 5 year olds (although findings are limited by the use of dichotomous scoring which reduces task sensitivity), Guajardo & Best (2000) used a computerised task where the PM task was embedded in an OG memorisation task. Although 5 year olds outperformed 3 year olds, recall of task instructions post-task was significantly disrupted in 3 year olds meaning age-differences in PM performance may be attributable to age deficits in RM. Also 5 year olds' performance was at ceiling which limits generalisability.

Data from two studies by Kvavilashvili et al. (2001) indicate PM abilities may develop only slightly during the preschool years and only at the end of that period (i.e. between ages of 5 and 7 rather than 4 and 5). Effect sizes for age effects were modest (η^2=.10 and η^2=.07), whereas the independent variable of task interruption produced larger detrimental effects on PM performance (η^2=.24). In contrast, Rendell et al. (2009) reported a large effect size for age differences in PM ability between ages of 5 and 8 using a computer driving game task (η^2=.23). By contrast, Meacham & Columbo (1980) reported no increase in PM ability between ages of 6 and 8. However, this latter study had several methodological limitations, such as lacking clear experimental hypotheses and not considering potential confounders. Consequently, it obtained the lowest methodological rating of all studies (23.3%).

Despite Kliegel et al. (2010) not reporting any age effects on PM performance in their study, a significant age by task-motivation interaction was found, with 5 year olds outperforming 3 year olds in low motivation conditions and performing equally in high motivation conditions. This study used an age-standardised OG task to reduce differential effects of OG task difficulty. Wang et al. (2008) highlighted that OG task interruption may also affect PM performance in preschoolers. As when replicating their first study with the experimental manipulation of removing the need for active task interruption no age effects in 3 to 5 year olds were found.

School Age-Adolescence

Of the nine studies in this category, seven reported significant age effects (Kliegel et al., 2008b; Maylor & Logie, 2010; Passolunghi et al., 1995 (study 1); Shum et al., 2008; Smith et al., 2010; Ward et al., 2005; Zimmermann & Meier, 2006).

The largest study was conducted by Maylor & Logie (2010) who used an internet-based PM task and found incremental increases in PM performance between the ages of 8 and 17, with females outperforming males. Although not explicitly stated, findings can be considered statistically robust given the large sample size, though issues such as sampling bias, variation in testing environment, and inability to assess recall of PM instructions post-assessment may impact on results. Smith et al. (2010) used an alternative formal modeling approach to measure the RM and PM components involved and found 10 year olds outperformed 7 year olds in recognizing PM cues. This study considered many methodological factors deemed essential in developmental PM research design, achieving a high quality rating (78.6%). Kliegel et al. (2008b) also demonstrated significant age effects in the formation, initiation and execution of intentions (with 10 year olds outperforming 7 year olds) using a multi-phase computerised six elements task. A significant age by task interruption interaction was reported for intention execution, with age effects being greatest with task interruption versus no interruption. However performance in the non-interruption condition was close to ceiling (potentially masking group differences) and the potential influence of task-difficulty between conditions was not accounted for. Moreover, as 7 year olds were impoverished at forming intentions versus 10 year olds this may have influenced intention execution.

Passolunghi and colleagues (1995) also found PM abilities to significantly vary by age, although this was qualified by an interaction with encoding modality; whereby 7-8 year olds performed better in a visual encoding condition and 10-11 year olds performed better in a motoric enactment condition. However, this study did not control for age-related confounders. Nigro et al. (2002) investigated PM across the same age range and found no age effect. Despite this study having attempted to equate OG task difficulty across ages, it did not specify how this was achieved, nor did it report descriptive statistics by age range or task performance in relation to retention of instructions. These shortcomings are reflected in its 30.4% quality rating.

Considering a slightly older age-range, Shum and colleagues (2008) used an OG reading task with word substitutions (PM task) to document a significantly higher PM performance in 12-13 versus 8-9 year olds. A trend for an age by task interruption interaction was reported, whereby 8-9 year olds' performance was detrimentally affected by task interruption compared to 12-13 year olds'. In contrast, Rendell et al. (2009) reported no age differences in PM ability between 8 and 11 year olds in post-hoc analyses. Although both studies were one of few to measure potential confounding variables such as IQ, Shum et al.'s (2008) methodology was considered more robust and allowed a wider range of PM responses and had higher control of confounding variables.

Zimmermann & Meier (2006) assessed PM performance across a wide age range (4-6 versus 13-14 year olds) as part of a larger study involving five age-groups up to aged 75. Age-groups displayed an "inverted U shape" trajectory in PM performance, with 4-6 and 13-14 year olds significantly differing (although adolescents' performance was near ceiling). Findings were consistent with Ward et al.'s (2005) results where a significant difference in PM ability between 7-10 and 13-16 year olds was found using an age-adjusted OG computerised lexical decision task under two conditions of cognitive demand (high or low) and two conditions of PM task emphasis (high or low importance). Children's proportional decrease in PM performance from low to high cognitive demand condition was also greater than that of adolescents.

Adolescence-Young Adulthood

Significant age effects were reported in seven out of nine studies that investigated this age range (Kliegel et al., 2008b; Maylor & Logie, 2010; Smith et al., 2010; Wang et al., 2006, 2011; Ward et al., 2005; Zimmermann & Meier, 2006, 2010; Zöllig et al., 2007).

Expanding upon abovementioned results, Maylor & Logie's (2010) internet study also documented significant increases in PM performance between adolescence and young adulthood. Additionally, both Smith et al. (2010) and Kliegel et al. (2008b) reported significant improvement in PM ability between 10 and 25 year olds, with both studies reporting large effect sizes. In contrast, neither Zimmermann and Meier (2006) nor Ward et al., (2005) found a significant age difference in PM performance between adolescents and young adults. Ward et al.'s findings (2005) held when the cognitive demands of OG tasks increased and the importance of the PM task was varied, although adolescents appeared to find the high demand task more difficult as their OG task performance was lower than young adults in this condition. Furthermore, both age groups' performance was near ceiling in Zimmermann & Meier's (2006) study which may limit generalisability. Nevertheless, a significant age difference was found in a later study by Zimmermann & Meier (2010) where 10-14 and 17-30 year olds' PM performance was compared on a computerised task that allowed for differentiation between the PM and RM components of prospective remembering, with young adults outperforming 10-14 year olds for the PM component only. The consideration of potential confounders in initial design (i.e. exclusion of participants who failed to recall task instructions and individually-paced OG stimuli presentation) was a key strength of this study, although performance on the RM component suffered from ceiling effects in both groups. Augmenting the evidence-base further is Zöllig et al. (2007) who, similar to Maylor & Logie (2010), reported an inverted U-shape function in PM performance between adolescents, young adults and older adults. Overall this study's methodology was considered high quality, with one of its only failings being its lack of consideration of potential age-differences in RM performance.

Age-related improvements in PM ability are also reported by Wang et al. (2006) and Wang et al. (2011) who used different methodologies to compare 13-16 and 19-22, and 11-14 and 17-21 year olds respectively. The former study used a pen and paper task under different conditions of PM task emphasis (low or high) and found adolescents had four times greater effect of task emphasis on PM performance versus young adults, being thought to relate to them having less capacity for attentional resource allocation. Whereas Wang et al. (2011) used a computerised working memory task with embedded PM task which varied by focality of the PM cue (focal versus non-focal). A significant age by focality interaction was reported, where young adults outperformed adolescents in the non-focal condition and both groups performed equally in the focal condition; again, non-focal cues were speculated to place more demands on attentional resources than focal. This study was one of the few to individually calibrate OG task difficulty and was considered of high quality (71.4%).

Time-Based PM Development

Preschool-School Age

In contrast to event-based studies, the literature on the development of time-based PM is markedly smaller. The only study conducted in the preschool-school age category used a narrow 5-7 age-range to investigate children's abilities to monitor (and turn) an hour-glass whilst playing an OG card game, and found that although PM performance (successful turns) correlated significantly with age, frequency of time-monitoring behaviours did not (Aberle & Kliegel, 2010).

School Age-Adolescence

The majority of studies involved this age-range, with two out of four reporting significant age-related improvements in PM abilities (Kerns, 2000; Mackinlay et al., 2009). Ceci & Bronfenbrenner (1985) compared 10 and 14 year olds using a naturalistic PM task about remembering to take cupcakes out of an oven (or recharge a battery) whilst engaged in an OG computer game in either familiar or laboratory settings. No age differences were shown in laboratory settings (with performance largely being at ceiling), although 10 year olds were more likely to remember late than 14 year olds when tested at home. As this study primarily focused on time-monitoring, statistical analysis of PM findings was lacking. Furthermore, methodological issues such as use of family-raters, reliance on one PM trial, and the failure to account for potential age-related confounders, limit the reliability of findings. Non-significant age effects were also reported by Nigro et al. (2002) in 7-11 year olds performance on a time-based PM task. Methodological shortcomings of this study are stated above.

Kerns (2000) used an alternative approach to examine time-based PM in children aged 7 to 12 and reported a significant age affect, with older children having fewer PM failures than younger children whilst engaged in a computer driving game with the PM task being to re-fuel the car. The fuel tank was monitored by pressing another button, and both older and younger children did not differ in monitoring behavior. Although this novel task was reported to be equally motivating across this age range, a methodological weakness of this study was its lack of consideration of potential age-effects of RM and OG task difficulty (i.e. as OG task performance is not reported it is unclear if true differences lie in differences in the requirements of the OG task). Mackinlay and colleagues (2009) also found a significant positive correlation between age and PM performance (with large effect size) in 7 to 12 year olds using a more traditional computerised PM task. Older children were more accurate than younger children even after age-differences in OG task performance were controlled. Time-monitoring also varied by age, with older children adopting a more strategic approach. Both studies achieved high methodological ratings (69.6%).

Adolescence-Young Adulthood

Mäntylä and colleagues (2007) found no age effects when comparing children (aged 8-12) and young adults (aged 20-29) on a task where participants had to indicate the passing of time every 5 minutes whilst watching a movie. Time could be monitored by pressing another button. The pattern of time-monitoring did not differ between groups; however children clock-checked more frequently than adults. Although Mäntylä et al. (2007) did attempt to alter the cognitive demands of the OG task by age (by using different movies), video length also varied meaning that frequency of PM cue exposure differed between groups. Results may also have been more sensitive to PM development over adolescence if a mid-adolescent group had been included. Furthermore, the cognitive demands required to watch a movie likely differ from those needed to actively participate in a computer game, and thus different processing systems and resources may be drawn upon depending on the experimental paradigm used. These issues shall be discussed further below.

Discussion

This review of developmental change in PM abilities between preschool and young adulthood indicates that event-based PM develops over this entire age-range, whereas evidence in relation to time-based PM development is more equivocal. This is due to the predominance of event-based studies and relative lack of time-based studies within preschool and adolescent age-ranges; although evidence for time-based PM maturation between school-age and adolescence is emerging (Kerns, 2000; Mackinlay et al., 2009). Conclusions are supported by the conspicuous finding that studies obtaining the lowest methodological quality ratings tended to report non-significant age effects on PM performance (Ceci & Bronfenbrenner, 1985; Mäntylä et al., 2007; Meacham & Columbo, 1980; Nigro et al., 2002; Somerville et al., 1983). Despite these overall trends, considerable variation exists in developmental trajectories reported between studies; seeming to result from a variety of experimental manipulations and methodological variations. Therefore the following discussion aims to address some of the common manipulations, variations and limitations in the literature under the headings of: subject-, measure- and methodological design-related issues. Review limitations, theoretical and practical implications, and recommendations for future research are subsequently outlined.

Subject-Related Issues

Despite the majority of studies in the preschool-school age and school age-adolescence categories reporting positive results, studies often used narrow age-ranges to conduct comparisons (spanning 2-3 years) making cross-study evaluation difficult, especially when several studies fail to report the age-ranges of their samples. Using multiple wider age-range comparisons would perhaps permit a more sensitive investigation of PM development, with the methodology applied by Maylor & Logie (2010) being an extreme example of this. Inadequate statistical power in comparisons is also an issue affecting many studies reviewed due to their small sample sizes increasing the chances of Type II error (e.g. Somerville et al., 1983), although task characteristics appear to mediate reported effect sizes. Furthermore, the majority of studies failed to report participant inclusion or exclusion criteria and only a handful reported demographic characteristics of their participants, with even fewer considering the potential impact of variables such as educational attainment and intellectual ability on age-differences reported (with the exception of Shum et al. (2008) and Ward et al., (2005)), which reduces reliability of findings. This may be particularly important for studies including young adults, as all studies which reported a specific recruitment source used university undergraduates. Nineteen out of 28 studies reported the gender distribution of their samples; however only seven took potential gender differences into account in their analyses (Atance & Jackson, 2009; Guajardo & Best, 2000; Kerns, 2000; Kliegel & Jäger, 2007; Kliegel et al., 2008; Maylor & Logie, 2010; Wang et al., 2006). Since differential developmental trajectories between the sexes was reported by Maylor & Logie (2010), and considering the evidence for gender differences in normative neural and cognitive development across childhood and adolescence (De Bellis et al., 2001; Lenroot et al., 2007; Schmithorst, 2009; Sowell et al., 1999, 2001), the potential impact of this variable has been hugely overlooked and should be considered in future research.

Measurement-Related Issues

Investigation of PM development has been hampered by several measurement issues. The heterogeneity of tasks used across studies makes an evaluation of validity and reliability of specific measures problematic. Ceiling effects were common and often PM performance was measured based on a single or small set of responses, which significantly reduced the sensitivity of the outcome measure by limiting variability. Inconsistencies in the scoring of PM performance exist between studies, for example measurements were either dichotomous or measured with respect to completing the PM response within a specific time period (Ceci & Bronfenbrenner, 1985; Kerns, 2000; Mäntylä et al., 2007). Furthermore, the reliance on subjective ratings to measure PM performance in the naturalistic studies of Somerville et al. (1983) and Ceci & Bronfenbrenner (1985) introduces potential sources of bias.

Many studies do not report the effect-size of findings and when these are reported they can often be modest with age only accounting for a small amount of the variance in PM performance (e.g. only 8% of variance in Kerns, 2000). One reason for this may be due to inherent assumptions of equality in cognitive processes across age-groups in many measures used. These assumptions include; the ability to process semantic information in reading asks (e.g. Passolunghi et al., 1995); the ability to read and understand a clock in certain time-based tasks (e.g. Ceci & Bronfenbrenner, 1985); and the level of insight into the thinking processes of others in tasks where the child is to remind the experimenter to do something (e.g. Meacham & Columbo, 1980). These abilities were rarely independently measured and moreover, even if comparable performance had been found across age-groups, groups may still have differed in the amount of cognitive resources required to achieve comparable performance, causing deficits to PM performance. Inconsistency in the measurement of OG task performance across age-groups will be discussed further below.

Methodological Design Issues

Strikingly, this review indicates that no longitudinal studies have been conducted in this field. All studies were cross-sectional and thus incorporate potential sources of bias including cohort effects. The preponderance of computerised PM tasks is notable as these often appear to bear little resemblance to real-world PM tasks. Naturalistic studies have tended to report non-significant findings, possibly due to age-effects becoming attenuated when children of varying ages engage in age-matched OG activities, or alternatively this may be due to these studies possessing poor methodological quality (Ceci & Bronfenbrenner, 1985; Somerville et al., 1983).

Factors such as task motivation (Somerville et al., 1983; Kliegel et al., 2010), encoding modality (Passolunghi et al., 1995), cue focality (Wang et al., 2011) and task interruption (Kliegel et al., 2008b; Kvavilashvili et al., 2001; Shum et al., 2008; Wang et al., 2008) significantly interact with age on PM performance. These findings have generally been understood in relation to speculated age differences in attentional resource allocation; whereby young children are considered less likely to engage in controlled strategic processes necessary for either processing non-focal cues[4], engaging in more sophisticated verbal or motoric encoding, or managing active task interruption, due to them not having the same cognitive resources available as older children. Moreover, it is thought that

[4] That is, the amount of processing overlap between OG and PM tasks in non-focal conditions may reduce demands on resources and lead to performance benefits for younger children.

increasing task motivation helps direct resource allocation by providing external support for these processes. This requirement for increased strategic control to improve PM has been thought to signify increasing reliance on the cognitive functions sub-served by the prefrontal cortex (PFC), such as inhibition, working memory and controlled attention (McDaniel et al., 1999). However irrespective of neuropsychological underpinnings, this pattern of results has several implications, as in everyday life (and in the majority of research paradigms reviewed) PM instructions are provided verbally which may be disadvantageous to younger children. Also cue focality, the necessity of task interruption and the degree of motivation associated with tasks are often over-looked as potential mediating factors. Consequently, the effects of these independent variables may mask age effects, unless they are manipulated in a controlled manner.

It has been hypothesized that an indicator of different age-groups being engaged in varying resource demanding processes to successfully perform in PM tasks is the observed differential cost to OG task performance (Smith et al., 2010). However, this conjecture has received limited support within the current literature-base due to inconsistencies in the measurement of OG task performance. Moreover, baseline differences in OG task performance between age-groups needs to be taken into account when interpreting such findings (as otherwise age-differences in PM performance may be overestimated due to differential levels of OG task absorption), which only a selected number of studies attempt to do. Some studies have made age-specific adjustments to the OG task to try equate difficulty across age-groups (e.g. Shum et al., 2008), whereas other studies have individually-calibrated OG task difficulty (e.g. Wang et al., 2011). Kvavilashvili and colleagues (2008) previously noted that when OG task difficulty was adjusted, age effects on PM performance often disappeared. This pattern was only partially replicated across currently reviewed studies, as out of the twelve age-group comparisons that made age-adjustments, only five reported non-significant age-effect analyses and these analyses spanned the entire preschool to young adulthood age range (Kliegel et al., 2010; Mäntylä et al., 2007; Nigro et al., 2002; Ward et al., 2005; Zimmermann & Meier, 2006). Undoubtedly, the process of making age-specific adjustments is fraught with assumptions regarding normative developmental abilities, and interpretation of results is entirely dependent on the accuracy of task-adjustments made

(Shum et al., 2008; Ward et al., 2005). Therefore, the recent move to individually-calibrate OG task difficulty may be a better option, although OG task performance must also be measured to ascertain differential detrimental effects on PM performance attributable to age-differences in attentional resources. However it is important to remember that in everyday situations OG task calibration will not be possible for younger children.

Approximately half of the studies measured and accounted for potential age-differences in RM performance. As PM is considered to be dependent on the ability to successfully retrieve intentions, PM failures may thus be erroneously attributed to a child's ability on the PM component of prospective remembering if RM performance is not concurrently measured. The separable developmental trajectories of PM and RM abilities are debated. For example, Smith et al. (2010) found 7 and 10 year olds differed only on the RM component of prospective remembering, whereas Zimmermann and Meier (2006) found 4-6 year olds to display similar RM performance to adolescents and young adults, but deficient PM performance versus these two older age groups. Given the uncertainties in the developmental trajectories of these components it is essential that future studies consider the measurement of RM integral to PM developmental research.

Implications, Limitations and Future Directions

Given that successful performance on many higher-order cognitive abilities require successful neural intercommunication between distinct regions of the brain (Johnson, 2005), the PM developmental trajectories being reported across childhood and adolescence may be a reflection of improvements in processing capacity and more efficient and specialised neural recruitment in areas such as the frontal lobes (Durston & Casey, 2006; Luna & Sweeney, 2004). Thus consistent with the *multi-process* account of PM (McDaniel & Einstein, 2005)[5], successful PM performance may be reliant on the successful intercommunication of other cognitive processes necessary for information retrieval, self-initiation and cognitive control, and given that neurocognitive processes such as myelination and

[5] The *multi-process* model proposes that a variety of cognitive processes are recruited to support the retrieval, initiation and execution of intentions; the relative contribution of each being determined by the resource-demand balance required on a task by task basis (McDaniel & Einstein, 2005).

synaptic pruning are more protracted in the prefrontal cortex (PFC) than other brain regions (Giedd et al., 1999; Gogtay et al., 2004), it is plausible that differences in PM performance over childhood and adolescence are attributable to prefrontal maturity and the consequent development of its underlying functional subsystems (Smith et al., 2010; Wang et al., 2011; Ward et al., 2005). This would be consistent with evidence from neuroimaging studies that indicate PM performance to be underpinned by the PFC (Burgess et al., 2001, 2003; Okuda et al., 1998; Simons et al., 2006) as well as the observation of selective PM deficits in individuals who have experienced injury to the PFC (Burgess et al., 2000; Shum et al., 1999).

Consequently, as tasks high in self-initiated processing and low in environmental support display some of the most pronounced age differences (Wang et al., 2011), it would be expected that young children may struggle to perform delayed intentions in complex real-world situations compared to older children and will likely need additional reminders to aid successful task completion. Incorporating PM tasks into an individual's daily routine, minimizing task interruptions and ensuring that the PM cue is presented as the focus of attention are ways by which performance may be improved, with this potentially freeing up cognitive resources and improving OG task performance. This has practical implications for parents and teachers of young children in terms of setting age-appropriate goals and highlighting areas for intervention (Guajardo & Best, 2000; Kliegel & Jäger, 2007). Furthermore, given that PM age-effects appear sensitive to variations in methodological design, the future development of child-orientated neuropsychological assessments to allow differentiation between impaired and normative PM performance would have to take the above-outlined considerations into account.

It is important to acknowledge several limitations of this review. Since this review only included published studies written in English it is susceptible to publication and reporting biases. Although care was taken to reduce risk of multiple reporting biases via exclusion of studies that may have used the same sample on more than one occasion, this may have been over-conservative. As the focus of this review has been age-related change in PM performance between preschool and young adulthood, other study findings have not been reported, including those pertaining to older age groups included in several studies and those relating to associations between PM and performance on executive functioning measures. Conducting a larger review incorporating these aspects would augment current findings.

Furthermore, given that the ecological validity of laboratory-tasks is questionable, future research should extend laboratory-based findings by conducting controlled naturalistic studies, or alternatively by using novel experimental procedures such as virtual-reality assessments. This may provide insight into aspects of real-life PM such as children's abilities to use strategies and adaptability, which currently little is known about. Future research is also warranted to determine the true developmental trajectory of time-based PM, and to extrapolate the core cognitive processes underlying PM. This might involve comparing developmental trajectories of PM with other executive functions using longitudinal research paradigms, or instead systematically manipulating task-related variables (i.e. task interruption) in both healthy and clinical samples (i.e. post-brain injury).

Conclusion

Evidence for the development of PM abilities across the younger end of the lifespan appears relatively robust, particularly with regards to event-based PM. However reporting significant age-effects on PM tasks alone does not elucidate how PM develops in children. Age effects have been shown to be highly sensitive to experimental manipulations, reflected by the interaction of age with several independent variables. Concurrent neuronal and cognitive maturation in areas such as the PFC and its related executive functions are likely candidates underpinning PM developmental trajectories. It is evident that in order to assist children in their performance on a PM task that multiple elements of the task need to be considered and the components children have difficulty with on account of their age may thus be targets for education and intervention. Conducting further well-controlled developmental studies on this unique cognitive ability will undoubtedly have much to offer theoretical, neuropsychological and educational contexts.

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Chapter 2: Major Research Project

An Investigation into the Ecological Validity of Virtual Reality Measures of Planning and Prospective Memory in Adults with Acquired Brain Injury

Fiona Scott[1]*

Written according to guidelines for submission to the *Journal of the International Neuropsychological Society*
(Author's Instructions – see Appendix 1.1)

[1] Academic Unit of Mental Health & Wellbeing, University of Glasgow

* Address for correspondence:
Academic Unit of Mental Health & Wellbeing
Institute of Health & Wellbeing
University of Glasgow
Gartnavel Royal Hospital
Administration Building
Trust HQ, 1st floor
1055 Great Western Road
Glasgow, G12 0XH

Email: fiona.scott7@nhs.net

Short Title: Virtual reality and executive functioning

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Lay Summary

Difficulties with planning and prospective remembering, that is, remembering future intentions (such as remembering to post a letter) are common after brain injury. When clinicians assess these problems, it is important that the tests applied are sensitive to difficulties experienced in real-life (i.e. that they are ecologically valid) and that different tests intended to measure the same function produce similar results (i.e. that they have convergent validity). Currently, traditional "desktop" tests of planning and prospective memory show only a moderate relationship with everyday functioning, suggesting that they may not be very sensitive to real-life difficulties. Virtual-reality (VR) assessments may offer a better way to assess these abilities. This study investigates the ecological and convergent validity of a new VR assessment tool, along with two traditional assessments of planning and prospective memory. These tests were given to a sample of adults with brain injury, and the strength of the relationship between participants' performance on these tests and scores on questionnaire measures of everyday functioning was examined. The strength of the relationship between the VR and traditional assessment measures was also investigated. Results indicate the VR task has promising ecological validity and has high convergent validity with traditional tests. Findings have implications for enhancing the validity of assessments used in clinical practice.

Abstract

Background*:** Improving the ecological validity of the assessment of executive functioning after brain injury has been an important focus of research in recent years. This study investigates the ecological validity of the "JAAM test", a novel office-based virtual-reality task, in assessing real-life difficulties post-brain injury in the domains of planning and prospective memory. The comparative ecological validity of two traditional "desktop" tests for these domains and the convergent validity between the measures are also explored. ***Methods: Forty adults with an acquired brain injury completed the JAAM test, the Tower Test (a test of planning) and the Cambridge Prospective Memory Test (CAMPROMPT). Self and informant versions of questionnaires (the Dysexecutive Questionnaire; DEX) and the Prospective and Retrospective Memory Questionnaire (PRMQ) designed to measure real-life difficulties in these cognitive domains were also completed. ***Results:*** Significant correlations were observed between JAAM planning scores and the DEX (r = -.49), as well as between the Tower Test and the DEX (r = -.39). The difference between the strength of these correlations was not significant. Neither the JAAM prospective memory score nor CAMPROMPT scores correlated significantly with the PRMQ. Significant correlations were found between the JAAM and Tower Test (r = .33) and CAMPROMPT (*rho* = .59). ***Discussion:*** Results suggest the JAAM possesses at least similar ecological validity to traditional assessments of planning and prospective memory, and it also has convergent validity with these measures. Implications and limitations of the current study are discussed and recommendations for future research proposed.

Keywords: Executive function; virtual-reality; ecological validity; convergent validity; brain injury

Introduction

Over the last few decades there has been a surge of theoretical and clinical interest in the development of ecologically valid assessments of executive functioning. Executive functions comprise a set of higher-order cognitive abilities that manage or "conduct" other cognitive systems such as memory or language in a goal-directed fashion (Lezak, 1982; Stuss & Levine, 2002). This executive system has been linked to the functioning of the frontal lobe and its neural projections, with injuries to this area having been associated with impairments in abilities such as initiation, planning and self-monitoring (Burgess et al., 1998; Greve et al., 2002). Prospective memory (PM) is one such executive skill that is prone to deficits after an acquired brain injury (ABI), often with detrimental effects on an individual's autonomous everyday functioning (Groot et al., 2002; Knight et al., 2005; Schmitter-Edgecombe & Wright, 2004; Shallice & Burgess, 1991; Shum et al., 1999). PM is the ability to remember to perform an intended action in the future (Ellis, 1996; Ellis & Freeman, 2008), and has been conceptualised as a multi-phase process involving the formation, retention, delayed initiation and execution of intentions (Kliegel et al., 2008). Successful PM performance is thought to rely on the integration of other cognitive processes such as retrospective memory (RM), attention, and other executive functions (Fish et al., 2010). For example, an individual's ability to plan is a skill likely to have bearing upon the ability to form coherent and effective intentions. Consequently, the ability to flexibly integrate separate cognitive abilities can be considered essential when faced with the multiple goals, sub-tasks and changing priorities commonly encountered in everyday life (Shallice et al., 1996).

Traditionally, many tests of executive functions have been developed within a diagnostic tradition having the primary purpose of determining whether a discrete cognitive impairment is present or not (Chan et al., 2008; Chaytor & Schmitter-Edgecombe, 2003). This approach has proven problematic for several reasons. The tests are frequently found to possess poor convergent validity (i.e. performance on tests intended to measure the same function markedly differ) or to lack ecological validity, whereby a dissociation is observed between test performance and ability to function in everyday life (Burgess et al., 1998, 2006; Eslinger & Damasio, 1985; Marcotte et al., 2010).

Resultantly, efforts have been made to develop assessment measures that are more ecologically valid. Examples include the Behavioural Assessment of Dysexecutive Syndrome (BADS; Wilson et al., 1996), which is now the most widely available in clinical practice, as well as the Executive Secretarial Task (EST; Lamberts, Evans & Spikman, 2010), the Hotel Task (Manly et al., 2002) and the Multiple Errands Test (MET; Shallice & Burgess, 1991) and its variants (Alderman et al., 2003; Knight et al., 2002). However, even the BADS is limited in its ability to accurately predict everyday functioning in patients with brain injury (McGeorge et al., 2001; Norris & Tate, 2000; Wood & Liossi, 2006)[6] and "real-world" tasks such as the EST and MET have many unavoidable practical difficulties and lack psychometric rigour. Typically, informant-rated questionnaires have been used as a measure of everyday cognitive ability due to them containing fewer systemic biases and easing the data collection process (Burgess et al., 1998; Chaytor et al., 2006). However the correlation between these measures and individuals' performance on tests of executive functioning has tended to range from only 0.2 to 0.5, indicating a low to moderate correspondence (Chaytor & Schmitte-Edgecombe, 2003). Several environmental, cognitive and emotional factors may mediate the strength of this relationship, including depression and premorbid IQ (Chaytor et al., 2007; Groot et al., 2002; Hannon et al., 1995). Manchester and colleagues (2004) have suggested that the assessment of real-life deficits may be best achieved by combining more naturalistic assessment measures with informant-derived information.

An alternative paradigm that addresses the pragmatic difficulties of conducting ecologically valid assessments of executive functions is the use of virtual reality (VR) (Rose & Foreman, 1999). VR aims to mimic complex real-world situations whilst maintaining control over stimulus presentation and measurement (Schultheis & Rizzo, 2001). Examples currently include VR versions of the MET (VMET; McGeorge et al., 2001 and VMALL; Rand et al., 2009), the Removals Task (Morris et al., 2002), the Breakfast Task (Craik & Bialystok, 2006) and the JAAM (Jansari et al., 2004). Despite a relative paucity of research conducted on these measures, there is promising evidence that they are able to successfully predict group membership (controls versus brain injured individuals) (Brooks et

[6] The debatable ecological validity of the BADS may be due to it lacking verisimilitude (that is, there is a lack of similarity between the demands of BADS subtests and the demands of real-life situations), for instance many of the desk-top paper and pen tasks bear more resemblance to traditional assessments than activities they might encounter in everyday life.

al., 2004; Jansari et al., 2004; Knight et al., 2005, 2006; Rand et al., 2009; Sweeney et al., 2010; Titov & Knight, 2005). There are also indications that distinct executive functions can be separately assessed via different components of the testing process (Jansari et al., in prep; Zhang et al., 2001). Furthermore, McGeorge and colleagues (2001) have shown using the VMET that the performance of individuals with brain injury, who did not meet the BADS criteria for executive impairment, significantly differed from that of controls, suggesting that VR assessments may be more sensitive to "real life" impairments. Further support for the ecological validity of VR tasks comes from a case study where a VR task detected deficits that limited a patient's everyday activities that remained undetected by traditional executive tests (Mendozzi et al., 1998). However, there is currently mixed evidence regarding the relationship between VR performance and questionnaire measures of real-life functioning, with some studies failing to find an association (Brooks et al., 2004; Sweeney et al., 2010), whilst others have found significant associations with large effect size (Rand et al., 2009) or associations only with performance on tasks with high cognitive demands (Knight et al., 2006). Variations in task characteristics, sample sizes and questionnaire measures may account for this inconsistency and further investigation is warranted.

The primary aim of the present study was to examine the ecological validity of the JAAM VR assessment measure, focusing particularly on derived measures of planning and PM. The extent to which scores on the JAAM correlated with scores on questionnaire measures of these two cognitive abilities was tested, using the Dysexecutive Questionnaire (DEX; Wilson et al., 1996) and the Prospective and Retrospective Memory Questionnaire (PRMQ; Crawford et al., 2003, 2006).

There were two exploratory aims of the study. The first was to compare the ecological validity of traditional desktop assessments of planning (the Tower Test; Delis, Kaplan & Kramer, 2001) and PM (the Cambridge Prospective Memory Test "CAMPROMPT"; Wilson et al., 2005) with the JAAM VR approach. The second exploratory aim was to assess the convergent validity of the JAAM test, examining whether measures of planning and PM on the JAAM correlate with the Tower Test and the CAMPROMPT respectively.

Hypotheses

***Primary Hypothesis*:** There would be a significant correlation between level of everyday functioning in planning and PM, as measured by self- and informant-rated questionnaires, and individuals' performance on respective measures of planning and PM derived from the JAAM task.

***Exploratory Hypotheses*:** It was hypothesised that the strength of the correlation between the VR measures and real-life difficulties in planning and PM would be larger than the correlation between individual's performance on traditional measures of these executive functions and reported real-life impairments. It was also predicted that the specific measures of planning and PM on the JAAM would significantly correlate with traditional assessments of planning (Tower Test) and PM (CAMPROMPT).

Method

Participants

Forty-seven individuals with acquired brain injury (ABI) were initially recruited (36 males and 11 females). Over the course of the study three individuals dropped out, three were unable to complete the JAAM due to difficulties interacting with the interface and one individual failed to return informant-rated questionnaires. Thus the final sample comprised 40 individuals (32 males and 8 females). Aetiology of injury was either traumatic brain injury (TBI) (n=27), stroke (n=5), non-traumatic brain haemorrhage (n=7) or viral infection (n=1). Mean time since injury was 6.9 years (SD = 7.7; range 0.5-31) and mean length of post-traumatic amnesia (PTA) was 47.0 days (SD = 60.1; range 0-240), with the majority of injuries being classed as severe to extremely severe (Bigler, 1990).

Mean age was 46.4 years (SD = 11.1) and mean years of education was 13.3 (SD = 3.1). Socio-economic status of participants was measured using the Scottish Index of Multiple Deprivation (SIMD; 2009) and was evenly distributed across bandings (χ^2 (9) = 7, p = .64), with the median ranking being 40-50%. Thirty-seven of the final participant group were right-handed. Regarding comorbidities, 7.5% experienced epilepsy secondary to their ABI and 27.5% reported experiencing mild psychological difficulties, including anxiety and depression. All participants met the following inclusion and exclusion criteria[7]:

Inclusion criteria*:* 18-65 years old with an ABI having been sustained after the age of 16 and occurring at least 6 months prior to testing. Individuals had to have English as their first language and have a significant other willing to complete informant questionnaires (which was a spouse, family member, friend or carer/professional in 40.0%, 37.5%, 2.5% and 20.0% of cases respectively). Only individuals deemed to have capacity to consent were approached.

Exclusion criteria**:** Individuals with severe mental illness, severe amnesia, learning disability or neurodegenerative conditions were excluded. Further exclusion criteria included having severe visual and hearing impairment, severe dysphasia, current substance abuse or physical disability if likely to impact on their ability to undertake the tasks involved in the study. Also, as assessment required individuals to read and write, illiterate participants were excluded.

Recruitment Procedure

Participants were recruited from a wide-range of community, inpatient and voluntary-sector settings across the central belt of Scotland. Verbal and written information about the study was provided to potential participants that invited them to participate, with this information typically being delivered via the worker or clinician responsible for their care in each setting (see Appendices 2.1 to 2.3). If participants initially stated their intention to take part in the study but had not formally indicated this to the researcher, a reminder letter was provided (see Appendix 2.4). Where appropriate, group-based presentations were used to explain what the study would involve and to answer queries potential participants had. Once subjects indicated their interest in participating in the study, a member of the

[7] Nine additional individuals were excluded from the study after application of inclusion and exclusion criteria via initial screening procedure. Reasons for exclusion included: paediatric brain injury (n=5), aged over 65 (n=1), learning disability (n=1), no ABI (n=1) and incapacity to consent (n=1).

research team contacted them via telephone to undertake a screening assessment to determine suitability (see Appendix 2.5).

Measures

Questionnaires: These included the PRMQ (Crawford et al., 2003, 2006) which was completed by both participants and their significant other to gauge the impact of memory failures on daily living. The score pertaining to PM was derived from this measure, along with RM and total scores. Both self and informant questionnaire versions have been shown to possess acceptable internal reliability (Cronbach's α of .80 to .89 and .83 to .92 respectively) (Crawford et al., 2003, 2006).

Significant others were asked to complete the DEX questionnaire (Wilson et al., 1996) which is designed to assess the presence of common everyday symptoms of executive dysfunction. The DEX has previously demonstrated strong psychometric properties and clinical utility (Burgess et al., 1998; Chan, 2001; Chan & Maylor, 2002; Chaytor et al., 2006). Previous studies have demonstrated this measure to possess a 5-factor structure (Amieva et al., 2003; Burgess et al., 1998; Chan, 2001), with a factor relating to "planning" having been demonstrated in a neurologically intact sample (Amieva et al., 2003). Furthermore performance on the Tower of London planning test (Shallice, 1982) has been shown to significantly correlate with two identified factors of "inhibition" and "intentionality", again in a non-clinical sample (Chan, 2001). Therefore in addition to the DEX total score, a "planning" score was devised for each participant as a summed score from the ten relevant DEX items (see Appendix 2.6 for item details).

Background Neuropsychological Assessment: The following tests were undertaken to characterise the sample: Wechsler Test of Adult Reading (WTAR; Wechsler, 2001) as a premorbid estimate of IQ; Symbol Digit Modalities Test (SDMT; Smith, 1982) as a measure of processing speed; Matrix Reasoning subtest of WAIS-III (Wechsler, 1997) as a measure of general ability; Trail Making Test A & B (TMT; Reitan, 1958) to examine processing speed and mental flexibility; Logical Memory subtest from the Wechsler Memory Scale – 3rd Edition (WMS-III; Wechsler, 1998) to assess immediate and delayed verbal recall and the Rey Complex Figure Test (RCFT; Meyers & Meyers, 1995) to assess immediate and delayed visual recall. Scoring criteria was followed as per manual, and age-adjusted scaled-scores (or Z scores in the case of the SDMT and TMT) calculated for all measures. The reader should consult respective test manuals or compendiums (Lezak et al., 2004; Strauss et al., 2006) for further details of test measures.

In addition, the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) was administered to measure participants' mood and anxiety, and a brief Likert-scale questionnaire was given to assess individual's prior familiarity with computer technology (see Appendix 2.7 for copy of questionnaire).

Traditional "Desktop" Assessment Measures: Traditional assessments of planning and PM included the Delis-Kaplan Executive Function Scale (D-KEFS) Tower Test (Delis et al., 2001), which is based upon Shallice's original Tower of London test (Shallice, 1982) and the CAMPROMPT (Wilson et al., 2005) respectively. Scoring protocols were followed according to each test manual and age-adjusted achievement scaled scores (Tower Test) or total scores (ranging from 0 to 36) and age and IQ adjusted categories of relative impairment (CAMPROMPT)[8] calculated accordingly. The reader is advised to consult respective test manuals for further details.

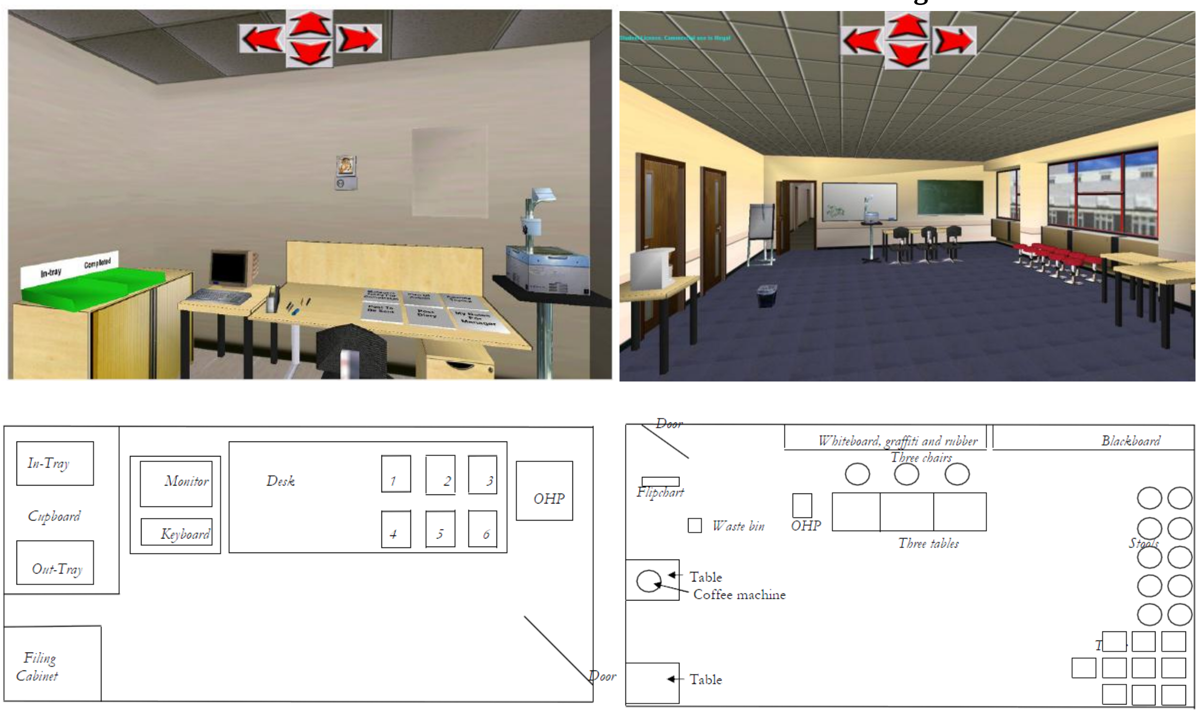
Virtual Reality Measures: The JAAM VR measure of executive function was used to assess planning and PM (Jansari et al., 2004). This assessment is delivered via a laptop computer and presents the participant with a novel office setting where they are asked to assume the role of an employee and complete a set of office-based tasks such as setting up a meeting (see Figure 1). The participant is required to complete activities both within the VR environment as well as real-life pen and paper tasks using a variety of desktop materials. Scoring thus involves the researcher monitoring the participant's activities and rating performance against predefined scoring criteria (see Appendix 2.8

[8] Categories of relative impairment were based on age and IQ norms of total scores: Impaired ≤ 5th percentile; Borderline = 5-10th percentile; Poor = 10-25th percentile; Average = 25-75th percentile; Above average = 75-95th percentile; Very Good ≥ 95th percentile.

for scoring sheet). This measure is designed to assess many facets of executive functioning and produces a separate score for each of the cognitive constructs it is purported to assess (i.e. prioritization, adaptiveness, creativity, selection, planning and PM) as well as a total score (0 - 38). Scores relating to planning and PM sub-tasks were used in the present study, ranging from 0 – 10 and 0 - 12 respectively.

Figure 1: Screen Captures and Bird's Eye View of JAAM Virtual Reality Environment [a]

The Office **The Meeting Room**



[a] Figures taken from JAAM Manual (Jansari, 2009)

Research Procedures

As this study was undertaken as part of a larger assessment and intervention based study, measures were completed over two sessions. Where possible, the assessment process was conducted by the same researcher in a quiet room within the setting from which the individual had been recruited. Questionnaire measures (DEX and PRMQ) were mailed out prior to assessment and subjects were asked to bring completed forms to their first session. During the initial session the participant completed the background neuropsychological measures and questionnaires (in addition to other assessment measures reported elsewhere). In the second session the participant undertook the JAAM assessment, the Tower Test and the CAMPROMPT, with the order of administration being counter-balanced across participants. Administration procedures and scoring protocols as outlined by test manuals were followed for all standardised tests and all data collected by the three researchers involved in this study was co-rated by an independent research assistant to ensure consistency in scoring.

The JAAM task was administered following the procedure as outlined in the manual (Jansari, 2009; see Appendix 2.9). Several hard copy documents were provided during the running of the programme, which relate to documents displayed in the VR environment. The task scenario was read out to the participant at the beginning of the task from a script and was repeated as necessary. A printed scenario sheet and the "Manager's Tasks for Completion" were provided to the participant, and these documents remained next to the computer throughout the assessment to reduce the likelihood of errors being made due to retrospective memory (RM). Other relevant documents were either available from the outset, or given as and when required from the researcher during the assessment process. Prior to starting the task participants practiced manoeuvring within the virtual environment to become familiar with its format (5 minutes). On occasions where the participant had difficulty interacting with the VR interface, the practice session was extended. However if difficulties persisted the experimenter would navigate within the virtual environment under direct instruction from the participant and record this accordingly. After reading the "Manager's Tasks for Completion" participants were invited to construct a plan of action in their own time, after which the assessment formally commenced. Questions relating to task operation were encouraged prior to the start of assessment, although if participant's questions related to how they might go about completing the task, the researcher directed them to the printed materials (see Appendix 2.10 for administration materials).

Sample Size Considerations

The *apriori* target number for recruitment was 46. Prior calculations estimated this number of participants would be required to detect an estimated medium-large effect size (r = 0.4), with power at 0.8 and alpha error at 0.05 when using a two-tailed Pearson's correlation between each specific VR measure of planning and PM and questionnaire measures of real-life difficulties. The estimated effect size was based on findings from previous studies that found medium to large effect sizes (ranging from r = 0.31 to -0.82) when comparing participants' performance on either naturalistic or VR measures with scores on questionnaire measures of everyday functioning (Knight et al., 2002, 2006; Lamberts et al., 2010; Rand et al., 2009).

Ethical Approval

This study was reviewed and approved by the West of Scotland Research Ethics Committee, NHS Greater Glasgow & Clyde Research & Development and NHS Ayrshire & Arran Research & Development departments (see Appendix 2.11).

Statistical Analyses

Data analyses were carried out using PASW Statistics 18 (SPSS, Chicago). Descriptive statistics were used to determine the demographic and neuropsychological characteristics of the sample. Two-tailed correlational analyses were conducted between various measures of interest for both planning and PM using $\alpha = 0.05$ (i.e. to ascertain ecological and convergent validity). As the JAMM is a novel test and the current study is exploratory by nature, no corrections were made for multiple comparisons, with this approach being consistent with previous similar research (McGeorge et al., 2001; Rand et al., 2009). Assumptions for parametric analyses were tested, and when necessary non-parametric equivalent analyses used. Statistical comparison of non-independent correlations was undertaken using Williams' (1959) test (i.e. to compare the ecological validity of traditional and VR tests)

Results

Questionnaire Data

Mean profile scores for the self and informant-rated questionnaire measures are presented in Table 1. One participant did not return self-rated questionnaires. Scores on the self-report PRMQ indicated that on average the sample reported both their PM and RM abilities to be in the low average range (T = 38

[Confidence Intervals (CI) 34-47] and *T* = 39 [CI 34-48] respectively), which is comparable to informant ratings of participant's PM (*T* = 39 [CI 34-46]) and RM abilities (*T* = 38 [CI 33-47]). The full range of scores was observed in both self- and informant-versions of this measure. When examining the relationship between self and informant ratings, significant correlations of large effect size emerged for both PM and RM scores ($r = .64$, $p < 0.001$, and $r = .67$, $p < 0.001$). Thus despite a reasonable degree of correspondence, a large amount of unexplained variance between the participant and significant other ratings of everyday difficulties existed.

The mean score on the DEX (*M* = 36.6, SD = 19.1) indicated that, on average, participants were experiencing dysexecutive symptoms at a level similar to that typically experienced by adults with brain injury (50th – 75th percentile; Wilson et al., 1996). Unfortunately no norms are available for the DEX planning construct, although responses on items varied widely, with the most frequent median response across items being "sometimes" (i.e. how often participants' experienced each symptom). The majority of depression and anxiety scores on the HADS were in the normal to mild range.

Table 1: Questionnaire Data for the Sample

Questionnaire		**Self-Rating**	**Informant-Rating**
PRMQ	*Total*	49.6 ± 16.1 (18-80)	48.0 ± 15.3 (16-80)
	PM	25.6 ± 8.4 (8-40)	25.0 ± 8.2 (8-40)
	RM	24.0 ± 8.0 (9-40)	23.0 ± 7.4 (8-40)
DEX	*DEX Total*	--	36.6 ± 19.1 (1-77)
	Planning	--	19.6 ± 10.4 (1-39)
HADS	*Anxiety*	8.9 ± 4.7 (2-19)	--
	Depression	6.9 ± 4.3 (0-17)	--

The computer familiarity questionnaire indicated that 47.5% of participants felt confident using a computer, whilst 25.0% did not feel confident (the remainder neither agreed nor disagreed). A similar pattern was reflected in participants' felt knowledge of computer technology (47.5% agreed, 35.0% disagreed and 17.5% neither agreed nor disagreed with the statement that they felt they had a good knowledge). The majority used computers regularly in daily life (52.5%) compared to 35.0% who reported not using computers, and most rated their computer use to be similar to same aged-peers

(47.5%) compared to 29.5% who considered their abilities to be poorer.

Neuropsychological Characteristics

Participants' performance on background neuropsychological measures is summarised in Table 2.

Table 2: Neuropsychological Characteristics of Sample

Measure	Mean ± SD [b]	Percentile	Range
Premorbid-IQ			
WTAR	100.0 ± 13.3	50th	70-119
Reasoning Ability			
Matrix Reasoning	10.1 ± 2.9	50th-53rd	5-16
Processing Speed			
SDMT (z score)	-1.8 ± 1.3	2nd-4th	-4.3-.6
TMT-A (z score)	-2.7 ± 2.8	0.2nd -0.4th	-9.6-.9
TMT-A (errors)	0.05 ± .2	--	0-1
Mental Flexibility			
TMT-B (z score)#	-4.2 ± 5.4	<0.1st	-18.5 – 1.7
TMT-B (errors)#	0.9 ± 1.9	--	0-9
Verbal Recall			
Logical Memory – immediate	7.8 ± 3.5	16-25th	1-16
Logical Memory – delayed	8.1 ± 3.7	25-37th	1-18
Visual Recall			
RCFT – immediate (T score)	36.7 ± 15.7	7-9th	19-76
RCFT – delayed (T score)	34.6 ± 15.8	5-7th	19-70

[b] Age-adjusted scaled score reported apart from SDMT and TMT where z-scores reported and RCFT where T scores reported; TMT errors = mean of freq.# One participant excluded due to z score being -41.4 for TMT B (extremely abnormal)

Relationship between Measures of Planning and PM and Everyday Functioning

Participants' performance on traditional and JAAM measures of planning and PM ability is summarised in Table 3. CAMPROMPT scores were also categorised by level of relative impairment with 30.0% being in impaired, 10.0% in borderline, 12.5% in poor, 35.0% in average and 12.5% in above average categories. Prior to analysis, variables were screened for outliers and normality of distributions using the Shapiro-Wilk test [9]. All variables were normally distributed with the exception of CAMPROMPT total score (Shapiro-Wilk =.94, p=0.04). Therefore Spearman's non-parametric correlations were used instead of Pearson's when considering analyses with this variable. No ceiling

[9] No extreme outliers were identified across all variables. One mild outlier (i.e. >1.5 interquartile range) was identified for Tower Test performance and four mild outliers for JAAM planning scores (balanced on either end of the distribution). As there was minimal difference between the mean and 5% trimmed mean values for these variables (0.08 and 0.04 respectively), these values were included in analyses (Pallant, 2007).

or floor effects were apparent across variables of interest.

Table 3: Participant's Performance on Planning and PM Measures [c]

Domain	Measure	Mean ± SD	Percentile	Range	Maximum Score
Planning	Tower	15.2 ± 4.4	37th	4-23	30
	JAAM Planning	6.4 ± 1.7	--	2-10	10
PM	CAMPROMPT	20.0 ± 8.1	10-25th	5-34	36
	JAAM PM	5.12 ± 3.1	--	0-10	12

[c] Raw scores reported for all measures as age-adjusted scaled scores not available for JAAM and CAMPROMPT

Results of correlational analyses are depicted in Table 4. When considering the correlation between JAAM measures and real-life questionnaire measures for planning, a significant correlation (medium-large effect size) was found between JAAM planning and DEX planning (r = -.49, p < 0.01) and DEX total scores (r = -.44, p = 0.01). PM performance on the JAAM did not significantly correlate with total or PM scores from the informant-rated PRMQ questionnaire, however a significant correlation was found with self-rated PRMQ total scores (r = -.31, p = 0.05).

Regarding traditional assessments, the Tower Test showed a significant correlation of medium effect size with DEX total score (r = -.36, p = 0.02) and a medium-large correlation with the DEX planning measure (r = -.39, p = 0.01). CAMPROMPT total scores did not significantly associate with either total or PM component scores from the self or informant-rated PRMQ questionnaires.

Table 4: Relationships between questionnaire measures and traditional & VR test performance [d]

Questionnaire	Correlations			
Measure	**JAAM Planning**	**Tower Test**	**JAAM PM**	**CAMPROMPT**
DEX	-.44**	-.36*	--	--
DEX Planning	-.49**	-.39*	--	--
PRMQ Informant PM	--	--	-.21	-.14
PRMQ Informant total	--	--	-.23	-.22
PRMQ Self PM	--	--	-.28	-.23
PRMQ Self total	--	--	-.31*	-.29

[d] Pearson's *r* used for all analyses apart from those involving CAMPROMPT where Spearman's *rho* was used as assumptions of normality not tenable. **correlation is sig at the 0.01 level * correlation is sig at the 0.05 level (2-tailed).

Comparison of Correlation Coefficients

Statistical comparison of non-independent correlation coefficients for planning was carried out using Williams' (1959) test, and involved comparison of measures relating to correlations between JAAM planning*DEX planning and Tower*DEX Planning. There was not a statistically significant difference between correlations coefficients (t = -0.61, df = 37, p = 0.54). The respective PM-related correlation coefficients were not compared due to both traditional and VR measures being found not to correlate significantly with informant-rated questionnaire measures of PM.

Convergent Validity

Examining the relationship between performance on VR measures of planning and PM with performance on traditional measures of these cognitive functions, demonstrated a significant correlation of large effect between the CAMPROMPT and JAAM PM (rho = .59, p < 0.001) as well as a correlation of medium effect between the Tower Test and JAAM Planning (r = .33, p = .04). This suggests JAAM measures possess convergent validity with traditional desktop tests meaning the tests are likely to be tapping similar component processes.

Controlling for Potential Confounders

Exploratory analyses were conducted to explore the extent other variables may be attenuating the significant correlations reported between the planning assessments and DEX planning measure. Further analyses were not conducted in relation to PM due to the correlations between the PRMQ PM measures and both the VR and traditional measures being non-significant.

To ascertain if the Tower Test contributed any unique variance in DEX planning beyond that of JAAM planning, an exploratory regression analysis was undertaken using the enter method, which resulted in a significant model (F (2, 37) = 7.98, p = 0.001), explaining 26.4% of variance where JAAM planning was the only significant predictor variable of DEX planning (β = -.41, p < 0.01). Therefore subsequent exploratory analyses focused on the JAAM planning measure.

Several demographic variables were observed to significantly correlate with DEX planning, including: premorbid IQ (*rho* = -.44, $p < 0.01$), years of education (*rho* = -.41, $p = 0.01$), HADS depression ($r = 0.43$, $p = 0.01$), HADS anxiety ($r = .46$, $p < 0.01$), SES (*rho* = -.33, $p = 0.04$) and length of PTA (*rho* = .39, $p = 0.02$). Gender, age or time since injury did not significantly correlate with this measure (all *p*s > 0.05; see Appendix 2.12 for details). To explore the possibility that variance in DEX planning was being accounted for by these variables an exploratory regression analysis was conducted. However due to potential power issues the number of predictor variables was limited to four, focusing on the variables that displayed the strongest correlations with DEX planning (JAAM planning, HADS anxiety, premorbid IQ and HADS depression). Using the enter method, a significant model emerged ($F(4, 35) = 7.07$, $p < 0.001$), explaining 38.4% of the variance. Interestingly, JAAM planning was the only significant predictor variable ($\beta = -.38$, $p = 0.01$). Tolerance values of predictor variables indicated there were no issues of collinearity between variables.

Furthermore, it was noted that DEX planning scores correlated significantly with all the background neuropsychological measures with medium to large effect sizes, ranging from Matrix Reasoning to SDMT (*r/rho* = -.35 to -.60) (see Appendix 2.12 for details). Therefore a separate regression analysis was undertaken, incorporating the three variables with the strongest correlations along with the significant predictor variable from the previous analysis (JAAM planning) to ascertain which explains the most variance in DEX planning. To reduce effects of multicollinearity between predictor variables, Logical Memory delayed recall was omitted due to its close relationship with Logical Memory immediate recall ($r = .84$, $p < 0.001$), with this latter variable being selected due to it having a marginally larger correlation with DEX planning. Thus predictor variables included JAAM planning, SDMT, RCFT Delayed and Logical Memory immediate recall. Using the enter method, a significant model emerged ($F(4, 35) = 7.16$, $p < 0.001$), predicting 38.7% of the variance. Interestingly, the SDMT measure of processing speed was the only significant predictor variable ($\beta = -.40$, $p = 0.01$). No issues with collinearity were indicated.

To explore whether the JAAM planning measure contributed unique variance over and above the measure of processing speed, a final hierarchical regression was undertaken that added JAAM planning to the regression model after SDMT, with DEX planning as the outcome measure. A significant model emerged ($F (2, 37) = 12.97$, $p < 0.001$) explaining 38.0% of the variance, with JAAM planning accounting for 5.2% of variance in DEX planning scores, although this contribution failed reach significance (R^2 change = .052, $p = 0.08$; $\beta = -.26$). Given that the present analysis is underpowered, this may tentatively indicate that despite the processing speed measure (i.e. a measure of general cognitive impairment) accounting for a large amount of variance in the measure of everyday planning ability, the JAAM planning measure still accounts for a small amount of unique variance in everyday planning abilities.

Spearman's correlations indicated that there was not a significant relationship between overall performance on the JAAM and participant's self-rated confidence, familiarity, experience and perceived ability in using computers (all *p*s > 0.05). However overall JAAM performance significantly varied with the requirement for experimenter assistance ($t = 2.68$, $p = 0.01$), where, individuals able to independently complete the JAAM scored significantly higher than those who required assistance to navigate ($M = 21.0 \pm 6.3$ (n = 21) and $M = 15.4 \pm 6.8$ (n = 19) respectively). These groups also significantly differed in their DEX total scores ($t = -4.10$, $df = 38$, $p < 0.001$), with those requiring assistance being rated as having more executive difficulties ($M = 47.6 \pm 15.6$) than those who did not ($M = 26.7 \pm 16.5$); suggesting participants with the most impairment had the most difficulty engaging with the VR methodology as opposed to experimenter-related factors influencing this difference.

Discussion

This study demonstrates that measures of planning and PM derived from the JAAM VR approach possess ecological validity that is at least similar, if not greater, to that of traditional desktop assessment tools. Both planning measures correlated significantly with informant ratings of everyday functioning, more so than the PM measures. Moreover, the VR planning and PM components also displayed moderate and high convergent validity with their traditional counterparts respectively. Given the pressures and practical complexities of ensuring accurate assessment of “real-world” cognitive difficulties post-brain injury, these findings are noteworthy and lend support to the use of VR methodologies.

The strong relationship found between performance on VR planning tasks and DEX measures is striking. The DEX has previously associated with performance on naturalistic “real-world” tests of executive functioning post-brain injury with medium to medium-large effect sizes (Alderman et al., 2003; Knight et al., 2002; Lamberts et al., 2010). Findings from VR studies have been more equivocal, with significant correlations appearing restricted to tasks of high demand (Knight et al., 2006; Sweeney et al., 2010). Several theoretical perspectives propose that raising the cognitive demands of executive functioning tasks increases the requirement for attentional and integrative resources (Einstein & McDaniel, 2005; Smith, 2003; Stuss et al., 2005). Thus it may be speculated that the tasks comprising the VR planning construct make cognitive and attentional demands similar to those typically encountered in real-life (i.e. that these tasks possess verisimilitude). The significant, albeit smaller, correlation found between the Tower Test and DEX planning is consistent with the findings of one of the studies on which the current DEX planning construct was based, where a medium-large correlation was found in a non-clinical sample (Chan, 2001). Despite the non-significant statistical comparison of the VR and traditional correlations with respect to DEX planning scores, the larger correlation observed for the VR measure tentatively supports the hypothesis that VR methodology offers a more ecologically valid assessment of everyday planning difficulties than its traditional counterpart. Further support for this comes from the regression analyses where JAAM planning emerged as a significant predictor variable of DEX planning scores, albeit superseded by the SDMT measure of processing speed. Thus, although the JAAM possesses a good degree of ecological validity, it appears that everyday planning tasks are highly dependent on processing and attentional resources, being core capacities particularly sensitive to deficit post-brain injury (McDowell et al., 1997; Stuss et al., 1985); the degree of impairment in which can be considered indicative of the general level of “neural efficiency” (Hillary et al., 2010; Rypma et al., 2006).

In contrast, neither VR nor traditional PM assessments significantly correlated with informant-rated questionnaire measures of PM, although VR correlations significantly correlated with total self-ratings (i.e. everyday memory impairment). Previous studies have reported non-significant correlations with small effect sizes between PM performance on VR tasks and the informant-rated PRMQ (Sweeney et al., 2010) and an idiosyncratic PM questionnaire (Brooks et al., 2004); thus the larger effect sizes in the present study are notable. Both the CAMPROMPT and JAAM PM tasks required participants to implement numerous intentions whilst engaged in an ongoing task. However in everyday life individuals will rarely be asked to recall as many as ten intentions over a relatively short period of time. Given that the current participant group appeared to be, on average, relatively insightful regarding the impact of their cognitive difficulties (reflected by the self- and informant-rated questionnaire responses being comparable), many individuals may compensate for their difficulties by routinely applying strategies or by avoiding demanding or novel multi-tasking situations (such as those encountered in work settings). Alternatively, some individuals may not have had the opportunity to be exposed to “real-life” situations (i.e. on account of being an inpatient) and may have rated their abilities in line with their current everyday environmental demands. Consequently, the relatively poor PM correlations may reflect the fact that participants may well be able to encode and execute a small number of instructions encountered in their own day-to-day lives, but still struggle under formal assessment conditions due to the increased cognitive demands and lack of accessibility to strategies and supports typically embedded in daily routines. In fact, Chaytor and colleagues (2006) have previously shown that incorporating measures of compensatory strategy use and impact of everyday environmental demands significantly increases the amount of variance in everyday executive functioning explained by neuropsychological assessment, suggestive that these factors are important to consider.

The comparatively stronger correlations between planning measures could suggest that this cognitive domain is more amenable to ecologically valid assessment using VR methodologies. Remembering to carry out a lengthy list of intentions whilst manoeuvring within a complex virtual environment full of distracting stimuli will call upon a variety of cognitive processes, whereas planning measures were typically derived from performance over a shorter time period, and were perhaps not as dependent upon other cognitive functions for successful performance. For example 6 out of 10 planning points could be achieved in the action planning task conducted prior to the task beginning which minimised the impact of distractions and the need for complex cognitive processes such as prioritization and mental flexibility that are needed in PM tasks. Being less reliant on the functioning of different cognitive abilities may decrease variance in performance attributable to impairments in underlying measures and thus strengthen correlations. An alternative explanation relates to the DEX questionnaire, in particular the derived planning construct, which may be more sensitive to real-world planning difficulties than the PRMQ is to real-world PM performance. There is a strong evidence-base for the DEX being considered a reliable and valid assessment (Burgess et al., 1998; Chaytor et al., 2006), though less evidence for this exists in relation to the PRMQ (Crawford et al., 2003, 2006). Thus variation in the psychometric properties of questionnaire measures may also contribute to the pattern of correlations reported. In addition, the usual caveats relating to self or informant-ratings apply to the present study (i.e. dependence on insight, recall and positive and negative halo effects[10]), which may reduce the reliability of ratings. These factors may also account for the relatively high amount of unshared variance that was found between self and informant questionnaire ratings.

Another key finding relates to the degree of convergent validity between assessment measures, being particularly prominent for the PM tests. Tests are likely to be seldom “process-pure”, which is further complicated by the fact ABI typically causes both selective and diffuse impairments to a diversity of cognitive functions. Both planning and PM are typically considered to be multi-dimensional constructs (Fish et al., 2010; Morris & Ward, 2005; Stuss & Alexander, 2000). For example, the formation and execution of an effective plan is thought to rely on a variety of cognitive processes such as abstract reasoning, problem solving and set-shifting, with the contribution of each depending on

[10] Halo effect refers to a cognitive bias whereby the perception of one trait (i.e. ability in one cognitive domain) is influenced by the perception of another trait, or several traits of that person or ability.

task characteristics and prior experience (Burgess et al., 2005). PM is similarly considered to be reliant on the successful integration of different cognitive abilities such as RM, sustained attention, working memory and planning (Fish et al., 2010). This complexity can be a reason why different tests of these cognitive domains may not correlate highly with each other (Craik & Bialystok, 2006). Therefore the strong association demonstrated between the JAAM PM measure and CAMPROMPT total scores is striking, and suggests both tasks capture much of the underpinning PM processes relatively successfully despite their different methodologies. This contrasts with prior speculations that VR tasks may measure different executive processes when compared to their traditional counterparts (McGeorge et al., 2001). Although the relatively weaker, albeit significant, correlations between planning measures is suggestive of the underpinning processes elicited by each task differing more so.

An essential part of neuropsychological assessment is being able to discern where in complex cognitive processes difficulties are occurring. This poses a challenge for traditional measures which tend to measure the end product of a holistic synthesis of processes. This has resulted in it being suggested that individual measurement of respective components may be best (Craik & Bialystok, 2006; Fish et al., 2010). However, the ability of the JAAM to generate concurrent measures of several executive functions under conditions of experimental control, whilst also allowing observable, potentially clinically-useful information to be elicited regarding the manner by which an individual approaches novel problem solving situations, means that it is well placed to provide in-depth information about where in the process deficits are occurring. It was beyond the scope of the current study to explore the inter-relationships between VR constructs, thus a more in-depth examination would be worthwhile. Although it was noted there is no measure of RM performance incorporated in the JAAM, meaning that it is unknown whether PM failures occur due to deficits in RM or PM, as prospective remembering is theoretically considered to be dependent on both components (Einstein & McDaniel, 1996). This could be remedied by asking participants to recall overall task goals both prior to and after assessment, following the methodology often applied in PM research paradigms (e.g. Kliegel et al., 2000).

Numerous factors have been associated with planning and PM performance, including depression, SES and intelligence (Chaytor et al., 2007; Groot et al., 2002; Hannon et al., 1995). The current study attempted to examine the impact of these variables on the significant correlations reported via multiple regression analyses. Despite a large amount of variance in everyday planning abilities being accounted for by processing resources (and a smaller amount being accounted for my JAAM planning), there was still much variance unaccounted for across analyses, highlighting the impact of potential variables either not controlled for (i.e. aetiology of brain injury), or that were not able to be adequately controlled for (i.e. participant's previous occupational experiences and motivation). Due to potential power issues it was not possible to examine the influence of all the demographic and neuropsychological variables seen to correlate with DEX planning, thus running regression analyses with larger sample sizes would be worthwhile. Furthermore, as the JAAM was dependent on individuals possessing good literacy skills, this ability, as well as language abilities generally, may account for some of this variance.

A strength of this study relates to its use of a clinically-based participant group who possessed a broad range of abilities, co-morbidities and brain injury severity, which enhances the generalisability of findings. Nevertheless, this heterogeneity may mean that individuals varied markedly on the selective processes underpinning their performance. For example, participants with temporal or diencephalic lesions may have noticed PM cues but have failed to recall the associated PM action, whilst individuals with frontal damage may have been unable to engage in effective self-initiated strategic processes necessary to plan and set-goals (Mathias & Mansfield, 2005). Furthermore, in order to implement an efficient strategy individuals are reliant on core cognitive abilities such as attentional processing capacity and speed, which was an area where the current participant group experienced marked impairment. It was therefore unsurprising that this cognitive domain accounted for most of the predictive variance in everyday planning abilities in regression analyses, being consistent with previous research where SDMT performance has accounted for 29% of the variance of PM task performance (Hannon et al., 1995). The centrality of attentional resources in executive functioning has been previously linked to the functioning of a supervisory attentional system which co-ordinates components of executive functioning (Shallice et al., 1996; Stuss et al., 2005). It was not possible to gather information on the locality of brain injury in the present study, thus to obtain information on the selective impairments and processes underpinning performance, future studies should consider using participant groups with locality-specific injuries (i.e. frontal lobe injuries) or a participant group possessing more selective cognitive difficulties (i.e. preserved processing speed but impaired executive functioning). Incorporation of a matched control group to compare differential patterns of correlations may also be worthwhile. Furthermore, given insights gleaned from neuroimaging studies on the neuroanatomical correlates of specific executive functions this is likely a lucrative avenue for research (Burgess et al., 2007; Stuss & Alexander, 2000).

A further limitation of this study is the fact that several correlational analyses were performed on the same outcome measure, raising a multiple comparison issue. However, a Bonferroni correction was not performed as this would have been too conservative given that the variables being examined may not be independent. Also, due to the relatively small sample size, several analyses are underpowered and thus results must be considered preliminary until future research using larges samples can evaluate the reliability of findings. The degree of "immersion" in this VR environment was also questionable, especially for the participants who required experimenter assistance to navigate. It should be noted that the data of three participants could not be included in the present study due to them having felt overwhelmed by the JAAM task demands resulting in difficulties engaging with the VR interface. Marcotte and colleagues (2010) have highlighted the risks of making tasks too difficult in that they can become "test like" and increase test anxiety. The office setting of the JAAM may be one that individuals vary widely with respect to their previous experience and familiarity and as such task verisimilitude (i.e. the degree of similarity between data collection methods and skills required in reality) may vary from person to person. Nevertheless, the fact that most individuals were able to successfully interact with the VR approach, alongside the lack of ceiling and floor effects in performance, would suggest that a reasonable balance between real-world similarity and task difficulty has been achieved.

Despite these limitations, comparable findings on the ecological validity of VR measures of specific executive functions are scarce. The finding that VR measures of planning and PM possess ecological validity comparable, if not potentially greater than that of traditional measures may have significant implications for improving neuropsychological assessment processes and measures applied in clinical practice. Additionally, the benefit of the JAAM methodology to measure distinct executive functions in tandem as well as provide qualitatively rich information highlights its potential use as an outcome measure for individually-tailored cognitive rehabilitation strategies. This contrasts with traditional measures, where intuitively it is difficult to extrapolate precisely which abilities in real life could be predicted from test performance (Burgess et al., 2006). Furthermore, the present pattern of correlations appear to support the concept of an executive function "system" that can be fractionated into a variety of executive abilities that can be integrated in different ways in order to carry out tasks with differing attentional resource implications (Shallice et al., 1996; Stuss et al., 2005). Future studies should focus on determining the predicative validity of the JAAM in assessment and rehabilitation contexts, as well as focus on establishing the specific executive processes being measured by constructs such as planning and PM.

Conclusion

In sum, findings suggest that VR assessment measures developed with ecological validity in mind are potentially valuable tools for attempting to predict real-world functioning. The JAAM may offer a superior method of evaluating the degree and nature of real-life difficulties in executive domains of planning and PM as compared to traditional measures. Furthermore, the qualitative data elicited from this VR test makes it clinically appealing, which contrasts traditional tests which typically provide only numerical scores. Investigating performance of specific executive functions in complex naturalistic environments, and combining this information with self- and informant-ratings of everyday executive performance is thus likely to allow a more holistic formulation of executive deficits than standardised executive function tests alone.

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Chapter 3: Advanced Clinical Practice I

Reflective Critical Account

(Abstract)

Disentangling Insight and Adjustment within a Multidisciplinary Team Context: A Reflective Critical Account on the Synergistic Roles of a Clinical Psychologist

Fiona Scott[1]*

[1] Academic Unit of Mental Health & Wellbeing, University of Glasgow

* Address for correspondence:
Academic Unit of Mental Health & Wellbeing
Institute of Health & Wellbeing
University of Glasgow
Gartnavel Royal Hospital
Administration Building
Trust HQ, 1st floor
1055 Great Western Road
Glasgow, G12 0XH

Email: fiona.scott7@nhs.net

Submitted in part fulfilment of the requirements for the degree of Doctorate in Clinical Psychology (D.Clin.Psy)

Abstract

Reflective practice aims to facilitate a Clinical Psychologist's understanding of their own work by enabling them to develop and learn through their professional experiences. This critical reflective account is structured around the Tri-Level Practice Model (De Hoyos, 1989) and draws upon Schön's (1983), Gibbs' (1988) and Atkins and Murphy's (1994) reflective models to reflect on my experience of working with a client in an inpatient setting who had experienced a traumatic brain injury (TBI) where issues regarding his capacity to make decisions against medical advice were frequently encountered. An analysis of my response to the anxiety and uncertainty present within the multidisciplinary team (MDT) regarding the application of the Adults with Incapacity (Scotland) Act (2000) is described. This includes an evaluation of my appraisals of MDT members' expectations regarding my profession-specific responsibilities. The learning experiences of communicating my psychological formulation to the MDT as well as to individuals at a service-based psychiatry-led seminar on incapacity are discussed, with particular reflection upon my changing awareness, emotional state and appraisals regarding my developing competence to carry-out the synergistic multi-level roles necessary of a Clinical Psychologist working within a medically-orientated MDT context. This account concludes with an evaluation of the manner by which my enhanced awareness and learning gleaned from my reflective and practical experiences is conceptualised, and also considers the impact of my experiences on my future professional development.

Chapter 4: Advanced Clinical Practice II

Reflective Critical Account

(Abstract)

Resistance, Roles and Responsibilities: A Critical Reflective Account on the Challenges of Implementing a Stepped-Care Framework within an Older Adult Community Mental Health Team

Fiona Scott[1]*

[1] Academic Unit of Mental Health & Wellbeing, University of Glasgow

* Address for correspondence:
Academic Unit of Mental Health & Wellbeing
Institute of Health & Wellbeing
University of Glasgow
Gartnavel Royal Hospital
Administration Building
Trust HQ, 1st floor
1055 Great Western Road
Glasgow, G12 0XH

Email: fiona.scott7@nhs.net

Submitted in part fulfilment of the requirements for the degree of Doctorate in Clinical Psychology (D.Clin.Psy)

Abstract

Reflective thinking can be considered the cornerstone of learning and self-development. Clinical Psychologists are encouraged to engage in this process of recurrent self-enquiry as a means of continually improving their professional practice. This critical reflective account focuses on my experiences of working in an Older Adult Community Mental Health Team (CMHT), where I became aware of an apparent mismatch between current service-structure regarding the delivery of psychological interventions and the purported roles and responsibilities inherent to working as a Clinical Psychologist within such a team setting. This account is broadly structured around Rolfe's (2001) model of reflection, and draws upon Pedler, Burgoyne & Boydell's (2001) and Gibbs' (1988) reflective models to analyse my thoughts, feelings and behaviours that occurred in response to particular experiences that arose in my active exploration of the dynamics, issues and felt resistance present within the team. Reflections about my changing perceptions, emotional states and resultant behaviours are described with respect to my developing abilities to carry-out integral training and management roles adopted by Clinical Psychologists working within multidisciplinary team (MDT) settings. The account concludes with an evaluation of my experiential learning and outlines plans for continuing personal, professional and organisational development with respect to fostering the roles and responsibilities that Clinical Psychologists have within complex organisations.

APPENDICES

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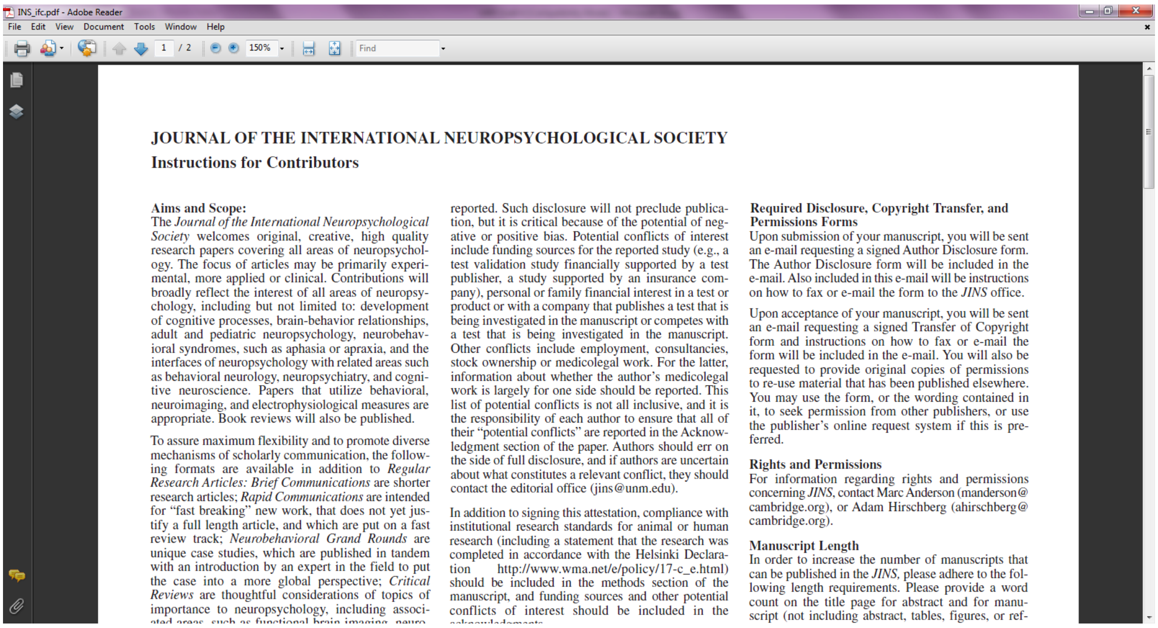
Appendix 1.1: Guidelines for Submission to the *Journal of the International Neuropsychological Society*



JOURNAL OF THE INTERNATIONAL NEUROPSYCHOLOGICAL SOCIETY

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The *Journal of the International Neuropsychological Society* welcomes original, creative, high quality research papers covering all areas of neuropsychology. The focus of articles may be primarily experimental, more applied or clinical. Contributions will broadly reflect the interest of all areas of neuropsychology, including but not limited to: development of cognitive processes, brain-behavior relationships, adult and pediatric neuropsychology, neurobehavioral syndromes, such as aphasia or apraxia, and the interfaces of neuropsychology with related areas such as behavioral neurology, neuropsychiatry, and cognitive neuroscience. Papers that utilize behavioral, neuroimaging, and electrophysiological measures are appropriate. Book reviews will also be published.

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Appendix 1.2: Table of Study Characteristics, Extracted Data and Key Findings

Study (Country) & Quality Rating (%)	Age (y;m) per group: Mean (SD &/or range)	N per group (Males) & IQ; SES	Setting	OG Task	PM task (by condition if applic.) & Measure	Modality, Nature & Freq. of PM cue	Interval Task (time of delay)	Age-Related Confounds [RM][OG]	Main Findings
EVENT-BASED PM									
Atance '09* **(Canada)** **58.9%**	3;6 (3;2-3;11) vs. 4;5 (4;0-4;10) vs. 5;5 (5;1-5;11)	24 (12) for all groups IQ: NR SES: all middle-class	Lab	1. None 2. PPVT-3	1. Card in basket, 2. Puppet retrieval Measure: score 1 for remembered action (1. 0-2 & 2. 0-1)	1. Visual, focal, twice. 2. Auditory, non-focal, once	1.None 2.approx 10mins (after OG task)	RM X OG 1 X. 2.~~m~~	• Sig main effects of age for both PM tasks. Task 1: 29, 67 & 83% of 3, 4 & 5 year olds scored 2/2. Task 2: 26, 54 & 57% scored 1/1 respectively. Sig Tukey's HSD tests for Task 1: 3 vs. 4; 3 vs. 5. Task 2: 3 vs.5.
Guajardo '00* **(USA)** **73.2%**	3;6 (3;1-3;11) vs. 5;3 (4;10-5;9)	48 (24) vs. 48 (24) IQ: NR SES: all middle-class	1. Lab 2. Nat.	1. Computer memory task 2.Lab task (short delay) vs. everyday activities (long delay)	Task by condition: (within-subject) 1. Press button in response to cue (with or without external cue). 2. Ask for sticker and close door (short delay) & return picture and ask for pencil (long delay) Measure: 1. No of correct responses 2. Categorised: rmbr with 0, 1 or 2 prompts	1. Visual, focal, 12 2. Temporal (or auditory prompt), non-focal, 4	1. None 2. 20mins (short delay) vs. 24-72hrs (long delay)	RM ~~m~~ ☑ (0%) OG 1. ~~m~~ 2. NA	• Lab task: Sig effect of age on PM performance; 5yos > 3yos. No sig effect of incentives or cue type, nor interactions (50% of 5yos - ceiling performance) • Sig main effect of age for RM (OG) task performance: 5yos higher recall of pictures • PM and RM performance sig. correlated for 3yo (med-large ES) but not for 5yo (small-med ES) • Sig more 3 yos could not recall task instructions (48%) vs. 5yos (19%) on 1st session • Nat task: Sig more 5yos remembered to perform tasks over ST and LT vs. 3yos. More variation across tasks for 3yos vs. 5yos.

Abbreviations:
adol = adolescent; EB = Event-based (i.e. task requires a response to a specific event cue); ES = Effect Size; HAWIK-R = Hamburg-Wechsler-Intelligenztestfür Kinder (the German-language version of the Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1974); II = Implementation Intentions; ITPA = Illinois Test of Psycholinguistic Ability (Kirk, McCarthy, & Kirk, 1968); IQ = Intelligence Quotient; K-ABC = Kaufman Assessment Battery for Children (Kaufman & Kamphaus, 1984); KBIT = Kaufman Brief Intelligence Test (Kaufman & Kaufman, 1990); Lab = Laboratory (experimenter designed and controlled tasks); LT = Long-term; Nat = Naturalistic (tasks performed during the course of participant's normal daily activities); NR = Not Reported; OA = Older Adult; OG = Ongoing; PM = Prospective Memory; PRMQ = Prospective and Retrospective Memory Questionnaire (Crawford et al., 2006); RM = Retrospective Memory; rmbr = remember; RT = response time/latency; SES = socio-economic status; ST = Short-term; TB = Time-based (i.e. task requires response at a specific time); YA = Younger Adults; yo = years old; vs. = versus; WASI = Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999); WM = Working Memory; > = sig. greater than; < = sig. less than.

Key for Symbols:
* Significant main effect of age on PM performance. # U shaped function indicates children to check clock most frequently during the first third of waiting section, then engage in little checking behaviour during middle period until final moments of waiting period. Age-related design confounds: RM ~~m~~☑ (%) = RM performance measured (~~m~~) and accounted for in analyses/design (☑) (% of participants excluded from analyses if applicable); OG ~~m~~☑ (aa) = OG task performance measured (~~m~~) and accounted for in analyses/design (☑) (aa=age-adjusted OG task used); X = neither measured not accounted for in analyses/design.

Continuation of Appendix 1.2

Study (Country) & Quality Rating (%)	Age (y;m) per group: Mean (SD &/or range)	N per group (Males) & IQ; SES	Setting	OG Task	PM task (by condition if applic.) & Measure	Modality, Nature & Freq. of PM cue	Interval Task (time of delay)	Age-Related Confounds [RM][OG]	Main Findings
Kliegel '07* **(Germany/ Switzerland)** **67.9%**	2;6 (2;0-2;11) vs. 3;6 (3;0-3;11) vs. 4;6 (4;0-4;11) vs. 5;6 (5;0-5;11) vs. 6;4 (6;0-6;10)	20 (8) vs. 27 (7) vs. 22 (10) vs. 30 (16) vs. 20 (14) IQ: NR SES: NR	Lab	Naming task	Place specific cue card in box (with or without external reminder) Measure: No of correct PM responses; Proxy-rated PRMQ	Visual, focal, 3	2mins (drawing task)	RM ~~m~~ ☑(16.8% - all 2yos excluded as 60% could not recall) OG ~~m~~ ☑	• Sig age effect on PM performance (large ES). Sig Tukey's HSD tests: 2&3yos < 4, 5, 6 yos. • Sig age effect on OG task performance (large ES). Sig Tukey's HSD: 2yos < all other ages. • Sig age effect on PM performance remained after OG task age effects controlled(large ES) • Sig age effect on PM performance for children with intact RM component (large ES): Sig Tukey's HSD: 3yo < 4, 5 & 6yos. Main effect memory aid (med-large ES) and interaction approached sig (medium ES): external aid increased 3yo performance most • All PRMQ scales (-vely) correlate with age.
Kliegel '08* **(Germany/ Switzerland)** **57.1%**	7;0 (7m) vs. 10;0 (7m) vs. 25;6 (60m) [vs. 67;1 (59m)]	51 (19) vs. 52 (29) vs. 79 (40) vs. 79 (40) IQ: NR SES: NR	Lab	Computer Six Elements Test (SET): with or without interruption	4 Aspects of PM: 1. Plan formation; 2. Plan recall 3.Intention initiation (starting SET when cued); 4. Intention execution (initiate five other tasks) Measures: 1. Dichotomous & complexity score; 2. Accuracy 3. Dichotomous 4. No of self-initiated switches	Temporal, focal, once	20 mins (distracter activities)	RM (~~m~~?)☑ OG X (aa)	• 1. 7yos sig less likely to provide plan vs. 10yos. Both 7 & 10yos less likely vs. adult. Plan complexity: 7yos =10yos<OA<YA. • 2. No age effect in plan recall. • 3. 7yos less likely to self-initiate SET vs. all other groups. YA sig better vs. 10yos. • 4. Sig effects of age (large ES), task interruption (large ES) & interaction: sig age effects in no-interruption condition (large ES), (7yos< all other groups) but effect sig greater in interruption condition (large ES) (all comparisons of age groups of interest sig.)
Kliegel '10 **(Germany)** **71.4%**	3;8 (4.1m) vs. 5;9 (9.4m)	20 (8) vs. 20 (7) IQ: NR SES: NR	Lab	K-ABC subscales (age-standardised)	Task by condition: (within-subject) 1. High motivation: Remind tester to give present after OG task 2. Low motivation: Remind tester to write name after OG task Measure: dichotomous	1. Temporal, non-focal, once 2. Temporal, non-focal, once	OG task (10 exercises from K-ABC – time NR)	RM ~~m~~ OG ~~m~~ ☑(aa)	• No main effect of age or motivational incentives on PM performance. Sig age x motivation interaction: high motivation 3yo = 5yo (small ES) vs. low motivation: sig 3yo < 5yo (medium ES). • No age effect on age-adjusted OG task performance

Continuation of Appendix 1.2

Study (Country) & Quality Rating (%)	Age (y;m) per group: Mean (SD &/or range)	N per group (Males) & IQ; SES	Setting	OG Task	PM task (by condition if applic.) & Measure	Modality, Nature & Freq. of PM cue	Interval Task (time of delay)	Age-Related Confounds [RM][OG]	Main Findings
Kvavilashvili '01 – 1st study* **(UK)** **53.6%**	5;5 (NR) vs. 7;4 (NR)	24 (12) vs. 24 (12) IQ: NR SES: NR	Lab	Naming Task	Remember to hide card with picture of animal (with or without self-initiated OG task interruption) <u>Measure</u>: No of times remembered to hide target card	Visual, focal, 4	2mins (drawing task)	RM ~~m~~ OG ~~m~~ (NR)	• Sig effect of age (7yos > 5yos; med-large ES) & task interruption (non-interrupt > interruption: large ES) on PM performance. Non-sig interaction. • All children who forgot to hide all 4 cards could recall task instructions • 74% of children who remembered at least once reported remembering PM task only when seeing cue. 26% said thought about task all the time.
Kvavilashvili '01 – 3rd study* **(UK)** **53.6%**	5;5 (NR) vs. 7;4 (NR) vs. 4;6 (NR)	32 (NR) vs. 32 (NR) vs. 32 (NR) IQ: NR SES: NR	Lab	Naming Task (with surprise recall)	Remember to hide card with picture of animal (with or without self-initiated OG task interruption that controlled for timing of cue exposure) <u>Measure</u>: No of times remembered to hide target card	Visual, focal, 4	2mins (drawing task)	RM ~~m~~ ☑ (5.2% exc. in exploratory analysis) OG X	• Sig effect of age (medium ES) & task interruption (non-interrupt > interruption: med-large ES) on PM performance. Planned comparisons on age effect: sig difference of 7yos > 4yos. • 87% of children who forgot to hide all 4 cards could recall PM task instructions • 67% of children who remembered at least once reported remembering PM task only when seeing cue. More 5&7yos vs. 4yos reported thinking of task all time (non-sig). • Multiple regression on PM scores: task interruption only sig predictor when other variables controlled.
Maylor '10* **(UK)** **62.5%**	8-50 divided into 21 age groups.	318, 614 (123, 803), with groups ranging from 936 (418) to 41, 267 (12, 791) IQ: NR SES: NR	Lab (internet)	Computerised WM tasks & questionnaire	Click on smiley face with or without prior target exposure and with or without temporal cue. <u>Measure</u>: score 1 for success; 0 failure (dichotomous)	Visual, non-focal, once	~20-30 mins (OG task)	RM ~~m~~ (☑) OG X	• Main effects of age on PM & RM performance (increasing then decreasing). Main effect gender (female > males) & memory task (PM>RM). All effects remained when analysis restricted 8-17yos. • Gender differences larger in older children & YAs vs. middle-age, and female superiority greater for PM vs. RM but more so in children vs. YAs (females achieved near adult levels at earlier ages (10-11 yo)) • Presence of cue at encoding & temporal uncertainty aided PM: effects decreased & increased respectively from childhood to middle-age

Continuation of Appendix 1.2

Study (Country) & Quality Rating (%)	Age (y;m) per group: Mean (SD &/or range)	N per group (Males) & IQ; SES	Setting	OG Task	PM task (by condition if applic.) & Measure	Modality, Nature & Freq. of PM cue	Interval Task (time of delay)	Age-Related Confounds [RM][OG]	Main Findings
Meacham '80 **(USA)** **23.2%**	5;10 vs. 7;8	38(NR) vs. 38(NR) IQ: NR SES: all middle-class	Lab	Interview or card game	Remind tester to open box at end (with or without external cue) Measure: dichotomous	Temporal, non-focal, once	7mins (OG task)	RM X OG X	• No age differences in PM performance • No effect of varying OG task activity • For both age groups PM performance improved with presence of external retrieval cue vs. not
Passolunghi '95 – Expt 1* **(Italy)** **41.1%**	7;6 (7-8) vs. 10;7 (10-11)	60 (NR) IQ: NR SES: NR	Lab	Computerised Reading task	Key press in response to specific word (following visual, verbal or motoric cue encoding Measure: No of times pressed key at appropriate time	Visual (verbal format), focal, 8	Training activity (time NR)	RM X OG X	• Sig age effect and age x encoding condition interaction: 7-8yos performed better in visual condition, whereas 10-11yos had higher PM scores in motoric condition. • 7-8yos: sig difference between visual & both the verbal and motoric conditions • 10-11yos: sig difference between visual & motoric and verbal & motoric conditions
Rendell '09 – 2nd study* **(Australia)** **51.8%**	5;0 (4m) vs. 8;1 (11m) vs. 11;1 (7m)	32(11) vs. 21(14) vs. 23(19) IQ: ITPA (verbal ability):17.7, 26.1 & 32.8 for each group respectively SES: NR	Lab	Computer driving game	Task by condition Remember to press refuel button when red light flashed & when attendant awake after: 1. 0 sec delay (retrieve-execute) or 2. 10 sec delay (delay execute) Measure: No of times remember to refuel	Visual, focal, 4 per condition	None	RM ~~m~~ NA OG X	• Sig effect of age (large ES) & task type (large ES), non-sig interaction. Sig Tukey's HSD: preschool < young & old primary groups. Sig more correct responses in retrieve-execute vs. delay-execute trials, i.e. delaying execution caused consistent level of performance reduction across age groups. • Error analysis: children's errors not due to difficulties with RM component (i.e. not confusion errors) but due to PM component
Shum '08* **(Australia)** **69.6%**	(8-9) vs. (12-13)	35(NR) vs. 28(NR) IQ (WASI): 8-9yos: 99.7 & 106.4 by cond. 12-13yos: 99.2 & 95.8 by cond. SES: upper working or lower middle	Lab	Reading task	Task by condition Substitute target word with another word: 1. with interruption (3 times) to complete questionnaire & puzzles 2. without interruption Measure: One point for each correct substitution	Visual, focal, 16	5mins (Stroop Test)	RM ~~m~~ ☑ (1.6% needed prompt – not exc.) OG ~~m~~ ☑ (aa)	• Sig age effect on PM performance: older children > younger children. • No effect of PM condition. Age x PM condition interaction approached sig: planned comparisons - 8-9yos performance in non-interrupt> interruption condition (med-large ES), whilst 12-13yo's non-sig difference between conditions (small ES) • IQ not associated with PM performance. • No age differences in engagement in OG task

Continuation of Appendix 1.2

Study (Country) & Quality Rating (%)	Age (y;m) per group: Mean (SD &/or range)	N per group (Males) & IQ; SES	Setting	OG Task	PM task (by condition if applic.) & Measure	Modality, Nature & Freq. of PM cue	Interval Task (time of delay)	Age-Related Confounds [RM][OG]	Main Findings
Somerville '83 **(USA)** **25.0%**	2;8 (2;0-3;0) vs. 3;5 (3;1-3;10) vs. 4;6 (3;11-4;11)	10 (4) vs. 10 (8) vs. 10 (6) IQ: NR SES: all middle-class	Nat	Everyday activities	Task by condition: (within subject) Remind caregiver to carry out action(high vs. low interest) after ST vs. LT delay Measure: dichotomous	Circumstantial, non-focal, 8	1-5mins (ST delay) or 4-8 hours (LT delay)	RM X OG X	• Non-sig age effect found. Sig effect of interest and delay. In high interest condition, % remembering 2 = 3 = 4yos (60-75%), whilst in low interest 2yos (19%) < 3yos (88%) & 4yos (70%) in LT delay
Smith '10* **(Germany)** **78.6%**	7;5 (6;8-8;0) vs. 10;7 (9;5-11;11) vs. 24;2 (18;0 – 31;0)	50 (21) vs. 53 (24) vs. 36 (17) IQ: NR SES: NR	Lab	Computerised colour-matching task	Press key in response to one of three target pictures during OG task (no PM task for control group) Measure: No of correct PM responses	Visual, focal, 6	4min filler task (puzzle) between block 1 (OG task) & block 2 (OG & PM task)	RM ~~m~~☑ (0%) OG ~~m~~☑	• Multinomial process tree modeling approach used to separate PM and RM components: • Overall, sig age effect on PM performance (large ES): 7yos <10yos (large ES) & adults (large ES). 10yos < adults (large ES) • PM & RM component: 7 & 10 yos < adults. 7 < 10 yos on RM component only. • Trend for age differences in PM false alarms: 7 & 10yos vs. adults. 10yos = adults • Post-test recognition: sig age effect (large ES), 7yos < 10yos & adults. 10yos = adults.
Wang '06* **(China)** **66.1%**	14;6 (7m; 13-16) vs.20;6 (8m;19-22)	122 (53) vs. 219 (54) IQ: NR SES: middle -income	Lab	Questionnaire (normal emphasis), plus maths problems (high emphasis)	Task by condition: Tick negative word (normal emphasis)& triple tick if also even no (high emphasis) Measure: Proportion of PM trials correct	Auditory, focal, 20	None	RM ~~m~~ ☑(2.5% adol group) OG X	• Sig effect of age (adols < YAs), OG task emphasis (normal < high) and PM emphasis (normal < high) on PM performance • Sig age x PM task emphasis interaction: larger ES of PM task emphasis effect in adols (med-large ES) vs. YAs (small-med ES)
Wang '08 – study 1* **(China)** **57.1%**	3;1 (8m) vs. 4;7 (6m) vs. 5;3 (5m)	20 (10) vs. 19 (9) vs. 21 (14) IQ: NR SES: NR	Lab	Naming Task (with or without RM load – memory task)	Throw ball when specific pictorial cue encountered Measure: PM accuracy and PM RT (i.e. time between receiving ball and turning to throw)	Visual; focal, once (interruption of OG task required)	2mins (physical activity)	RM ~~m~~ ☑ (6.7%) OG X	• Sig age effect on PM accuracy: 50% 3yos vs. 95-100% for 4 & 5yos. Non-sig effect of RM load on PM performance in all ages. • Sig age effect on PM RTs. Sig Tukey HSD: 5yos faster vs. 3yos & 4yos. Sig interaction of RM load on PM RT's by age: 3 & 4yos slower vs. 5yos = faster when RM load added. • Sig age effect on RM: 3yos < 4 & 5yos. • RM & PM performances correlated (med-large ES), reduced but still sig after age effects controlled (medium ES)

Continuation of Appendix 1.2

Study (Country) & Quality Rating (%)	Age (y;m) per group: Mean (SD &/or range)	N per group (Males) & IQ; SES	Setting	OG Task	PM task (by condition if applic.) & Measure	Modality, Nature & Freq. of PM cue	Interval Task (time of delay)	Age-Related Confounds [RM][OG]	Main Findings
Wang '08 – study 2 **(China)** **55.4%**	3;5 (6m) vs. 4;6 (6m) vs. 5;2 (4m)	20 (9) vs. 22 (12) vs. 20 (12) IQ: NR SES: NR	Lab	Naming task (with or without RM load – memory task)	Throw ball when specific pictorial cue encountered <u>Measure</u>: PM accuracy & PM RT (i.e. time between receiving ball and turning to throw)	Visual, focal, once (no interruption of OG task required)	2mins (physical activity)	RM ~~m~~ ☑ (0%) OG X	• Non-sig age effect on PM accuracy (all groups at least 80% correct) and no influence of RM load on PM performance. • Non-sig effects of age or RM load on PM RTs. • Sig age effect on RM performance: 3yos < 4 & 5yos. • RM & PM not correlated (small ES)
Wang '11* **(China)** **71.4%**	13;3 (6m; 11-14) vs. 19;8 (10m;17-21)	69 (32) vs. 59 (19) IQ: NR SES: all middle-class	Lab	Computerised Spatial WM task	<u>Task by condition:</u> (between subjects) 1. Focal: key press for specific target stimulus 2. Non-focal: key press for specific background colour <u>Measure:</u> PM accuracy	1. Visual, focal, 5 2. Visual, non-focal, 5	10mins (distracter activities)	RM ~~m~~ ☑ (0%) OG ~~m~~ ☑ (aa)	• Sig effect of age (YA > adol, med-large ES) & focality (focal > non-focal, large ES) on PM accuracy. Sig age x focality interaction: age effect in non-focal (large ES) but not focal • OG task: no age effect on OG task accuracy or RTs, but sig age x focality interaction: in focal condition adol > YAs (med-large ES), no diffs for non-focal condition. Sig age x focality interaction for RTs: YAs had faster RTs than adol in non-focal condition (large ES), whereas no diffs in focal condition.
Ward '05* **(Australia)** **75.0%**	8;7 (14m;7-10) vs. 14;7 (14m;13-16) vs. 19;1 (14m;18-21)	30 (NR) vs. 30 (NR) vs. 30 (NR) IQ (WASI): 114.8, 112.0 & 109.7 per group respectively SES: all upper working or middle-class	Lab	Computerised Lexical decision task (low and high cog demand)	<u>Task by condition</u>: Key press in response to embedded Italic letter. Variation in importance of PM task (unstressed vs. stressed) <u>Measure:</u> No of correct responses	Visual, focal, 12	None	RM ~~m~~ ☑ (0%) OG ~~m~~ ☑ (aa)	• Sig age effect on PM performance: Sig Tukey's HSD: 7-10 < 13-16 & 18-21yos (both low & high demand). Sig effect of demand: low > high. No effect of importance & no interactions • Children's proportional decrease in PM performance from low to high demand condition was sig greater vs. adols & YAs • Remembering strategies: majority of children & adults said remembered PM task only when saw cue vs. 48% adols reporting thinking about cue all time. • Sig effect of age & demand on OG task & sig interaction: Low demand: children < adols. High demand: children<adols & adols<adults

Continuation of Appendix 1.2

Study (Country) & Quality Rating (%)	Age (y;m) per group: Mean (SD &/or range)	N per group (Males) & IQ; SES	Setting	OG Task	PM task (by condition if applic.) & Measure	Modality, Nature & Freq. of PM cue	Interval Task (time of delay)	Age-Related Confounds [RM][OG]	Main Findings
Zimmermann'06* **(Switzerland)** **44.6%**	5;6 (7m; 4-6) vs. 13;4 (6m; 13-14) vs.21;2 (21m;19-26) [vs. 58;8 (38m;55-65) vs.70;5 (43m; 65-75)]	40 (NR) for all groups IQ: NR SES: NR	Lab	Computerised visual decision task	Computer task: release and press key in response to general cue Measure: Proportion of correct responses (i.e. times released key: signifying cue detection = PM component)	Visual, focal, 4	5mins (questionnaire)	RM ~~m~~ ☑ (0%) OG☑ (aa)	• Sig quadratic effect of age on PM performance. Sig Tukey HSD: adol & YAs > children (& 65-75yos) - inverted "U shape" trajectory in performance across age groups. • Sig age effect on false alarms for PM component: Sig Tukey HSD: children > 19-26yos (& 55-65yos.)
Zimmermann'10* **(Switzerland)** **57.1%**	12;10 (13m; 10-14) vs. 22;8 (37m;17-30) [vs. 68; 8 (40m; 64-75)]	185 (NR) vs. 193 (NR); (reduced to 116 & 178 when <80% accuracy OG task removed) IQ: NR SES: NR	Lab	Computerised lexical decision task	Task by condition: Release and button press for word in "animal" category under 3 conditions: 1. PM instructions 2. PM + II instructions 3. no PM instructions Measure: Proportion of correct responses (i.e. time release key & press another key)	Visual, focal, 4	10 mins (questionnaire)	RM ~~m~~ ☑ (10.8% & 4.6% [& 9.8%]) OG☑ (aa)	• Sig age effect on PM performance (medium ES): Sig Tukey HSD: YA > adol (& OA). Sig effect of instruction (small ES). Non-sig interaction • Sig effect of age (medium ES) & instruction type (small ES) on PM component (key release). Non-sig interaction. Sig Tukey HSD (age): YA > adol (&OA). • Sig age effect on RM component (OG task interruption) (medium ES). Non-sig effect for instruction & interaction. Sig Tukey HSD (age): OA < adol, YA = adol.
Zöllig '07* **(Switzerland)** **76.8%**	12;10 (7m) vs. 22;6 (17m) [vs.70;1 (46m)]	14 (7) for all groups IQ: all ± 1SD verbal intelligence SES: NR	Lab	Computerised semantic judgment task	Task by condition 1. Press button & rmbr colour of letter & cue (initiation formation). 2. Notice cue & postpone response (prospective inhibit: PI). 3. Prospective response to word in cue colour (prospective execute: PE) Measure: PI and PE: Accuracy & RTs PI: rate of false alarm & time outs PE: categorized: correct responses, confusions, misses & time-outs	Visual, focal, 48	None	RM X OG ~~m~~ ☑	Reported for behavioural data only: • PM execution. Age effect for accuracy (large ES): adol < YA (&YA > OA). Errors: adols made more confusion errors (small-med ES) vs. YA • Sig age effect in PI accuracy: adols < YAs (medium ES) and for PI time outs (med-large ES): adols > YAs • Age effect on OG task accuracy (large ES): adols < adults(& adols < OAs) • No age effect on RT differences between baseline & OG task (i.e. similar cost to OG task across age groups) • Sig age effect for RTs – decreasing adol to YA (& increasing YAs to OAs). Sig effect of trial – RTs increasing from PE to OG trials& from OG to PI trials. Sig age x trial interaction – sig across all age groups

<u>**Continuation of Appendix 1.2**</u>

Study (Country) & Quality Rating (%)	Age (y;m) per group: Mean (SD &/or range)	N per group (Males) & IQ; SES	Setting	OG Task	PM task (by condition if applic.) & Measure	Modality, Nature & Freq. of PM cue	Interval Task (time of delay)	Age-Related Confounds [RM][OG]	Main Findings
TIME-BASED PM									
Aberle '10* **(Switzerland)** **57.1%**	5;8 (2m) vs. 6;3 (5m) (5;2-7;3)	42 (19) IQ: NR SES: NR	Lab	Memory pairs game	Monitor an hourglass to ensure sand runs continuously. <u>Measure:</u> No. of hourglass turns (PM performance). Freq. of clock checking (time monitoring)	Temporal, non-focal, 6	None	RM ~~m~~ OG ~~m~~ ☑	• Age & PM performance sig correlated: older children turning hourglass more often vs. younger children (medium ES). • Age groups did not differ in time monitoring, with this being correlated with PM performance (large ES) • No age effects in OG task performance (small-med ES)
Ceci '85 **(USA)** **37.5%**	10;9 (NR) vs. 14;11 (NR)	48 (24) vs. 48 (24) IQ: NR SES: NR (no differences btwn groups)	Nat & Lab	Computer game	<u>Tasks by condition:</u> (between-subjects) Check cupcakes or battery charge at home or in lab <u>Measure</u>: freq. of clock checks (& PM performance: remember or not, dichotomous)	Temporal, non-focal, once	None (30mins OG task)	RM X OG X	• No age effects in familiar setting (home). In lab, 14yos had sig less clock-watching vs. 10 yos & made more use of strategic time-monitoring# (U shaped pattern over time). • Late responders (60secs+): all tested at home bar one (21 total) & did not engage in strategic time monitoring nor increase clock-watching over time and had low level of clock checking vs. those who remembered (mean 6 vs. 10-16) (no age analyses)
Kerns '00* **(Canada)** **69.6%**	10;0 (9m; 6;11-12;11) [later separated into individual years]	80 (NR) IQ (KBIT): 109.8 ("roughly equivalent" across ages) SES: NR	Lab	Computer driving game	To monitor fuel level (once per min) & refuel <u>Measure</u>: no of times run out fuel (PM failure) & no. fuel checks (time monitoring)	Temporal, non-focal, 4 or 5 (within brief window of time)	None	RM X OG X	• Sig age differences in PM performance: older children having less PM failures vs. younger children (medium ES). • All age groups engaged in similar pattern of strategic monitoring of fuel checks (J shaped distribution over time). • No sig gender effects on PM performance or time checks.

Continuation of Appendix 1.2

Study (Country) & Quality Rating (%)	Age (y;m) per group: Mean (SD &/or range)	N per group (Males) & IQ; SES	Setting	OG Task	PM task (by condition if applic.) & Measure	Modality, Nature & Freq. of PM cue	Interval Task (time of delay)	Age-Related Confounds [RM][OG]	Main Findings
Mackinlay '09* **(Germany)** **69.6%**	10;1 (20m; 7;2-12;7). Later split 8;1 (1m;7-9) vs. 11;1 (1m;10-12)	56 (26) IQ: NR SES: all middle-class	Lab	Computerised one-back task	To press specific key on keyboard every 2 mins (pressing alternative key to check clock) Measure: No of correct PM key presses (within 5 sec time window) and number and freq. of clock checks (time monitoring)	Temporal, non-focal, 5	Information subtest of HAWIK-R (time NR)	RM ~~m~~ OG ~~m~~ ☑	• Age sig correlated (+vely) with PM performance (large ES), remained after OG performance partialed out (large ES) • OG task accuracy sig related to age (med-large ES), although costs to PM performance not related to age (small ES) • No. of clock checks not correlated with age (small-med ES) • Sig age x time period interaction: older children had more accelerated time monitoring pattern vs. younger children (slight linear increase)
Mäntylä '07 **(Sweden)** **48.2%**	10;4 (8-12) vs. 24;4 (20-29)	51(NR) vs. 62(NR) IQ: NR SES: NR	Lab	Movie	Indicate passing of time (5mins) with button press Measure: PM performance: proportion of responses with max delay of 10secs Monitoring: freq. (no of clock checks)	Temporal; non-focal; 4 vs. 6	None (5mins OG task)	RM X OG X (aa)	• Non-sig age group effects for PM performance • Children checked clock more freq. than adults to obtain same accuracy (large ES) • Both groups showed similar accelerated clock checking over 5min period. • 8-9yos & 10-12yos had similar monitoring behaviour apart from first 3-4 minutes of task, with 8-10yos maintaining higher rate of clock checking for this period
BOTH									
Nigro '02 **(Italy)** **30.4%**	9;7 (11m;7; 9-11;2) (Later 3 age categories created: 7;9-8;6 vs. 9;7-10;6 vs. 10;7-11;2)	80 (46) IQ: NR SES: NR	Lab	Puzzles	Task by condition: (between subjects) TB: Remind tester to call in 5 or 10 mins. EB: Remind tester to pass on message to co-tester (5 or 10mins) Measure: Categorised as rmbr or not (within 90sec) & time monitoring (no clock checks)	Temporal, Non-focal, once Circumstantial, non-focal, once	None (5 or 10mins OG task)	RM X OG X (aa)	• Subjects executed intention more freq. for EB vs. TB tasks (for 5 & 10mins) • Length of retention interval sig. associated with PM performance on TB tasks only • Freq. of clock checking not related to age • PM performance not related to age in discriminant analysis (PM performance, chronological age, type of task and delay as predictor variables)

References for Appendix 1.2

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Appendix 1.3: Quality Assessment Checklist

Methodological Quality Criteria	**Ratings**
STUDY OBJECTIVES	
Study addresses an appropriate and clearly focused question	Well addressed (2) Partially or poorly addressed (1) Not addressed/reported (0)
Specific study hypotheses are stated *(i.e. they are congruent, consequential and unambiguous in relation to the scientific background/study rationale)*	Well addressed (i.e. explicitly stated) (2) Partially or poorly addressed (i.e. not stated but inferred) (1) Not addressed/reported (0)
STUDY DESIGN	
Overall study design *([1] i.e. groups matched in gender distribution, SES or IQ)*	Longitudinal (4) Cross-sectional age-group comparison (groups comparably matched on at least two other demographic factors[1]) (3) Cross-sectional age-group comparison (groups not matched on at least two other demographic factors[1]) (2) Cross-sectional one group with later division into age groups (i.e. by group median) (1)
STUDY SAMPLE	
Recruitment *(Representative?)*	Geographical cohort or random sample (2) Convenience or volunteer sample (1) (i.e. particular school) Unclear how sample was obtained (0)
Sources and methods of recruitment are clearly stated *(type of site, approach used etc.)*	Well addressed (includes info on both sources and methods) (2) Partially or poorly addressed (information on just one) (1) Not addressed/reported (0)
Inclusion and exclusion criteria are clearly defined	Well addressed (2) Partially or poorly addressed (i.e. only mentions one inclusion/exclusion criterion) (1) Not addressed/reported (0)
METHODS AND MEASURES	
Pre-operational definitions of constructs provided *(i.e. definition of PM cue/PM task being used in study is outlined in introduction or method section)*	Well addressed (i.e. defines nature of PM cue/PM task and links to its use in present study) (2) Partially or poorly addressed (i.e. fleetingly mentioned but does not specify how relevant to current study) (1) Not addressed/reported (0)
Outcome measures clearly defined *(i.e. includes info on (1) how (and if applicable, who) scores performance and (2) the nature of measure e.g. frequency, score range or RT)*	Well addressed (includes info on both aspects) (2) Partially or poorly addressed (only includes one aspect) (1) Not addressed/reported (0)
Standardised and/or valid and reliable measures used *(i.e. as evidenced from other sources/adult samples or check of reliability/validity in study)*	Well addressed (i.e. source or method clearly documented) (2) Partially or poorly addressed (i.e. fleetingly mentioned) (1) Not addressed/reported (0)
PM construct measured by more than one method *(i.e. to avoid mono-operation/mono-method bias)*	Yes (i.e. by two or more separate measures) (2) No (0)
Appropriate instrumentation *(are ceiling or floor effects present*?)* **Consider in relation to key measure of PM performance*	No ceiling or floor effects in instrumentation (i.e. either explicitly mentioned or N/A due to study design) (2) Acknowledges ceiling/floor effects and accounted for this in any further analyses (1) Ceiling/floor effects reported & not accounted for in analyses or not reported when possible with study design (0)
Randomisation introduced into conditions whenever possible *(i.e. counterbalancing of within-subjects conditions)*	Yes and outlines valid procedure to randomise, or N/A (2) Yes but randomisation procedure not explained (1) No (0)
Standardised procedural protocol used *(i.e. the same procedure/protocol was used within/between groups)*	Yes and is appropriate for all age groups (i.e. no potential effect of OG task difficulty and same frequency and duration of exposure) or only OG task difficulty is adjusted for age with clear rationale (2) Yes but is not appropriate for all age groups (i.e. age differences in OG task demands present) and/or is adjusted for different age groups without stated rationale (1) No (0)
CONFOUNDERS	
Retrospective memory (RM) performance is measured	RM performance is measured either with independent measure or

	before and after completion of PM task (2) Measured either before or after completion of PM task (1) Not measured/reported (0)
RM performance is taken into account in study design or analysis (with regards to PM performance) *(i.e. omission of participants with RM failure of task instructions from analyses)*	Well addressed or N/A (i.e. if all participants remembered task instructions so no exclusion/additional analyses required) (2) Partially or poorly addressed (i.e. exploratory analysis only) (1) Not addressed/reported (0)
Measurement of ongoing (OG) task performance	OG performance is measured with respect to age (i.e. measured for different age groups) (2) OG performance is measured but not with respect to age (1) OG performance is not measured/reported (0)
OG task performance is taken into account in study design or analysis *(i.e. to account for potential age differences in OG task difficulty)*	OG task performance is considered in initial study design or in analysis of age differences in PM performance (2) Potential age-differences in OG task performance are acknowledged but not accounted for in analysis/study design, or only partially accounted for (1) Potential age-differences in OG task performance not considered(0)
Other potential confounders are appropriately measured and taken into account in study design or analysis *(i.e. gender, IQ/reading ability, SES, or if appropriate, age differences in RT)*	Key potential confounders measured and taken into account in study design/analysis (2) One or more potential confounders are measured but not taken into account in study design/analysis (1) Potential confounders are neither measured nor addressed in study design/analysis (0)
STATISTICAL ANALYSIS	
Power calculation or effect sizes reported for main outcome of interest *(i.e. sample sizes determined by power calculation)*	Yes (2) No (0)
Demonstrates that assumptions of statistical tests have been met *(i.e. homogeneity of variances, data normally distributed for parametric tests?)*	Well addressed (i.e. explicitly reported) or NA (i.e.non-parametric)(2) Partially or poorly addressed (i.e. only inferred) (1) Not addressed/reported (0)
All statistical methods described to conduct group comparisons (and control for confounders)	Well addressed (i.e. all methods described) (2) Partially or poorly addressed (i.e. not all methods described) (1) Not addressed/reported (0)
Describes appropriate methods for additional analyses (e.g. post-hoc, sub-groups, interactions and sensitivity analyses), clearly stating if pre-specified or exploratory	Well addressed or N/A (2) Partially or poorly addressed (1) Not addressed/reported (0)
RESULTS	
Demographic characteristics of sample clearly reported (gender, SES, IQ)	Well addressed (i.e. two characteristics) (2) Partially or poorly addressed (i.e. one characteristic) (1) Not addressed/reported (0)
Reports outcome events (unadjusted estimates and, if applicable, confounder-adjusted estimates)	Well addressed (i.e. all relevant data reported and clear to understand) (2) Partially or poorly addressed (i.e. some outcome data not reported (e.g. means/SD) or reported in disorganised manner) (1) Not addressed/reported (0)
DISCUSSION	
Provides summary of key results with reference to study objectives	Yes (2) No (0)
Acknowledges and discusses limitations of the study *(i.e. takes into account sources of potential bias or imprecision)*	Well addressed (i.e. both acknowledges and discusses in context of future research) (2) Partially or poorly addressed (i.e. key limitations omitted or only acknowledged without further discussion) (1) Not addressed/reported (0)
Gives an overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies and other relevant evidence and generalizability of findings.	Well addressed (2) Partially or poorly addressed (i.e. some key aspects omitted) (1) Not addressed/reported (0)
TOTAL SCORE	__/56 x 100 = ____%

Appendix 1.4: Detailed Breakdown of Checklist Ratings per Study

Criteria		Aberle & Kliegel (2010)	Atance & Jackson (2009)	Ceci & Bronfenbrenner (1985)	Guajardo & Best (2000)	Kerns (2000)	Kliegel & Jäger (2007)	Kliegel et al (2008)	Kliegel et al (2010)	Kvavilashvili et al (2001) –Expt 1	Kvavilashvili et al (2001) –Expt 3	Mackinlay et al (2009)	Mäntylä et al (2007)	Maylor & Logie (2010)	Meacham & Colombo (1980)
Study Objectives	Question	2	2	1	2	2	2	2	2	2	2	2	2	2	1
	Hypotheses	1	2	2	2	2	0	2	2	1	0	1	2	1	0
Study Design	Overall	1	2	3	3	3	2	2	2	2	2	3	2	2	2
Study Sample	Recruitment	1	0	1	2	2	1	0	1	1	1	1	1	1	1
	Source/Method	2	0	1	1	1	1	0	1	1	1	1	1	2	1
	I/E Criteria	0	0	0	0	2	1	0	0	0	0	2	0	1	0
Methods & Measures	Constructs	2	2	0	2	2	2	2	1	2	2	2	1	1	0
	Outcomes	2	2	1	2	2	2	2	2	2	2	2	2	2	1
	Std. or val/rel	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	>1 measure	2	2	0	2	2	2	2	2	0	0	2	2	0	0
	Instrumentation	0	2	0	1	2	0	0	0	0	0	2	0	2	0
	Randomisation	0	1	1	1	2	1	1	1	1	1	0	2	1	1
	Protocol	2	2	2	2	2	1	1	2	2	2	2	1	1	1
Confounders	RM Measure	1	0	0	2	0	1	1	1	1	2	1	0	2	0
	RM Design/Anal.	0	0	0	2	0	2	2	2	1	2	0	0	2	0
	OG Measure	2	2	0	2	0	2	0	2	0	0	2	0	0	0
	OG Anal. (age)	2	0	0	1	0	2	1	2	0	0	2	0	0	0
	Other potential	1	2	2	1	2	2	0	0	0	0	1	0	1	0
Statistical Analyses	Power/ES	2	0	0	0	2	2	2	2	2	2	2	2	0	0
	Assumptions	0	0	0	0	0	0	0	2	0	0	0	0	0	0
	Group compar.	1	2	0	2	2	2	2	2	2	2	2	1	2	1
	Add. analyses	1	2	0	2	1	2	2	2	2	2	2	2	2	0
Results	Demographics	1	1	2	1	2	1	1	1	1	0	1	1	1	0
	Outcomes	1	2	1	2	2	2	2	2	2	2	2	2	2	0
Discussion	Summary	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Limitations	1	2	1	2	0	1	1	2	1	1	1	0	2	1
	Interpretation	2	1	1	2	2	2	2	2	2	2	1	1	2	1
Total (/56)		**32**	**33**	**21**	**41**	**39**	**38**	**32**	**40**	**30**	**30**	**39**	**27**	**35**	**13**

Criteria		Nigro et al (2002)	Passolunghi et al (1995) Expt 1	Rendell et al (2009) – Expt 2	Shum et al (2008)	Smith et al (2010)	Somerville et al (1983)	Wang et al (2006)	Wang et al (2008) – Expt 1	Wang et al (2008) – Expt 2	Wang et al. (2011)	Ward et al (2005)	Zimmermann & Meier (2006)	Zimmermann & Meier (2010)	Zöllig et al (2007)
Study Objectives	Question	1	2	2	2	2	1	2	2	2	2	2	1	2	2
	Hypotheses	1	1	2	2	2	0	1	1	1	2	2	1	2	1
Study Design	Overall	1	2	2	2	2	2	3	2	2	2	3	2	2	3
Study Sample	Recruitment	1	1	0	1	1	0	1	1	1	1	2	0	0	2
	Source/Method	1	1	0	1	2	0	1	1	1	2	1	1	1	2
	I/E Criteria	0	0	0	0	2	0	0	0	0	0	0	0	0	2
Methods & Measures	Constructs	2	2	2	2	2	0	2	2	2	2	2	1	1	2
	Outcomes	1	2	2	2	2	2	1	2	2	2	2	2	2	2
	Std. or val/rel	0	0	0	1	0	1	0	0	0	1	1	0	1	1
	>1 measure	0	0	0	0	2	0	0	2	2	0	0	0	0	2
	Instrumentation	0	0	0	0	2	0	2	0	0	2	2	0	0	0
	Randomisation	0	1	1	1	1	1	0	1	1	0	1	1	1	1
	Protocol	1	1	1	2	1	0	1	1	1	2	2	2	2	1
Confounders	RM Measure	0	0	1	1	2	0	2	2	2	1	1	2	1	0
	RM Design/Anal.	0	0	2	2	2	0	2	2	2	2	2	2	2	0
	OG Measure	0	0	0	2	2	0	2	0	0	2	2	0	1	2
	OG Anal. (age)	1	0	0	2	2	0	0	0	0	2	1	2	2	1
	Other potential	0	0	1	1	0	0	2	0	0	0	1	0	0	2
Statistical Analyses	Power/ES	0	0	2	2	2	0	2	0	0	2	0	0	2	2
	Assumptions	0	0	0	0	0	0	0	0	0	0	2	0	0	2
	Group compar.	1	2	2	2	2	1	2	2	2	2	2	2	2	2
	Add. analyses	1	2	2	2	2	1	2	2	2	2	2	2	2	2
Results	Demographics	1	0	1	1	1	1	2	1	1	2	1	0	0	1
	Outcomes	1	2	2	2	2	1	1	2	2	2	2	1	2	2
Discussion	Summary	2	2	2	2	2	1	2	2	2	2	2	2	2	2
	Limitations	0	1	1	2	2	1	2	2	1	1	2	0	1	2
	Interpretation	1	1	1	2	2	1	2	2	2	2	2	1	1	2
Total (/56)		**17**	**23**	**29**	**39**	**44**	**14**	**37**	**32**	**31**	**40**	**42**	**25**	**32**	**43**

Appendix 2.1: **Letter of Invitation**

Dear

We are writing to see whether you would be interested in contributing to a research project that is being carried out by the Section of Psychological Medicine, University of Glasgow.

The project looks at the effect of brain injury on memory. In particular we are studying difficulties with remembering to do things in the future (e.g. remembering to go to an appointment or to call a friend at a certain time or take medication on time and so on). People often say that they have more problems with these types of tasks following certain types of neurological illness or brain injury. We are looking for people with acquired brain injury (e.g. head injury or stroke) as well as people with no previous history of head injury or other neurological condition.

In summary, you would be initially asked to come to meet with us on two occasions during which we would ask you to carry out short 'paper and pencil' tasks, tasks using everyday materials, questionnaires and tasks on computer. This does not require previous knowledge of using computers. If you an individual with an acquired brain injury and are found to have significant difficulties in remembering to do things in your everyday life, you will be asked to take part in a single training session. If you continue to use the strategies that you have learned during this, it is possible that this may improve your memory for doing things in the future. Participant information sheets for both of these studies have been included with this letter.

We would very much appreciate your involvement in this research but understand that you may not wish to be involved or may have other commitments at this time.

If you are interested in taking part, please return the attached form in the free post envelope or call 0141 232 7566 or 074 2414 2681 to set up an appointment with Fiona, Satu or Andrew.

Even if you agree to take part you are completely free to withdraw from the project at any time without needing to give us a reason.

Yours sincerely,

Fiona Scott
Trainee Clinical Psychologist

Satu Baylan
PhD student

Andrew Wood
Trainee Clinical Psychologist

Jonathan Evans
Professor of Applied Neuropsychology

If you are interested in taking part in the study please fill out the tear-off slip below and return it in the freepost envelope provided.

A member of the research team will then contact you to give you more information / arrange your first meeting at a time that is suitable for you.

Alternatively, you may e-mail us:
Fiona Scott: f.scott.1@research.gla.ac.uk
Satu Baylan: s.baylan@clinmed.gla.ac.uk
Andrew Wood: a.wood.1@research.gla.ac.uk

Study on the Assessment of Prospective Memory and Planning

Name ………………………………………………………………………

Telephone Number ……………………………………………………...

Address …………………………………………………………………….

Please tick:

☐ **I would like to participate in this study/ would like more information on this study.**

Please return this reply slip in the freepost envelope provided or return to a member of your clinical team or group leader.

Appendix 2.2:

PARTICIPANT INFORMATION SHEET

Assessment of Everyday Executive Functioning in Individuals with Acquired Brain Injury

Purpose of the study

Planning ahead and remembering to do things in the future (e.g. planning what to buy before going to the supermarket and remembering to post a letter on the way home) is difficult and most people make mistakes from time-to-time. This type of memory is called prospective memory. People often say that they have more problems with these types of tasks following certain types of neurological illness or brain injury. When clinicians assess for these problems, it is important that the tests they use are accurate (i.e. that they can measure this difficulty) and sensitive to these types of difficulties experienced in real life. This research study will be investigating the usefulness of different tests of planning and prospective remembering of future actions, and will involve "pencil and paper", real life and computer tasks.

What does taking part involve?

If you decide to take part you will initially be asked to come along to meet with us on two occasions, for up to a maximum of two hours each. Those found to have difficulties with remembering to do things will be invited to take part in a third treatment session lasting a maximum of 2.5 hours. In these sessions, you will do the following:

Session One

You will be asked to complete some short tasks lasting a few minutes each. For example you will be asked to read out loud a list of words. This will be recorded for scoring purposes using an audio recorder. No other tasks will be recorded. The information from these will help us find out more about the current difficulties you experience in everyday life. You will then complete a task on the table top using everyday objects and two short tasks on a computer which involve making simple responses to images you see by pressing one of the response buttons. In addition, you will also be asked to complete short questionnaires concerning your day to day life.

Session Two

You will be asked to carry out two tasks involving some puzzle activities and "pencil and paper" tasks. Lastly, you will complete a task on a computer that involves you taking on the role of an office employee. This task simulates you doing a set of office activities such as setting up a meeting.

Session Three

If you are someone who has difficulty with remembering to do things in the future, you will be invited to take part in a training session. This aims to improve this type of memory and will involve practising different strategies and techniques such as imagery and repetition. You will also be asked to do two computer tests similar to the ones you did before. We have included a participant information sheet explaining this part of the study in more detail. If you decide to take part, you will be asked to give your consent again at the beginning of this session.

Does the research involve any medical examination or medication?

No.

Do I have to take part?

No. You are free to decide whether or not you wish to take part. This project is separate from any clinical services you may be receiving. Your decision has no effect on your access to, or care received from, these services. If you do decide to take part, you will be given this form to keep and be asked to sign a consent form. You are free to withdraw from the study at any time without giving a reason.

What happens to the information?

All information collected during this study will be kept in strict confidence. The data are held in accordance with the Data Protection Act, which means that we keep it safely and cannot reveal it to others without your permission. If we publish any findings from the study, this will be in the form where your results are combined with those of many other people and average scores are presented. We take great care not to publish any details from which you could be identified.

Will taking part have any advantages for me?

Our research is entirely experimental. Our aim is to improve understanding about the assessment of planning and prospective remembering and to try to ensure that tests are accurately measuring the specific real life problems often reported after a neurological illness or injury. If the tests completed as part of this study are similar to tests you may do as part of any NHS clinical care you may be receiving, with your permission, we can provide your clinical team with information on your test scores, which may be of help to them in planning your ongoing treatment. This will also avoid you doing unnecessary testing. If you take part in the training session, and continue to use the strategies that you have learned, it is possible that this may improve your memory for doing things in the future (e.g. remembering to attend appointments).

Are there any disadvantages or risks of taking part?

There are no significant risks or disadvantages for taking part. You may feel a little tired but there will be regular breaks during the study to minimise this.

Will you contact my GP?
With your permission, we will send your GP a short letter to let them know that you are taking part in the study. If you would like to see an example of the letter, please just ask a member of the study team. If you have a clinical team you are already involved with, we will, with your permission, let them know the results of your tests.

Who is funding the research?
This research is being funded by the Sackler Institute of Psychobiological Research and the University of Glasgow Doctorate in Clinical Psychology programme.

Who is conducting the research?
The study is being carried out by Fiona Scott (Trainee Clinical Psychologist), Satu Baylan (PhD Student) and Andrew Wood (Trainee Clinical Psychologist) from the Section of Psychological Medicine at the University of Glasgow. This research is supervised by Prof. Jonathan Evans (Professor of Applied Neuropsychology).

Who has reviewed the study?
This study has been reviewed by the West of Scotland Research Ethics Service REC.

If I have any further questions?
If you would like more information or would like to receive a summary of the main findings once the study has completed, please contact:

Fiona Scott or Andrew Wood
(Trainee Clinical Psychologists)
Section of Psychological Medicine
Gartnavel Royal Hospital, 1055
Great Western Road, Glasgow
G21 0XH Tel. 07424142681
f.scott.1@research.gla.ac.uk
a.wood.1@research.gla.ac.uk

Satu Baylan
(PhD Student)
Sackler Institute of
Psychobiological Research
Southern General Hospital
Glasgow, G51 4TF
Tel. 0141 232 7566
s.baylan@clinmed.gla.ac.uk

If you would like to contact someone, who is not directly involved in the study, for general advise about taking part in research, please contact Dr Denyse Kersel, Clinical Director, Community Treatment Centre for Brain injury on 0141 300 6313 or denyse.kersel@ggc.scot.nhs.uk

<u>Thank you for taking the time to read this information</u>

Appendix 2.3: Recruitment Leaflet

IS THE RESEARCH SAFE?

There are no significant risks or disadvantages to taking part. You may feel a little tired but you can take breaks during the experiment.

WHAT IF I CHANGE MY MIND?

Participation is entirely voluntary. You are free to withdraw at any time should you later decide that you do not wish to take part.

CAN ANYONE TAKE PART?

Due to the nature of the tasks you will be asked to complete, it would not be appropriate for you to take part if you have any of the following: a severe aphasia, severe visual or hearing impairment or learning disability, neurogenerative disorder (e.g. multiple sclerosis, dementia) or current or history of significant substance use problem.

WHERE THE RESEARCH IS BEING CONDUCTED?

It is possible to take part in one of our testing locations in Glasgow or where possible, we can see you at the location from which you were recruited. Please contact the research team for information on current other testing locations.

HOW CAN I HELP?

To take part in our research, or simply to find out more please contact:

Fiona Scott, Satu Baylan or Andrew Wood

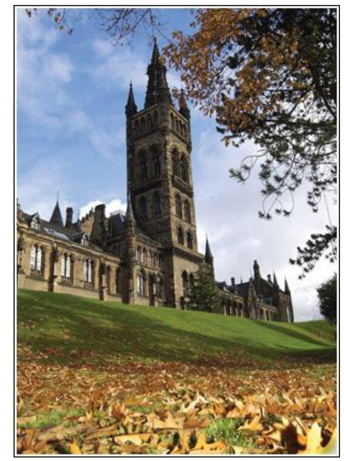
Telephone:
0141 232 7566 or
074 2470 7546
email:
f.scott.1@research.gla.ac.uk
s.baylan@clinmed.gla.ac.uk
a.wood.1@research.gla.ac.uk

This research is being funded by the Sackler Institute of Psychobiological research and the University of Glasgow.

NHS Greater Glasgow and Clyde

University of Glasgow | Section of Psychological Medicine

Can you help with research into brain injury?



CAN YOU HELP?

After certain types of neurological illness or brain injury people often say that they have more problems with memory and particularly with remembering to do things at some point in the future (e.g. remembering to go to an appointment). This type of memory is called prospective memory. When clinicians assess for these problems, it is important that the tests they use are accurate (i.e. that they can measure this difficulty) and are reflect the kinds of difficulties experienced in real life.

We are looking for people who speak English as their first language and are between the ages of 18-65 with- or without acquired brain injury (e.g. stroke, head injury, encephalitis, brain tumour), who are interesting in taking part in a research study.

WHAT IS THE NATURE OF THE RESEARCH?

The aim of the research study is to investigate the usefulness of different tests of planning and prospective remembering of future intentions. We would ask you to come in on two occasions. You will be asked to complete short questionnaires concerning your day to day life. During your first visit we will ask you to complete some short tasks lasting few minutes each, such as reading out loud a list of words. The information from these will help us find out more about the current difficulties you experience in everyday life. You will then complete a task on the table top using everyday objects and two short tasks on a computer which involve making simple responses to images you see by pressing one of the response buttons.

During your second visit we will ask you to carry out two tasksinvolving some puzzle activities and "pencil and paper" tasks. Lastly, you will complete a task on a computer that involves you taking on the role of an office employee. This task simulates you doing a set of office activities such as setting up a meeting.

The study takes approximately 4 hours to complete in total. Testing takes place over two sessions broken into shorter blocks with rest breaks. If you take part as a healthy control with no history of brain injury, the study takes 1-1.5 hours to complete.

If you are someone who has difficulty with prospective remembering you may be invited to another session (approx. 2hrs) in which we are studying whether certain strategies can help people remember to do things. You are free to decide whether or not you wish to participate in this.

Appendix 2.4: **Participant Reminder Letter**

Dear

You recently received information on a research project being conducted by the Section of Psychological Medicine, University of Glasgow. This is a quick reminder to see if you are interested in participating in this study. If you would like to participate, or would like more information on the study you can return the tear-off slip below or discuss this with a member of the clinical team at your next appointment. Alternatively, you can contact a member of the research team on 0141 232 7566 or 075 3646 6149, or e-mail (see below).

Remember, this study is voluntary; you are not obliged to take part and if you feel you would rather not, this will not affect your clinical treatment in any way. Even if you agree to take part, you are completely free to withdraw from the project at any time without needing to give us a reason.

Yours Sincerely,

Fiona Scott
Trainee Clinical Psychologist
f.scott.1@research.gla.ac.uk

Satu Baylan
PhD student
s.baylan@clinmed.gla.ac.uk

Andrew Wood
Trainee Clinical Psychologist
a.wood.1@research.gla.ac.uk

Study on the Assessment of Prospective Memory and Planning

Name ....

Telephone Number ....

Address ....

Please tick:

☐ **I would like to participate in this study/ would like more information on this study.**

Please return this reply slip in the freepost envelope provided.

Appendix 2.5

Participant Screening Form

Place of recruitment

Headway group at ___________________________	
Momentum	
BIRT	
Community Treatment Centre for Brain Injury	
Community Stroke Services	
Douglas Grant Rehabilitation Centre	
CHSS Group at ____________________________	
West Dunbartonshire ABI team	
Other:	

Personal details

<table>
<tr><td colspan="3">Name:</td><td colspan="2">D.O.B:</td><td colspan="2">Age:</td></tr>
<tr><td colspan="7">Address:

Postcode:</td></tr>
<tr><td colspan="4">E-mail:</td><td>Gender</td><td>M</td><td>F</td></tr>
<tr><td colspan="3">Telephone number:</td><td colspan="4">Years in full-time education:</td></tr>
<tr><td>Native English Speaker</td><td>yes</td><td>no</td><td>Dominant hand</td><td colspan="2">L</td><td>R</td></tr>
</table>

For experimental group

<table>
<tr><td>Significant other: _______________________ relationship__________________

Post questionnaires Y / N Address:____________________________________
____</td><td>None</td></tr>
<tr><td colspan="2">GP surgery ____

Who do you normally see?</td></tr>
</table>

Page 1 is to be stored separate from page 2 with participant ID and medical history.

History	YES	NO
Neurological conditions (e.g. Head injury or stroke, Encephalitis, Brain tumour, Aneurysm, Epilepsy, Parkinson's Disease Dementia, Alzheimer's)		
Psychological and psychiatric condition (e.g. Depression, Anxiety disorder or Schizophrenia that has required treatment by a professional)		
Substance abuse How many units of alcohol on average do you take per week? (One standard (175ml) glass of wine = 2 units One pint of standard lager = 2.3 units Spirit & Mixer = 1 unit)	No of Units:	
Current medications whether prescribed or non- prescribed		

Can you: hear (normal speech) Y / N	Read (study information sheet, self) Y / N	Write Y / N

Participant type: patient ☐ control ☐

PATIENT GROUP ONLY	ABI	TBI
Nature of injury (Type, lesion location, where)		Open Closed
Time since injury		
1st memory after injury, how long after?(PTA) = **The time between loss of consciousness and return of continuous memory for day to day events**	____ hrs ____ days ____ months	
Do you remember being taken to hospital		
being in casualty		
being in intensive care unit		
being on the ward NSU/DHG/rehab		
being taken to other hospital		
going home from hospital		
special event (birthday/Xmas)		
GCS 0-15 (in coma, loss of consciousness, 30mins +, able to speak, move, open eyes)		

Additional notes:

Appendix 2.6: Items on DEX Questionnaire Previously Associated with Planning Abilities[1] [2]

Item	
2.	"Acts without thinking, doing the first thing that comes to mind"
4.	"Has difficulty thinking ahead or planning for the future"
5.	"Sometimes gets over-excited about things and can be a bit "over the top" at these times"
7.	"Has difficulty realizing the extent of his/her problems and is unrealistic about the future"
9.	"Does or says embarrassing things when in the company of others"
13.	"Seems unconcerned about how s/he should behave in certain situations"
15.	"Tends to be very restless, and "can't sit still" for any length of time"
16.	"Finds it difficult to stop doing something even if s/he knows s/he shouldn't"
18.	"Finds it difficult to keep his/her mind on something, and is easily distracted"
19.	" Has trouble making decisions, or deciding what s/he wants to do"

[1] Amieva and colleagues (2003) found their "Planning" factor related to high loadings on items 4, 7 and 19 on the informant DEX. [2] Chan's (2001) study found significant correlations between the Tower of London test and the later named "Inhibition" factor (items 5, 9, 13, 15 and 16) and "Intentionality" factor (items 2, 4, 18 and 19).

Appendix 2.7: Computer Familiarity Questionnaire

University of Glasgow

NHS Greater Glasgow and Clyde

Participant ID________________ Date:________________

COMPUTER FAMILIARITY QUESTIONNAIRE

This short questionnaire looks at how familiar you are with using computer technology in your day to day life. Please answer the following questions using the scale below:

1 = Strongly disagree
2 = Disagree
3 = Neither agree nor disagree
4 = Agree
5 = Strongly agree

Please circle one number for each question	Strongly Disagree		Neither Agree or Disagree		Strongly Agree
1. In general, I feel confident in my abilities to use a computer	1	2	3	4	5
2. I feel I have a good knowledge of computer technology	1	2	3	4	5
3. I use computers at least once a week for work or leisure activities.	1	2	3	4	5
4. I feel my abilities to use a computer are similar to other people my age	1	2	3	4	5

Thank you for taking the time to complete this questionnaire.

Appendix 2.8

JAAM Scoring Criteria for Planning and Prospective Memory Tasks*

START TIME: **REQUIRED END TIME:** **ACTUAL END TIME:**

Construct	Task	Requirements	Points	Qualitative Observations
Planning	Write plan of action (6)	Plan of action is written out taking into account all tasks	2	TIME SPENT ACTION PLANNING
		Plan of action is written out, omitting up to 25% of tasks	1	
		Plan of action written briefly, omitting more than 25% of tasks	0	
		All events regarding meeting placed together, post tasks placed together, and time-based tasks placed together – 10% leeway	2	
		Only events regarding meeting placed together, other haphazard OR more than 10% leeway	1	
		No change/very little change from order on manager's tasks	0	
		Task completed in acceptable completion time	2	
		Task completed in an unsatisfactorily long time	1	
		Failure to complete task	0	
	Arrange furniture for meeting (4)	All external members of the meeting can see the whiteboard	2	PLAN OF FURNITURE
		25% of the external members cannot see the whiteboard or 25% have their backs to the internal members of the meeting	1	
		The chairs and stools are in a totally random arrangement	0	
		Task completed in acceptable completion time	2	TIME SPENT ACTION PLANNING
		Task completed in an unsatisfactorily long time	1	
		Failure to complete task	0	
Action-based Prospective Memory	Update the post diary when new package needs to be send (2)	The new parcel is added to the post diary immediately	2	
		The new parcel is added to the post list but at a later date, i.e. after checking the action plan at the end of the task, OR written on "Notes for Manager"	1	
		The post diary is not updated	0	
	Record if any of the equipment breaks (2)	It is recorded on the "Notes for Manager" when the OHP breaks	2	
		It is recorded on the "Action Plan" when the OHP breaks, or only after referring to the "Action Plan"	1	
		Nothing is written down	0	
Event-based Prospective Memory	Note the times of the fire alarms (2)	Both alarms are recorded on the "Notes for Manager"	2	TIMES OF FIRE ALARM
		Only 1 alarm is recorded, they are written on the "Action Plan" or are written only after referring to the "Action Plan"	1	
		None of the times are recorded	0	
	Turn on coffee machine when the first person arrives (2)	Turn on the coffee machine after the memo arrives without referring to the "Action Plan"	2	
		Turn on the coffee machine after referring to the "Action Plan"	1	
		The coffee machine is not turned on, or it is turned on before the memo from reception arrives	0	
Time-based Prospective Memory	Turn on projector 10 minutes before the meeting starts (2)	Turn on projector at exact time	2	
		Turn on projector but not at designated time	1	
		Never turn on the projector	0	
	Indicate whether the company postman has arrived (2)	Write down that the company postman has not arrived and be aware that the post must be sent another way	2	
		It is not recorded that the company postman has not arrived but the post is sent another way, or vice versa	1	
		Do not notice that the company postman has not arrived to take the post	0	

* Adapted from JAAM Manual (Jansari, 2009)

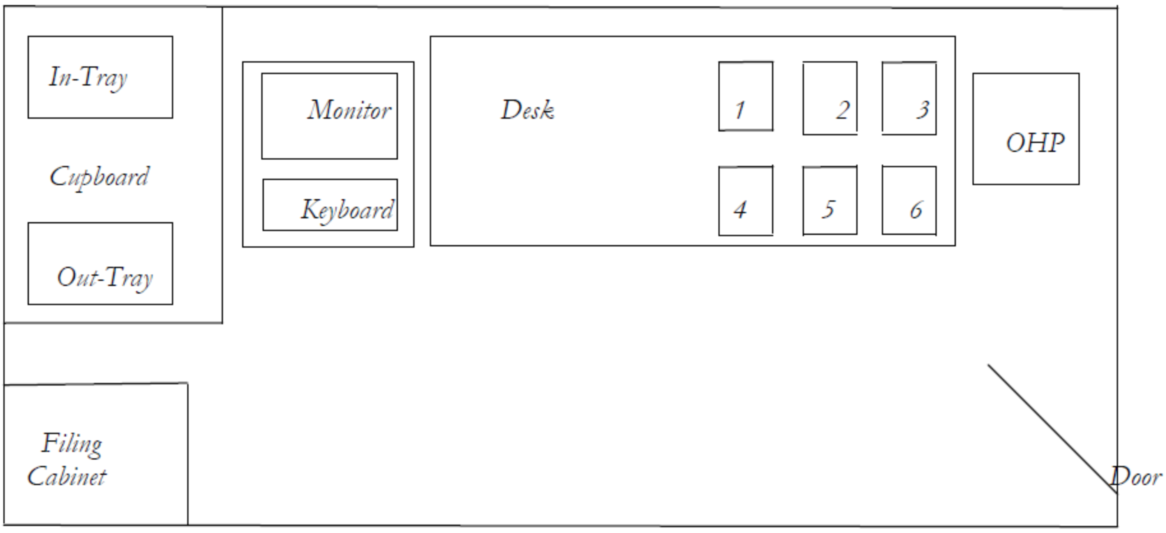
Construct	Task	Requirements	Points	Qualitative Observations
Prioritisation	Arrange which order the agenda topics should be discussed in (2)	B, E are in 1st or 2nd place, C, D, A are in 3rd, 4th or 5th	2	SWITCHING ATTENTION
		Only one of B & E are in 1st or 2nd place	1	
		B & E are not in 1st or 2nd place, or the topics are not arranged	0	
	List the order of the cleaner's jobs in the meeting room (2)	B, E are in 1st or 2nd place, C, D, A are in 3rd, 4th or 5th	2	
		Only one of B & E are in 1st or 2nd place	1	
		B & E are not in 1st or 2nd place, or the topics are not arranged	0	
Selection	Choose which company should send each item of post (2)	All post is recorded in the right order: Company Postman – Letters for Cheltenham branch Royal Mail – Personnel 2 bags of letters Speedy Delivery – Legal 1 package Parcel Force – Personnel 1 parcel; Legal 1 parcel We Deliver – Finance 1 bag of letters	2	
		Between 1 and 3 of the items are written in the wrong place	1	
		Post list is not filled in, or over 3 items are in the wrong place	0	
	Memo 3 – choose company to send package from finance(2)	Speedy Delivery is chosen	2	
		Parcel Force is chosen	1	
		One of the other companies or no company is chosen	0	
Adaptiveness	Replacing the broken overhead projector (2)	The projector is replaced by the one in the office and put in the correct position	2	
		The projector is replaced by the one in the office but put in the wrong place, or the broken one remains next to the new one	1	
		They do not try to fix the problem	0	
	Arrange for another company to pick up the post when the courier does not arrive(2)	The internal post is added to the Royal mail post on the post diary	2	
		The post is added to any of the other post on the post diary, OR it is written on My Notes for Manager	1	
		The post is not sent another way	0	
Creative	Cover the writing on the whiteboard (2)	The board rubber is initially used and the flip chart is placed in front of the graffiti	2	
		The board rubber is not initially used and the whiteboard is placed in front of the graffiti	1	
		The graffiti is still on the board at the end of the task or the OHP is moved so it is projecting onto another wall	0	
	Leak in rook above coffee machine (2)	The coffee machine is moved to another table and something, i.e. the bin, is put in its place	2	
		The coffee machine is moved to another table but the bin is not put in its place, or the bin is put next to the coffee machine without moving it	1	
		The examinee does not take any action	0	

Notes:

<u>Appendix 2.9</u> **<u>JAAM: Instructions for Test Administration</u>**

Adapted from JAAM Manual (Jansari, 2009; pp 14-15)

Figure 1: Bird's-eye view of Virtual Reality Office Environment



Key
1. Post To Be Sent
2. Agenda Topics
3. Manager's Tasks for Completion
4. Post Diary
5. My Notes for Manager
6. Plan of Action

The testing area should be set up as shown in Figure 1. Before commencing the formal assessment programme, ensure that the participant is comfortable in navigating around the VR environment. Ensure that the computer <u>sound volume is audible</u> since part of the task requires the participant to be able to hear certain alarms. Allow as much time as required for the participant to move within the environment; <u>encourage the use of the mouse when navigating around in VR</u>, as this will free up the keyboard for the person running the assessment to press specified keys when the formal assessment begins. Ensure that the participant knows how to click on objects, as this will allow them to develop the required skill for working with the formal VR assessment, e.g. to focus on selecting specific items on the screen to pick up, put down where they want it, etc.

When the participant has familiarised themselves with navigating around the VR environment, move to introduce the JAAM scenario. <u>Follow the script as given, answering any questions as required</u>. It is important for the participant at this stage to <u>become familiar with selecting items</u> by clicking on them, and then clicking on the horizontal surface upon which they wish to place the item. The Office that contains most of the participant's paperwork is the first door on the right along the corridor and the switch for turning on the lights is to the right once the room has been entered. The Meeting Room where the participant will set up the meeting is at the end of the main corridor. It is very important so allow time for the participant to practice this, as otherwise <u>items within the VR environment may 'disappear' or 'distort' thus adding to any initial anxiety regarding the use of the computer</u>. Due to the nature of the programme, objects can sometimes become “lost” when the participant moves them, so that they are no longer visible. As the programme is not designed to test the participant’s ability to use it this will not affect the scoring or the participant’s performance. Apologise to the participant and explain that this will not affect their scoring. Ask them where they were planning to place that item of furniture and then continue with the programme.

Welcome the participant to the assessment and read from the Script and Scenario, following the instructions in **[*italics*]**. Ensure that the participant is well-versed in the information given in the script and the scenario sheet – in particular the rules - before proceeding to start the tasks. All questions relating to the running of the assessment should be encouraged before the start of the assessment.

Only questions relating to technical aspects of operating the VR programme, for example, a reminder for how to pick items up, should be answered. If questions arise in relation to how to go about completing the tasks either before or during the assessment, the assessor should refrain from directing the actions of the participant, and refer them to the Scenario Sheet or other relevant instructions available to them. If it becomes apparent that the participant cannot proceed past a particular stage, help should be provided by the assessor to enable the participant to carry on to the next stage of the task, and a note made on the scoring criteria that such a prompt had to be given.

The first task after the Script and Scenario have been read and the participant has understood the ‘Manager’s Tasks for Completion is for them to write their ‘Plan of Action’. After they have completed this first task, put the ‘Manager’s Tasks For Completion’ back in its original place on their desk so that it is not in their way, i.e. they will work from their ‘Plan of Action’ but they still have access to the ‘Manager’s Tasks for Completion’ if it is needed. Leaving it in accessible like this avoids an additional memory load if they do not write down all the tasks on their ‘Plan of Action’ since writing the ‘Plan of Action’ tests planning and is not a memory task. However the participant is informed in the script that they will have to work from their Plan of Action and therefore should write down all the tasks on this. Once the participant has finished writing the Plan of Action, ask if they have any questions and then press “S” to start the timings.

To reduce reliance on having to read documents that arrive in the virtual office from the screen, hard copies are available. These are indicated in red writing in the virtual environment with the physical copies being placed next to the computer during the assessment within easy reach of the participant at the appropriate time. However, there are some documents, four separate memos (please see below for a list of their contents) that will be provided to the participant during the course of the assessment, some of which the participant will know about in advance while others will not be expected. When each memo arrives, a sound occurs on the computer stating “There is a new memo in your in-tray” and the memo will automatically appear in the in-tray in the small office. To read the memo the participant has to click on it in the in-tray and the memo will appear at the bottom right-hand corner of the computer screen. When the memos arrive, allow the participant time to read them and then pass them the paper version. If they do not realise that a memo has arrived, maybe because they are too engrossed in doing something else, please indicate this to the participant and then write this as a qualitative observation on the Scoring Sheet. If they have difficulty opening the memos on the virtual reality environment just use the paper copies.

In situations where a particular participant feels that they have completed all tasks even though this is evidently not the case, prompts should be given to encourage them to undertake remaining tasks in order that appropriate scores can be obtained for the constructs that would otherwise be missed out; again, a note should be made on the scoring criteria that prompts had to be given.

Timings of programme:

These events all occur automatically once the start of the programme has been triggered by the pressing of the 'S' key:

- **5 minutes** – Fire Alarm (relates to TBPM)
- **10 minutes** – 1st memo (relates to Adaptive Thinking)
- **18 minutes** – 2nd memo (relates to Prioritisation)
- **20 minutes** – company postman should arrive (relates to TBPM)
- **25 minutes** – 3rd memo (relates to Selection)
- **30 minutes** – Fire Alarm (relates to TBPM)
- **32 minutes** – 4th memo (relates to EBPM)

Memos which arrive in In-Tray

1. From maintenance regarding leak in roof above coffee machine
2. Jobs for cleaner to do after meeting has finished
3. New package from Finance Department
4. First person attending meeting has arrived

Appendix 2.10: JAAM Administration Materials

Appendix 2.10.1: # JAAM Script

Hello…………….. I am going to read to you from a script for purposes of continuity. I am going to explain all aspects of the task to you, however if you have any additional questions please ask them at any point.

Thank you for agreeing to take place in this study, which is investigating how well different people work in an office environment. The study takes place in a virtual reality environment on the computer. Do not worry if you haven't used a computer before, clear instructions about how to use the virtual reality programme will be given to you. Would you like to practice using this type of environment before we proceed any further? [***The participant is given the choice of using the training programme***]

I will now let you read, in your own time, the office-scenario in which the assessment will take place. You shall be referred to as the participant and I shall be referred to as the assessor throughout. [***Assessor allows the participant to read the scenario in their own time.***]

Right, now I shall summarise this scenario for you to help you become more familiar with it. This will include only information that you have just read, I will not be telling you anything new.

This study is set in an office, where you will be working as an assistant within the administration department of a large company. Today is your first day on the job, but unfortunately your manager is away so cannot oversee your work. However, they have left you a list of jobs they would like you to complete which will be shown to you shortly. There is a meeting being held today and it is your main priority to ensure that the room for this is set up in time, which will be 40 minutes after you start the study. I will inform you what the exact time will be later. The meeting is for 3 people from your branch of the company, and for 10 external members of the company from other branches. Your other main job involves making sure the post for the rest of the branch is sent, details about this will be provided shortly. There will also be some other time-based tasks which you will need to complete, details will either have been provided for you by your manager or other departments may send you details regarding these. Therefore there are three main categories of tasks for you to do; those to do with the meeting, those to do with the post, and extra time-based tasks. It may be useful for you to perform your tasks around these three categories as much as you can.

Now I will show you around your office. To move around the environment click on these arrows at the top in the direction that you wish to move [***enter the office***]. On your desk you have six sheets of paper, which you also have here in hard copies [***point to real-life copies on their desk***]. These are the Manager's Tasks for Completion, Plan of Action, My Notes for manager, Post Diary and Post to be Sent, and a list of Agenda Topics **[*demonstrate how to pick them up and put them down*]**. The purpose of these sheets of paper will become apparent soon. Please note that you are not required to type anything, everything that needs to be written should be done so by hand on these paper copies just to make things easier for you. Now can you please identify what other objects you have in your office **[*make sure they see the in-tray, completed tray, desk, computer, overhead projector, filing cabinets, sellotape, pens*]**. So as you can see you have many resources, but please note that you do not have to use them all if you do not think it is necessary. Also you can only use the resources that you can see in the office.

Now I will show you the room where the meeting is going to take place. The room has already been booked so you do not need to do this **[*take them into the meeting room*]**. Please can you identify all the objects in here, feel free to move around the room using the arrows if you wish. **[*Make sure they identify the coffee machine, the bin, the overhead projector, the 10 tables and stools, the blackboard, the fixed whiteboard and graffiti, the portable whiteboard and the 3 table and chairs at the front of the room*]**. Please note that these 3 tables and chairs which are for the internal members of staff to use **[*point to tables and chairs at the front of the room*]** and this table which the coffee machine is on **[*point to table*]** are fixed and therefore cannot be moved. The tables and stools at the back of the room, however, can be moved. What you need to do in the meeting room will become apparent once you have read the Manager's Tasks For Completion.

Let's go back into your office and then we can see what tasks your manager has left for you to do **[*Go back into their office and hand them the Manager's Tasks for Completion sheet*].** These are your tasks, which your manager has written in a **random** order. Please can you read this list out loud, I will fill in all the blank times just before the study starts **[*Participant reads them out loud; give any help or further explanations if needed*]**. OK now in your own time please group these tasks on the action plan in the order that you will do them; this should be in the most logical order possible. This list will be taken away from you later so please write as much information as you think you will need to do the tasks on the Plan of Action.

Do you have any questions? This time shown on the clock is 11:00am **[*indicate to the clock on the desk*]**, which means that the company postman should arrive at 11:20am and the meeting should start in 40 minutes at 11:40am. You may begin your tasks **[*press "S" to start the programme at same time as starting the clock*].**

Appendix 2.10.2: Scenario

You are an assistant working within the administration department of a large company. Today is only your first day at the company, but things are beginning to get busy. In particular, an important and urgent meeting has been scheduled to take place. Unfortunately your manager is away today so is unable to supervise your work. You have been left in charge to make sure that the office runs smoothly in the manager's absence.

Your manager expects you to undertake some tasks that are to do with the setting up of the meeting, as well as those to do with organising the post to be sent for the rest of the company. Some other time-based tasks have also been left for you. Therefore there are three main categories of tasks for you to do; those to do with the meeting, those to do with the post, and additional time-based tasks. A list of these tasks will be shown to you shortly, and you may find it useful to arrange the order in which you do them around the three categories. Other tasks may also be given to you from other departments throughout the duration of the study. All the resources that you will need to complete your tasks with will be provided, and these resources will also be pointed out to you later on. You'll be required to use your initiative somewhat, as it may not always be obvious how to complete the tasks and there will be plenty to keep you busy. Although there is **no time limit** the tester will be timing you on tasks and may also take notes whilst you are completing your tasks; however, try not to be distracted by their actions.

The Meeting

The meeting needs to be set up to accommodate the **10 external members** of the company who are coming from other branches – you will need to arrange tables and chairs for them to use. 3 internal members of your company will also be attending the meeting, but their tables and chairs have already been set in place at the front of the meeting room. An overhead projector will need to be used during the meeting.

Please remember that the meeting will take place 40 minutes after the study starts. You should complete tasks as close to 40 minutes as possible, although the tester will not stop you; **it will be up to you to let the tester know when you think that the meeting is ready to start**. Any time taken over the 40 minutes will be noted and scored accordingly, so it is in your best interests to only complete those tasks that have been given to you, and to do so as efficiently as possible.

Appendix 2.10.3: Desktop Materials

Post to be Sent

Department	Post
Personnel	- 2 bags of letters – URGENT - 1 parcel – Next day delivery
Legal	- 1 package – URGENT - 1 package – Next day delivery
Finance	- 1 bag of letters for Cheltenham branch - 1 bag of letters – Not Urgent

Agenda topics for today's meeting

The topics below need to be discussed in today's meeting; please arrange the order in which they should be discussed.

There may not be enough time to cover all of these five topics, so please place them in order of importance so that the main topics definitely get discussed and give this form to the tester.

A New lunch hours for the administrative department
B Recent fatal accident in the company
C Cost analysis of the new development in the IT department
D New heating system for the building
E Emergency budget proposal

1. ....
2. ....
3. ....
4. ....
5. ....

Manager's tasks for completion

I am away from the office today but please could you ensure that the following tasks are dealt with in my absence. They are in a ***random*** order so after you have read this list please group the tasks together on the Plan of Action in the order you shall tackle them before you start your work. ***This list will later be removed***. The times written below relate to the clock on the desk in front of you.

- A list of Agenda Topics which need to be discussed in the meeting has been left for you. Please arrange in which order these should be discussed, placing the most important first.
- Arrange the furniture for the 10 external members who are attending the meeting in a suitable manner, ensuring the room is of good quality appearance. The meeting will start at **11:40 am**.
- A list of today's post which needs to be sent has been left on your desk. Please use the Post Diary, also on your desk, to arrange which company should collect each item of post according to their criteria.
- The fire alarm will sound at different points whilst you are in the office. Please record these times on your notes so I know whether the testing is occurring at the correct times.
- Turn on the overhead projector 10 minutes before the start of the meeting so that it has enough time to warm up.
- Record whether the Company Postman comes to your office at **11:20 am** to collect the mail for other branches. I need to know whether he does not arrive so please record this on your notes. It is ESSENTIAL that the mail for the other branches arrives at its destination today, therefore you need to arrange for another company to collect the mail if he does not arrive.
- A memo will be sent to you from Reception when the first person arrives for the meeting. Please turn on the coffee machine when they arrive so it is ready for the meeting. Please note that for this task on the computer please turn on the coffee machine by clicking on it with the right-hand mouse.
- There is a crack in the ceiling of the meeting room above the coffee machine. I have contacted maintenance to get them to fix this and they shall send you a memo to let you know when they are going to arrive.
- When moving the furniture, if you see any of it is broken or damaged please make a record of this on your notes.
- If you receive a memo informing you that more post needs to be collected from a department, please arrange for a company to do this by adding it to the Post Diary.

Many thanks. I hope your day goes well.

Post Diary

Each company specialises in a certain type of post, which is listed under their name. The different companies are coming at various times throughout the day. Please arrange which company should collect the items of post on the Post List according to their criteria – by writing the post in the right-hand column you have arranged for the company to pick it up. You may need to add or rearrange this post throughout the day accordingly.

Post company	Post
• Company postman (Mail for other branches)	
• Royal Mail (Same day delivery letters)	
• Speedy Delivery (Same day delivery packages and parcels)	
• Parcel Force (Next day delivery packages and parcels)	
• We Deliver (Next day delivery letters)	

My Notes For Manager

Plan of Action

Appendix 2.10.4: Memos Provided during Task

Memo

Your manager has sent us an email regarding the leak in the ceiling located above the coffee machine in the meeting room. Unfortunately we will not be able to fix this until 10 a.m. tomorrow. If it rains today this will leak, therefore you need to take appropriate action before today's meeting.

Steve Jones
Maintenance

Memo

Listed below are the jobs we need the cleaner to do in the meeting room once the meeting has finished. Please arrange them in the order that the cleaner should do them in the spaces provided below, and then pass to the tester.

Thanks
Reception

A Empty bin
B Wipe tables and chairs
C Hoover room
D Refill coffee machine
E Place tables and chairs back in corner of room

1. ....
2. ....
3. ....
4. ....
5. ....

URGENT MEMO:

An important parcel needs to be picked up from the Finance department today. Please choose which company should collect this, write it in the space below and arrange for the company to pick it up.

Thanks

Company: ....

Memo

The first person attending today's meeting has arrived.

Reception

Appendix 2.11: Ethics Committee and Research and Development Letters of Approval

Appendix 2.11.1: West of Scotland Research Ethics Service (WoSRES)

WoSRES
West of Scotland Research Ethics Service

NHS
Greater Glasgow and Clyde

West of Scotland REC 5
Western Infirmary
Ground floor, Tennent Institute
38 Church Street
GLASGOW
G11 6NT

Telephone: 0141 211 2102
Facsimile: 0141 211 1847

08 October 2010

Miss Fiona Scott
Trainee Clinical Psychologist
Section of Psychological Medicine
Gartnavel Royal Hospital
1055 Great Western Road
Glasgow
G12 0XH

Dear Miss Scott

Study Title: **Everyday Executive Functioning in Individuals with Acquired Brain Injury: Evaluating the Ecological and Convergent Validity of Traditional, Life-like and Computerised Tests of Prospective Memory and Planning**

REC reference number: **10/S1001/49**

Thank you for your letter of 29 September 2010, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

The favourable opinion applies to the following Non-NHS research site(s):

Research Site	Principal Investigator / Local Collaborator
The Brain Injury Rehabilitation Trust	Dr B O'Neill
Headway Scotland	Ms G McCann
Momentum	Ms L Burke
Chest Heart and Stroke Scotland	Ms K Frew

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Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

For NHS research sites only, management permission for research ("R&D approval") should be obtained from the relevant care organisation(s) in accordance with NHS research governance arrangements. Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk.

Sponsors are not required to notify the Committee of approvals from host organisations.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Investigator CV		
Protocol	1.0	16 August 2010
Supervisor CV		19 August 2010
Clinical Team letter template	1.0	09 August 2010
Advert poster - patients	2.0	August 2010
Appointment letter - controls	1.0	25 August 2010
Advert leaflet	1.1	15 September 2010
REC application		31 August 2010
Covering Letter		30 August 2010
Questionnaire: HADS	1.0	25 August 2010
Questionnaire: GMQ - Relative version	1.0	25 September 2010
Letter of invitation to participant: ABI	1.1	25 August 2010
GP/Consultant Information Sheets	1.0	09 August 2010
Participant Information Sheet: ABI	2.1	28 September 2010
Response to Request for Further Information		29 September 2010
Participant Information Sheet: Control	2.1	28 September 2010
Participant Consent Form: Control	1.1	15 September 2010
Participant Consent Form: Patient	1.1	15 September 2010
Questionnaire: MDQ	1.0	25 August 2010
Questionnaire: CFQ	1.0	August 2010
Questionnaire: PRMQ	1.0	June 2009
Questionnaire: PRMQ Relative	1.0	25 August 2010
Questionnaire: GMQ	1.0	June 2009

Student CV (Baylan)		
Clinical team letter template - appendix	1.0	09 August 2010
Evidence of insurance or indemnity		09 August 2010
Letter of Invitation: controls	1.1	25 August 2010
Letter of Invitation: reminder	1.0	25 August 2010
Clinical Recruiter Checklist	1.0	25 August 2010
Scholarship letter		29 May 2010
Flow chart	1.0	25 August 2010
Advert poster - controls	1.0	August 2010
Newspaper/web advert		
Appointment letter 1 - ABI	1.0	19 August 2010
Appointment letter 2 - ABI	1.0	19 August 2010

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Now that you have completed the application process please visit the National Research Ethics Service website > After Review

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

The attached document *"After ethical review – guidance for researchers"* gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

We would also like to inform you that we consult regularly with stakeholders to improve our service. If you would like to join our Reference Group please email referencegroup@nres.npsa.nhs.uk.

10/S1001/49	**Please quote this number on all correspondence**

Yours sincerely

p. S Macgregor

Dr Gregory Ofili
Chair

Email: sharon.macgregor@ggc.scot.nhs.uk

Enclosures: "After ethical review – guidance for researchers"

Copy to: Dr Erica Packard, R&D office, NHS Greater Glasgow & Clyde

Appendix 2.11.2: WoSRES Amendments

WoSRES
West of Scotland Research Ethics Service

NHS
Greater Glasgow and Clyde

West of Scotland REC 5
Ground Floor – The Tennent Institute
Western Infirmary
38 Church Street
Glasgow G11 6NT
www.nhsggc.org.uk

Mrs Fiona Scott
Dept of Psychological Medicine
Gartnavel Royal Hospital
Glasgow
G12 0XH

Date 15 April 2011
Your Ref
Our Ref
Direct line 0141 211 2123
Fax 0141 211 1847
E-mail Liz.Jamieson@ggc.scot.nhs.uk

Dear Mrs Scott

Study title: **Everyday Executive Functioning in Individuals with Acquired Brain Injury: Evaluating the Ecological and Convergent Validity of Traditional, Life-like and Computerised Tests of Prospective Memory and Planning**
REC reference number: **10/S1001/49**
SSA reference number: **11/AL/0136**

The REC gave a favourable ethical opinion to this study on 8th October 2010.

On behalf of the Committee, I am pleased to confirm the extension of the favourable opinion to the new site(s) and investigator(s) listed below:

Research Site	Principal Investigator / Local Collaborator
IntoWork	Mrs Fiona Scott

The favourable opinion is subject to management permission or approval being obtained from the host organisation prior to the start of the study at the site concerned.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

10/S1001/49	**Please quote this number on all correspondence**

Yours sincerely

Mrs Liz Jamieson
Committee Co-ordinator

Copy to: Dr Erica Packard, NHS Greater Glasgow & Clyde R&D

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www.nhsggc.org.uk

WoSRES
West of Scotland Research Ethics Service

NHS
Greater Glasgow and Clyde

West of Scotland REC 5
Ground Floor – The Tennent Institute
Western Infirmary
38 Church Street
Glasgow G11 6NT
www.nhsggc.org.uk

Mrs Fiona Scott
Department of Psychological Medicine
Gartnavel Royal Hospital
Glasgow
G12 0XH

Date 21st April 2011
Your Ref
Our Ref
Direct line 0141 211 2123
Fax 0141 211 1847
E-mail Liz.Jamieson@ggc.scot.nhs.uk

Dear Mrs Scott

Study title: **Everyday Executive Functioning in Individuals with Acquired Brain Injury: Evaluating the Ecological and Convergent Validity of Traditional, Life-like and Computerised Tests of Prospective Memory and Planning**
REC reference number: **10/S1001/49**
SSA reference number: **11/AL/0234**

The REC gave a favourable ethical opinion to this study on 8th October 2010.

Notification(s) have been received from local assessor(s), following site-specific assessment. On behalf of the Committee, I am pleased to confirm the extension of the favourable opinion to the new site(s) and investigator(s) listed below:

Research Site	Principal Investigator / Local Collaborator
The Huntercombe Services Murdostoun Brain Injury Rehabilitation Centre	Mrs Fiona Scott

The favourable opinion is subject to management permission or approval being obtained from the host organisation prior to the start of the study at the site concerned.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

10/S1001/49	**Please quote this number on all correspondence**

Yours sincerely

Mrs Liz Jamieson
Committee Co-ordinator

Copy to: Erica Packard, NHS Greater Glasgow & Clyde R&D

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Appendix 2.11.3: Research & Development (GG&C NHS)

NHS
Greater Glasgow and Clyde

Coordinator/Administrator: Dr Erica Packard/Ms Elaine O'Donnell
Telephone Number: 0141 211 6208
E-Mail: erica.packard@ggc.scot.nhs.uk
Website: www.nhsggc.org.uk/r&d

R&D Management Office
Western Infirmary
Tennent Institute
1st Floor 38 Church Street
Glasgow, G11 6NT,

30 November 2010

Miss Fiona Scott
Trainee Clinical Psychologist
Dept of Psychological medicine
Gartnavel Royal Hospital
1055 Great Western Road
G12 0XH

NHS GG&C Board Approval

Dear Miss Scott,

Study Title:	**Everyday Executive Functioning in Individuals with Acquired Brain Injury: Evaluating the Ecological and Convergent Validity of Traditional, Life-like and Computerised Tests of Prospective Memory and Planning**
Principal Investigator:	**Miss Fiona Scott**
GG&C HB site	**Community Treatment Centre for Brain Injury**
Sponsor	**NHS Greater Glasgow & Clyde**
R&D reference:	**GN10NE340**
REC reference:	**10/S1001/49**
Protocol no: (including version and date)	**V1.0;16/08/10**

I am pleased to confirm that Greater Glasgow & Clyde Health Board is now able to grant **Approval** for the above study. **This approval now includes Mrs Satu Baylan.**

Conditions of Approval

1. **For Clinical Trials** as defined by the Medicines for Human Use Clinical Trial Regulations, 2004
   a. During the life span of the study GGHB requires the following information relating to this site
      i. Notification of any potential serious breaches.
      ii. Notification of any regulatory inspections.

It is your responsibility to ensure that all staff involved in the study at this site have the appropriate GCP training according to the GGHB GCP policy (www.nhsggc.org.uk/content/default.asp?page=s1411), evidence of such training to be filed in the site file.

NHS
Greater Glasgow and Clyde

2. **For all studies** the following information is required during their lifespan.
   a. Recruitment Numbers on a quarterly basis
   b. Any change of staff named on the original SSI form
   c. Any amendments – Substantial or Non Substantial
   d. Notification of Trial/study end including final recruitment figures
   e. Final Report & Copies of Publications/Abstracts

Please add this approval to your study file as this letter may be subject to audit and monitoring.

Your personal information will be held on a secure national web-based NHS database.

I wish you every success with this research study

Yours sincerely,

EPackard

Dr Erica Packard
Research Co-ordinator

Cc Miss Satu Baylan, NRSPCC

Appendix 2.11.4: Letter of Access (Research & Development: A&A NHS)

Healthcare Quality, Governance and Standards Unit
Research, Development & Evaluation Office
58 Lister Street
Crosshouse Hospital
Kilmarnock
KA2 0BB

NHS Ayrshire & Arran

Tel: (01563) 825856
Fax: (01563) 825806

Fiona Scott
Section of Psychological Medicine
Gartnavel Royal Hospital
1055 Great Western Road
Glasgow
G12 0XH

Date: 28 January 2011
Your Ref:
Our Ref: CAW/KLB/NM R&D 2010AA062
R&D 2010AA063

Enquiries to: Karen Bell
Extension: 25850
Direct Line: 01563 825850
Email: Karen.bell@aaaht.scot.nhs.uk

Dear Miss Scott

Letter of access for research

As an existing NHS employee you do not require an additional honorary research contract with this NHS organisation. We are satisfied that the research activities that you will undertake in this NHS organisation are commensurate with the activities you undertake for your employer. Your employer is fully responsible for ensuring such checks as are necessary have been carried out. Your employer has confirmed in writing to this NHS organisation that the necessary pre-engagement check are in place in accordance with the role you plan to carry out in this organisation. This letter confirms your right of access to conduct research through NHS Ayrshire and Arran for the purpose and on the terms and conditions set out below. This right of access commences on **28 January 2011** and ends on **13 January 2012** unless terminated earlier in accordance with the clauses below.

You have a right of access to conduct such research as confirmed in writing in the letter of permission for research from this NHS organisation. Please note that you cannot start the research until the Principal Investigator for the research project has received a letter from us giving permission to conduct the project.

You are considered to be a legal visitor to NHS Ayrshire and Arran premises. You are not entitled to any form of payment or access to other benefits provided by this organisation to employees and this letter does not give rise to any other relationship between you and this NHS organisation, in particular that of an employee.

While undertaking research through NHS Ayrshire and Arran you will remain accountable to your employer **NHS Greater Glasgow and Clyde** but you are required to follow the reasonable instructions of your nominated manager **Dr Rani Sinnak, Consultant Clinical Psychologist** in this NHS organisation or those given on her behalf in relation to the terms of this right of access.

Where any third party claim is made, whether or not legal proceedings are issued, arising out of or in connection with your right of access, you are required to co-operate fully with any investigation by this NHS organisation in connection with any such claim and to give all such assistance as may reasonably be required regarding the conduct of any legal proceedings.

You must act in accordance with NHS Ayrshire and Arran policies and procedures, which are available to you upon request, and the Research Governance Framework.

You are required to co-operate with NHS Ayrshire and Arran in discharging its duties under the Health and Safety at Work etc Act 1974 and other health and safety legislation and to take reasonable care for the health and safety of yourself and others while on NHS Ayrshire and Arran premises. Although you are not a contract holder, you must observe the same standards of care and propriety in dealing with patients, staff, visitors, equipment and premises as is expected of a contract holder and you must act appropriately, responsibly and professionally at all times.

You are required to ensure that all information regarding patients or staff remains secure and *strictly confidential* at all times. You must ensure that you understand and comply with the requirements of the NHS Confidentiality Code of Practice (http://www.dh.gov.uk/assetRoot/04/06/92/54/04069254.pdf) and the Data Protection Act 1998. Furthermore you should be aware that under the Act, unauthorised disclosure of information is an offence and such disclosures may lead to prosecution.

NHS Ayrshire and Arran will not indemnify you against any liability incurred as a result of any breach of confidentiality or breach of the Data Protection Act 1998. Any breach of the Data Protection Act 1998 may result in legal action against you and/or your substantive employer.

You should ensure that, where you are issued with an identity or security card, a bleep number, email or library account, keys or protective clothing, these are returned upon termination of this arrangement. Please also ensure that while on the premises you wear your ID badge at all times, or are able to prove your identity if challenged. Please note that this NHS organisation accepts no responsibility for damage to or loss of personal property.

We may terminate your right to attend at any time either by giving seven days' written notice to you or immediately without any notice if you are in breach of any of the terms or conditions described in this letter or if you commit any act that we reasonably consider to amount to serious misconduct or to be disruptive and/or prejudicial to the interests and/or business of this NHS organisation or if you are convicted of any criminal offence. Where applicable, your substantive employer will initiate your Independent Safeguarding Authority (ISA) registration in-line with the phasing strategy adopted within the NHS (as from 26th July 2010 at the earliest). Once you are ISA-registered, your employer will continue to monitor your ISA registration status via the on-line ISA service. Should you cease to be ISA-registered, this letter of access is immediately terminated. Your substantive employer will immediately withdraw you from undertaking this or any other regulated activity and you MUST stop undertaking any regulated activity.

Your substantive employer is responsible for your conduct during this research project and may in the circumstances described above instigate disciplinary action against you.

If your circumstances change in relation to your health, criminal record, professional registration or ISA registration, or any other aspect that may impact on your suitability to conduct research, or your role in research changes, you must inform the NHS organisation that employs you through its normal procedures. You must also inform your nominated manager in this NHS organisation.

Yours sincerely

Professor Craig A White
Assistant Director (Healthcare Quality, Governance and Standards)

c.c. HR department of the substantive employer

Appendix 2.12: Correlation table for demographic and neuropsychological measures with DEX planning

Demographic or Neuropsychological Measure	**Pearson's *r* (or Spearman's *rho*)** [f]
Age	-.07
Gender	-.06
SES	-.33*
Education	-.41**
Length of PTA	.39*
Time since head injury	.17
Psychological symptomatology	
HADS Depression	.43**
HADS Anxiety	.46**
Premorbid-IQ	
WTAR	-.52**
Reasoning Ability	
Matrix Reasoning	-.35*
Processing Speed	
SDMT (z score)	-.60**
TMT-A (z score)	-.39*
TMT-A (errors)	.08
Mental Flexibility	
TMT-B (z score)#	-.37*
TMT-B (errors)#	.35 *
Verbal Recall	
Logical Memory – immediate	-.45**
Logical Memory – delayed	-.44**
Visual Recall	
RCFT – immediate (T score)	-.38*
RCFT – delayed (T score)	-.41**

[f] Spearman's *rho* used for analyses involving education, gender, deprivation, time since ABI, length of PTA, premorbid IQ, RCFT Immediate and Delayed, TMT A & B (z scores and errors) as assumptions of normality not tenable. # One participant excluded due to z score being -41.4 for TMT B (extremely abnormal). **correlation is sig at the 0.01 level * correlation is sig at the 0.05 level (2-tailed).

Appendix 3.1: Major Research Project Proposal

(submitted 12th July 2010)

Striving for Ecological Validity in the Assessment of Executive Functions: An Investigation into the use of Virtual Reality Measures of Planning and Prospective Memory in Individuals with Acquired Brain Injury

Abstract

Background: Improving the ecological validity of the assessment of executive functioning after brain injury has become an increasingly important issue. Traditional tests for specific executive functions show only a moderate relationship with everyday functioning. Virtual reality (VR) methodologies may offer a means to better assess real-world performance in these abilities. ***Aims:*** This study will primarily investigate the ecological validity of a novel VR measure in assessing real-life difficulties post-brain injury in the domains of planning and prospective memory. The comparative ecological validity of traditional tests for these domains will also be explored. ***Methods:*** The magnitude of the correlation between performance on planning and prospective memory subcomponents of the VR assessment and level of everyday functioning in these domains as measured by client and carer-rated questionnaires shall be ascertained. Further exploratory analyses shall compare the size of this relationship to that respectively seen between traditional tests and real-life measures for each domain. ***Applications:*** Findings may have implications for enhancing the ecological validity of executive functioning assessments used in routine clinical practice.

Introduction

Over the last few decades there has been growing interest in the development of ecologically valid assessments for the domain of executive functioning. This has been driven both by an emerging appreciation in clinical settings of the central role that executive functions have in maintaining adaptive independent functioning following brain injury, as well as by an analogous proliferation of theoretically-based research within the field. According to theory, executive functions comprise a set of higher-order cognitive abilities that executively manage or "conduct" other cognitive systems such as memory or language in a goal-directed fashion (Lezak, 1982). Despite debate, there is general consensus that this executive system can be fractionated into discrete cognitive elements, such as planning, initiation, goal management, prospective memory and self-monitoring, which can be flexibly used when faced with the multiple goals, sub-tasks and changing priorities commonly encountered in everyday life (Shallice et al., 1996). This differentiation appears supported by the pattern of cognitive impairment often seen after an acquired brain injury (ABI) which is characterised by deficits in several distinct areas of executive functioning, such as planning and prospective memory, while other primary cognitive functions such as memory or language remain intact (Shallice & Burgess, 1991).

Given their importance, the assessment of executive functions has become a core feature of the neuropsychological assessment of individuals with brain injury. Traditionally, many tests of executive functions have been developed within a diagnostic tradition having the primary purpose of determining whether a discrete cognitive impairment is present or not (Chaytor & Schmitter-Edgecombe, 2003). This approach has proven problematic for several reasons, the most notable being that tests are often found to lack ecological validity – with dissociation frequently being observed between an individual's test performance and their abilities to function in everyday life (Burgess et al., 1998; 2006; Eslinger & Damasio, 1985). Resultantly, efforts have been made to develop new assessment measures that are more ecologically-valid such as the Behavioural Assessment of

Dysexecutive Syndrome (BADS; Wilson et al., 1996), which is now the most widely available in clinical practice, as well as the Executive Secretarial Task (EST; Lamberts, Evans & Spikman, 2009), the Hotel Task (Manly et al., 2002) and the Multiple Errands Test (MET; Shallice & Burgess, 1991). However, even the BADS is limited in its ability to predict everyday functioning in patients with brain injury (Norris & Tate, 2000; McGeorge et al., 2001; Wood & Liossi, 2006) and "real-world" tasks such as the EST and MET have many unavoidable practical difficulties and lack psychometric rigour. Manchester, Priestly and Jackson (2004) have also suggested that although office-based tests of executive functioning may prove useful in rehabilitation contexts, the assessment of real-life deficits may be best achieved by combining more naturalistic assessment measures with information derived from informants.

A further issue in research on ecological validity concerns the lack of a perfect way to measure someone's true everyday cognitive abilities. Typically research has used informant-based questionnaires, which are deemed to contain fewer systemic biases and ease the data collection process (Chaytor et al., 2006). However, the relationship between these measures and individual's performance on tests of executive functioning has only tended to range from 0.2 to 0.5 when found significant, indicating a low to moderate correspondence (Chaytor & Schmitte-Edgecombe, 2003). Understandably, many environmental, cognitive and emotional factors are believed to mediate the strength of this relationship (Chaytor et al., 2006), which are typically not considered in formal assessment. Although it has been demonstrated that including a formal assessment of such variables (such as, use of compensatory strategies, impact of environmental cognitive demands and presence of depressive symptoms) significantly increases the amount of variance in everyday executive functioning abilities accounted for by neuropsychological assessment (Chaytor et al., 2006; 2007), resulting in the development of the Modified Dysexecutive Questionnaire (Chaytor et al., 2006).

An alternative paradigm that addresses the difficulties of conducting ecologically valid assessments whilst reducing pragmatic difficulties has been the use of VR methodologies. Such assessments utilise a novel procedure designed to mimic complex real-world situations, and currently include VR versions of the MET (VMET; McGeorge et al., 2001 and VMALL; Rand et al., 2009), the Removals Task (Morris et al., 2002) and the JAAM (Jansari et al., 2004). Despite a relative paucity of research conducted on these measures, there is promising evidence that they are able to successfully predict group membership (controls versus brain injured individuals) on basis of task performance (Jansari et al., 2004; Rand et al., 2009) and that several distinct executive functions can be separately assessed via different components of the testing process (Jansari et al., in prep). Furthermore, McGeorge and colleagues (2001) have shown using the VMET that the performance of individuals with brain injury, who did not meet the BADS criteria for executive impairment, significantly differed from that of controls, which is evidently suggestive of VR assessments being more sensitive to "real life" impairments.

Therefore the primary aim of the present study is to test the hypotheses that VR measures of specific executive functions (planning and prospective memory) will show a significant association with reported real-life functioning in these specific domains, with real-life functioning being measured using both the Prospective and Retrospective Memory Questionnaire (PRMQ; Crawford et al., 2003; 2006) and the aforementioned Modified Dysexecutive Questionnaire (DEX) which is advocated by Chaytor and colleagues (2006) as providing a more holistic perspective of everyday executive functioning. The speculation that these correlations will be larger than the comparable relationship between traditional neuropsychological tests of these cognitive domains and real-life difficulties will also be considered in additional exploratory analyses. Results could have important implications for enhancing the ecological validity of executive functioning assessments used in clinical practice.

Aims and Hypotheses

Aims

Primary aim is to determine if there is a significant correlation between the performance of individuals with brain injury on planning and prospective memory components of the JAAM task with measures of everyday functional ability reported in these two cognitive abilities.

An exploratory aim of this study is to investigate the difference between related correlation coefficients with respect to comparing the degree of correspondence seen between traditional tests of planning and prospective memory with measures of everyday functioning in these specific domains, with the magnitude of correspondence seen between VR measures of these domains and everyday functioning. This is to gauge the respective levels of ecological validity between traditional and VR assessment methods.

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Hypotheses

1. That there will be a significant correlation between level of everyday functioning in planning and prospective memory, as measured by self- and carer-rated questionnaires, and individuals' performance on respective measures of planning and prospective memory derived from the JAAM task.

Exploratory Hypothesis:

2. It can be tentatively speculated from the burgeoning literature-base that the strength of the correlation between the VR measures and real-life difficulties in planning and prospective memory will be larger than the correlation between individual's performance on traditional measures of these executive functions and reported real-life impairments.

Plan of Investigation

Participants: Forty-six participants with Acquired Brain Injury (ABI following head injury, stroke etc.) shall be recruited.

Inclusion Criteria: Participants will be between 18 and 65 years old with ABI of varying severity and aetiology. They also require a significant other willing to complete informant questionnaires.

Exclusion Criteria: Individuals with severe mental illness, learning disability and neurodegenerative conditions will be excluded. Further exclusion criteria will include having severe visual and hearing impairment, severe dysphasia or current substance use problem which is likely to impact on participants' ability to undertake the tasks involved in the study. Also, as assessment requires individuals to read and write, illiterate participants will be excluded.

Recruitment Procedures: Participants will be recruited from Momentum and Headway organisations in the Glasgow area as well as from the Community Treatment Centre in Glasgow. Further NHS organisations such as the Brain Injury Rehabilitation Trust (BIRT) based at Graham Anderson House in Springburn, the West Dumbartonshire ABI Team, the Douglas Grant Rehabilitation Centre in Ayrshire and the Glasgow Community Stroke Service will be approached for recruitment. Chest Heart and Stroke Scotland patient groups will also be approached. Verbal and written information about the study will be provided to potential participants and accompanying carers/family members that will invite them to participate. Where appropriate, group-based presentations may be used to explain what the study would involve and to answer queries potential participants may have. Care will be taken during these procedures to ensure the following: that no pressure is placed upon clients to participate in this study; that all clients meeting the inclusion criteria are invited to participate; and that experimenter expectations regarding interventions are not transmitted to potential clients. Once subjects give their informed consent to participate, the researcher will use their clinical judgement in line with the aforementioned inclusion and exclusion criteria to determine suitability for undertaking the study.

Measures

Pre-experimental Measures: Initial measures will include the client version of the Dysexecutive Questionnaire (DEX) from the BADS (Wilson et al., 1996) as well as a modified informant version of the DEX. The DEX is designed to assess the presence of common symptoms of executive functioning impairment in everyday settings including emotional, motivational, behavioural and cognitive aspects. Previous studies have demonstrated this measure to possess a 4-factor (Mooney et al., 2006) or 5-factor structure (Amieva et al., 2003; Burgess et al., 1998; Chan, 2001) based upon the client and informant versions respectively. Although a preliminary finding, a factor relating to “planning” has been demonstrated in a neurologically intact sample (Amieva et al., 2003), and performance on the Tower of London planning test (Shallice, 1982) has been shown to significantly correlate with two identified factors of “inhibition” and “intentionality”, again in a non-clinical sample (Chan, 2001). Therefore a tentative “planning” score can be devised for each participant as a summed score from relevant DEX items (see Appendix 1 for item details). Furthermore, using the methodology previously applied by Chaytor and colleagues (2006), the informant questionnaire will be adapted to include two additional questions to be asked after each of the 20 items, where informants will be asked to rate responses on a 5-point Likert scale from 0 (never) to 4 (very often). The first question aims to obtain information about the individual’s daily routine and what cognitive abilities they typically utilise for each of the executive symptoms (i.e. by asking “how often do problems in this area interfere with his/her usual daily activities?”). The scores will be collated for each of the 20 executive symptoms from the DEX to obtain an overall measure of environmental executive demands. Similarly, the second additional question will aim to elicit information about compensatory strategies the individual utilises to reduce problems in each of the 20 executive symptom areas (i.e. “how often does he/she do something to compensate for, or prevent, difficulties in this area?”), and again ratings will be collated to form an overall compensatory strategy score. Therefore in addition to the original DEX total scores and planning scores, scores relating to the impact of everyday executive demands and to the individual's use of compensatory strategies will be derived.

In addition, the Prospective and Retrospective Memory Questionnaire (PRMQ; Crawford et al., 2003; 2006) will also be completed by both clients and their significant other to gauge the impact of memory failures on participant's daily living. A score pertaining to prospective memory can be derived from this measure.

Background Neuropsychological Assessment: The following tests shall be undertaken to characterise the sample:

- Wechsler Test of Adult Reading (WTAR; Wechsler, 2001) as a premorbid estimate of IQ
- Symbol Digit Modalities Test (Smith, 1982) as a measure of processing speed
- Matrix Reasoning subtest of WAIS-III (Wechsler, 1997) as a measure of general ability.
- Logical Memory subtest from the Wechsler Memory Scale – 3rd Edition (WMS-III; Wechsler, 1998) to assess immediate and delayed verbal recall
- Rey Complex Figure Test (RCFT; Meyers & Meyers, 1995) to assess immediate and delayed visual recall.
- Modified Six Elements test from the BADS (Shallice & Burgess, 1991; Wilson et al., 1996) as a general measure of executive functioning impairment which encompasses planning, self-initiation and self-monitoring facets in task completion.

In addition, the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) will be used to measure participant's mood and anxiety. Socio-economic status (SES) will be rated using Scottish Index of Multiple Deprivation (SIMD; 2009) and a brief Likert-scale questionnaire will be given to assess individual's prior familiarity with computer technology. Information regarding previous difficulties with substance use, history of psychopathology, head injury and neurological illness will also be collected.

Traditional Assessment Measures: "Traditional" assessments of planning and prospective memory will include the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan & Kramer, 2001) Tower Test, which is based upon Shallice's original Tower of London test (Shallice, 1982) and the Cambridge Prospective Memory Test (CAMPROMPT; Wilson et al., 2005) respectively.

Virtual Reality Measures: The JAAM virtual reality measure of executive function will be used to assess planning and prospective memory (Jansari et al., 2004). The JAAM uses a novel office setting and asks the participant to assume the role of an employee, requiring them to complete a set of office-based tasks such as setting up a meeting. This measure is designed to assess many facets of executive functioning and produces a separate score for each of the cognitive constructs it is purported to encompass as well as a total score. Therefore scores relating to planning and prospective memory sub-tasks will be used for the primary purpose of the present study, whilst the total score measure will be used in exploratory analyses. Sub-tasks are detailed in Appendix 2.

Design: Cross-sectional correlation study examining the relationship between VR measures of planning and prospective memory with client or carer reported "real-life" impairments in these areas of executive functioning. Exploratory aspects include comparison of related correlation coefficients, that is, comparison between initial VR correlations and those found between traditional planning and prospective memory tests and measures of everyday functioning. Presentation of the traditional and VR tests will be counterbalanced across participants.

Research Procedures: Pre-experimental measures (DEX and PRMQ) will be disseminated prior to assessment and subjects asked to bring completed forms to the session. The assessment process will last between 2 and 2.5 hours and will be broken down into three sections with a 10-15 minute break.

These sections include;

1. Traditional neuropsychological tests
2. VR assessment (including 10 minute training)
3. Background neuropsychological measures, questionnaire completion and collection of demographic information

Prior to running the procedure with the study sample, experimenters will undergo procedure administration training with pilot subjects recruited from the same sample population to ensure that administration is consistent. This data will not be included in statistical analyses.

The JAAM task is administered via laptop computer, however the majority of assessment involves the researcher monitoring the participant's activities in the VR environment and rating performance against predefined scoring criteria (see Appendix 3). To ensure consistency between experimenters in the scoring of participant's performance, a 10% subsample of participants will be co-rated. Several hard copy documents are provided during the running of the programme, which relate to documents displayed in the VR environment (see JAAM Manual; Jansari, 2009). Thus the participant is also required to complete tasks by engaging in pen and paper activities. The task scenario is read out to the participant at the beginning of the task from a script and this is repeated as necessary to ensure that they are well versed in the information provided. A printed scenario sheet and the "Manager's Tasks for Completion" is provided to the client, and these documents remain next to the computer throughout the assessment to reduce the likelihood of errors being made due to added demands on memory. Other relevant documents are either available from the outset, or given as and when required from the researcher during the assessment process. Questions relating to the operation and running of the task will be encouraged prior to the start of assessment, although if participant's questions relate to how they might go about completing the task, the researcher will direct them to the printed materials.

Justification of Sample Size: This is considered in relation to the primary aim of the study and utilises Cohen's (1988) guidance that correlations of 0.10., 0.30, and 0.50 correspond to small, medium and large effect sizes, respectively. Despite there being no known studies that have compared performance of a brain injured sample on specific measures of a VR task to their scores on the DEX, a relevant study by Rand and colleagues (2009) found a large effect size (r = -0.82) between performance on the VMET (considered comparable to the JAAM assessment) and level of independence as rated by the Instrumental Activities of Daily Living Questionnaire using a post-stroke sample (IADL; Chevignard et al., 2000). Also using the DEX, Knight and colleagues (2002) found medium-large effect sizes (r = 0.46 and -0.46) between performance measures of the MET-HV and DEX total scores, whilst Lamberts, Evans and Spikman (2010) have shown a medium effect (r = 0.31) between informant DEX scores and performance on the EST. However, these studies relate to global executive functioning ability and not specific cognitive domains, and the former study utilised a more homogenous sample than the latter two and to that proposed in the present study. Also the MET-HV and EST are considered "naturalistic" assessment measures as opposed to VR measures. Therefore, given the increased methodological rigour entailed in VR methodology, there is justification for assuming that the correlation between specific VR measures and DEX-rated everyday functioning in a general neurological sample will provide a medium-large effect size in the present study.

Therefore, using Cohen's guidelines (Cohen, 1988) and the statistical programme G*Power (Faul et al., 2007), a two-tailed Pearson's correlation undertaken between each specific VR measure of planning and prospective memory and questionnaire-based measures of real-life difficulties using an estimated medium-large effect size (r = 0.4), with power at 0.8 and alpha error at 0.05, it is predicted that at least 46 participants will be required.

Settings and Equipment: When possible, assessment will occur in a quiet, secure, non-stimulating room within the setting from which individual was recruited. All other testing will take place at the Community Treatment Centre for Brain Injury. Equipment includes: NHS security-encrypted laptop with VR software, the aforementioned neuropsychological assessments, record forms and questionnaires. Also require desk for running VR test and access to locked facilities for data storage to ensure confidentiality.

Data Analyses: Descriptive statistics will be used to determine the demographic and neuropsychological characteristics of the sample. Two-tailed correlational analyses will be conducted between various measures of interest for both planning and prospective memory domains, with non-parametric equivalents being used if parametric assumptions are violated (Hypothesis 1). Exploratory analyses will compare correlation coefficients using either "Williams procedure" if parametric (Hotelling, 1940 as cited by Wuensch, 2007) or using values of difference between correlations to produce a confidence interval through bootstrap analysis if non-parametric (Hypothesis 2).

Health and Safety Issues

Researcher Safety Issues: Research will be conducted during normal working hours within staffed organisational settings. As in clinical practice, testing shall not commence if participant is deemed to be under the influence of alcohol or substances or if they are exhibiting anger or distress. Testing room will be set-up to allow researcher to exit easily and to access panic alarm system if appropriate. Supervisor will be informed of all testing sessions.

Participant Safety Issues: As stated above, assessment will be carried out during normal working hours within staffed organisational settings. The researcher will be present at all times and will remain vigilant to levels of client distress and incorporate further breaks into testing process as required. Clients will be informed at all stages of recruitment and testing that they can withdraw from the study at any time.

Ethical Issues

Application for ethical approval will be made to NHS Greater Glasgow Primary Care Division Local Research Ethics Committee. Possible extension of ethical approval to neighbouring NHS board areas including NHS Ayrshire and Arran. Only participants considered to possess capacity will be approached to undertake the study and written consent will be obtained from these individuals. Participants will be free to leave the study at any point and will be reassured that this will not affect any clinical treatment that they receive. Data will be coded and stored in locked facilities to ensure confidentiality, and participants will be informed prior to consenting to the study under what circumstances their confidentiality rights may be superseded by the researcher's duty of care for that individual.

Financial Issues

Overall cost to complete study is estimated to be £288.83, which covers purchase of record forms and questionnaires and administration (Appendix 4). Costs will be halved with a concurrent intervention study.

Timetable

Study will be conducted between October 2010 and July 2011 (see Appendix 5 for details).

Practical Applications

Results may have implications for improving the ecological validity of executive functioning assessments utilised in clinical practice. In particular, the speculated ability of VR methodologies to address the often limited correspondence between individuals' test performance in clinical settings and everyday functioning for specific executive functions may be verified. Findings may therefore have potential value in guiding the development of novel comprehensive and ecologically valid assessment practices, which are undoubtedly sought-after given the renowned difficulties associated with both the assessment and conceptualisation of executive functioning.

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Appendix 3.2: Proposal Appendices

Appendix 3.2.1: Items on DEX Questionnaire Previously Associated with Planning Abilities[1 2]

[please see Appendix 2.6 above]

Appendix 3.2.2: JAAM Sub-tasks for Planning and Prospective Memory

Construct of Executive Functioning *	Details of sub-tasks
Planning *"Ordering events/objects due to logic, not importance"*	1. Writing down plan of action in a logical sequence based upon information available at start of test. 2. Arranging furniture in meeting room in a logical configuration.
Action-Based Prospective Memory *"Remembering to execute a task cued by a stimulus related to an action the individual is already engaged in"*	1. Updating the post-diary when new package needs to be sent 2. Recording if any of the equipment breaks
Event-Based Prospective Memory *"Remembering to execute a task cued by an external stimulus"*	1. Noting the times that the fire alarms sound. 2. Turning on the coffee machine when first person arrives
Time-Based Prospective Memory *"Remembering to execute a task at a pre-determined future point in time"*	1. Turning on overhead projector 10 minutes before start of meeting 2. Indicating whether the company postman arrives at a specified time

* Constructs as defined by Jansari (2009) in JAAM Manual.

Appendix 3.2.3: JAAM Scoring Criteria for Planning and Prospective Memory Tasks*

[please see Appendix 2.8 above]

Appendix 3.2.4: Study Costs

Item	No. required	Approximate Cost
Questionnaires		
Adapted DEX Questionnaires (carer & client)	100	Create own (100 x £0.05 = **£5.00**)
PRMQ Questionnaire: client	50	Free to photocopy (£0.05 x 50 = **£2.50)**
PRMQ Questionnaire: carer	50	Free to photocopy (£0.05 x 50 = **£2.50)**
HADS Questionnaire	50	Free to photocopy (£0.05 x 50 = **£2.50**)
Formal Recording Forms		
Symbol Digit Modalities Forms[2]	50	2 x pack of 25 (2 x £44.00 = **£88.00**)
CAMPROMPT Record Forms[1]	50	2 x pack of 25 (2 x £49.94 = **£99.88**)
Constructed Recording Forms		
WTAR Record Forms	50	Create own (P/C £0.05 x 50 = **£2.50**)
Matrix Reasoning subtest (WAIS-III)	50	Create own (P/C £0.05 x 50 = **£2.50**)
Modified six element test (BADS)	50	Create own (P/C £0.05 x 50 = **£2.50**)
Logical Memory subtest (WMS-III)	50	Create own (P/C £0.05 x 50 = **£2.50**)
Rey Complex Figure Test	50	Create own (P/C £0.05 x 50 = **£2.50**)
Tower-Test (D-KEFS)	50	Create own (P/C £0.05 x 50 = **£2.50**)
Demographic recording sheets & Computer Familiarity	50	Create own (P/C £0.05 x 50 = **£2.50**)
JAAM Scoring Sheet	50 (3 sheets)	Photocopying (£0.05 x 50 x 3 = **£7.50)**
JAAM Materials		
Re-usable documents	7 sheets	Printing (covered by paper costs)
Used task-specific documents	6 sheets x 50	Photocopying (£0.05 x 50 x 6 = **£15.00)**
Information Packs		
Printed Material	3 sheets x 65	Photocopying (£0.05 x 65 x 3 = **£9.75)**
P/C Headed Paper	65 sheets	Photocopying (£0.05 x 65 = **£3.25**)
Envelopes (size A4)	65	1 box of 250 = **£6.50**
Postage	65	Freepost at £0.35 x 65 = **£22.75**
White Paper (500 sheets A4)	1 ream	**£3.70**
Consent Forms	50	Create own (P/C £0.05 x 50 = **£2.50**)
TOTAL COST		**£288.83**

[1] Prices from http://www.psychcorp.co.uk or [2] http://www.hogrefe.co.uk/ on 12th March 2010

Appendix 3.2.5: Research Timetable

Date	**MRP Progress/Tasks**
April 2010	MRP Proposal submitted Costing form submission Completion of health and safety form
May – September 2010	MRP research supervision agreement Start research logbook Ethics approval Research & Development approval Site preparation Ordering materials and administration supplies
October 2010	Research Progress Meeting 1
October – December 2010	Start data collection
January – March 2011	Complete data collection Research Progress Meeting 2
April – May 2011	Complete data analyses Research Progress Meeting 3
June – July 2011	Submit drafts to supervisor
July 2011	Loose bind and submit
August 2011	Viva preparation
September 2011	Viva
September – November 2011	Submit corrections (if required)

Appendix 3.3: Addendum to Proposal

Prior to submission to ethics this project was combined with a PhD study which used over-lapping measures (in order to reduce the risk of repeat testing of participants and to ease data collection). Thus a few minor amendments were made to the main study. These included: assessment taking place over two sessions as opposed to one; exclusion of the Modified Six Elements test due to time constraints and the inclusion of the Trail Making Test; and omission of the self-rated DEX questionnaire to reduce the risk of overwhelming participants via the use of multiple questionnaires given that a further questionnaire was incorporated by the concurrent PhD study (reported elsewhere). Furthermore, although the modified Dysexecutive questionnaire (mDEX) was used in this study, only DEX-related scores are reported as these were most relevant to the current study's aims.