Smartphones as Prospective Memory Aids after Traumatic Brain Injury

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Abstract

Individuals living with traumatic brain injury (TBI) commonly have difficulties with prospective memory—the ability to remember a planned action at the intended time. This can result in difficulties managing every day functioning, and increased reliance on others. Traditionally a memory notebook has been recommended as a compensatory memory aid. Electronic devices have the advantage of providing a cue at the appropriate time to remind participants to refer to the memory aid and complete tasks, and are currently widely used. Research suggests these have potential benefit in neurorehabilitation. This study investigated the efficacy of a memory notebook and specifically a smartphone as a compensatory memory aid.

Seven participants with moderate to severe TBI completed the study. Two participants first received the memory notebook, and later the smartphone. The remainder received the smartphone as the memory aid of particular interest. Performance was measured using a *message task* in which participants were to place a call or text message at an assigned time, and answer a question and were to post a postcard during the week. During weekly sessions, participants rated mood and provided information about their use of the memory aid. Formal measures of prospective memory function, community and household integration and mood were completed at the start of the study, the end of each treatment and at a follow up two to four months after conclusion of the study.

The smartphone showed improvements in the ability to complete assigned memory tasks accurately and within the assigned time periods. The benefits of the smartphone occurred over and above benefits seen with those who received a memory notebook first, or who already used a memory notebook on entry to the study. Half the participants learnt to use the smartphone with ease, while others had difficulty. However, despite difficulties participants could still benefit from the smartphone. This study suggests smartphones have the potential to be a useful and cost effective tool in neurorehabilitation practice. This research informs clinicians and researchers of factors that may be important for successful implementation of smartphones as a neurorehabilitation tool.

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Chapter 1: Introduction

Common Effects of Traumatic Brain Injury

Prospective memory is the ability to remember to perform a planned action at the intended time, and is critical for every day functioning. Deficits in prospective memory have devastating effects on a person's ability to be independent, and increases caregiver burden (Sohlberg & Mateer, 2001). In general memory is impaired after moderate –severe traumatic brain injury (TBI, unless specified TBI will refer to moderate-severe TBI throughout this thesis), with 50% having at least mild memory impairment and most having severe impairment at 6 months with little improvement over time (Kersel, Marsh, Havill, & Sleigh, 2001). Individuals with TBI report more everyday memory impairments than non-injured controls (Olsson, Wik, Ostling, Johansson, & Andersson, 2006; Ownsworth & McFarland, 1999). While the focus of the current reseach is on prospective memory and use of memory aids to compensate for this common difficulty, there are numerous other common difficulties after TBI which can impact on the ability to use a memory aid.

The potential cognitive difficulties that may occur after TBI are numerous. Cognitive functions show improvements over the first 2 years, but can leave long term impairments (Hellawell, Taylor, & Pentland, 1999). Long term difficulties include impaired memory and learning, with an increased rate of forgetting and a need for more repetitions to learn (Uomoto, 2004). Working memory may be a particular difficulty (Uomoto, 2004). This means during memory aid training a person is likely to have difficulty remembering instructions, and due to working memory deficits may require more repetition to learn to use the memory aid and to be more likely to forget what they have learnt. Memory difficulties may be in part due to difficulties with attention. Individuals with brain injuries tend to become distracted more easily (Rao & Lyketsos, 2000; Uomoto, 2004).

Impairments in several aspects of attention can be found after severe TBI, including difficulty with attention span, sustaining attention and selective attention (J. L. Mathias & Wheaton, 2007). When learning a memory aid attention may need to be repeatedly drawn towards the training when the person becomes distracted from the task. For a person using a memory aid it may be important to learn to enter items in the memory aid immediately, as they will likely become distracted and subsequently forget to enter the task. Sustained attention, which is a conscious process of maintaining attention, particularly when stimuli is repetitive or does not capture attention appears to the common difficulty of being unaware of errors (McAvinue, O'Keeffe, McMackin, & Robertson, 2005). This means a person with TBI may be less inclined to notice errors they make when entering tasks into a memory aid, such errors could include errors in the process such as not saving the event, recording it on the incorrect day or at the incorrect time, placing insufficient or incorrect details into the memory aid.

A reduction in processing speed, the speed at which a person can take information from the environment and analyse it, is one of the most common cognitive impairments after TBI (Hellawell et al., 1999; Hoofien, 2001; J. L. Mathias & Wheaton, 2007; Ríos, Periánez, & Munoz-Céspedes, 2004; Uomoto, 2004). Limited processing speed is important as it limits the pace and quantity of information and instruction which a person can be presented with during training.

Failure to accommodate for these difficulties (e.g., through not slowing instruction and chunking information) may mean a person is unable to process and learn from the information presented. Executive difficulties, such as impairment in planning and organisation of tasks are also common impairments after TBI (Rao & Lyketsos, 2000), though use of a memory aid may assist in compensating for these difficulties.

Fatigue is common but usually reduces over time (Hellawell et al., 1999). When completing rehabilitation it is important to monitor for fatigue and end training where necessary. Additionally the memory aid may be specifically used to assist in appropriate management of fatigue through scheduling nap times and ensuring that a person is in a safe environment at a time where they may be more prone to fatigue.

Individuals with TBI may have physical injury and impairments in fine motor control (Uomoto, 2004), which may impair their ability to write or manipulate buttons on technology such as a smartphone. Language impairments that may occur as a result of TBI, such as aphasia, can impair a person's ability both to understand verbal communication and to express themselves (Uomoto, 2004). This has important consequences both for learning a memory aid through instruction, and for entering reminds into memory aids designed primarily for language-based functions. Fortunately, these difficulties tend to be due to damage in a specific brain region and are less common than other cognitive effects.

TBI can result in a number of emotional difficulties both due to neurobiological changes and as a reaction to the consequences of a TBI. A person may have a change in personality after TBI. For example, they may become aggressive, or no longer inhibit impulsive behaviours (E. Kim, 2002; Rao & Lyketsos, 2000). Due to TBI, individuals may be unable to control the expression of their emotions and have outbursts of anger and hostility (Hoofien, 2001; Prigatano, 1992; Rao & Lyketsos, 2000). Behaviours may become disinhibited, resulting in socially inappropriate (E. Kim, 2002) or childlike actions, and irritability (Rao & Lyketsos, 2000). Irritability may be in part due to other cognitive difficulties such as difficulties in keeping up with changes in conversation or changes in perception of environment, such as noise which becomes difficult to manage (Prigatano, 1992).

The behavioural and emotional changes have implications for rehabilitation with memory aids. Learning to use a memory aid is a time consuming process and could lead to frustration with themselves, the memory aid, or their instructor. With limited ability to control emotions frustration may rapidly result in anger and aggression (Prigatano, 1992), disrupting the time that could otherwise be used for learning to use the memory aid. Use of a memory aid may be impulsive and unorganised, or in the case of smartphones has the potential for inappropriate contacts of others. Unless precautions are in place, an individual with disinhibition and impulsivity may be at greater risk of excessive use of a smartphone resulting in large bills. In addition, the effect that impulsive and disinhibited behaviour can have on others means it is likely a priority for treatment (E. Kim, 2002), resulting in potential neglect of memory compensation. TBI sufferers may have anosognosia, a lack of awareness of their difficulties and the impact it is having on their functioning, and may impair rehabilitation (McAvinue et al., 2005).

Individuals with TBI are also at significant risk of developing major depressive disorder or apathy (Prigatano, 1992). It is estimated that one quarter of those with TBI will also develop major depression (Rao & Lyketsos, 2000), with those with more severe TBI and poorer functioning being at greatest risk (Satz et al., 1998). Depression may be caused through biological mechanisms relating to the injury or develop as result of their brain injury when they attempt to resume their lives (Rao & Lyketsos, 2000). Individuals may have apathy, characterised by a lack of interest and motivation, disinterest and emotional responses (Rao & Lyketsos, 2000), fatigue and helplessness (Prigatano, 1992). Mood difficulties may impair rehabilitation through increasing cognitive difficulties (Uomoto, 2004) and reduced motivation to fully engage in rehabilitation (Rao & Lyketsos, 2000).

Neuroanatomy of Prospective Memory

Prospective memory tasks activate a range of brain regions including the frontal poles, anterior cingulated gyrus, and parahippocampal gyrus (Okuda et al., 1998). The prefrontal region, specifically the frontal poles (Brodmanns area 10) have been specifically implicated in prospective memory (Burgess, Quayle, & Frith, 2001; Burgess, Scott, & Frith, 2003; McFarland & Glisky, 2009; Okuda et al., 2007; Ramnani & Owen, 2004). Prospective memory tasks activate the prefrontal cortex and inferior parietal regions (Burgess et al., 2001). More specific investigations have shown increased activation in the lateral frontal poles during prospective memory, which is not accounted for by complex attention (Burgess et al., 2003). This activation during a prospective memory task is sustained until the task is performed, at which time additional transitory activation in the temporal lobes also occurs (Reynolds, West, & Braver, 2009).

A reduction in frontal lobe functioning with age is associated with poorer prospective memory functioning (McFarland & Glisky, 2009). As the rostral frontal lobes are the most anterior of the brain they are particularly prone to injury in TBI. Individuals who have suffered a TBI effecting the rostral prefrontal cortex have impairments in prospective memory impacting on their daily life functioning (Volle, Gonen-Yaacovi, de Lacy Costello, Gilbert, & Burgess, 2011). Lesion studies demonstrated that damage to the right prefrontal area results in time-based prospective memory failures but not deficits in event based prospective memory (Volle et al., 2011). This occurs even when other cognitive components such as attention detection, inhibition and processing of instructions are controlled for, indicating a specific role of the right prefrontal area in time-based prospective memory (Volle et al., 2011). While the specific areas involved in time base and event based prospective memory differ, they both involve the rostral frontal cortex (Okuda et al., 2007).

Stages of Prospective memory

Prospective memory is the ability to remember to perform a planned action at the intended time, and is critical for every day functioning. Prospective memory involves development of an intention, which cannot be immediately performed (Fish, Wilson, & Manly, 2010). Prospective memory requires not only on remembering a task that needs to be completed, but doing so at the appropriate time (Ellis & Kvavilashvili, 2000; Ellis & Milne, 1996). Prospective memory can be time based where an action needs to occur at a particular time, or event based in which it must occur in a particular situation (Fish et al., 2010). Prospective memory is thought to consist of four phases: planning and encoding the intention, retaining the intention across a delay, reinstating the intention at the appropriate time, and finally executing the task (Ellis & Milne, 1996; Kliegel, Eschen, & Thöne-Otto, 2004). Frequently, at the appropriate time for completion of the prospective memory task, there may be no obvious cues for completion of the task, and the person must interrupt another activity in order to complete the intended task (Ellis & Kvavilashvili, 2000; McDaniel & Einstein, 2000).

The encoding phase includes the action, the intent, and when this should be retrieved (Ellis & Milne, 1996). There is then a retention period during a delay, followed by the retrieval time either based on the appropriate context or time (Ellis & Milne, 1996). Greater planning at the stage of encoding a prospective memory task improves later retrieval through stronger encoding and potentially though increasing the number of cues available which result in activation of the memory to complete the task (McDaniel & Einstein, 2000). Time based prospective memory tasks tend to be rehearsed more often than event based prospective memory tasks. However, this rehearsal is not a deliberate process but rather it seems the task comes to awareness from time to time (Kvavilashvili & Fisher, 2007).

Prospective Memory Theories

One theory of prospective memory is that an intended action is associated with an environmental cue during encoding, and when the cue is later encountered is automatically reactivates the intention in memory (McDaniel & Einstein, 2000). This is called a reflex associated process whereby the cues which were attended to in the environment activate memory traces encoded during development of the intention, and if the memory traces is activated strongly enough the memories associated with the cue will become conscious (McDaniel, Guynn, Einstein, & Breneiser, 2004). This system requires few cognitive resources (McDaniel et al., 2004).

A second theory of prospective memory is the preparatory attentional process theory, which poses that prospective memory is not automatic and requires use of a person's limited cognitive resources (Smith & Bayen, 2004). In this model, attention is allocated to monitor the environment for cues to complete a prospective memory task, and brings the task to mind when the cue is found (McDaniel et al., 2004). Therefore, keeping a prospective memory task in mind takes a person's attention resources, and delays performance in other tasks, with better prospective memory performance resulting in poorer performance in other attention demanding tasks (McDaniel & Einstein, 2000)

Finally, a further theory, the multi-process theory, poses that prospective memory utilises both an automatic cueing system and a attention monitoring system (McDaniel & Einstein, 2000). This model suggests retrieval of prospective memory tasks can be both through an ongoing, cognitive monitoring for the appropriate cues, and through an automatic triggering of the intention (McDaniel & Einstein, 2000). It is suggested that when a cue is strongly associated with the intended prospective memory task a reflexive associative process is utilised to prompt prospective memory (McDaniel & Einstein, 2000; McDaniel et al., 2004). Less associated and more important tasks utilise a monitoring attention system (McDaniel et al., 2004). Prospective memory is also more likely to be successful when a cue is strongly associated with the intention, such as may occur through regular associations or through conceptual similarities (McDaniel & Einstein, 2000). When greater attention is placed on monitoring time for a prospective memory task the task is more likely to be performed early, while when attention is required on the ongoing task the prospective memory task may be late or forgotten (Waldum & Sahahykan, 2013). It is thought that prospective memory tasks which are of importance to the person may be more likely to result in the effortful, ongoing monitoring to ensure the intention is performed (Dockree & Ellis, 2001; Kliegel, Martin, McDaniel, & Einstein, 2004; McDaniel & Einstein, 2000; McDaniel et al., 2004). Less important tasks may rely on automatic processes, and may be less likely to be remembered (Kliegel, Martin, et al., 2004; McDaniel & Einstein, 2000). It is thought that a metacognitive process is used to decide if they will automatically remember or need to monitor such as when the task will not be easily cued for automatic remembering (Kliegel, Eschen, et al., 2004).

It may be that event based prospective memory is relatively automatic with cues causing the prospective memory task to be automatically remembered (McDaniel & Einstein, 2000). In contrast time based prospective memory tasks may require a cognitive monitoring system to remember (McDaniel & Einstein, 2000). In time based prospective memory tasks individuals are thought to use an internal clock in order to keep track of the time elapsed (Waldum & Sahahykan, 2013).

Individuals will also use a memory component where possible to base time estimates from (e.g. song length) alongside attention strategies (Waldum & Sahahykan, 2013). In time-based prospective memory where the task is important attention is allocated to monitoring of time (Waldum & Sahahykan, 2013). A person with a high cognitive workload will have greater difficulty with prospective memory (Stone, 2001). Unsurprisingly, if a person is particularly engrossed or focussed on an activity there will be fewer resources available to interrupt this activity and alert attention towards a prospective memory task (McDaniel & Einstein, 2000).

Neurorehabilitation for Prospective Memory Deficits

Neurorehabilitation focuses on assisting in improving both the cognitive and social consequences of the brain injury (Tsaousides & Gordon, 2009). It is not limited to a discrete time-period and can be effective at any time post-injury (Tsaousides & Gordon, 2009; van Hulle & Hux, 2006). In order to be most effective neurorehabilitation needs to be a two way process whereby people involved in the care and support of a person living with TBI and the person with TBI work together (Wilson, 2002). There are two theoretical models for neurorehabilitation of prospective memory difficulties. Rehabilitation can focus on cognitive restoration, whereby a treatment (often intense practice) is thought to restore lost cognitive capacity (van den Broek, 1999). However, the primary approach in neurorehabilitation is compensation, in which residual skills are utilized to reduce the disability caused by cognitive impairment (van den Broek, 1999). These will be discussed separately.

Cognitive restoration

Cognitive restoration focuses on repeated practice to improve underlying connections in the brain (Raskin & Sohlberg, 2009). In prospective memory this involves practicing a task while gradually increasing time intervals between task assignment and task completion time (Raskin & Sohlberg, 2009). This has shown some efficacy (see Raskin & Sohlberg, 2009, for an example). However, the time period in which prospective memory tasks have been successfully completed is a maximum of 10 minutes (Fish et al., 2010; van den Broek, 1999). In daily life this would still result in disability as prospective memory tasks frequently would span longer than this time. Reviews of cognitive restoration literature have revealed improvements are not always maintained and do not necessarily generalise from the specific task to everyday life. They therefore recommend compensatory strategies over restoration (Cicerone et al., 2000; Cicerone et al., 2005; Fish et al., 2010; Rees, Marshall, Hartridge, Mackie, & Weiser, 2007; Sohlberg & Mateer, 2001).

Compensation

It has been recommended that rehabilitation should be focused on the consequences of the cognitive difficulty and in reducing disability due to the impairment (van den Broek, 1999; Wilson, 2002). Compensatory approaches work to amplify the use of previously learnt skills and remaining abilities to compensate for the cognitive difficulties which have occurred (Tsaousides & Gordon, 2009) and hence are focused on reducing disability.

Compensation can include internal memory aids, such as visual imagery and mnemonics, or external memory aids such as notebooks and asking others. The cognitive load of internal memory aids is often too great for individuals with TBI to manage, as it requires remembering to use the strategy and imagination to come up with, and to use it later (Sohlberg & Mateer, 2001; van den Broek, Downes, Johnson, Dayus, & Hilton, 2000). For this reason external memory strategies are more appropriate for individuals with TBI, as instead of increasing the cognitive load, external memory aids reduce cognitive load, likely a key part of why they have been shown to be more effective(Zencius, Wesolowski, & Burke, 1990). It has been argued that the rapid benefits of compensating is both more effective and simple than the extensive retraining which would be required to see a benefit from restoration strategies (Cicerone et al., 2000; Cicerone et al., 2005; Cicerone et al., 2011; Zencius et al., 1990; Zencius, Wesolowski, Burke, & McQuade, 1991).

Review studies recommend external memory aids for clinical practice for more generalised benefits than restorative approaches (Cicerone et al., 2005; Cicerone et al., 2011), with strong evidence for their benefits for every day memory compensation (Rees et al., 2007). They also provide more flexibility and are therefore more applicable to a broad range of memory difficulties and severities (Tate, 1997). Additionally, external memory aids allow for storage of large quantities of information, as well as providing cues to keep track of upcoming tasks (Ownsworth & McFarland, 1999). Optimal efficacy of a given aid occurs when its use generalizes; this can be assisted by providing sufficient practice in training and naturally occurring rewards (van den Broek, 1999). The cost of supplying and training an individual in the use of an memory aid is outweighed by the benefits of greater independence and integration as well as emotional well-being of the person, who therefore will require less assistive services in the long term (Bergman, 2002; Gillespie, Best, & O'Neill, 2012).

Several years after their injury, TBI patients who initially receive memory assistance after their injury use more memory aids than they had pre-injury (Wilson, 1992). Predominant strategies used after TBI include asking others to remind them (Olsson et al., 2006; Wilson, 1992), using notes, calendars and wall charts (Evans, Wilson, Needham, & Brentnall, 2003; Wilson, 1992). Wilson (1992) found less than half of individuals with TBI used an appointment diary pre-injury and no change after injury. More recently, and in a larger sample, Evans et al. (2003) found appointment diaries were used by more than half of participants after TBI, and asking others was used by just below half of the sample. In these studies, the use of electronic devices was in the minority (Evans et al., 2003; Olsson et al., 2006; Wilson, 1992). A more recent New Zealand study similarly found a preference for non-electronic memory aids despite the availability of electronic devices, although younger individuals with TBI were more likely to make use of electronic aids than older individuals with TBI (Mackie, 2008).

Integration of an aid into a person's life depends on a number of factors (Pape, Kim, & Weiner, 2002). This includes the performance of the device, and whether it assists in completing enjoyable experiences (Pape et al., 2002). Other important factors are the level of independence the user desires, the sense of control over the device and whether the self-image using the device is acceptable to the person (Pape et al., 2002). Failure to integrate a memory aid can also be due to personal beliefs about the use of a memory aid, such as that it will hinder recovery, or that using it is ‘cheating’ (Wilson & Watson, 1996). Other cognitive difficulties associated with a person’s injury (e.g., physical or sensory impairments) can also impact on use of a memory aid (McKerracher, Powell, & Oyebode, 2005).

Compensatory prospective memory aids are able to assist a person with prospective memory impairments in a number of ways. Recording the intention assists in improving encoding of the intention and therefore increases the likelihood of retrieval. Through referring to the memory aid tasks which may not have been retained during the delay can be refreshed, and finally, if desired the person can add notes to the reminder to assist in appropriate execution of the task. Electronic memory aids may be particularly useful for time-based prospective memory tasks, as the utilisation of an alarm means the person does not have to use their limited cognitive resources to monitor for time since a reminder will be provided. Event-based tasks may be improved through regular checking of the memory aid for reminders of prospective memory tasks.

Memory notebook

Traditionally a memory notebook has been used as an external memory aid in rehabilitation to compensate for prospective memory difficulties. Memory notebooks have demonstrated efficacy in remediation of prospective memory after TBI (Ownsworth & McFarland, 1999; Zencius, Wesolowski, Krankowski, & Burke, 1991) and are more effective than internal strategies such as rehearsal and acronym formation (Zencius et al., 1990), and therapy alone (Schmitter-Edgecombe, Fahy, Whelan, & Long, 1995). Training with a memory notebook can be effective long after the injury with success being shown at 15 years post-injury (Ownsworth & McFarland, 1999).

Whilst it may be common in the general population to use an appointment diary, acceptance of the memory notebook is often an issue. Efforts to increase portability and make the memory notebook more inconspicuous help, as does seeing non-injured people using similar appointment diaries (Fluharty & Priddy, 1993). Sohlberg and Mateer (1989) recognized provision of unsystematic memory notebooks and a lack of training in how to use them may contribute to individuals failing to continue to use memory notebooks outside of the clinical setting. Even when the individual accepts the notebook, an ongoing difficulty with memory notebooks is that the person with memory difficulties must remember to refer to the memory notebook in order to benefit from it. Electronic aids have the potential to overcome this difficulty.

Electronic memory aids

With the benefit of alarms to alert attention towards the memory cue at an appropriate time, electronic aids have potential advantages over paper-based memory notebooks (Kapur, Glisky, & Wilson, 2004). Several authors have investigated various forms of electronic memory aids for rehabilitation of prospective memory difficulties. A past survey of clinicians demonstrated the importance of clinicians' experiences with technology and their confidence in their ability to train a person to use the technology as a memory aid (Hart, O'Neil-Pirozzi, & Morita, 2003). At the time of the survey clinicians indicated common use of computers but not of portable electronic devices such as Personal Digital Assistants

(PDAs). As can be expected, those who were familiar with the use of PDAs were more confident in their ability to train someone in the use of it as a cognitive aid (Hart et al., 2003). Those clinicians who were confident in the use of a portable electronic aid such as a PDA were three times more likely to also use them with clients in neurorehabilitation (O'Neil-Pirozzi, Kendrick, Goldstein, & Glenn, 2004). In the case of PDAs it was not the personal use but the confidence in ability to teach the memory aid that was linked with use with clients (O'Neil-Pirozzi et al., 2004). It is feasible that as technology becomes simpler to use this relationship may change, where personal use of an electronic device is more strongly linked with confidence in ability to teach the use of the device as a memory aid, and hence with use in neurorehabilitation.

Neuropage is a paging system specifically designed to compensate for memory and executive function difficulties. Pre-programmed messages are sent at the appropriate time to a pager worn by the patient, accompanied by an audible tone and vibration (Wilson, Emslie, Quirk, Evans, & Watson, 2005; Wilson, Evans, Emslie, & Malinek, 1997). An initial group study demonstrated benefit of the Neuropage for all 15 participants (Wilson et al., 1997). In a large randomized controlled cross-over trial more than 80% of participants were significantly more successful in completion of everyday activities when using the pager than at baseline (Wilson, Emslie, Quirk, & Evans, 2001). The study showed that Neuropage improved the ability to perform set activities at the appropriate time for most participants, and for those where little or no benefit was seen generally there were other reasons such as intellectual deterioration or significant changes occurring outside of the trial (Wilson et al., 2001). This trial was reanalyzed to investigate only those who had a TBI, it was demonstrated the Neuropage improves performance in prospective memory tasks for this group (Wilson et al., 2005). Neuropage has also been shown to be effective in children and adolescents with memory difficulties (Wilson et al., 2009).

Results from trials in a community healthcare setting are more varied, although the majority of participants benefited for routine scheduled activities (Wilson, Scott, Evans, & Emslie, 2003). Regular reminders assist in the establishment of routines and can result in the individual no longer needing the reminder for that task as it becomes routine (Wilson, Emslie, Quirk, & Evans, 1999). Not only does Neuropage reduce prospective memory difficulties it also reduces carer strain as measured on caregiver questionnaire (Teasdale et al., 2009). Trials with more generic paging devices have similarly shown improvement in repetitive prospective memory tasks (Kirsch, Shenton, & Rowan, 2004).

While Neuropage is simple for the individual with TBI to respond to, it can take up to three days for a new message to be programmed through the Neuropage service provider, therefore only occasions known well in advance can be included in the Neuropage prompts (Fish et al., 2010). Messages cannot be cancelled if the user remembers ahead of time, or cancels an event (Wilson et al., 2003). Neuropage is a specialized service that is not internationally available—it is currently available in the United Kingdom at a price of £60 per month (The Oliver Zangwill Centre, 2013). While for some, wearing Neuropage may give a sense of prestige (Wilson et al., 1997) others may find a pager identifies them as different to the general population

(Wade & Troy, 2001). Therefore some researchers suggest technology in more general use is preferable (Wade & Troy, 2001).

Given the limitations in flexibility and availability of Neuropage, other electronic devices have been investigated as a memory aid. Gentry (2008) investigated PDAs as a memory aid within a community setting 1 year post-injury. After a maximum of 9 hours of training with the PDA, participants self-reported greater memory performance and satisfaction in occupational settings, along with a reduction of disability (rated on the Craig Handicap Assessment and Reporting Technique). De Pompei (2008) found PDAs to be effective in children and adolescents when events are programmed by someone else, and use continued to varying degrees 6 months after the trial (DePompei et al., 2008). The efficacy of PDAs has been demonstrated to be greater than the efficacy of other previously used paper-based memory aids such as notes and calendars (Gentry, 2008) and memory notebooks (DePompei et al., 2008; Fleming, Shum, Strong, & Lightbody, 2005).

To overcome the major deficit of Neuropage—that the user cannot program it—the Voice Organizer was developed (van den Broek et al., 2000). It allows users to verbally record a message and the time that it should be relayed. An improvement in randomly assigned tasks was seen using the Voice Organiser (van den Broek et al., 2000). Similar results were found in another study using a voice recorder, in which assigned tasks showed dramatic improvement when spoken messages were received at assigned times (Yasuda et al., 2002). In this study messages were recorded by the researcher and played out loud at the correct time for participants (Yasuda et al., 2002).

A case series of three participants's demonstrated computers or laptops with individually custom-designed software can be used to assist the individual to complete their own scheduling and to remember tasks (Cole, Dehdashti, & Petti, 1994). A case study of a microcomputer in an inpatient setting demonstrated immediate improvement in attending appointments when programmed by staff, as well as satisfaction from the individual with TBI with the increased independence (H. Kim, Burke, Dowds, & George, 1999). This improvement occurred after ineffective attempts at using a memory notebook (Kim et al., 1999), again suggesting electronic aids such as microcomputers are more effective than memory notebooks and other paper-based aids. Long term follow-ups 2-4 years after training with microcomputers in a rehabilitation service found seven of 12 continued to use microcomputers and the remaining participants wished to resume use (H. Kim, Burke, Dowds, Boone, & Parks, 2000). Cost was a prohibitive factor for two of the participants who had not continued to use the microcomputer (H. Kim et al., 2000).

Based on reviews and theory, several requirements for an ideal technological memory aid have been suggested. This includes the ability for the aid to be individualised to the strengths and weaknesses of the person (LoPresti, Mihailidis, & Kirsch, 2004), portable with long battery life and sufficient storage capacity, and simple to use (Kapur et al., 2004). One study specifically suggested the ideal memory aid would have the reminder functions of a PDA with the addition of mobile communication and email facilities (Kapur et al., 2004). Recent developments in mobile technology present smartphones as a device meeting these functional requirements, while being relatively simple to use through touch screen technology. In light of these advances Gillespie et al., (2012) predicted the increasing use of smartphones and their portability would make them a useful tool in neurorehabilitation. The particular advantage they pointed out was the ability for smartphones to be modified to suit an individual through applications and additional tools, whilst maintaining the primary neurorehabilitation features of storing information and providing reminders.

There is little research utilising smartphones, although a few have investigated the use of mobile phones. Wade and Troy (2001) delivered computerised calls to cell phones with a voice message when answered. This resulted in improvement in task completion, with four of the five cases included reaching 100% completion after 12 weeks (Wade & Troy, 2001). Participants reported they liked the mobile phone, while caregivers reported enjoying not having to remind the person throughout the day, and knowing they could contact the person if required (Wade & Troy, 2001). One difficulty was that one participant who benefited had to withdraw due to an inability to control excessive phone call use and was unable to manage the large bills which followed (Wade & Troy, 2001). The more recent introduction of pre-pay billing plans for mobile phones should overcome this problem. Stapleton, Adams and Atterton (2007) looked directly at the reminder function on mobile phones for improvement in a set of routine targets specific to the individual. Improvements were variable, with two of five demonstrating improvement and three not showing significant improvement. These three had more severe impairments and were unable to live independently (Stapleton et al., 2007). As seen in other studies, when the phone was removed the gains continued for a period, suggesting routine tasks were learnt with the reminders and were maintained even without the reminders. Overall improvements were of a similar effect size to that seen in the Neuropage studies (Stapleton et al., 2007), probably reflecting the similarity to Neuropage, with the phone acting as a paging device.

Other studies have used mobile phones to less directly assist goal related activity. One study used goal-related text messages sent to participants three times daily for 2 weeks, and this demonstrated better memory for goals and motivation towards their goal (Culley & Evans, 2010). Even just texting the word "STOP" to participants is enough to allow participants to stop and review goals and improve memory for goals, even though the message does not provide a cue to the goal (Fish et al., 2007). In this study one participant had previously attempted to use a PDA on her own, with the same operating system as the smartphone, emphasising the importance of formal training particularly using errorless learning and fading out instructions (Svoboda & Richards, 2009).

Mackie (2008) provided Nokia 60 Smartphones to six individuals with brain injury to investigate the ability to benefit from mobile cues. It was demonstrated that individuals with TBI were able to learn to use the smartphone and respond to reminders entered by others, resulting in most cases in an improvement in task performance. In some, but not all, cases improvement was over and beyond that seen using paper based memory aids (Mackie, 2008). Two case studies have demonstrated the efficacy of the scheduler on a smartphone as a compensatory memory aid, with task completion rate increasing in both cases, and dropping to baseline or below with smartphone withdrawal (Svoboda & Richards, 2009; Svoboda, Richards, Polsinelli, & Guger, 2010). The improvements in task completion lasted at least 4 months following the treatment, and participants were able to generalize to other memory difficulties they were faced with (Svoboda & Richards, 2009; Svoboda et al., 2010). The authors extended this with a larger study investigating both PDAs and smartphones. All ten individuals with TBI benefitted both on target task measures, questionnaires and family reports, and improvements were maintained 3-8 months later (Svoboda, Richards, Leach, & Mertens, 2012).

Recently the combination of Google calendar accessed from a computer, and reminder messages sent automatically via text message to personal mobile phones (of any type) was assessed as a memory aid after TBI (McDonald et al., 2011). Google calendar is a freely available internet based calendar system and can be set up to send reminder text messages to any mobile phone. McDonald et al. (2011) found this combination more effective than a memory notebook and reported the added advantages of ease of use, ability to add repeating events and attach notes to reminders, and ability for the individual to learn to add their own events in their own time were particularly useful.

There are a variety of potential study designs that can be of use when studying the efficacy of external memory aids after TBI. Potential study designs and the selection for the current research are outlined.

Study Designs

Health clinicians in many disciplines, including those working in neurorehabilitation, are guided by an evidence based practice model. Under this model, treatments must be supported by research findings providing good quality evidence for their efficacy as well as cost effectiveness in comparison to other available and effective treatments (National Health and Medical Research Council, 1998). In an evidence-based practice model, clinicians also use their clinical judgment to decide if an evidence based treatment is suited to their individual client (Haynes, 2002). Therefore, when designing or evaluating research, both the quality of research design and applicability to a clinical setting needs to be considered. Choi, Ryu, Yoo and Choi (2012) suggest a ranking system for grading evidence on both quality of the methods and relevance to clinical questions. Additionally, research should consider not only the primary measured target, but other changes that the client may experience, such as in quality of life (National Health and Medical Research Council, 1998) or subjective improvement in the absence of significant measured change.

Randomised controlled trials (RCTs)

In any single study, RCTs are rated as the highest quality of evidence (Bandelow, Zohar, Kasper, & Mollier, 2008; Logan, Hickman, Harris, & Heriza, 2008; National Health and Medical Research Council, 1998, 2009; Slade & Prieve, 2001; Tate & Douglas, 2011). Randomization reduces bias based on selection, and differences between comparison treatment groups (e.g., treatment versus control) both for factors researchers may be aware of, but also other factors (Tate & Douglas, 2011).

In psychology, conducting experiments in this way is often difficult as some variables are not easily measured or manipulated; therefore, accurately determining the efficacy of a treatment is difficult (Slade & Prieve, 2001). It has been recognized that there are constraints in measuring outcomes and in blinding of treatment categories in psychological research. Guidelines for classifying levels of evidence recognize this and reiterate that other research designs should not be overlooked (National Health and Medical Research Council, 1998). Further, even when methodologically possible, the ability to conduct RCTs in areas such as brain injury may be limited by difficulties in recruiting sufficient numbers of participants to achieve suitable statistical power to have a meaningful result (Tate & Douglas, 2011). Experimental studies often aim to establish a causal effect on a treatment. To do this, strict inclusion criteria are often applied to remove extraneous variables that may alter the outcome. For example, in a TBI population, research could set inclusion criteria based on anatomical location of the injury, severity, type of injury, cause of injury and a variety of other factors. A population of people who have experienced a severe frontal lobe with blunt injury due to a fall may have different outcomes in a research trial to the population of individuals with TBI as a whole. Further, as participants are generally volunteers, they may differ on important variables such as motivation for change, level of insight into their difficulties, and help seeking behaviour. As a result, extrapolating such findings to the remaining population with the same general disorder will not necessarily result in the same success rate due to limited external validity (Simon, 2001). According to Slade and Prieve (2001) if RCTs are adopted as the only source of good evidence in mental health settings the evidence base will be skewed. Evidence should be collated from a number of sources rather than taken from RCTs alone.

Single subject designs

While RCTs are commonly seen to be the gold standard in experimental research, a well designed single subject design also provides strong causal evidence of efficacy of a treatment (Kratochwill et al., 2010; Perdices et al., 2006). Single case studies were designed for clinical settings (Lundervold & Belwood, 2000). They may be particularly valuable in neurorehabilitation settings where the effects of a brain injury can vary widely (Perdices & Tate, 2009).

For these reasons it has been suggested a single subject design could be used for research in the TBI population (Kratochwill et al., 2010; Logan et al., 2008; Perdices & Tate, 2009). Individual differences in efficacy between participants are obscured into group means in an RCT. In a single case design these individual differences remain apparent. This allows researchers to further investigate factors that may contribute to a treatment working in one person, but not another (Kratochwill et al., 2010).

A well-designed single subject design should be prospective (Tate et al., 2008), and include manipulation of an independent variable as well as strategies to control for other variables that could influence change (Kratochwill et al., 2010; Perdices & Tate, 2009; Tate et al., 2008). With each participant acting as their own control, and measures before, during and after the treatment, causality is more evident

(Kratochwill et al., 2010). There should be at least three phases such as baseline, treatment and withdrawal (Kratochwill et al., 2010) with a minimum of three measure points in each phase (Kratochwill et al., 2010; Logan et al., 2008; Lundervold & Belwood, 2000; Perdices & Tate, 2009). Before providing the treatment, the baseline should be seen to be stable (Logan et al., 2008; Perdices & Tate, 2009). Following each participant closely allows researchers to track whether changes occur due to the treatment or concurrent factors (Logan et al., 2008), while replication across subjects strengthens the evidence that change is due to the treatment. This increases the validity of the study and allows patterns of change to be seen (Perdices & Tate, 2009). Where possible a withdrawal phase should be included as this demonstrates change is due to the treatment and reduces internal validity threats (Kratochwill et al., 2010). Staggering the baseline length across participants increases internal validity by demonstrating change is due to the treatment rather than non-specific or maturation changes (Kratochwill et al., 2010). Where more than one treatment is being compared, allocation to treatment group and to baseline length should be randomized to prevent selection bias (Kratochwill et al., 2010; Logan et al., 2008). Finally, there should be more than one assessor, and inter-assessment agreement should be demonstrated (Kratochwill et al., 2010).

Qualitative Designs

With quantitative experiments as the gold standard in research design, qualitative research has been negatively depicted in the literature (see Sandelowski, 2000 for a review). In quantitative studies, areas of potential change must be determined prior to beginning the research so suitable measures can be incorporated into the design. In qualitative research, whatever happens during the study can be described and hence included in the data (Sandelowski, 2000). This allows for changes that had not previously been predicted to be brought into light. Qualitative research can explore how changes occur and the impact of these changes from a person's perspective. In neurorehabilitation not only is the statistical significance, or magnitude of a measurable change important, but the clinical relevance or impact the change has on a person's life is also important (Perdices & Tate, 2009). Here, a small or statistically insignificant change may be of great clinical or personal significance for the person.

Qualitative research often takes a specific methodological approach to interpret and understand data. Sandelowski (2000) argues that there is also room for qualitative research which does not fit to a specific methodological theory, whereby the data is simply described rather than interpreted. In this method, of qualitative description, the data are described without interpretation or in-depth search for underlying meaning. With this method, multiple researchers and participants themselves should agree that what is described is what happened, irrespective of their own understandings of meaning or importance of the description (Sandelowski, 2000).

The use of a mixed methods design is beneficial as qualitative description can be used to understand what happened in a quantitative study. This allows information to be gathered about what was helpful and unhelpful, and for data driven opinions to be developed to guide how research and clinical practice could continue.

Research Quality in Neurorehabilitation

The Psychological Database of Brain Impairment Treatment Efficacy (PsycBITE, 2012) lists all quantitative studies investigating non-pharmacological treatments in acquired brain injury. Studies are given grades based on methodological strength using the PEDro-P (Physiotherapy Evidence Database) scale for controlled trials (Physiotherapy Evidence Database, 2012) and the SCED (Single Case Experimental Design) scale for single case design (Tate et al., 2008). Both scales provide a design quality grading, with a maximum of ten points. An evaluation of all studies in PsycBITE revealed 39% of the research in TBI is single subject designs and 21% RCTs (Perdices et al., 2006). This trend continued in the following years (Perdices & Tate, 2009). Using their database to search for research with adults with TBI and prospective memory difficulties retrieved 43 studies, 15 of which had been graded at that time; of these, the highest ranked study received a 7/10 grade (PsycBITE, 2012). It is not unexpected that neurorehabilitation research fails to achieve higher scores, as criteria such as blinding of the participant and the researcher are not possible with the types of treatments being assessed. The National Health and Medical Research Council of Australia (1998) recognize that much research in the public health and social sciences sectors will inherently be unable to reach higher levels of evidence as expected of other fields such as pharmaceuticals.

Rationale for the Study

Suffering a moderate-severe TBI has long term and extensive implications for the person’s ability to participate in everyday life, as well as implications for the family and community. Large scale outcome studies have reasonably consistently shown poor rates of return to employment after TBI. One study found just 17.8% of participants with TBI had gained paid employment one year after injury (Novack, Bush, Meythaler, & Canupp, 2001). Return to work continues to be low between two and five years after TBI, with failure to return to employment ranging from 30% (Dikmen, Machamer, Powell, & Temkin, 2003) to 53% (Fleming, Tooth, Hassell, & Burchan, 1999). This reflects a change in unemployment rate from 18% pre-injury to around 42% five years after TBI (Dikmen et al., 2003). Reports of total reliance on income from sources other than employment (e.g., family or welfare support) represent a large proportion of the TBI population, with 25% in one study (Dikmen et al., 2003) and 30% in another (Mazaux et al., 1997). For those who do return to work, this may not be the same as previously, with these individuals working in lower levels and/or taking lower pay (Dikmen et al., 2003). Individuals who were not in employment at the time of their injury also have difficulties gaining employment subsequent to their injury, with 63% of these individuals remaining unemployed. Employment remains low in the much longer term, with a 10-20 year post-injury follow up study demonstrating 40% of severe TBI patients remained unemployed, compared to an unemployment rate of 10% in the general population at that time (Hoofien, 2001). Similar to the five year follow up studies participants were found to be in unskilled jobs (73% of employed participants) and many in a sheltered or voluntary work environment (39% of employed participants). Just 14% of participants in one study indicted their main income was from employment, 59% relied on injury related allowances and 24% had a mixture of injury allowances and income. Fortunately only 4% relied on family for income (Hoofien, 2001).

People with TBI not only have difficulties securing employment but also in reintegrating into their community. Deficits on community integration are seen at one year post injury (Novack et al., 2001). Deficits continue to be seen at five years' post injury and include difficulties in management of finances and other administrative tasks, as well as access to transportation and difficulties planning their day (Mazaux et al., 1997). These difficulties were seen in 20% of one studies sample, with a further 9% suffering deficits to an extent where full-time supervision was required (Mazaux et al., 1997). The social circle of people with TBI is smaller than that for others. It has been shown that one third of these people report having no friends, and a mean social network size of four people, including family members (Hoofien et al., 2001). Sadly a small proportion (8%), indicate they have no support from friends or family (Hoofien et al., 2001). Individuals with TBI are less likely to be married and more likely to divorce than others in the general population (Hoofien et al., 2001).

A key contributor to difficulties in returning to pre-injury function is deficits in memory. Individuals with TBI report both greater levels of memory difficulties and greater distress about these difficulties than non-injured controls (Olsson et al., 2006). Self reports of memory deficits indicated a difficulty in at least 40% of moderate and severe TBI patients 2 years post-injury (Hellawell et al., 1999) and 71% 5 years after injury (Olver & Ponsford, 1996). One reason for the apparent increase in memory difficulties with time is that the memory difficulties are less noticeable during acute rehabilitation, but become apparent as the person attempts to resume their pre-injury functions (Hellawell et al., 1999). Difficulties are also present in organisation and planning for 47% of individuals five years on from their injury. Prospective memory difficulties are a likely impact of TBI (e.g., Vakil, 2005 for a review). Prospective memory is required for important tasks of daily living such as attending appointments and taking medication, keeping up with bill payments, personal care as well as smaller tasks such as remembering a grocery item (see Shum, Fleming, & Neulinger, 2002 for a review). Almost half of individuals with TBI report requiring more prompting to complete tasks (Olver & Ponsford, 1996) and 60% require partial or full assistance from others in their daily activities (Dikmen et al., 2003). Prospective memory relies on functions of the prefrontal lobes such as planning and initiation, and hence is often impaired as TBI frequently damages the prefrontal lobes (Shum et al., 2002). Due to the sudden change in memory abilities individuals with TBI are prone to overestimating their memory capabilities (e.g., as similar to pre-injury) and therefore underutilise strategies to improve memory (Knight, 2005).

Memory and executive function deficits have been associated with poor long term overall outcome (Mazaux et al., 1997). Several authors have attempted to quantify both the cost of TBI, and the savings to be made through effective TBI rehabilitation. While there is extensive variation across studies and methods of quantifying, the general consensus is that TBIs represent a large financial cost and there is financial benefit in engaging the person in rehabilitation (see Humphreys, Wood, Phillips, & Macy, 2013 for a review). These studies often do not take into consideration the indirect costs often taken by the family, or the personal impact for the individual with TBI. The current research outlines a relatively inexpensive rehabilitation technique to specifically compensate for long-term prospective memory deficits.

As noted earlier, neurorehabilitation research has demonstrated that external compensatory memory aids are the more effective tool for rehabilitation for prospective memory deficits. Whilst the traditional memory notebook has demonstrated efficacy, it is limited by the need for the individual with memory difficulties to remember to refer to it in order to benefit. Further, there have been difficulties with acceptance within the TBI population, whereby individuals with TBI do not wish to carry or use the memory notebook. In acknowledgement of these limitations, several electronic devices with audible reminders have been trialled. These have been shown to be more acceptable than the memory notebook and have the significant advantage of not drawing attention to the use of a memory aid.

As previously outlined, theory suggests a simple to use integrated portable electronic device would be best for neurorehabilitation purposes. Recent developments in smartphone technology mean that devices are now available which appear to meet these theoretical requirements. Further, that smartphone use is rapidly growing in the general population means that it is more likely to be accepted as a memory aid. With touch screen technology making use of smartphones simpler than some other devices, there is the possibility that not only would individuals with TBI be able to learn to respond and benefit from reminders but they would be capable of entering their own reminders and using the smartphone independently within a community setting. Therefore, this study aims to investigate the use of smartphones as a memory aid for prospective memory difficulties after TBI and compare it to a paper-based memory notebook.

New Zealand has an incidence rate of 48/100,000 person years in individuals over the age of 15 years suffering a moderate to severe TBI (Feigin et al., 2013). Thus there are approximately 2,100 new moderate or severe brain injuries in this age group each year. With the expected rate of unemployment and difficulties in reintegrating into daily activity outlined above being partially due to prospective memory difficulties, the potential benefits of an effective compensatory memory aid may be extensive. This study utilises a relatively inexpensive memory aid and limited clinician's hours, with the potential to assist an individual to reintegrate into their daily life, and potentially improve employability and community integration. The greater independence would have a pay-off to family members and support services involved in this person's daily care.

Before a new device is commonly used in clinical practice it is important for research to investigate whether the device is able to be effectively utilized by individuals who have suffered a TBI (de Joode, van Heugten, Verhey, & van Boxtel, 2010). In the case of memory aids, it anecdotally appears that clinical use is often being made of new devices in advance of such information on efficacy; this of course only heightens the importance of conducting such research.

Research Objectives and Hypotheses

The primary objective of this research was to establish whether individuals with moderate to severe TBI could learn to use and benefit from reminders on a smartphone as a memory aid. The specific research questions and hypotheses relating to this objective were:

1. *Is the smartphone an effective memory aid for individuals living with memory difficulties after TBI?*

Based on previous literature and developments in smartphone technology it was expected that most individuals with TBI would be able to learn to enter tasks into their smartphone and respond to the reminder notifications.

2. *Is the smartphone more effective than a paper-based memory notebook?*

It was expected that the smartphone would be more effective than the memory notebook for compensating for prospective memory difficulties after TBI. This was based on the limited previous literature which suggested that this was the case. Further, the advantages of audible reminders, increased portability and likely greater acceptability of the smartphone indicated this would be more effective than the memory notebook.

3. *Do participants living with TBI report the smartphone to be helpful, irrespective of measured changes in ability to manage memory difficulties?*

It was expected that participants would find both the memory notebook and the smartphone helpful memory aids, but that the smartphone would be rated more helpful.

A secondary objective was to gain data-driven knowledge about the process of implementing a memory aid with individuals living with TBI. This was to be used to make clinical and research recommendations. These research questions are outlined below. As these were to be assessed qualitatively through interview and observation no hypotheses are provided.

4. *What changes do participants report when using a memory aid?*
5. *What features of the memory aid and training are helpful?*
6. *What difficulties with the memory aid and training are likely to occur?*

The third and final objective was to assess whether potential improvement in management of prospective memory difficulties would result in more general improvements for the person living with TBI:

7. *Does mood improve with potential changes in ability to manage prospective memory difficulties after TBI?*

It was hypothesised that as ability to manage memory difficulties after TBI improves through use of a memory aid, mood would improve.

8. *Does provision of a memory aid to manage memory difficulties after TBI result in improved integration in the household and community?*

It was expected that when a person living with TBI was provided with a way to better manage memory difficulties they would become more independent and more involved in their household and in the broader community.

Research Overview

This thesis addresses the research questions outlined above, using data collected from single case experimental design with a series of people with moderate to severe TBI. Data collection included both quantitative measures as well as qualitative information obtained through clinical interview and direct observation. The thesis takes the format of dissertation by publication, in accordance with Massey University regulations. This thesis contains two chapters presented in a format ready for publication. For readability, figures and tables in these papers have been left in-text. In addition, table and figures numbering continue from previous sections; this would be altered before submitting for journal publication. Page numbers continue throughout the thesis. Repetition of material between thesis chapters and chapters written as a paper has been minimised as much as possible but repetition of introduction and method sections was unavoidable.

The thesis begins with the current introductory chapter. Chapter 2 presents the methods of the study in its entirety. Chapter 3 is the first paper, which presents quantitative results on efficacy of the memory aids. Chapter 4 presents supplementary results that were beyond the scope of the papers. This paper is in thesis format and does not duplicate material contained in other chapters. Chapter 5, the second paper, presents qualitative data-driven recommendations for clinicians and researchers who are considering implementing smartphones as neurorehabilitation aids. Finally, Chapter 6 concludes the thesis with a discussion of the main findings of the research, relevance to literature in this area, as well as outlining the limitations of the research and areas for future study.

The candidate conducted all components of the research. The second and third authors of the papers presented in this dissertation were research supervisors. The candidate prepared the full draft of the version of the manuscript presented in the dissertation and supervisors' comments and input to the manuscript have been to the same of extent as the usual thesis chapter supervision input.

Chapter 2: Methods

Design

This study aimed to compare a paper-based memory notebook and smartphone. The study design was based on the understanding that a randomised controlled trial (RCT) would provide the best evidence of treatment efficacy, but that with a population group of Traumatic Brain Injury (TBI) patients there would be the potential of insufficient numbers for group statistical analysis. Therefore,a single case series was selected as the most appropriate study design for the population of interest. The Single Case Experimental Design scale (SCED; Tate et al., 2008) was used to guide the research design.

Criteria from the SCED scale for single case design informed the design. Interrater reliability can be established for both an individual and a consensus rating. For the SCED this is excellent in both cases, with .85 (95% CI .73-.92) for individual raters interclass correlation and consensus ratings interclass correlations of 0.88 95% CI .78-.95. Item reliability was .48 to 1.0 for consensus ratings. Content validity was assessed through experts in the field designing the scale, testing and discussing the ability to rate single case research using the scale, and the ability to differentiate between obviously good quality and poor quality research, as determined by experts in the field of rating quality of research (Tate et al., 2008). Below the criteria set on the SCED are listed and the degree to which the study was able to meet these criteria briefly outlined:

- A clinical history including age, sex, aetiology and severity of the injury- Information regarding each of these areas was collected for all participants.
- Target behaviours operationally defined and measures of target behaviour outlined- Target behaviour was prospective memory and measured by questionnaire, assigned memory tasks and clinical interview.
- Sufficient sampling in baseline- A baseline of a minimum of three points was included for all participants, with options to extend if stability was not established.
- Sufficient sampling in treatment- All participants had eight weeks of sampling during treatment.
- Raw data was reported- Weekly performance on both assigned memory tasks are shown for all participants.
- Statistical analysis- Effect sizes were calculated for change between phases for all participants
- Replication either across subjects, therapists or setting- The study was replicated across seven participants, two with the memory notebook and all seven participants with the smartphone.
- Evidence for generalisation- The personal use for activities independent to the research was assessed. The majority of participants entered tasks not related to the research in their memory aids, and reported improvements in performance on these tasks.

Some SCED criteria could not be met in the current research, these criteria and reasons for not being met are outlined:

- ABA or multiple baseline design- A three phase design was not incorporated as it was felt a true washout period was not justified as it would involve taking the persons primary mobile phone away from them (not simply the memory aid). It also could not be ensured that participants would not make an attempt to either replace or replicate the memory aid in some form or another. The use of a memory aid for regularly scheduled activities may assist them to learn a routine. This may become a habit for which the person no longer requires a memory aid, and therefore would not return to baseline levels of forgetting during the washout period.
- Interrater reliability established for at least one measure of target behaviour- As part of a Doctorate the primary researcher was to carry out all components of the research therefore there was a single rater.

In addition to the formal measures qualitative information was gathered through semi-structured interviews, directly asking participants about their memory strengths and weaknesses, the use of their assigned memory aid, whether it had been helpful and difficulties which occurred. Additional qualitative information was collected through discussing the task completion logs, structured interviews, and from answers to questions for the message task administered as part of the quantitative measures.

Participants

Participants were recruited through local agencies working with individuals who had suffered a brain injury. This included one non-acute rehabilitation service, one acute rehabilitation service, one community support group, and a Psychology clinic attached to the university. A media release about the study with contact details for volunteers was used to attempt to reach a wider audience (see Appendix 2). Additional agencies, including a residential rehabilitation service, two Māori health providers, inpatient rehabilitation services and private practices were contacted but could not assist with recruitment, in most cases as their clientele would not meet criteria of the study.

Inclusion criteria were:

- Suffered a moderate or severe TBI at least 2 years prior to entering the study. Severity measures were based on post-traumatic amnesia period, loss of consciousness time or Glasgow Coma Score. Moderate injuries were defined as a post traumatic amnesia period of 1–7 days, loss of consciousness of 30 minutes to 24 hours, or a Glasgow Coma Score of 9–12. Severe injuries were defined as a posttraumatic amnesia period of more than 7 days, loss of consciousness of more than 24 hours or a Glasgow coma Score of 3–8. Where multiple levels of severity were reported, the most severe measure was taken.
- Self-report of everyday memory difficulties.
- Over the age of sixteen at the time of their injury,
- Be out of posttraumatic amnesia, and have no current psychosis.
- Scores on effort testing indicated adequate effort

- Currently not consistently and systematically using a memory notebook/diary or smartphone as a memory aid [1] (after recruitment with this exclusion criterion was exhausted, those who made systematic and consistent use of a memory notebook/diary were included in the study and assigned to the smartphone treatment). Prior consistent and systematic use of a smartphone always resulted in exclusion.

A total of nine of the 17 potential participants screened met criteria for the study. These participants were aged 26 to 62 years. Three participants had sustained moderate TBI and six a severe TBI. Two participants with severe TBI withdrew during baseline. One withdrew due to increased working hours preventing attendance for appointments. The other due to severe depression, which was a treatment priority and he did not have the finances to fund travel to both a therapy and a research appointment on a regular basis. The eight other participants were recruited and completed the initial assessment but did not meet criteria. Two participants reported memory difficulties in the initial phone contact but not in person; both had behavioural disinhibition rather than memory difficulties as a deficit. Two participants were unable to supply sufficient evidence of a brain injury. One other potential participant made extensive use of the calendar function on an iPad, and yet another of the calendar on an Android smartphone. Two made extensive use of a memory notebook and so were excluded from the initial recruitment round, and were unavailable when this exclusion criterion was removed. Two additional participants agreed to participate, one cancelled her

[1] This was operationally defined as using a memory aid structured into dates, which they used in the same manner at each use, and used on a daily basis.

appointment due to medical issues and these became ongoing so she was unable to participate, the other asked to be called back to confirm a booking time but the only number he had went directly to voicemail from this point onwards, no response was made to a letter to his last known address.

The researcher contacted an additional 14 participants who declined to participate for a variety of reasons. These were, no longer being in the area (3), physical limitations (1), severe aphasia (1), no indication of memory difficulties (2) systematic and consistent use of or smartphone (3), or for personal reasons (4). Multiple attempts were made to contact other participants identified by clinicians as potential participants, this included posting an invitation letter to the last known address of a further eight participants. None of these participants responded.

Contact in response to the media release was received from six potential participants. None of these participants were able to participate, one due to being based in America (having seen an online version of the media release), one being more interested in the research itself rather than from a participant view, and the remaining four having either acquired brain injury (i.e., stroke/tumour) rather than TBI, or having memory difficulties other than prospective memory as the main memory difficulty. Finally, two additional potential participants were referred after the study was completed.

Full demographic details of the final participants are presented in the method section of the quantitative paper presented in the next chapter. A flow chart of the recruitment process and participant numbers is shown in Figure 1.

Recruitment through local agencies: Random Assignment and Matching	
Seven participant assessed and eligible for main study (two later withdrew) Eight additional did not meet criteria after initial assessment Two matching pairs formed, one of which was broken when a participant withdrew	Two participants interested and eligible for the study loss of contact prior to attending initial assessment Fourteen additional participants contacted by phone and either declined to participate or clearly did not meet criteria for the study

⇩

Recruitment through local agencies: Assignment to smartphone	
Two additional participants included in the study. One previously assessed and excluded due to use of a memory notebook, and one new.	Two others previously assessed and excluded due to use of a memory notebook were invited to participate but declined at this time due to other commitments

⇩

Media Release: To Reach a Wider Audience	
No additional participants included	Six responses which did not meet criteria

⇩

Recruitment Closed (after 10 months)	
Final study numbers were nine who completed the study, and two which withdrew during baseline	Two referrals from locality agencies after recruitment closed

Figure 1. Flow chart of recruitment process

Measures

Psychometric measures

Test of Memory Malingering

The Test of Memory Malingering (TOMM; Tombaugh, 1996) was selected as a standard measure of memory testing effort commonly administered in neuropsychological assessments where there is potential benefit for low effort. In the current study participants could consciously or unconsciously score low on memory testing in order to receive clinician time and a memory aid. Excluding those who put in insufficient effort means apparent improvement on memory testing across assessment points could not be attributed to increased effort. The TOMM has suitable psychometric properties. The TOMM is able to discriminate between control groups, healthy individuals simulating malingering, and TBI patients who are, and are not likely to malinger (Tombaugh, 1996). The TOMM has demonstrated 100% specificity and 93% sensitivity (Tombaugh, 1996). Participants who demonstrated insufficient effort in the TOMM were excluded from the study and therefore no parallel measures were required. Cut-off criteria defined by the publisher were used in making this determination. For reasons of test security, these are not detailed here. Readers are referred to the test manual for more information (see Tombaugh, 1996).

Rivermead Behavioural Memory Test

Underlying prospective memory needed to be assessed to ensure any change in memory function was due to compensating for memory deficits rather than an improvement in the underlying memory deficit. The Rivermead Behavioural

Memory Test–II (RBMT-II; Baddeley, Wilson, & Cockburn, 2003a) was selected as the measure of underlying prospective memory function. It is specifically designed for testing everyday memory performance in individuals living with brain injury. It has excellent interrater reliability (e.g., overall score agreement of 100% across ten raters of 40 subjects), good parallel form reliability and test-retest reliability (r = .83-.88 and r = .85 respectively; Baddeley, Wilson, & Cockburn, 2003b). Validity measures indicate the RBMT-II is sensitive to memory deficits after brain injury, and has positive correlations with other memory measures (e.g., r = .63 with word subtest Recognition Memory Test for Words, r = .62 with the paired associate learning subtest and, r = .28 with Corsi block; Baddeley et al., 2003b). The RBMT-II is designed to assess everyday memory performance rather than specific aspects of memory. Importantly the RBMT-II has respectable correlation with observational measures of prospective memory (r = - .75; Baddeley et al., 2003b)—lower scores on the RBMT-II correlated with higher rates of observed memory lapses. Similarly, Baddeley et al., (2003b) reported correlations between the RBMT-II and self (r = -.44) and other (r = -.57) reports of prospective memory (though did not specify what the prospective memory measures were). Cronbach's alpha has been assessed in the Chinese version (α = .86; Wai-Kwong & Li, 2002) , and although apparently not assessed in other versions it is likely to be similar.

The RBMT-II was used in the current study to assess memory impairment. With four parallel forms, a different form was used at each of the key assessment points to reduce practice effects. Two participants had five assessment points and so the first version was repeated (by this point approximately one year had passed since the first version was administered). The ratings of memory capacity (normal–

severely impaired) were used as indicated in the test manual, using the standardized score classifications; as the authors indicate this gives a more reliable measure of memory capacity than screening scores. In deference to the New Zealand population in the study, the orientation item, “Who is the prime minister of Britain?” was changed to the prime minister of New Zealand.

The Comprehensive Assessment of Prospective Memory

A measure of current memory function was needed to assess for changes in prospective memory function through compensation with a memory aid. The Comprehensive Assessment of Prospective Memory (CAPM; Shum & Fleming, 2012) was selected as a measure of prospective memory. The CAPM comprises three sections a self and caregiver report of *frequency* prospective memory function (Section A), the perceived *importance* of the memory items (Section B), and *reasons* for forgetting and remembering (Section C). It has reliabilities of α = .74 for basic activities of daily living, α = .92 for instrumental activities of daily living and α = .94 overall (Chau, Lee, Fleming, Roche, & Shum, 2007) . The CAPM has two week test-retest reliability of r = .76 for the overall memory difficulties score, with r = .77 for instrumental activities of daily living items and r = .74 for basic activities of daily living items in general population (Chau et al., 2007). When used as an informant measure the CAPM can discriminate between TBI and control groups for both basic activities of daily living scores (TBI M = 1.65 SD = .59 vs controls M = 1.4, SD = .36; t = 1.97, p < .05) and instrumental activities of daily living (TBI M = 2.25 SD = .72 vs controls M = 1.89, SD = .49; t = 2.33, p < .05; Roche, Fleming, & Shum, 2002). The self-report version did not demonstrate discriminative ability reflecting a lack of insight into memory difficulties in the TBI group (Roche et al., 2002). Scoring of

Section A and B was completed according to Chau et al. (2007) providing a mean score of the items endorsed. The scoring manual also indicated using a mean score for Section C, with high scores indicating agreement with reasons for remembering *and* forgetting. For this current study agreement with reasons for forgetting was considered more useful, therefore items relating to agreement for reasons for remembering were reversed score. This resulted in a higher mean score on Section C indicating greater agreement with reasons for forgetting.

Although shorter prospective memory tests are available than the CAPM, the CAPM was chosen as it assesses *frequenc*y of prospective memory failures, the perceived *importance* of these tasks, and information about *reasons* the person forgets. Collecting information about the importance of prospective memory tasks to the person is valuable, as intuitively, forgetting something that the person sees as important reflects more severe functional difficulties than forgetting a task that is not seen as important. Collecting information about reasons for forgetting is important as changes from previous memory strategies, such as asking others can be expected as a person begins using a memory aid and would be reflected in this measure. Both the self-report and caregiver report versions of this test were collected if possible.

Community Integration Questionnaire

As more general outcome measures are recommended in the literature (e.g., National Health and Medical Research Council, 1998) the Community Integration Questionnaire (CIQ; Willer, Rosenthal, Kreutzer, Gordon, & Rempel, 1993) was selected as it measures a person's independence and involvement in the community. The Cronbach's alpha for the total score in the CIQ self-report measure is good (α = .84; Corrigan & Deming, 1995). Test retest reliability over 10 days is high both for self-report (*r* = .91) and family report (r = .97; Willer et al., 1993). Total scores on the CIQ and Craig's Handicap Assessment and Reporting Technique showed statistically significant correlations (e.g., r = .72 between productive scale of CIQ and occupation scale of Craigs Hanidacap Assessment and Reporting Technique; Willer et al., 1993). It has suitable discriminative ability with mean total scores of TBI (*M* = 13.02, *SD* = 6.02) significant lower than controls (M = 20.71, SD= 3.21; p < .001; Willer et al., 1993).

A critical review of studies investigating the CIQ demonstrates variation in reliability and validity and a lack of suitable norms (Dijkers, 1997). The CIQ is a brief measure, and is focused on integration rather than independence in self care which is closely linked to physical limitations. For this reason the CIQ was selected as most suitable for this research. The total scores rather than home integration, social integration and productive activity subscale scores were used as recommended by the developer (B. Willer, personal communication, December 1, 2011). Measuring participation and quality of life is important as irrespective of the magnitude of change in memory change a change in outcome is clinically important.

Depression Anxiety and Stress Scale – 21 item Version

A measure of depression was included since depressive symptoms could accentuate memory deficits and intuitively depressive symptoms may improve with increased ability to cope with memory difficulties and greater independence. The Depression Anxiety Stress Scales 21 item version (DASS-21; Lovibond & Lovibond, 2004) was used as a measure of mood. The DASS-21 is a shortened version of the original full 42-item questionnaire. The DASS-21 findings are correlated with the full

DASS pattern of scores and so are comparable (r = .85; Antony, Bieling, Cox, Enns, & Swinson, 1998) . The DASS-21 has good internal consistency for the total score (α = .93) and its subscales, the Depression scale (α = .88), Anxiety scale (α = .82), and Stress scale (α = .93; Henry & Crawford, 2005). The DASS-21 Depression scale correlates with the Beck Depression Inventory (r = .79), and the DASS-21 Anxiety scale with the Beck Anxiety Inventory. The DASS has been shown to discriminate between control groups, groups under greater stress due to physical illness, and clinical populations (Lovibond & Lovibond, 2004). It is useful for monitoring changes in levels of depression, anxiety and stress across time (Lovibond & Lovibond, 2004). Intuitively it seems depression, anxiety and stress may all be relevant to individuals dealing with deficits in every day memory. Conversely, major changes in mood could at least partially explain alteration in functional memory performance. While a pre-post measure of mood will not provide a causal explanation for whether a change in mood occurred as a result of memory performance change, or whether memory performance changed as a result of mood, qualitative data from interviews may help identify these changes if they occurred.

Functional measures

Memory tasks

Participants were provided with two tasks at the end of each appointment- one scheduled task, the other unscheduled. The scheduled task was to either call or send a text message (*message task)* to the researcher at a specified time and answer a specific question (see Appendix 8). The day of week and time was randomly assigned with available times being between 9am and 8.30pm Monday-

Friday. The assigned time had some room for flexibility around participant's schedules and if the task was not completed at the appropriate time it was made clear that it was acceptable for participants to complete it at another time and provide an explanation for why it was not possible at the appropriate time. Participants progressed through a series of questions relating to the study.

For the unscheduled To Do task participants were provided a postage-paid postcard (*postcard task;* see Appendix 8*)* and asked to send it before the next week's appointment (one week). This is based on the message task from the RBMT-II and has been used similarly in other studies of prospective memory (such as Kinsella et al., 1996; J. Mathias & Mansfield, 2005).

These two tasks were designed to mimic real life situations and provide a measure of prospective memory. These provided quantitative measures of performance according to whether they were completed, whether they were on time, and whether the message related to the assigned question. Qualitative information was also gained from the answer to the phone task message if completed.

Performance on these memory tasks was rated by the researcher. In the *message task,* completion time was deemed the most important aspect of the phone call task and so was given a higher weighting. This decision was based on the idea that in real-life it would be more important that a person is on time for scheduled tasks (e.g., attending appointments, calling people at an appropriate time) than knowing what the meeting or call was about. This was based on the idea that once the task is initiated (i.e., the person has arrived at the appointment or made the phone call) cues may be available to assist them in knowing what the meeting was regarding (content), and if not, the person may be able to ask directly. In the *postcard task* an additional day was allowed for the maximum score for completion within a week to allow for delays within the postal system. Percentage performance was calculated. The scoring system is outlined in Table 1.

Table 1. *Scoring criteria for message and postcard memory tasks*

	Criteria	**Score**
Message task	Sum of *Message Time* and *Message Content*	(Max. 9)
Message time	Within an hour of assigned time	6
	Same day as assigned time	4
	Completed any time	2
	Not completed	0
Message content	Clear answer to assigned question	3
	Answer may relate to question but unclear	2
	Answer relates to memory or memory aid	1
	Answer not related to memory or memory aid	0
Postcard task	Completed within a week	2
	Completed any time	1
	Not completed	0

Task completion log

Daily memory performance was measured using a task completion log (see Appendix 3). This was based on the techniques used in other studies of prospective memory (e.g., DePompei et al., 2008; McDonald et al., 2011; Wade & Troy, 2001; Wilson et al., 2001; Zencius et al., 1990) but custom designed for the current study. The task log was a self-report measure of memory. Participants were asked to record both scheduled and unscheduled tasks ahead of time, and to then put the task log out of sight. At the end of the day they were to record whether they remembered to do the tasks, whether they were on time for scheduled tasks, and the strategy they used to remember the task. Participants were to complete this each day throughout the study. The task completion log would provide both quantitative and qualitative information. There would be a quantitative measure of percentage completion of tasks and raw number of tasks completed. Qualitatively, changes in the type of task being completed and strategy for remembering could be seen. For example, a participant could demonstrate no alteration in memory performance on quantitative measures but could have changed from relying on others to remind them to using their memory aid as a prompt, and this would still be a clinically important change.

Likert Rating Scales

To detect other potential changes in the areas of mood, independence and self-esteem—as well as gain quantitative ratings about the use of the memory aid—Likert rating scales were used. The purpose of these ratings was to provide quantitative evidence of changes. Collection of these ratings was based on the preliminary hypothesis that as memory performance and independence increases mood may also become more positive. Changes in mood are clinically important, in terms of overall wellbeing. Likert rating scales were selected as they provided a quick quantitative measure of a variety of emotions, which could therefore be measured on a weekly basis. This extended beyond the clinical measures of depression and anxiety as measured in the DASS-21 and addressed emotional states that the researcher selected as being potentially relevant for these participants. These included various emotions (sad, happy, tense, confused, angry, frustrated, lonely, and cheerful). It also included level of independence, and self-thoughts taken from various measures of self-esteem (I feel: good about myself, useless, like a failure, satisfied with myself, worthless, like a burden, I have good self-esteem).

Likert ratings were also used to assess the memory aid throughout the study (How helpful has your memory aid been this week?), during training (How did you find learning to use your memory aid?), and at the end of the study and follow up (How likely would you be to recommend your memory aid to others with memory difficulties after a brain injury? Would you say your ability to remember tasks has improved using your memory aid? Overall how helpful is your memory aid?). See Appendix 7 for a full list of the questions and the rating scales used.

Materials

The primary functions of both the memory notebook and smartphone were to assist memory. As much as possible parallel features were incorporated into each memory aid. They were each to have a calendar for scheduled tasks, and To Do list for unscheduled tasks. They needed to have a section for contacts to be stored, and allow for grouping of contacts to assist memory. They needed to be easy to use, acceptable and portable.

Memory notebook

The memory notebook was custom designed for this research, based on literature, advice from clinicians in the field, and practical constraints in designing an individualized, professional and sturdy notebook. Commercially available scheduler diaries frequently contain pages of information designed for business executives. Unnecessary sections have the potential to confuse individuals who have memory and executive function deficits after TBI. Meanwhile, such commercially produced diaries do not contain enough space to include all the valuable information a person with these deficits might need. It was therefore decided that a memory notebook would be designed specifically for this research. Careful design of the memory notebook to meet this group's needs was undertaken to minimise any differences between the memory notebook and smartphone treatment that might otherwise be due to inappropriate memory notebook selection.

The memory notebook contained four main sections, informed by Sohlberg and Mateer (1989). The primary researcher identified the 'calendar' and 'things to do' sections as most critical to manage prospective memory deficits. The 'orientation' and' names' sections were identified as being particularly useful to clients with TBI in clinical practice by a senior clinician experienced in neuropsychological rehabilitation (Personal Communication, Professor Janet Leathem 22nd June 2011). The order of content was the *Orientation* section, *Schedule* and *To Do* section, *People* section (previously called names by Sohlberg and Mateer (1989)) and *Notes* section. The overall memory notebook, the contents of each section divider, and sample pages from each section are presented in Appendix 4.

The main component of the memory notebook was the *Schedule* section. The *Schedule* section combines two of Mateer and Sohlberg's (1989) suggested sections: Calendar and Things To Do. This was based on the findings that combining schedule and To Do lists, so both lists are visible without changing sections, therefore eliminating the memory requirement to check both sections throughout the day, is more effective than the traditional format (McKerracher, Powell, & Oyebode, 2005). The current *To Do* list was always adjacent to the current date. The first task was printed on all *To Do* pages and was to copy any unfinished tasks to the current page. The Monday-Thursday schedule was shown on the left page, and *To Do* for Monday-Thursday on the right. Friday-Sunday schedule was printed on the right, with its matching *To Do* list on the left. This format was selected so participants could more easily see the entire week by lifting the *To-Do* pages perpendicular. It also meant both pages of the weeks *To Do* list were printed on a single sheet of paper, which could be removed from the book when completed if the participant desired.

The *Orientation* section included pages where participants could include important relatively unchanging information about themselves, their work, medical care and groups that they attend.

The section traditionally called 'names' was renamed '*People'* to reflect the content of the section; this included a space to write the person's name, contact information, birth date, where the participant knows them from, and a space to write additional notes such as identifying features or other information important for the participant. There was also a box in which to attach a picture of the person. To assist participants finding specific people, the overall people section was divided into three parts with their own tabs. Additionally, each page was headed up with a title for the group to allow for subgroups. (For example, a participant could have a section tab titled 'friends' and within the section could have subgroups such as 'soccer friends' and so on.)

The *Notes* section was left blank to allow as much individualization as possible.

Clinician experience was that people using a memory notebook benefited from having instructions for each section written on the section divider (Professor

Janet Leathem, personal communication, 22 June, 2011). Instructions were printed on the front of each section divider as well as an overview to the entire memory notebook printed on card as the first page. The need for memory notebooks to be as individualized as possible was also emphasized during this consultation. In clinical practice this clinician would individually construct memory notebooks with clients, starting from an empty binder. A compromise was made between complete individualization and sturdy design by having diaries designed and printed specifically for people with TBI and the inclusion of an extra section titled “Notes” with lined paper which could be set up to fit a participants individual needs.

To increase acceptance, the memory notebook had a plain cover with no logo or writing to identify it as being a memory notebook for neurorehabilitation. Two colours of cover were available, red and black to increase individualisation and a sense of ownership of the memory notebook. Section dividers with printed tabs were included to assist changing between sections of the memory notebook. Spiral binding was preferred to allow the memory notebook to sit flat on the table. To assist with re-locating the current date, a marker ribbon was attached. Additionally, a pen attached to another ribbon was sewn to the diary ensuring participants would not have to remember to carry a pen when they took their diary.

Having decided on the content and features for accessibility, practical considerations for the construction of a portable and sturdy memory notebook were also considered. The printed and bound notebook was A5 page size (148 x 210 mm; 5.8 x 8.2 inches), 20mm thick and weighed 580g to balance between maximum portability and visibility of the content. Plain coloured 280gsm card with heavy duty laminating was used for covers. Section dividers were 240gsm white card with heavy duty lamination and tabs. Heavy duty 100gsm paper was used to minimize the risk of pages tearing out with general use. Wire binding was used for strength, and allowed unwanted pages to be torn out if desired. If desired by the participant a clear plastic sleeve was securely taped into the inside of the back cover of the memory notebook to be used as needed. Potential uses included, but were not limited to, recording of instructions for work activities, maps of important routes, and bus timetables.

Smartphone

Several criteria were identified for selection of a smartphone. Firstly, it had to be simple to use, had to have a cloud-based calendar, a To Do list, contacts list that could be arranged into groups, and an ability for the location of the smartphone to be found (in case it is lost). Additionally, to generalise use in the wider TBI population, it needed to run on a widely available operating system and be relatively affordable for those who may have financial difficulties after injury. These features could be met through either selection of the handset or through installation of applications (programmes for smartphones). The smartphone allows for four icons to remain on a task bar across the bottom of the screen. These were set up left to right as calendar, contacts, messaging and task list.

As with the memory notebook, the primary feature for the smartphone was the calendar. The calendar was to enter tasks which were to occur at a scheduled time, and provide an audible alarm to alert attention towards the smartphone, which would display the details of the task. It was also thought that having a display of the day’s events on the home screen would assist participants both to plan their day, and remind them to make use of the calendar for new appointments. To meet these requirements Google Calendar was used as the primary component. Google Calendar allows entry of tasks at a set time, as well as allowing additional information including location and notes to be added. There are several options for repeating events (e.g., daily, weekly, annually) reducing the number of events a person has to enter for a routine activity. Google Calendar can be set to have a default reminder time (e.g., 45 minutes before the event) and the user can change or add in additional reminders. Google Calendar is a cloud based service, therefore data and/or wireless access is required to allow automatic backup of the contents of the calendar. This is important as it means should the smartphone settings be altered, or the smartphone lost, broken or replaced the calendar entries can be recovered onto either the same smartphone, or a new Android based smartphone, without loss of data. Additionally items could be added through online access from any internet accessible device.

To allow repetition of reminders if they were missed the first time, and to allow snoozing of reminders should the participant be unable to respond at that time the CalendarSnooze (Bitfire-development, 2011) application was installed. This would allow continual repetition of reminders until a response was made. It also included several snooze intervals which would allow participants to delay the reminders whilst finishing one task, knowing they would be reminded of the next task again. To display the contents of the calendar on the home screen the Simple Calendar widget (MYCOLOURSCREEN, 2011) was used. This allowed the days appointments to display on the home screen, and disappear after the allotted time was completed. It also allowed display of to the To Do list.

GTasks (Dato, 2011) was selected as the To Do list. This was in part because of the simplicity to use, and partly for the ability to make more than one list (e.g., to do list and shopping list). GTasks also works in with the online version of Google calendar whereby tasks are saved online with cloud-storage to Google calendar, and tasks entered from Google Calendar tasks synchronised to GTasks on the smartphone. It also worked with Simple Calendar widget allowing display of tasks on the home screen.

To assist with finding contacts when memory for names was difficult, a contact manager which allowed grouping was required. For example a person could create a group of people they would be likely to meet at a community group they attend, all those who are family, people from work, or any other category that would help the person find contacts. The onboard contacts manager for the smartphone in this study did not have this feature, and therefore GoContacts EX (Go Dev Team, 2011) was used. This incorporated the contacts list and phone dial pad into one program and had the benefit of being able to include as many numbers, email and home addresses into a single contact as needed. It also had the ability to select contacts as 'favourites' for quick access.

The SlideIT (Dasur Ltd, 2011) keyboard was installed as an alternative keyboard. This was primarily on the basis that the keyboard could be enlarged and additionally was highly customizable allowing additional features to be removed (such as settings and language keys) and ability for participants to easily turn predictive texting on and off with a single screen touch. Finally, Where's My Droid (Alienman Tech, 2011) was installed in case a participant should forget where they left their smartphone. This application can be remotely activated by sending a code word to the smartphone via text message. This can turn on full volume ringtone, and send a GPS location of the smartphone to the sender's phone.

To support the main criteria for a suitable smartphone, the handset would need to be touch screen, for simplest use. The touch screen needed to be reasonably responsive to touch inputs and have good screen clarity. The smartphone needed to be wireless capable to assist synchronisation of calendar and To Do data. It would need GPS for smartphone location if it should be lost.

The LG Optimus One p500 was the handset selected for the study. It met the above criteria for handset selection and retailed at $250NZD at the time of purchase (January 2012), making it relatively affordable. It had similar technical specifications to smartphones retailing in the $400-500 price bracket at the time. It came installed with Android 2.3 Gingerbread. It was 113mm x 59mm in dimensions and 13.3mm thick. It had a 3.2" 320 x 480px capacitive LCD touch screen. It came with a 2GB SD card which could be upgraded to 32GB. It had a 600MHz central processing unit and 512MP RAM, running on Li-ion 1500mAH battery with 5 hour talk time and up to 450 hours standby. It was Wi-Fi and GPS capable. Images of the smartphone are presented in Appendix 5.

Procedure

A flow chart of the procedure is outlined in Figure 2 and each component explained in full in text.

Initial contact

Initial contact with potential participants was made either by the recruitment agency or the primary clinician, as selected most appropriate by the organisation.

One organisation completed the initial consent process prior to the researcher making contacting. Other agencies provided contact numbers of interested participants to the researcher. The community support group was recruited through both the provision of numbers through the agency and through the primary researcher attending the group meeting. The university Psychology clinic allowed potential participants to be identified by the primary researcher (who was completing psychological studies through the clinic and therefore allowed access to client information), and the primary clinician was approached for permission for the researcher to make contact with the participant.

The initial contact by the researcher was by phone call. The call primarily involved describing the study and what would be involved as the participant. The participant was asked about the cause of the injury and for any initial evidence that indicated severity of injury. Memory difficulties were discussed to identify whether prospective memory was an ongoing difficulty, and memory strategies were briefly discussed. In order to avoid excluding participants who described use of a memory notebook or smartphone in most cases participants were offered to attend an initial assessment session and to bring their memory aid. In this way participants with a memory notebook who did not systematically and consistently use it were not excluded in error.

Initial assessment

Potential participants were screened for eligibility (as per the criteria described in the participants section of this chapter) for the study during an initial assessment. The initial assessment could take up to 3 hours, allowing time for breaks to manage fatigue. The study was described in detail and any questions addressed. Informed signed consent was gathered (see Appendix 1). Participants were then interviewed about their memory difficulties, and asked to provide examples of these. They were then asked about the strategies they used to manage their memory difficulties. Participants were asked about a number of memory aids people may have such as calendars, black/whiteboards, diaries, smartphones, tablets, PDAs and computers. This was completed using a checklist in order to keep the participant blind to the treatments included on the list (see Appendix 7 for interview questions). Following the interview formal measures were administered.

Initially the TOMM was administered first, to rule out insufficient effort prior to formal memory testing using the RBMT-II. However, it was found that some items in the picture recognition task of the RBMT-II overlapped with the TOMM. As it was deemed the RBMT-II was most important, it was subsequently administered first. Participants then completed the CAPM followed by the CIQ and the DASS-21. These questionnaires could be completed either with the researcher reading them and writing the answers or the participant doing so themselves. This was particularly important to manage fatigue.

Matching and randomisation

Baseline weeks

During the first baseline week participants were assisted to identify potential target tasks that they may encounter during the week. This included reviewing the CAPM and the initial interviews, examples of common memory difficulties, and a run through of a typical day and what might be forgotten during those days (see

Appendix 7). Participants were instructed in how to use the task completion log (see Appendix 3), with emphasis being placed on it being a recording instrument to keep track of how their memory is using their current strategies (if any). Participants were provided their first *message task* and *postcard task* (see Appendix 8 for full list of *message tasks* and image of the *postcard task*).

In subsequent baseline interviews participants were interviewed about their memory over the week using semi-structured interview (see Appendix 7). The Likert ratings were then completed. For most participants the baseline interviews lasted less than an hour.

Baseline lengths were randomly assigned as per above. Participants could be in the study for baseline lengths of 3, 5 or 7 weeks. In all baseline lengths the first 3 weeks participants were required to attend appointments, were given the memory tasks and asked to record their memory on the task completion log. The requirements for week 4 depended on stability of the task completion log data. Where there was more than 50% variability on the task completion log across the initial 3 weeks the data was considered unstable. For all baseline lengths unstable data resulted in a 4th week of completing an appointment, task completion log and memory tasks. The 3 week baseline therefore could be extended to four weeks if the data was unstable. The 5 week baseline included appointments, memory tasks and the task completion log during weeks 1-3 and week 5, with week 4 included if the data was unstable. The 7 week baseline included recording on week's 1-3, week 5 and week 7 but could also include week 4 for unstable data. Therefore all baseline lengths included the first 3 weeks of baseline, and the final week before moving to the treatment.

Care was taken in the baseline not to reveal what the memory aids were until the end of the final baseline interview, at which point participants were informed and asked to bring information to assist in setting up the memory aid (e.g., SIM card, any calendar information or appointment notes). At the end of each appointment the two functional memory tasks were assigned to be completed before the next week's appointment. If they did not spontaneously do so, participants were prompted each week to enter these tasks into their memory aid. (Initially, "How are you going to remember?", then "Where could you record that?", and finally "Let's put it in your memory notebook/smartphone.")

Training and Treatment

Training and treatment took place over 8 weeks for all participants. The first two weeks were considered the primary training period. During the first two weeks of training participants attended additional sessions completing a minimum of 4 hours and maximum of 8 hours of training. Training took an errorless learning approach. Participants were first instructed on the importance and rationale of the errorless learning approach. The researcher explained each step and demonstrated on their own memory notebook or smartphone to allow the participant to complete each step for themselves. If the participant was unsure they were prompted to either ask the researcher or to refer to the appropriate place for instructions. For the memory notebook, instructions for each section were on the front of the section divider (see Appendix 4). For the smartphone, an instruction booklet with written instructions and a screenshot of each step was provided by the researcher (see Appendix 5).

Initially the researcher demonstrated each step and gave verbal instructions. As participants mastered each step the level of instruction and cuing was gradually reduced. The initial focus was to teach the overall structure and use of the memory aid, followed by the *Schedule*/Calendar (memory notebook and smartphone respectively), then the To Do list. Once use of the *Schedule*/Calendar and To Do lists could be completed independently the majority of the time, participants were taught to use the Contacts list and other features of the memory aid. An acquisition chart was developed based on Sohlberg and Mateer's (2001) recommendations for memory notebook training to track progress (see Appendix 6). A parallel form was developed for the smartphone treatment that was as similar as possible to the original (also presented in Appendix 6). Whilst the majority of training occurred in the first two weeks, additional training was provided as required throughout the treatment period.

The treatment period included weekly meetings as per the baseline, the *message task* and *postcard task,* likert ratings and semi-structured interview. The interview included additional questions regarding the extent of use of the memory aid, aspects which were helpful or unhelpful, and any difficulties that occurred (see Appendix 7).

The final treatment appointment took up to two hours, and included the usual activities of the treatment appointments as outlined above. Further questions were added to the interview to assess what they had found helpful about the memory aid and study more generally, what they would change, and how they would redesign their memory aid if they could (see Appendix 7). Participants were then asked to complete the RBMT-II, CAPM, CIQ, DASS-21. Participants were then able to keep their memory aids to use independently.

Follow up

Participants were asked to return for a follow up appointment between two and four months after the end of the main treatment. During this appointment a semi-structured interview was used to gather information about the use of the memory aid in the intervening months, where it was helpful and unhelpful and any difficulties that had occurred (see Appendix 7).

Participants also completed the Likert rating scales, as well as the RBMT-II, CAPM, CIQ and DASS-21. After completion of follow-up, participants who initially received the memory notebook were offered to continue in the research and receive the smartphone treatment. These participants proceeded to the 8 weeks of training and treatment with the smartphone after the follow-up week, and completed a second follow-up 2–4 months after completion of this second treatment phase. As smartphones were the primary memory aid of interest, and were expected to be the most effective, those who received the smartphone initially were not offered the memory notebook.

This study was approved by Central Regional Health and Disability Ethics Committee.

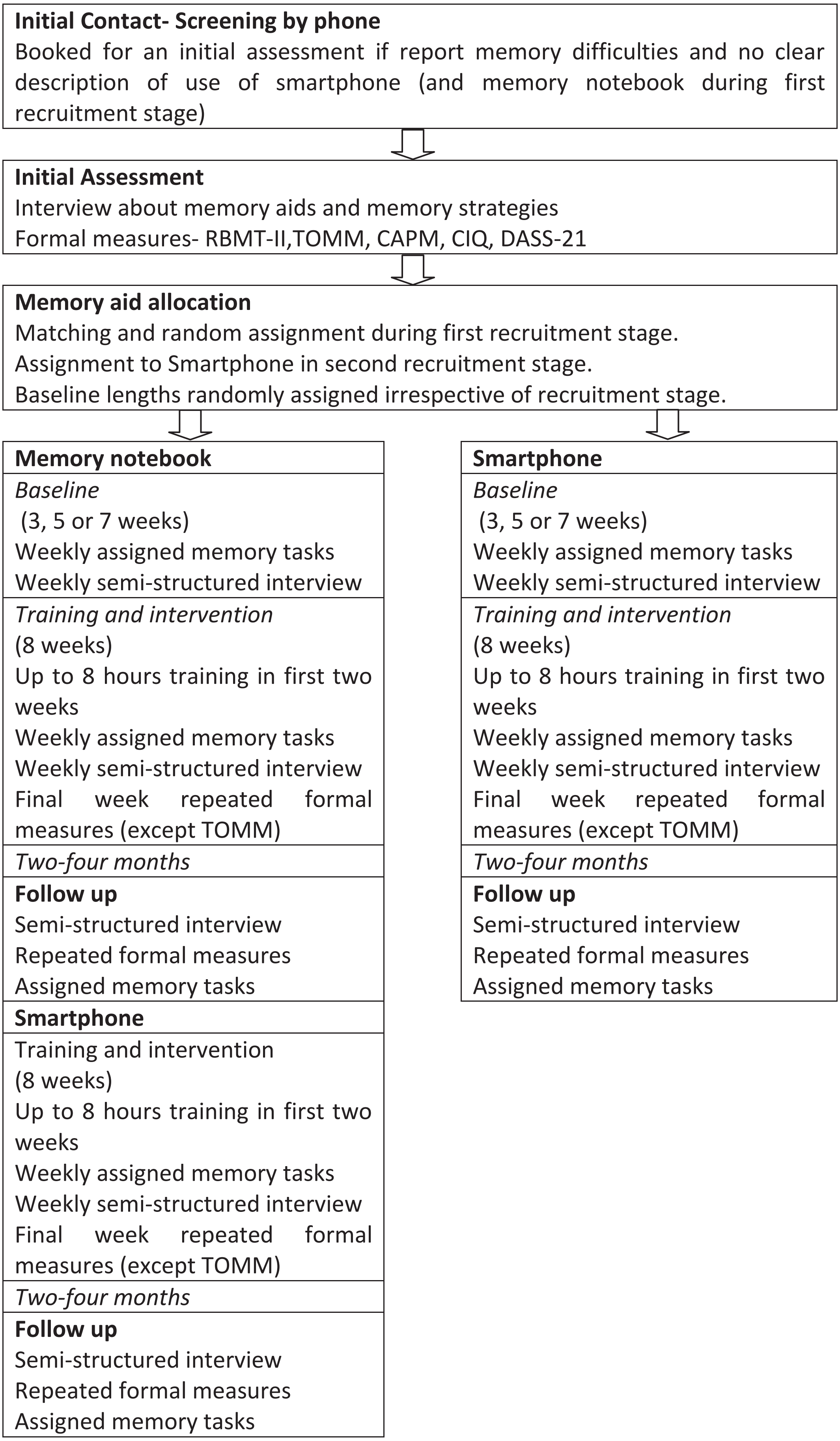

Figure 2. Flow chart of procedure

Chapter 3 Efficacy Results

This chapter takes the format of a paper prepared for submission to a journal. The data presented relate to the efficacy of the memory aids. To aid reading in the format of the thesis page numbers, table and figure numbering continue from previous sections. In-text citations have been included for the overall thesis reference list and are also shown for this paper alone. The introduction and methods sections are selected information from Chapter 1, and the relevant methods from Chapter 2 for this paper. While this results in significant duplication, it is included to show the paper in the form which will be submitted for publication.

DRC 16

MASSEY UNIVERSITY

GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
TO DOCTORAL THESIS CONTAINING PUBLICATIONS

(To appear at the end of each thesis chapter/section/appendix submitted as an article/paper or collected as an appendix at the end of the thesis)

We, the candidate and the candidate's Principal Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

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Efficacy of Memory Aids after Traumatic Brain Injury: A Single Case Series

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Abstract

Individuals living with traumatic brain injury commonly have difficulties with prospective memory—the ability to remember a planned action at the intended time. This can result in difficulties managing everyday functioning and increased reliance on others. Traditionally a memory notebook has been recommended as a compensatory memory aid. Electronic devices have the advantage of providing a cue at the appropriate time to remind participants to refer to the memory aid and complete tasks. Research suggests these have potential benefit in neurorehabilitation. This single case series investigates the efficacy of a memory notebook and specifically a smartphone as a compensatory memory aid. Participants using a smartphone showed improvements in their ability to complete assigned memory tasks accurately and within the assigned time periods. Use of a smartphone provided additional benefits over and above those already seen for those who received a memory notebook first. Four of the seven participants learnt to use the smartphone with ease, while others had difficulty. However, despite difficulties all but one of these participants still benefitted from the smartphone. Smartphones have the potential to be a useful and cost effective tool in neurorehabilitation practice.

Prospective Memory after Brain Injury

Prospective memory — the ability to remember to perform a planned action at the intended time— is a critical component of everyday functioning. Deficits in prospective memory are common sequelae of traumatic brain injury (TBI) and have devastating effects on a person's ability to be independent, and increase carer burden (Sohlberg & Mateer, 2001). The use of external memory aids is recommended over both cognitive restoration techniques (Cicerone et al., 2000) and internal memory aids, as these are either not maintained or do not generalise to everyday life (Sohlberg & Mateer, 2001). External memory aids compensate for memory deficits while loading as little as possible on valuable cognitive resources such as executive functions (Sohlberg & Mateer, 2001). The cost of supplying and training an individual in the use of a memory aid is outweighed by the benefits of greater independence and integration as well as emotional well-being of the person, who therefore will require less assistive services in the long term (Bergman, 2002).

Memory Notebook

Traditionally a memory notebook has been the preferred external memory aid method in rehabilitation to compensate for prospective memory difficulties. It allows individuals to schedule tasks which must be completed at a set time such as appointments, and tasks which need to be completed with no set time ('to do') such as chores. Memory notebooks have demonstrated efficacy in remediation of prospective memory after TBI (Ownsworth & McFarland, 1999; Zencius, Wesolowski, Krankowski, et al., 1991), and are more effective than internal strategies such as rehearsal and acronym formation (Zencius et al., 1990) and therapy alone (Schmitter-Edgecombe et al., 1995). Steps to make the memory notebook more inconspicious as a memory aid and more portable assists in gaining acceptance of the memory notebook (Fluharty & Priddy, 1993). A limitation of the memory notebook is that individuals with TBI with memory difficulties must rememer to refer to it in order to benefit from it. Electronic memory aids with reminder functions have the potential to overcome this limitation.

Electronic Memory Aids

A variety of electronic memory aids have shown potential as external memory aids after brain injury. These include the specifically designed paging system Neuropage (Wilson et al., 2009; Wilson et al., 1999; Wilson et al., 2005; Wilson et al., 1997; Wilson et al., 2003), Personal Digital Assistants (DePompei et al., 2008; Gentry, Wallace, Kvarfordt, & Lynch, 2008), and automated systems sending messages or calls to mobile phones (Culley & Evans, 2010; Fish et al., 2007; Wade & Troy, 2001). Reviews of cognitive aids have been reported elsewhere (e.g., Cicerone et al., 2000; Cicerone et al., 2011; de Joode et al., 2010; Gillespie et al., 2012).

A limitation of the Neuropage device is inflexibility, since messages must be provided to the Neuropage service in advance (Wilson et al., 2005; Wilson et al., 2003). A similar limitation is encountered using automated systems to provide text and phone messages, which tend to be most useful for routine activities. Patients with brain injury prefer a memory aid that they are able to operate independently which allows storage of information which is both personal to them and not routine (Bergman, 2002). The ideal electronic memory aid would be able to be individualised (LoPresti et al., 2004) yet easy to use, and would integrate the functions of a calendar and reminding service with additional features such as cell phone functionality, email access, high portability and long battery life (Kapur et al., 2004).

A few studies have used electronic memory aids that are in wide use in the general population. For example, one utilised the freely available Google calendar, teaching individuals and caregivers who had access to both a computer and mobile phone to enter tasks into the calendar on their home computer. Google would then send a text reminder at the appropriate time. This reminder system was found to be successful for target tasks and was more effective than a standard diary (McDonald et al., 2011). In other studies, individuals with brain injuries have learnt to use the scheduler on smartphones as a memory aid using training based on errorless learning and fading cues. In each of these studies individuals with moderate-severe TBI have demonstrated improvements in completion of prospective memory tasks using the smartphone (Svoboda & Richards, 2009; Svoboda et al., 2010; Svoboda et al., 2012).

As smartphones have continued to develop and become simpler to use (e.g., through the interface flexibility offered by touch screen technology) it has become more apparent that these devices meet the criteria from Kapur et al. (2004) and LoPresti et al. (2004) outlined above. The widespread use of these smartphones in the general population leads these to be a normalising and likely more acceptable memory aid, if individuals living with TBI can learn to use them. If these people are able to benefit from using a smartphone as a memory aid the potential impact is large. Given the clinician and client time commitment and costs involved in provision and training of a memory aid, it is important for clinicians to know the likely efficacy of their treatment and whether a new treatment poses any benefit over traditional and less expensive paper-based memory aids. Further, it is important to know whether these memory aids are effective in a community setting since much of the research investigates improvements within rehabilitation services. The current study investigated the efficacy of a memory notebook, and more specifically a smartphone as a memory aid after TBI. It was expected that both memory aids would be effective, but that the smartphone would be *more* effective.

Method

Participants

Participants were nine males aged 26 to 62 years, who had suffered moderate to severe TBIs at least 2 years prior to recruitment. They were recruited through local agencies working with individuals who have suffered a brain injury. Severity measures were based on post-traumatic amnesia period, loss of consciousness time or Glasgow Coma Score. Moderate injuries were defined as a post traumatic amnesia period of 1–7 days, loss of consciousness of 30 minutes to 24 hours, or a Glasgow Coma Score of 9–12. Severe injuries were defined as a post traumatic amnesia period of more than 7 days, loss of consciousness of more than 24 hours or a Glasgow coma Score of 3–8. Moderate and severe injuries were included as they are more likely to result in long term difficulties for the person. Where multiple levels of severity were reported, the most severe measure was taken. All participants were out of post traumatic amnesia, had completed acute rehabilitation, had no evidence of psychosis and reported everyday memory difficulties. They demonstrated sufficient effort on effort testing as measured on the Test of Memory Malingering. Initially participants were excluded from the study if they already demonstrated consistent and systematic use of a diary or memory notebook (i.e., if they had a structured way of using the notebook, which they applied the majority of the time). Once recruitment was exhausted with these criteria, potential participants who already made consistent and systematic use of a memory notebook were also recruited into the study—these participants were provided with a smartphone. Prior consistent and systematic use of a smartphone always resulted in exclusion.

Seventeen participants completed the initial assessment, with nine meeting criteria and continuing into the main study. Of the nine participants who entered the main study, two withdrew, one due to increased work commitments during baseline, following five missed appointments and the other participant due to severe depression and the inability to fund transport. A summary of the demographics those who completed the study is shown in Table 2.

Table 2. *Summary of demographics of participants shown for the memory notebook group, the smartphone group and for participants as a whole.*

Demographic	Memory notebook group	Smartphone Group	Total Group
Age: Mean, Range	38.5yr, 25-52yr	56.5yr, 48-62	51.4yr, 25-62
Injury Severity	1x Moderate, 1x Severe	1x Moderate 4x Severe	2x Mod, 5x Severe
Cause of injury	1x fall, 1xmotor vehicle	1x fall, 4x motor vehicle	2x fall, 5x motor vehicle
Time since injury: Mean, range	2 years, 2 years	11 years, 5-19 yrs	8.6yr, 2-19yr
Ethnicity	1x NZ European, 1x Māori	4x NZ European, 1x German	5x NZ European, 1x Māori, 1x German

Materials

The memory notebook was custom designed for this research, based on literature, advice from clinicians in the field, and practical constraints in designing an individualized, professional, and sturdy notebook. The memory notebook contained four main sections. Sections were selected from Sohlberg and Mateer's (1989) proposed sections. These included an Orientation section for personal information relating to the individual, a Schedule section for appointments and tasks, a People section, and a Notes section. The main component of the memory notebook was the Schedule section. The Schedule section combined two of Mateer and Sohlberg's (1989) suggested sections: *calendar* and *things to do*. This was based on the findings that combining schedule and To Do lists so both lists are visible without changing sections is more effective than the traditional format as it eliminates the memory requirement to check two separate sections throughout the day (McKerracher et al., 2005). The memory notebook had tabbed laminated section dividers with instructions for how to use the sections printed on the front of the section divider. The People section had two additional sections to allow for grouping of people. The Notes section was lined paper. The overall notebook was A5 sized and plain laminated card cover (red or black).

The smartphone was an android LG Optimus One p500, a mid-price range smartphone at the time of purchase. It came installed with the Android 2.3 Gingerbread operating system. It was 113mm x 59mm and 13.3mm thick. It had a 3.2" 320 x 480px capacitive LCD touch screen. It came with a 2GB SD card which could be upgraded to 32Gb. It had a 600MHz central processing unit and 512MP RAM, running on Li-ion 1500mAH battery with a reported 5 hour talk time and up to 450 hours standby. This model is Wi-Fi capable and has GPS capabilities. It comes installed with calendar and email access that synchronize with Google accounts. The main application was Google Calendar which comes installed on Android phones. A number of applications were installed on the phones for participant use. GTasks (Dato, 2011) was a To Do list which synchronises with Google calendar. SimpleCalendar Widget (MYCOLOURSCREEN, 2011) was used to display the content of the Calendar and To Do on the home screen. CalendarSnooze (Bitfire-development, 2011) was used to allow notifications to repeat until an action was recorded as taken, and to allow snoozing of the reminder. In order to increase keyboard size and ease of operation, SlideIT (Dasur Ltd, 2011) was installed as the keyboard. GoContacts EX (Go Dev Team, 2011) was installed as an address book as it was deemed simpler to use than the default address book on the phone, and allowed for grouping of contacts (e.g., into lists of friends, professionals, businesses, and so on).

Measures

Test of Memory Malingering.

Effort on memory testing was examined with the Test of Memory Malingering (TOMM; Tombaugh, 1996). The TOMM is able to discriminate between control groups, healthy individuals simulating malingering, and TBI patients who are and are not likely to malinger (Tombaugh, 1996). The TOMM has demonstrated 100% specificity and 93% sensitivity (Tombaugh, 1996). The TOMM was primarily administered to rule out lack of effort at baseline as an explanation for any apparent improvements which were observed, particularly on memory measures. There was a slight possibility that some individuals might consciously or unconsciously perform below ability during the initial assessment in order to be included in the study, given that a free memory aid and training by a clinician were being offered to participants.

Rivermead Behavioural Memory Test

The Rivermead Behavioural Memory Test–II (RBMT-II; Baddeley et al., 2003a) is a test of everyday memory designed for individuals living with a brain injury. Cronbach's alpha has been assessed in the Chinese version (α = .86; Wai-Kwong & Li, 2002), and although apparently not assessed in other versions it is likely to be similar. It has excellent inter-rater reliability (e.g., overall score agreement of 100% across ten raters of 40 subjects), good parallel form reliability and test-retest reliability (r = .83-.88 and r = .85 respectively; Baddeley et al., 2003b). Validity measures indicate the RBMT-II is sensitive to memory deficits after brain injury, and has positive correlations with other memory measures (e.g., r = .63 with word subtest Recognition Memory Test for Words, r = .62 with the paired associate learning subtest and, r = .28 with Corsi block; Baddeley et al., 2003b). The RBMT-II is designed to assess everyday memory performance rather than specific aspects of memory. Importantly the RBMT-II has respectable correlation with observational measures of prospective memory (r = - 0.75; Baddeley et al., 2003b)—lower scores on the RBMT-II correlated with higher rates of observed memory lapses. Similarly, Baddeley et al. (2003b) reported correlations between the RBMT-II and self (*r* = -

.44) and other (*r* = -.57) reports of prospective memory (though did not specify what these measures were). The RBMT-II was used in the current study to assess memory impairment. The ratings of memory capacity (increasing in severity from normal, to poor memory, to moderately impaired and severely impaired) were used as indicated in the test manual, using the standardized score classifications, as the authors indicated this gives a more reliable measure of memory capacity than screening scores. In deference to the New Zealand population in the study, the orientation item, “Who is the prime minister of Britain?” was changed to the prime minister of New Zealand.

Depression Anxiety Stress Scales

The Depression Anxiety Stress Scales 21 item version (DASS-21; Lovibond & Lovibond, 2004) was used as a measure of mood. It was included in the current study since depressive symptoms may accentuate memory deficits, and meanwhile better compensation for memory deficits could potentially elevate mood. The DASS-21 is a shortened version of the original full 42 item questionnaire. The DASS-21 findings are correlated with the full DASS pattern of scores and so are comparable (r = .85; Antony et al., 1998). The DASS-21 has good internal consistency for the total score (α = .93) and its subscales, the Depression scale (α = .88), Anxiety scale (α = 82), and Stress scale (α = .93; Henry & Crawford, 2005). The DASS-21 Depression scale correlates with the Beck Depression Inventory (*r* = .79), and the DASS-21 Anxiety scale with the Beck Anxiety Inventory. The DASS has been shown to discriminate between control groups, groups under greater stress due to physical illness, and clinical populations (Lovibond & Lovibond, 2004). It is useful for monitoring changes in levels of depression, anxiety and stress across time (Lovibond & Lovibond, 2004).

Functional memory tasks

Two functional memory tasks were used in this study. The first was a *message task* and had two components: to place a text message or phone call at a scheduled time (*message time*), addressing a particular question (*message content*). As these questions related to clinically-meaningful information (e.g., tell me something good about your memory aid) answers to the questions also provided qualitative data. The time for the *message* task was randomised to occur at different times each week, for each participant, and so could not become part of a routine. *Message tasks* were scheduled for week days between 9am and 8pm, and participants were able to negotiate these parameters if it did not fit with their schedules. The second task was an unscheduled task, in which participants were provided with a postage-paid postcard (*postcard task*) and asked to return it via the post before their next weekly appointment.

Performance on these memory tasks was rated by the first author. Participants were given a 0-6 score for *message time*, receiving a 6 if they were within one hour of the assigned time, a 4 if they completed the task on the assigned day, a 2 if they completed the task outside this timeframe and 0 for not completing the task. *Message content* was rated on 0-3 scale, with 3 points being assigned if participants clearly answered the assigned question, 2 if the answer related to the question but was not clear, 1 if the message related to their memory or their memory aid and 0 if it did not refer to the question, their memory or the memory aid. In this task, message completion time was deemed the most important aspect of the phone call task and so was given a higher weighting. The *postcard task* was scored 2 for completion within the week between appointments (allowing one additional day for delays within the postal system), 1 for completion after this time, and 0 for not completing the task. Percentage performance was calculated.

Procedure

Potential participants were screened for eligibility for the study during an initial assessment. This assessment could last up to three hours. Eligible participants who agreed to be part of the research entered into the main study. The main data collection period took between 11 and 15 weeks to complete. This included a 3 to 7 week baseline and an 8 week treatment. During the first 2 weeks of treatment additional appointments were included whilst training with the memory aid. Having completed the main study participants were followed up 2 to 4 months later in an appointment which could last up to 2 hours.

Participants attended weekly one hour appointments throughout the main data collection period. At each appointment they were interviewed using a semi-structured interview. During this interview participants were also asked to provide 0-10 ratings of various emotions (e.g., happy, confused) and statements (e.g., I feel good about myself, I feel like a failure), both positive and negative. At the end of each appointment the two functional memory tasks were assigned to be completed before the next week's appointment. If they did not spontaneously do so, participants were prompted each week to enter these tasks into their memory aid.

(Initially, “How are you going to remember?”, then “Where could you record that?”, and finally “Let’s put it in your memory notebook/smartphone.”)

Participants were also asked to record their memory performance on a daily basis using a task completion log. This was custom designed for the current study but based on several other studies using similar techniques to measure prospective memory performance (e.g., DePompei et al., 2008; McDonald et al., 2011; Wade & Troy, 2001; Wilson et al., 2001; Zencius et al., 1990). At the initial assessment, the end of treatment and at follow up participants completed the RBMT-II (Baddeley et al., 2003a), DASS-21 (Lovibond & Lovibond, 2004), the Comprehensive Assessment of Prospective Memory (Shum & Fleming, 2012) and the Community Integration Questionnaire (Willer et al., 1993). The TOMM was administered during the initial assessment only. Parallel forms of the RBMT-II were used to reduce practice effects. (All measures administered are listed here; for reasons of primacy and brevity only RBMT-II, DASS-21, and TOMM findings are discussed in this paper.)

Minimum baseline lengths were randomly assigned as 3 weeks, 5 weeks or 7 weeks. Final baseline lengths for each participant were dependent on stability being observed on the task log during the baseline period. Stability was assessed by visual inspection; logged observations were considered unstable if there was more than 50% variance in percentage completion of tasks, total number of tasks, or number of recording days over one week. Where the first 3 weeks were not stable additional weeks were included up until a maximum of 7 weeks. Participants were required to record their memory and complete the assigned *message task* and *postcard task* on a maximum of 6 weeks during baseline. In all cases these assigned tasks were to be completed on the first 3 weeks and the final baseline week.

Having completed the assigned baseline, and any additional weeks required, participants were given their assigned memory aid. The treatment period was 8 weeks, including 2 weeks for training. Training followed methods suggested for memory notebooks and utilised an errorless learning approach (Sohlberg & Mateer, 2001). Participants were provided with in-person training with the first author for four to eight hours over the first two weeks. Instructions for use of the memory notebook were contained within the notebook itself. A step-by-step printed manual with screenshots and instructions was provided for basic smartphone use, covering the main components of the phone. An acquisition chart was developed based on Sohlberg and Mateer's (2001) recommendations for memory notebook training. A parallel form was developed for the smartphone treatment that was a similar as possible to the original. This was used to chart the progress of participants during training and to decide when sufficient training had been provided. When sufficient competence with the phone was achieved participants were assisted to transfer their existing mobile phone number to the smartphone. (All participants already had a basic mobile phone.)

It was initially planned that participants would be matched based on injury severity (moderate vs. Severe), age (<30 and 30+), and gender. Matched pairs would receive the same baseline length and message time schedule, and one member of each pair would receive each treatment. Due to recruitment challenges only two matched pairs were formed (of which one participant withdrew during baseline). Once the exclusion criteria were relaxed allowing inclusion of participants who already made systematic use of a memory notebook, these participants were automatically assigned to the smartphone treatment with baseline lengths and message schedule randomly assigned.

After completion of follow-up, participants who initially received the memory notebook were offered to continue in the research and receive the smartphone treatment. These participants proceeded to the eight weeks of training and treatment with the smartphone after the follow-up week, and then completed a second follow-up 2–4 months after completion of this second treatment phase. As smartphones were the topic of interest and expected to be the more effective memory aid, those who initially received the smartphone were not offered the memory notebook.

This study was approved by Central Regional Health and Disability Ethics Committee.

Results

Below a summary of results is shown, followed by the individual results of participants, grouped by those who first received the memory notebook and later the smartphone, and those who received the smartphone alone.

Summary Results

Overall, six of the seven participants (86%) showed improvements in their ability to perform assigned functional memory tasks using the smartphone. One participant (S2) showed a reduction in performance with the smartphone. On the *message* time two participants had high baseline performance (67% and 75% performance) and so had ceiling effects. N2 showed no improvement from baseline but a 45% improvement from memory notebook as he had reduced 43% with the notebook. The remaining three improved by greater than 40%. Improvement size on the *message content* ranged from 32% to 71%. Over 90% performance on both *message time* and *message content* was reached by three participants with smartphone (N1, S3 and S4).

Improvement on the *postcard task* was more variable. Three participants' performance improvements with the smartphone ranged from 8% to 33%. All reported they would not usually post letters, and two had difficulty finding a post-box. Two participants showed no improvement, one (S5) had 100% performance throughout, the other (N1's) performance returned to baseline after an improvement of 20% with the memory notebook. Three participants performance declined with the smartphone. S3 declined due to inability to find a post-box when staying in alternative houses, S4 reported disinterest in the task and did not post other letters, and S2 declined on all memory tasks with the smartphone. Figure 3 shows the mean performance on each memory task for those in who received the memory notebook and later the smartphone. Figure 4 shows the weekly performance on the memory tasks. Likewise, Figure 5 shows the average memory task performance, and Figure 6 the weekly memory task performance for those who received the smartphone. The number of baseline weeks differs due to randomisation of length of baseline. Some weeks are excluded during interventions where it was deemed that circumstances meant the person could not be expected to complete the memory tasks (e.g. serious illness or attendance at funerals).

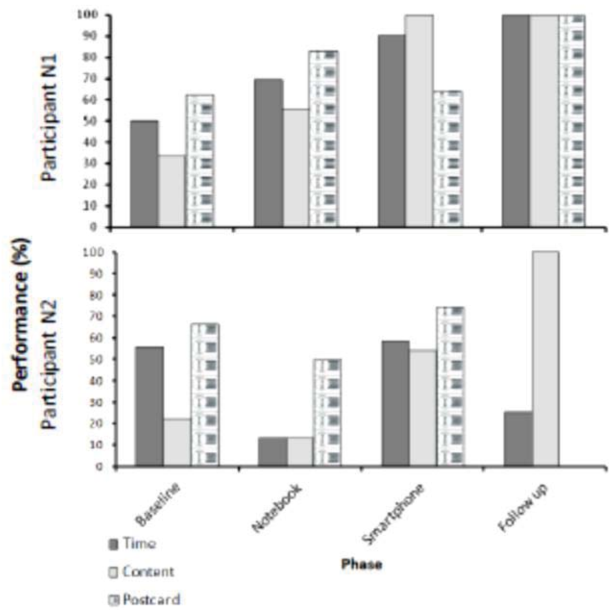

Figure 3. Mean completion rate of assigned memory tasks during baseline and treatment for those who received the memory notebook followed by the smartphone

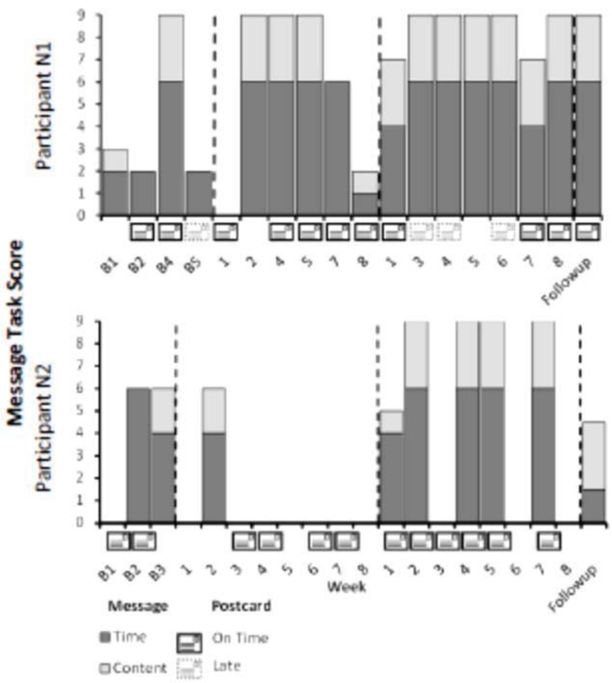

Figure 4. Weekly *message task* score and postcard completion for those who received the memory notebook followed by the smartphone.

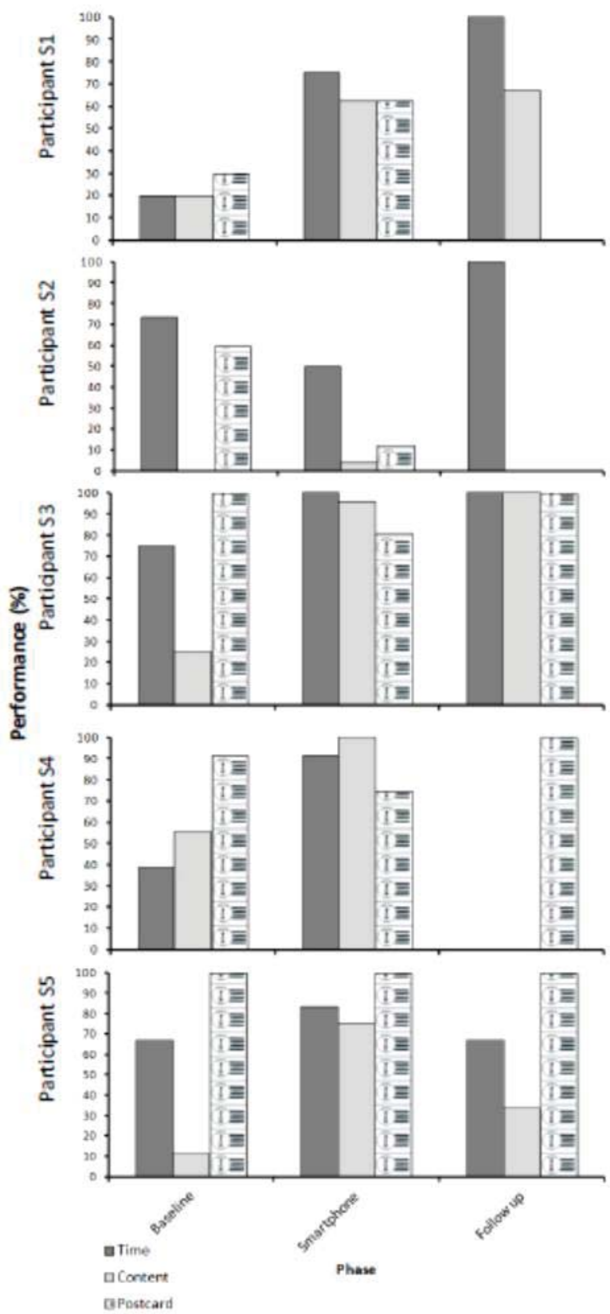

Figure 5. Mean completion rate of assigned memory tasks during baseline and treatment for those who received the smartphone.

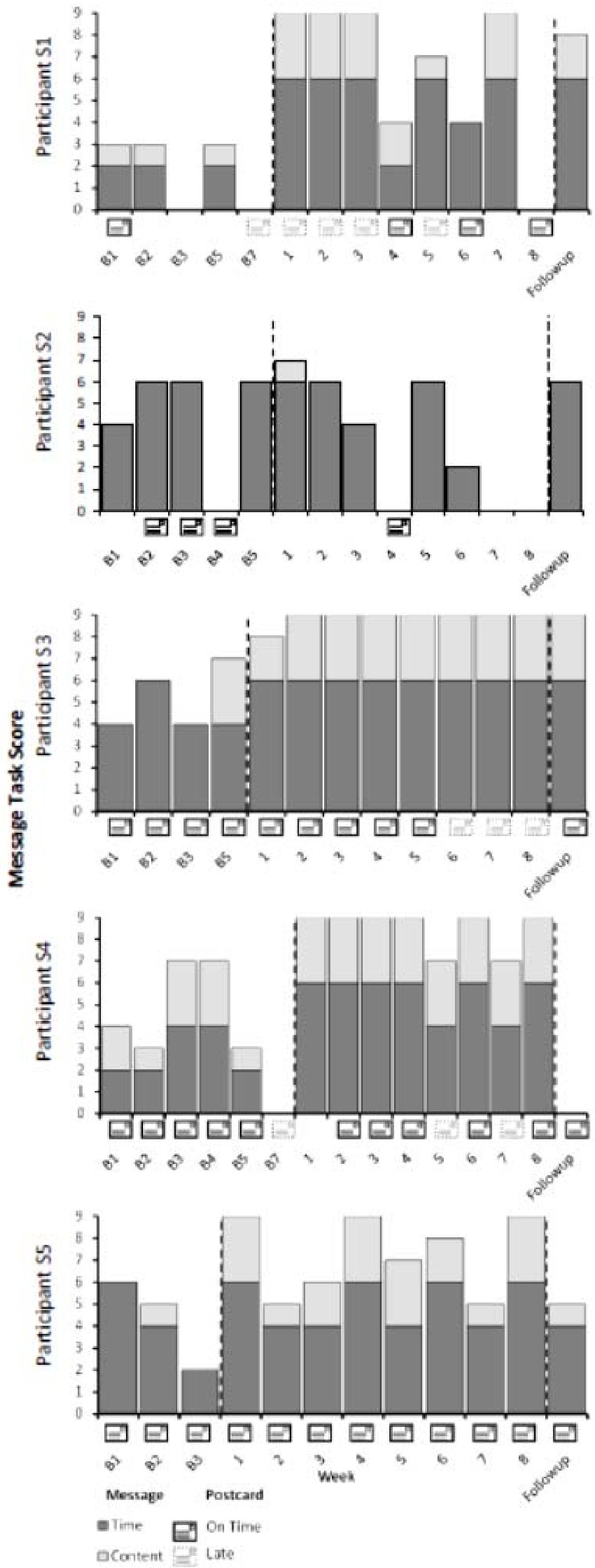

Figure 6. Weekly *message task* score and postcard completion for those who received the memory notebook followed by the smartphone. The number of

baseline weeks differs due to randomisation, and some weeks are excluded where it was not reasonable to expect the tasks to be completed.

All participants included in this study demonstrated sufficient effort on the TOMM. Reported baseline performance on the task completion log was very high. Participants predominantly lived independently and so had no observer to monitor memory. They were unable to recall items which they had not completed and therefore only completed tasks were recorded. Although asked to continue with the task completion log during the treatment stage, all participants stopped doing so. The results of the task completion log are therefore not reported. Little change was seen in either the CAPM or the CIQ for all participants and for reasons of brevity these are also not reported here. The results for each participant on other measures are presented below. Performance on the *message task* and *postcard task* is reported both on a weekly basis and for mean performance across stages of the study. Standard mean difference effect sizes have been calculated using the pooled variance of baseline and treatment. Where the memory notebook and smartphone were being compared the standard deviations of these data points were used. All participants allowed the researcher to view the contents of their memory aid during weekly sessions. Deleted items from the smartphone to do list were able to be viewed from online, but this was not the case for calendar items.

Participant N1

N1 was a 52 year old New Zealand Māori man who had sustained a moderate TBI in a fall 2 years earlier. N1 received a memory notebook after a 7 week baseline.

At follow-up 2 months after completion N1 agreed to remain in the study and receive the smartphone treatment.

N1 reported having excellent memory pre-injury and no need for memory aids. Post-injury a memory notebook was recommended, but attempts at implementing this independently were unsuccessful. To assist his memory he always wore a waist bag containing pen and paper. He collected business cards and stored them in this bag to help cue him. For important appointments he would ask his daughter to send him a reminder text message. Following this pattern, during the baseline the primary author sent him text message reminders for his appointments in the study, at his request. His current mobile phone enabled him to set up to five alarms with a short note attached, which he used for his most important appointments. At the initial interview he was unsure what most of the business cards were meant to remind him of, and reported losing notes or washing them off his hand. His friends knew to ring or text to remind him of appointments, although he reported few knew of his injury. At the time of entry into the study, all five alarms on his phone were set for important future appointments, so there were no alarms available for day to day usage.

Memory task performance

Figure 7 presents N1's mean percentage performance for the *message time*, *message content* and *postcard* memory tasks during baseline and treatment. Using the memory notebook, increases in mean performance were seen for *message time* from 50% at baseline to 69% with the memory notebook (*SMD* = .58 moderate ES), or *message content* from 33% at baseline to 56% with the memory notebook (*SMD*

= .47 moderate ES), for the *postcard* task from 63% at baseline to 83% with the memory notebook (*SMD* = .43 medium ES).

Using the smartphone, further increases in mean performance were seen for *message time* up to 90% for *message time* (*SMD* = .61 medium ES from memory notebook, *SMD* = 1.34 large ES from baseline). M*essage content* increased to 100% with the smartphone (*SMD* = 1.12 large ES from memory notebook, *SMD* = 1.57 large ES increase from baseline). *Postcard task* performance declined with the smartphone to 64% (*SMD* = -.49 medium ES reduction from memory notebook, *SMD* = .05 small ES change from baseline). Performance at follow up was 100% for *message time*, *message content* and the *postcard task*.

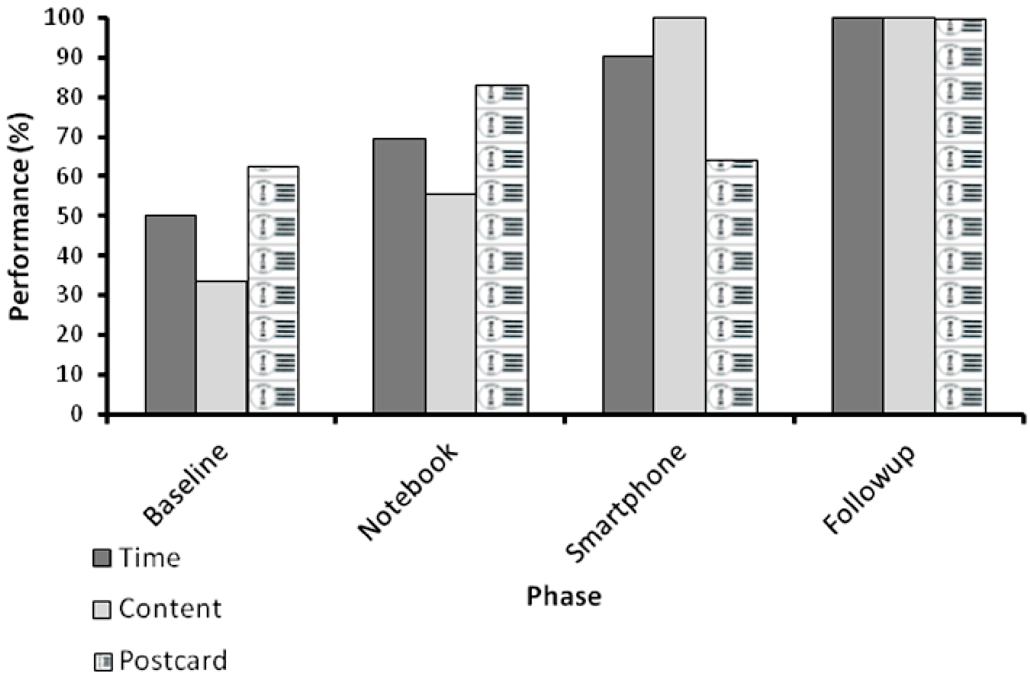

Figure 7. Mean completion rate of assigned memory tasks during baseline and treatment for N1.

Weekly memory performance across baseline and treatment is shown in Figure 8. After the first week with the memory notebook, N1 was able to complete the task within an hour of the assigned time on the majority of weeks. *Message content* also improved. Further improvement occurred with the smartphone, with N1 achieving almost 100% performance the majority of the time for both *message time* and *message content*. During the two occasions in the smartphone treatment where he was late he explained that when the reminder presented 45 minutes before the assigned time (the default for this client) he wrote down the message but waited to send it at the correct time, at which time he forgot. During several weeks he was unable to complete tasks due to extended funeral commitments, a highly stressful personal event, and being extremely unwell. These weeks are excluded from the figure as task completion was not expected. During the smartphone treatment the postcard was mostly late—N1 reported he stored the postcard inside the memory notebook whereas he tended to misplace the postcard when he had the smartphone.

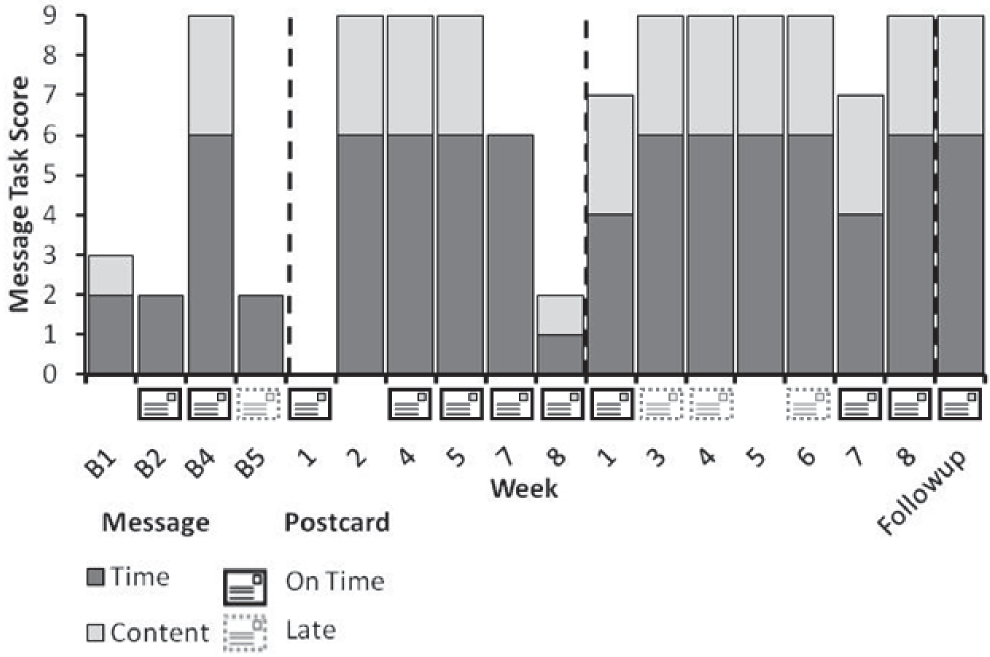

Figure 8. Weekly *message task* score and postcard completion for N1. Baseline week 3, memory notebook week 3 and 6, and smartphone week 2 were not included due to funerals, a highly stressful personal event and illness.

Pre- and post-treatment measures.

Table 3 presents the scores and descriptors where available for the formal testing. Apparent changes in underling memory measured on the RBMT-II likely reflect borderline descriptor scores on the RBMT-II along with reduction in depression and anxiety as measured on the DASS-21. Interestingly a vast improvement in mood occurred after the smartphone treatment and continued at follow up. A further one point reduction in both depression and anxiety would result in *normal* mood across all categories.

Table 3. *Psychometric test score descriptors across phases for N1.*

	Baseline	**Memory Notebook**	**Follow up**	**Smartphone**	**Follow up**
RBMT-II	*Poor memory*	*Moderately impaired*	*Moderately impaired*	*Poor memory*	*Normal memory*
DASS-21					
Depression	*Extremely Severe*	*Extremely Severe*	*Extremely severe*	*Mild*	*Mild*
Anxiety	*Moderate*	Extremely Severe	Moderate	Moderate	Mild
Stress	Severe	Extremely severe	Moderate	Moderate	Normal

Summary of N1

N1 was pleased with the memory notebook. He made use of each section and followed the strategies of ticking off tasks as completed and carrying uncompleted tasks to the next page. Performance on the memory tasks improved using the memory notebook. N1 took steps to take care of the memory notebook. Indeed, contrary to normal advice on memory aid use, he left his memory notebook at home during the day to prevent damage, and instead took a note with him with a copy of the day's tasks on it. N1 was surprised how quickly he leant to use the smartphone, which became his primary phone within two weeks. He was quickly using the Calendar to remind himself of meetings and jobs, and he entered birthdays into the Calendar. He made extensive use of the To Do list. He carried the smartphone at all times. Performance on *message tasks* improved over performance with the memory notebook, though as discussed, *postcard* performance declined with the smartphone, an unexpected treatment condition–assessment task interaction. He continued to make extensive use of the smartphone at follow up.

Participant N2

N2 was a 25 year old New Zealand European man who sustained a severe TBI in a motor vehicle accident 2 years earlier. N2 had a diary but did not make use of it and so was randomly assigned to receive the memory notebook with a 3 week baseline. At follow-up 3 months after completion with the memory notebook he chose to continue and receive the smartphone treatment.

N2 reported having a good memory pre-injury. He had never needed a memory aid, and had not had the type of job which would require one. Since his injury rehabilitation services had tried to implement a diary, which he "hated" and refused to use. This had been slightly larger than A5 size, hard covered and clearly identified as being provided for neurorehabilitation. N2's primary strategy for remembering appointments was to wait for someone to either arrive at his house for his appointment, or for someone to take him to the appointment. This was in part due to inability to drive and lack of access to public transport. Due to these reasons all appointments for this study were based at his home. He suffered fatigue and was often asleep if he had forgotten about an appointment, including several of these appointments.

Memory task performance

Figure 9 presents N2's mean percentage performance for the *message time*, *message content* and *postcard* memory tasks during baseline and treatment. Using the memory notebook, decreases in mean performance were seen for *message time* from 56% at baseline to 8% with the memory notebook, for *message content* from 22% for to 8% with the memory notebook. During three weeks in the memory notebook treatment N2 did not have access to a phone to complete the *message task*. When these weeks were removed *message time* mean performance still declined to 13% for both *message time* (*SMD* = -1.01, large ES) and *content* (*SMD* = -.29, small ES). Mean performance on the *postcard task* declined from 67% performance at baseline to 50% with the memory notebook (*SMD* = -.29 small ES).

Performance increased from the memory notebook to smartphone. *Message time* increased to 59% with the smartphone (*SMD* = .66, medium ES from memory notebook, *SMD* = -.23 small ES from baseline). *Message content* increased to 54% performance (*SMD* = .60 medium ES from memory notebook, *SMD* = .41 medium ES from baseline). The *postcard task* also improved with the smartphone to 75% performance (*SMD* = .52 medium ES from memory notebook, *SMD* = .18 small from baseline).

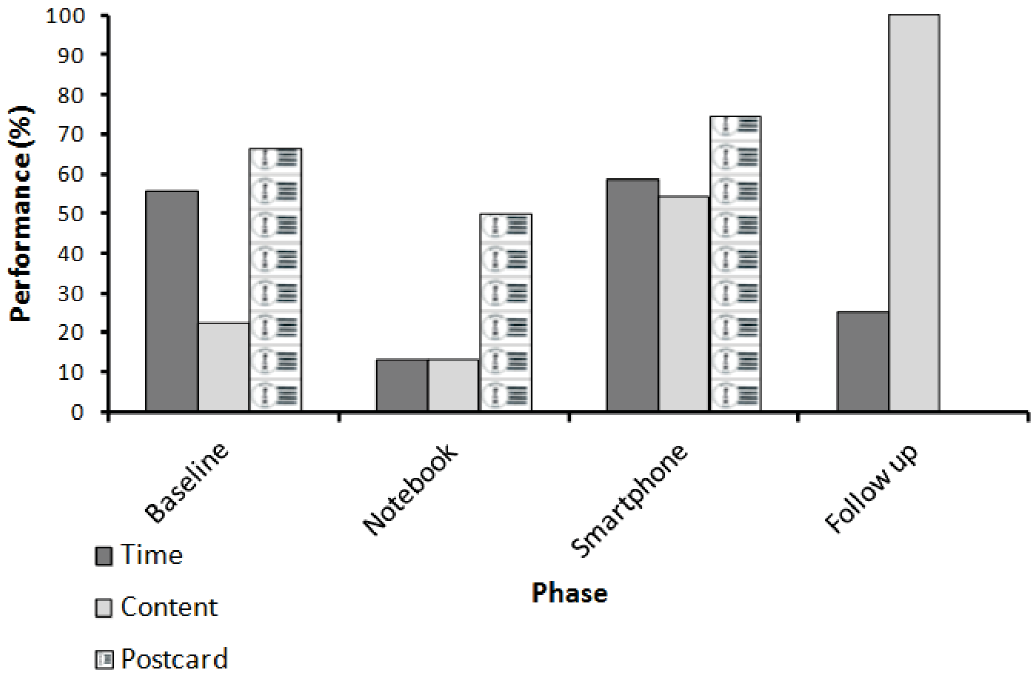

Figure 9. Mean completion rate of assigned memory tasks during baseline and treatment for N2. Weeks 4 to 6 of the baseline were removed from the *message task* data as it was not possible for N2 to complete the task on these weeks.

Weekly memory performance across baseline and treatment is shown in Figure 10. N2 completed the *message task* twice during the three week baseline but just once in the eight weeks with the memory notebook. On receiving the smartphone there was an immediate improvement in the *message task* and *content*. The message task tended to be completed on time and with appropriate content, or not completed at all. Improvement with the smartphone occurred despite a heavy increase in daily commitments. N2 consistently had difficulty with the *postcard task* as there were no post boxes in his vicinity and due to his injury relied on others to transport him. However, with the smartphone he was more likely to remember to take the postcard with him when going out where he could find a post box.

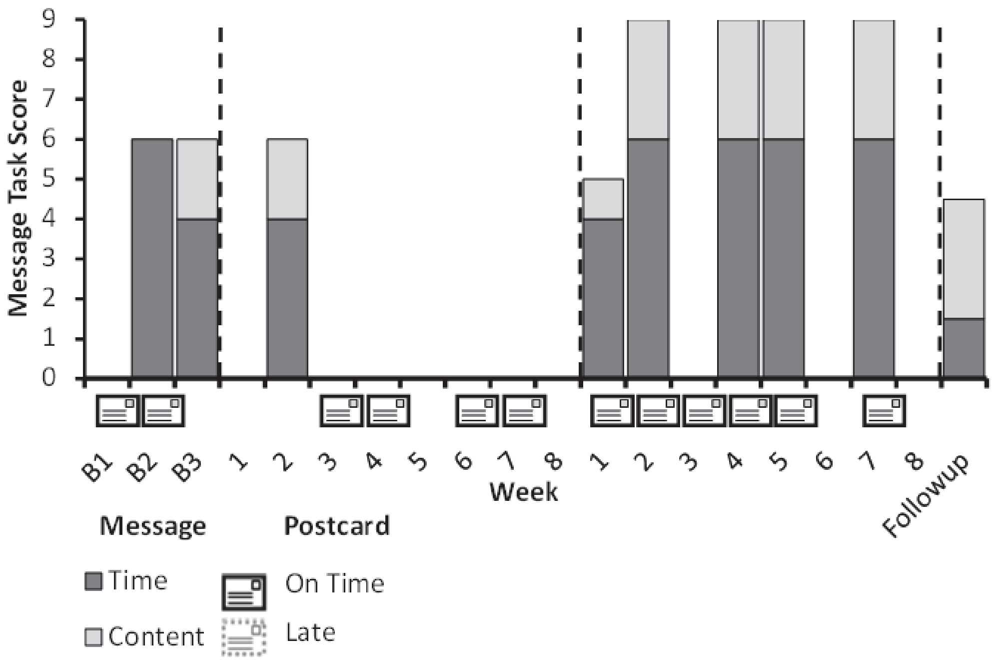

Figure 10. Weekly message task score and postcard completion for N2.

Pre- and post-treatment measures.

Table 4 presents the scores and descriptors where available for the formal testing. There was a slight improvement from *moderately impaired* to *poor memory* according to the RBMT-II between the initial baseline and treatment period, and the subsequent smartphone phase assessment. This could be due to random fluctuation in test scores, practice effects from similarities across the parallel forms, or possibly due to reduction in fatigue. As N2 was just over two years post-injury there is the possibility improvements were due to underlying spontaneous improvements. This is particularly a possibility since fatigue also appears to have improved between the memory notebook and first follow up. There is no reason to believe the treatments themselves led to a change in underlying memory impairment. Mood was stable and in the *normal* range throughout as measured on the DASS-21.

Table 4. *Psychometric test score descriptors across phases for N2.*

	Baseline	**Memory Notebook**	**Follow up**	**Smartphone**	**Follow up**
RBMT-II	*Moderately impaired*	*Moderately impaired*	*Moderately impaired*	*Poor memory*	*Poor memory*
DASS-21					
Depression	*Normal*	*Normal*	*Normal*	*Normal*	*Normal*
Anxiety	*Normal*	*Normal*	*Normal*	*Normal*	*Normal*
Stress	*Normal*	*Normal*	*Normal*	*Normal*	*Normal*

Summary of N2

N2 was initially frustrated with his memory and fatigue due to his brain injury. He knew his short term memory was impaired but seemed less aware than his mother of his memory difficulties. Although he reported preferring the memory notebook over his previous diary, memory performance declined from baseline and use of the memory notebook was sporadic. He never used the To Do list saying that he would use it more in the future when he had more things he wished to do.

N2 was very pleased to receive the smartphone and immediately inserted his own SIM card. Once told he would be shown how to use the Calendar he immediately worked through it with minimal assistance on his own, mastering the basic use of the Calendar in the first half hour. He consistently carried the smartphone and managed his own appointments. For the first time since his injury he was up and ready for the appointment all but one time during the smartphone treatment. He independently looked into his Calendar several times each day in addition to responding to reminders. As with the memory notebook he never used the To Do list. Despite this, memory performance on the functional measures in this study did not demonstrate a particularly large improvement beyond baseline. This may have been due to N2 being at work or in appointments at the times where the tasks should be performed, which were deemed more important than the memory task. At follow up N2 continued to use the Calendar, and would record his To Do jobs in it at a set time. He made rare use of the formal To Do list. He reported that he would be “lost without” the smartphone.

Participant S1

S1 was a 56 year old New Zealand European man who sustained a moderate TBI (post traumatic amnesia recorded as 1-2 days) in a motor vehicle accident five years earlier. Based on matching to participant N1, S1 was assigned to receive a smartphone, with a 7 week baseline.

S1 did not make use of external memory aids pre-injury as he was able to manage a large contracting company without one. Since his injury S1 had made attempts to use a family planner, calendar, a whiteboard, and used his own system of managing appointments through emails and sending himself text messages. He reported difficulty consistently using any of these strategies and primarily relied on others to remind him.

On entry to the study S1 owned an android smartphone but did not use it as a memory aid. Within the first two weeks of baseline he began the process of getting a refund on that phone due to ongoing technical difficulties. He remained blind to the study treatments until baseline week four, when he informed the researcher his phone refund had gone through and he would be buying a new smartphone. At this point the primary author opted to disclose that he would be receiving a smartphone as the treatment, rather than risk loss of rapport and possible drop-out should the participant be presented with a replacement smartphone shortly after he had paid for his own replacement. He reported he had not considered using the smartphone for his memory before and was pleased to learn he would receive assistance in learning to do so.

Memory task performance

Figure 11 presents S1's mean percentage performance for the *message time*, *message content* and *postcard* memory tasks during baseline and treatment. Using the smartphone increases were seen for *message time* from 20% at baseline to 75% (SMD = 1.3, large ES), for *message content* from 20% at baseline to 63% (SMD = 1.01, large ES) and for the *postcard* from 30% at baseline up to 63% with the smartphone (SMD = .81, large ES). At follow up performance was 100% for *message time*, 67% for *message content,* and the *postcard* task was not completed.

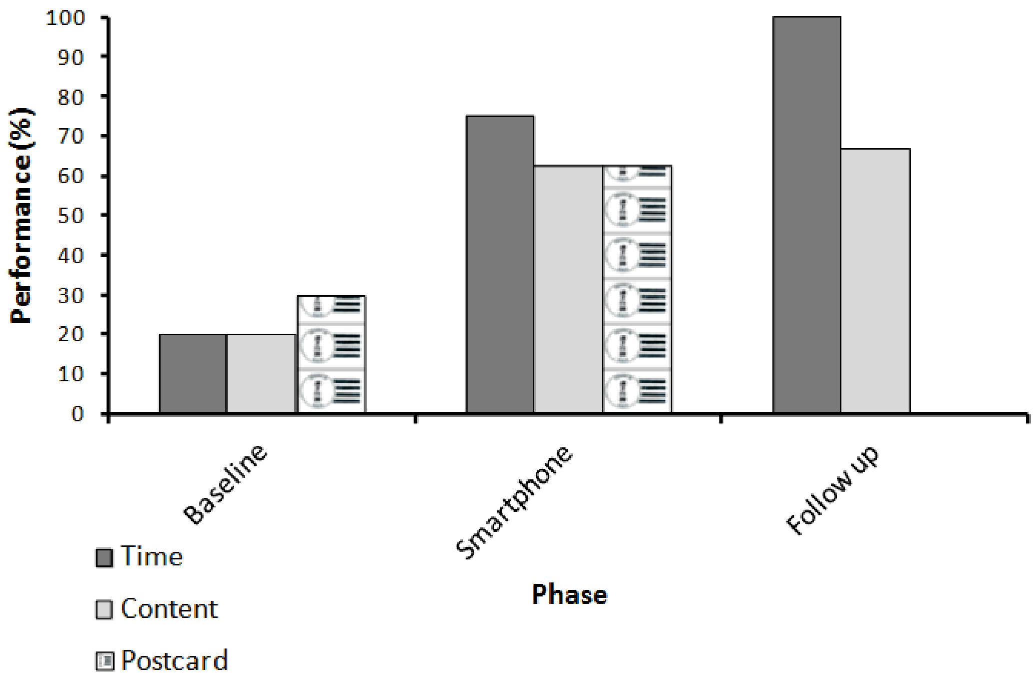

Figure 11. Mean completion rate of assigned memory tasks during baseline and treatment for S1

Weekly memory performance across baseline and treatment is shown in Figure 12. From the first week with the smartphone, S1 was able to complete the task within an hour of the assigned time on the majority of weeks, as well as showing an improvement in memory content. Those weeks where performance on the *message task* was not 100% were explainable by other factors, i.e., in week four as he was out of network reception, week 6 as a family member was hospitalised and week eight as he was moving house and did not carry his smartphone with him. As all or parts of the tasks were completed in these weeks, the weeks were not removed from the data. S1 reported difficulty completing the *postcard task* as he did not otherwise post letters and had to go out of his way to find a post box

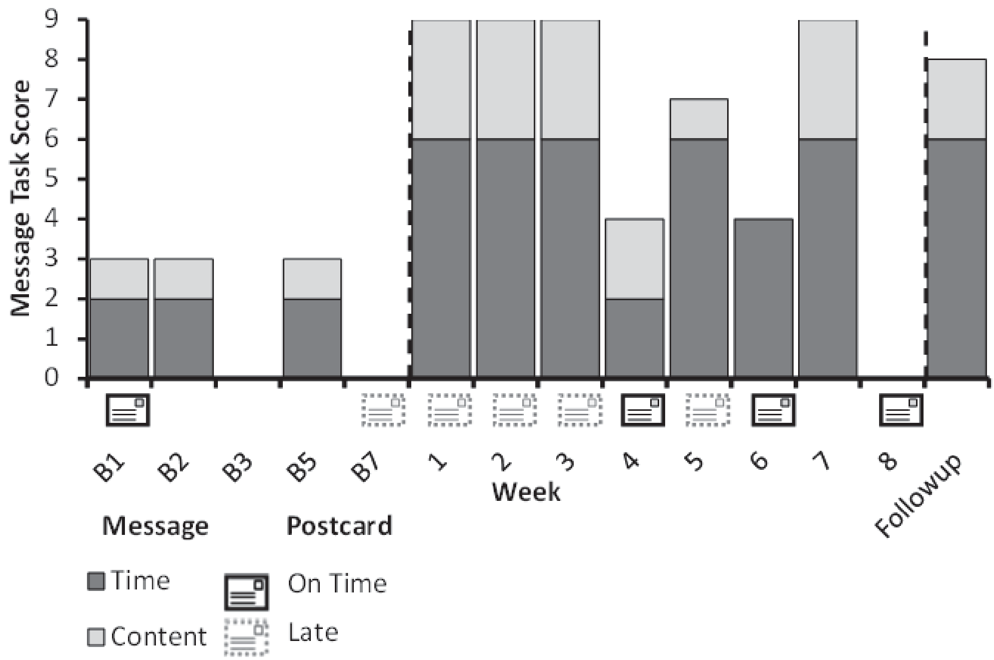

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Figure 12 Weekly message task score and postcard completion for S1.

Pre- and post-treatment measures.

Table 5 presents the scores and descriptors where available for the formal testing. As expected there were no changes in underlying memory impairment, with S1 having *poor* memory throughout. Mood was stable and in the *normal* range throughout as measured on the DASS-21.

Table 5. *Psychometric test score descriptors across phases for S1.*

	Baseline	**Smartphone**	**Follow up**
RBMT-II	*Poor memory*	*Poor memory*	*Poor memory*
DASS-21			
Depression	*Normal*	*Normal*	*Normal*
Anxiety	*Normal*	*Normal*	*Normal*
Stress	*Normal*	*Normal*	*Normal*

Summary of S1

From the outset, S1 found the smartphone an intuitive memory aid and he quickly took to using it effectively. He immediately transferred his own SIM card to the phone and had mastered the main components of the smartphone within the first 3 hours of training. He entered times to drop off and pick up family from work. He used the To Do list to remind himself of items to collect and jobs to do. The improvements in the memory tasks demonstrate that items entered in the Calendar or To Do list on his smartphone were more likely to be completed than previously. At follow up, S1 had stopped using the Calendar and was using the To Do list occasionally. He thought if he could enter Calendar tasks from his home computer this may be more effective as he had difficulty seeing the smartphone screen without his glasses. This was an option available to him, but he had not been trained to do this, and was unaware of the possibility.

Participant S2

S2 was a 55 year old New Zealand European man who sustained a severe TBI (Glasgow Coma Scale score of 3, Post traumatic amnesia 4-5 weeks) in a fall six years earlier. S2 was randomly assigned to receive the smartphone with a 7 week baseline.

S2 reported having an excellent memory pre-injury. He had previously had no need for a memory aid. Since his injury he used a wall calendar for important appointments, which he wrote on scraps of paper if out. Often these were receipts or bus tickets from in his wallet and they tended to be forgotten. His primary strategy was to avoid using prospective memory and do everything immediately, as much as possible. Additionally, he bought in bulk so he would not run out should he forget an item at the store. His primary concern was lack of sleep as his pattern of completing tasks as soon as they occurred to him often meant he was completing tasks late into the night at the expense of a good night's sleep.

Memory task performance

Figure 13 presents S2's mean percentage performance for the *message time*, *message content* and *postcard* memory tasks during baseline and treatment. Using the memory notebook, decreases in mean performance were seen for *message time* from 73% at baseline to 50% with the smartphone (*SMD* = -.51 medium effect size), *message content* was 0% at baseline and 4% with the smartphone (*SMD* = .45, medium ES), and for the *postcard* task from 60% at baseline to 13% with the smartphone (*SMD* = -.98, large ES). At follow up *message time* was 100% but *message content* and the *postcard* task 0%

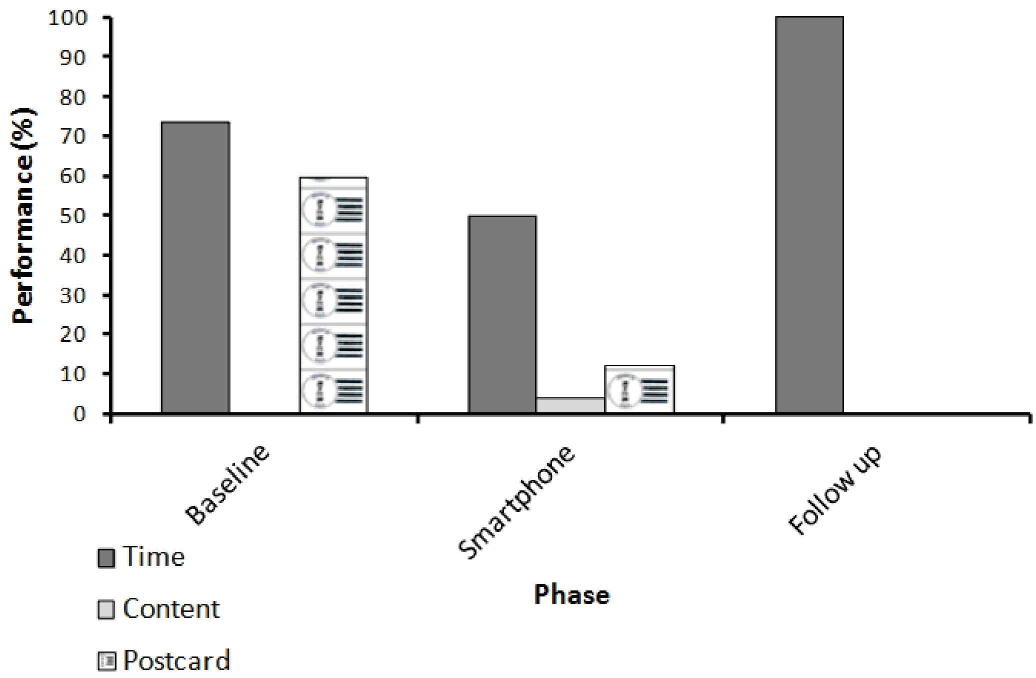

Figure 13. Mean completion rate of assigned memory tasks during baseline and treatment for S2.

Weekly memory performance across baseline and treatment is shown in Figure 14. Performance on the *message task* tapered off after the first 2 weeks with the smartphone but was on time during the follow up. The *message content* was consistently unrelated to memory or the smartphone. Performance on the *postcard task* also declined with the smartphone.

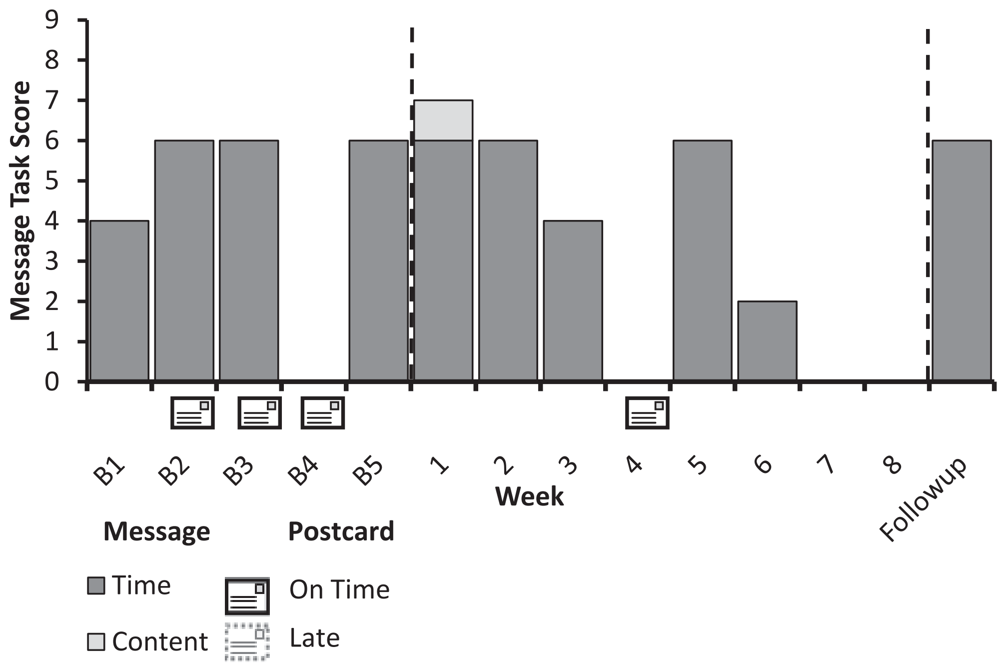

Figure 14. Weekly *message task* score and postcard completion for S2.

Pre- and post-treatment measures.

Table 6 presents the scores and descriptors where available for the formal testing. Performance on the RBMT-II declined—perhaps due to lack of effort as S2 had become disinterested and frustrated with the study and did not appear to be applying full attention to the task. As can be seen in the mood ratings on the DASS-21, S2 was *moderately stressed* at the end of the smartphone treatment. This was due to external factors in attempting to organise a move overseas and difficulties in a community activity. At follow up it had been established that S2 could not move overseas. He was *severely depressed* at this time.

Table 6. *Psychometric test scores descriptors across phases for S2.*

	Baseline	**Smartphone**	**Follow up**
RBMT-II	*Poor memory*	*Moderately impaired*	*Moderately impaired*
DASS-21			
Depression	*Normal*	*Normal*	*Severe*
Anxiety	*Normal*	*Normal*	*Normal*
Stress	*Normal*	*Moderate*	*Moderate*

Summary of S2

S2 reported memory difficulties in the initial assessment and a desire to change these, particularly so he could sleep more. However, from this point onwards he was rigid about not changing his patterns of activity. Following the initial assessment he reported no memory difficulties, aside from forgetting conversations.

From the outset S2 disliked the idea of using a mobile phone or smartphone as a memory aid. He thought phones were only to be used for “phone functions”. He expressed great dislike for the smartphone and was reluctant to use any additional features including the Calendar and To Do list. Attempts were made to increase use of the smartphone by installing a sleep recording application since sleep was his main concern. This resulted in use of this application on a small number of occasions, with difficulty. On most weeks S2 declined to enter the memory tasks into his smartphone. At follow-up he had not used it for anything other than “phone functions” and asked for the additional application icons to be removed from the main screens. He expressed a desire to return to his prior phone. Performance in the memory tasks declined using the smartphone, although S2 reported he had not noticed any changes in his memory across time in the study.

Participant S3

S3 was a 62 year old New Zealand European man who sustained a severe TBI in a motorcycle accident 19 years earlier. S3 was randomly assigned to receive the smartphone with a 5 week baseline.

S3 reported good memory and no particular need for memory aids pre-injury. Since his injury he had become accustomed to taking notes to help his memory. He had three or four notebooks, with one small one in his pocket, a larger one at home, and others in various locations. These were blank page notebooks and no organisational system was used as he recorded appointments or chores, in addition to thoughts, concerns, ideas and recipes in the notebooks.

Memory task performance

Figure 15 presents S3's mean percentage performance for the *message time*, *message content* and *postcard* memory tasks during baseline and treatment. Using the smartphone, increases in mean performance were seen for *message time* 75% at baseline to 100% using the smartphone (*SMD* = 1.66, large ES), for *message content* from 25% at baseline to 96% performance with the smartphone (*SMD* = 1.59, large ES).*Postcard* task performance declined from 100% at baseline down to 81% with the smartphone (*SMD* = -.83, large ES). At follow up S3 demonstrated 100% performance on all tasks.

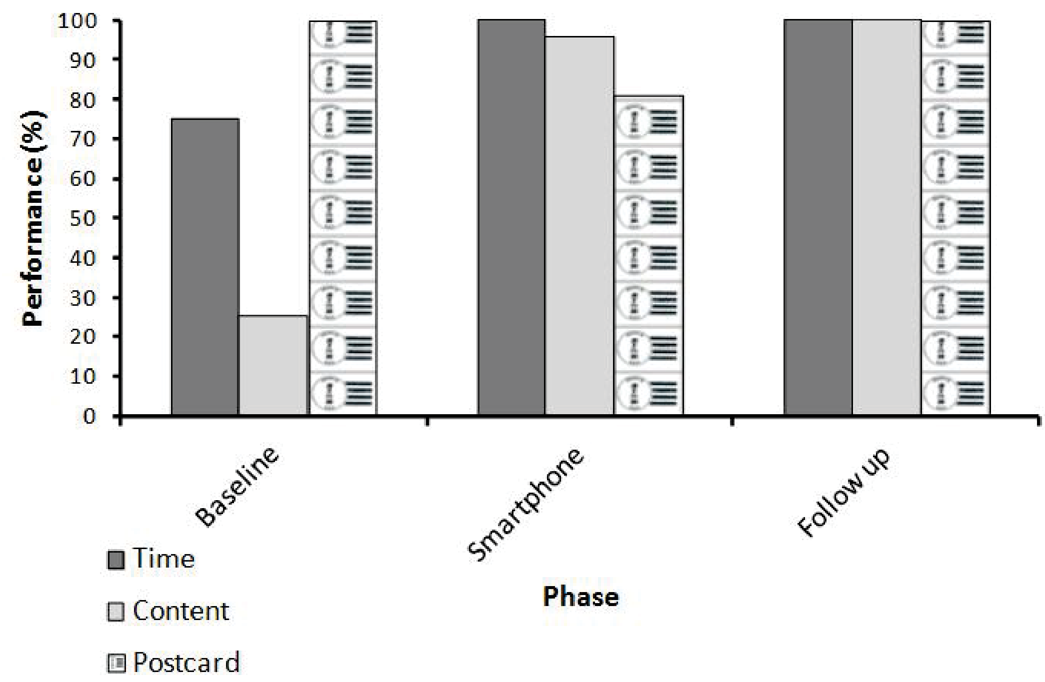

Figure 15. Mean completion rate of assigned memory tasks during baseline and treatment for S3.

Weekly memory performance across baseline and treatment is shown in Figure 16. S3 consistently completed both the *message tasks* and the *postcard task* throughout the study. Whilst S3 always completed the *message tasks* on the correct day during baseline the *content* was not usually related to the study. With the smartphone he was immediately able to complete the *message task* within an hour of the assigned time and *content* related to the study on all occasions, with all but the first being a direct answer to the assigned question. Performance on the *postcard task* was high. Postcards were late in the final weeks of the study as S3 was moving around houses and could not always find a post box. At follow up performance was 100% for all tasks.

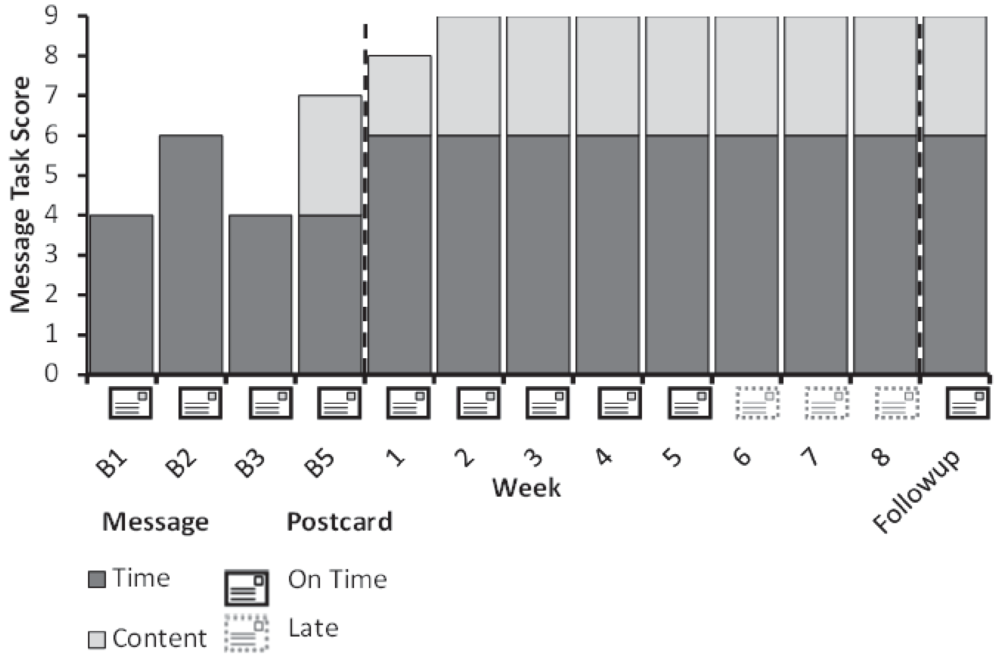

Figure 16. Weekly *message task* score and postcard completion for S3.

Pre- and post-treatment measures.

Table 7 presents the scores and descriptors where available for the formal testing. Underlying memory was in the *severely impaired* range at both baseline and after the smartphone. At follow up the score was in the range of *poor memory*. Given S3 was 20 years post-injury it seems likely this change was due to practice on the test as evidenced by a slight improvement across the board resulting in a higher overall score. Mood was stable and in the *normal* range throughout as measured on the DASS-21.

Table 7. *Psychometric test score descriptors across phases for S3.*

	Baseline	Smartphone	Follow up
RBMT-II	*Severely impaired*	*Severely impaired*	*Poor memory*
DASS-21			
Depression	*Normal*	*Normal*	*Normal*
Anxiety	*Normal*	*Normal*	*Normal*
Stress	*Normal*	*Normal*	*Normal*

Summary of S3

S3 was initially enthusiastic about the smartphone. He found it both difficult and frustrating to learn to use but was determined to do so for his own benefit. He had the full eight hours of training in the first 2 weeks and continued to be trained throughout the treatment with some appointments extended to provide additional assistance. He found it an improvement having everything in one place and without scribbles. He appeared to be able to use both the Calendar and To Do list when prompted but independently would use either the Calendar or the To Do list, but not both. He tended to use the To Do list the most and write in times for meetings. The clear improvement in ability to perform the memory reflects that whilst he has difficulties using the Calendar independently he was able to respond and benefit from entries. S3 was able to make extensive use of his To Do list to manage his memory difficulties. At follow up S3 was finding the smartphone much easier to use, and mostly used the To Do list but recorded important appointments into the Calendar.

Participant S4

S4 was a 48 year old New Zealand European man who sustained a moderate – severe TBI in a motorcycle accident 7 years earlier. S4 was known to make consistent use of a diary with the intention of it being systematic. He was therefore assigned to receive the smartphone and randomly assigned to a 7 week baseline.

S4 reported not having particular difficulty with his memory pre-injury. Since his injury he had become aware of the need to use his diary, and he carried a pocket-sized diary with him at all times. The diary had two pages per week. He also recorded notes on random pages in his diary, and he found it confusing at times. While he was excellent at recording appointments in his diary he had difficulty remembering to refer to it, and often had difficulty knowing the day's date. Consistent with this, he had initially forgotten the first appointment for this study, but was provided a reminder by the primary author. He asked for reminders for appointments during baseline.

Memory tasks performance.

Figure 17 presents S4's mean percentage performance for the *message time*, *message content* and *postcard* memory tasks during baseline and treatment. Using the memory notebook, increases in mean performance were seen for *message time* from 39% at baseline to 92% using the smartphone (*SMD* = 1.59, large ES), for *message content* from 56% at baseline to 100% with the smartphone (*SMD* = 1.31, large ES). Mean performance on the *postcard* task showed a reduction from 92% at baseline to 75% with the smartphone (*SMD* = -.53, medium ES). At follow up he did not use the smartphone as a reminder, did not complete the *message task*, but he completed the *postcard task* on time.

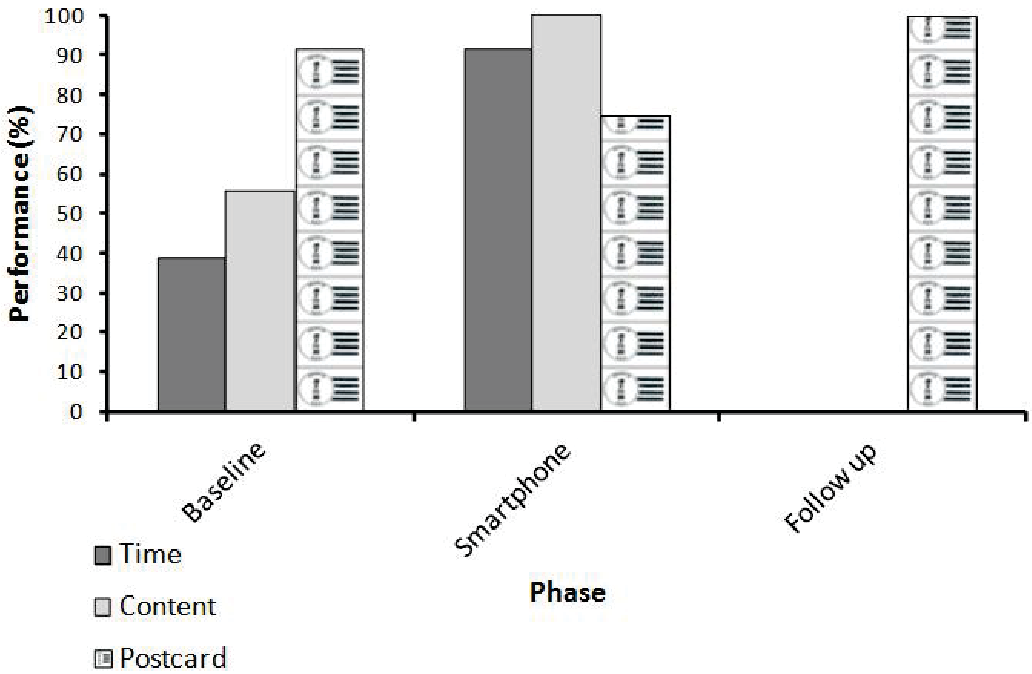

Figure 17. Mean completion rate of assigned memory tasks during baseline and treatment for S4.

Weekly memory performance across baseline and treatment is shown in Figure 18. While S4 generally completed the *message task* during baseline, with the smartphone he was immediately able to do this on time on most occasions. Previously variable performance on the *message content* task immediately improved to clearly answer the assigned question on all occasions with the smartphone. The *postcard task* was completed across all phases on all but one occasion, when the postcard was lost in a house clean-up. Postcards were slightly more likely to be late during the smartphone treatment. By S4's report this was because he was becoming tired of the task as he did not need to post other letters.

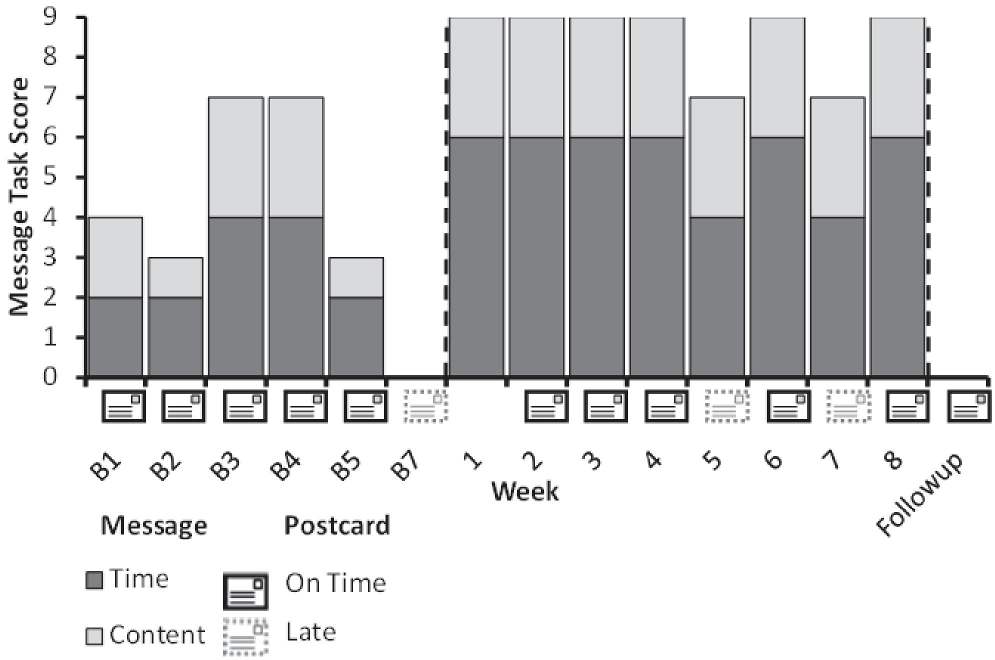

Figure 18. Weekly *message task* score and postcard completion for S4.

Pre- and post-treatment measures.

Table 8 presents the scores and descriptors where available for the formal testing. The apparent decline from *poor memory* to *moderately impaired,* may be explainable by borderline scores and a reported desire to complete the follow up quickly. Mood was stable and in the *normal* range throughout as measured on the DASS-21.

Table 8. *Psychometric test score descriptors across phases for S4.*

	Baseline	Smartphone	Follow up
RBMT-II	*Poor memory*	*Poor memory*	*Moderately impaired*
DASS-21			
Depression	*Normal*	*Normal*	*Normal*
Anxiety	*Normal*	*Normal*	*Normal*
Stress	*Normal*	*Normal*	*Normal*

Summary of S4

S4 was enthusiastic to learn to use the smartphone. He learnt to make use of it quickly and could see the benefit of it. He made frequent and successful use of it for calls and text messaging but more sporadic independent use of it as a memory aid. Use of the To Do list increased over time. Improvement in the *message task* and content reflected S4's ability to respond to notifications on his smartphone appropriately and indicated so long as he regularly used the Calendar he would be able to benefit from it. Despite this, at follow up S4 had reverted to using a paper diary and was not using the smartphone as a memory aid. He did not give a specific reason as to why he had stopped using the smartphone, but reported being excited about choosing a new paper diary for the New Year. He reported he thought he may try to use the smartphone again.

Participant S5

S5 was a 62 year old German man who sustained a severe TBI in a motor vehicle accident 19 years earlier. S5 was randomly assigned to receive the smartphone with a 3 week baseline.

S5 reported a long standing habit of being precise, having a set routine and order and documenting everything in a daily diary. He kept strict business records. This habit has assisted him since his injury and he continued to work to a strict routine. He maintained use of his diary post injury. He used this highly systematically and consistently and relied heavily on it for recording appointments, phone numbers and things to do. His diary was a large A4 planner, which he left at home rather than taking it with him. He disliked taking it with him as then he needed to carry a briefcase. He found the large diary cumbersome and was keen to learn some other strategy for managing his memory. He would send himself a text message on his mobile phone to assist his memory on occasion.

Memory task performance

Figure 19 presents S5's mean percentage performance for the *message time*, *message content* and *postcard* memory tasks during baseline and treatment. Using the smartphone, increases in mean performance were seen for *message time* from 67% at baseline to 83% using the smartphone (*SMD* = .74, medium ES), *message content from* 11% at baseline to 75% with the smartphone (*SMD* = 1.6, large ES). *Postcard* performance was 100% throughout (*SMD* = .00).

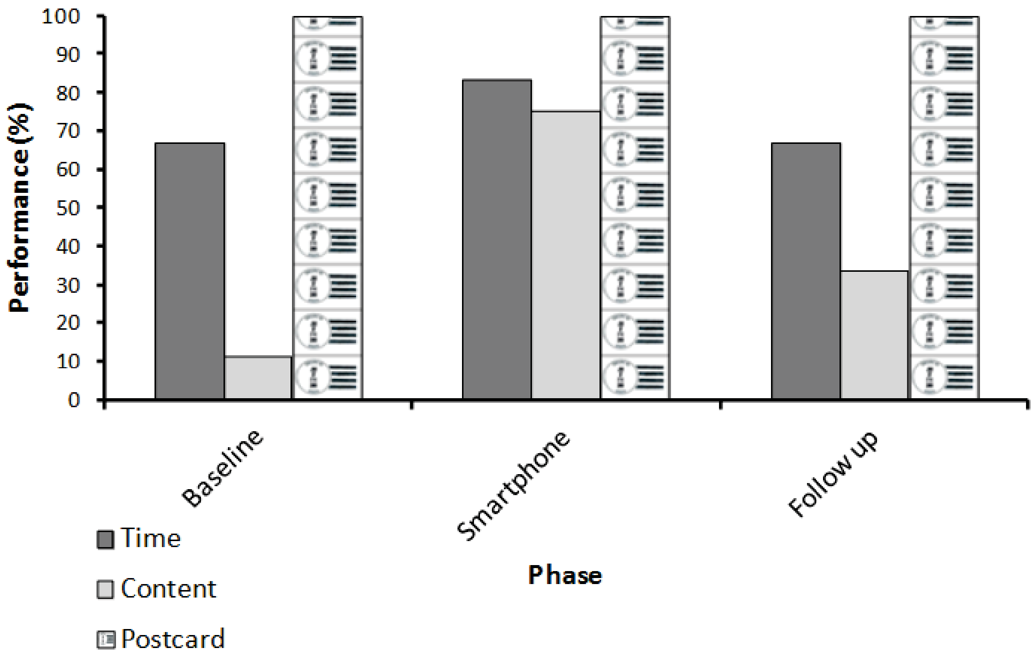

Figure 19. Mean completion rate of assigned memory tasks during baseline and treatment for S4.

Weekly memory performance across baseline and treatment is shown in Figure 20. *Message task* completion time was variable throughout the study, but was within an hour of the assigned time on half of the occasions during the smartphone treatment. There was an immediate improvement in the ability to relate the *content* of the message to memory or the smartphone and half the answers were direct responses to the assigned questions. The *postcard task* was always completed within the week. At follow up S5 scored 67% for performance on the *message time* task, and 33% for *message content*. He completed the *postcard task* on time. He completed the follow up measures without the use of his smartphone.

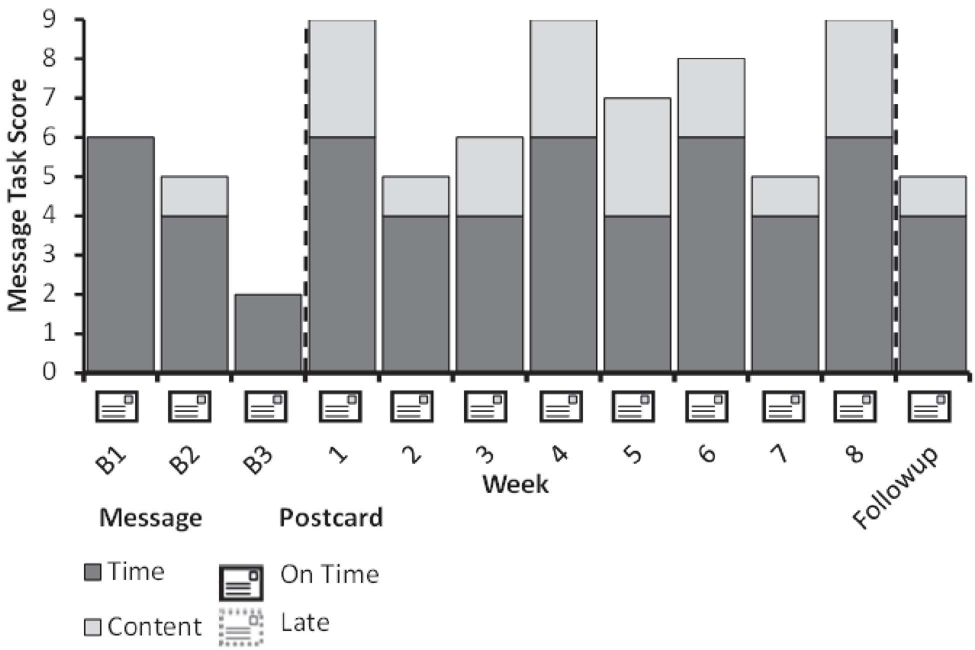

Figure 20. Weekly *message task* score and postcard completion for S4.

Pre- and post-treatment measures.

Table 9 presents the scores and descriptors where available for the formal testing. As expected there were no changes in underlying memory impairment, with S5 having *moderately impaired* memory throughout. Slight changes in mood occurred as seen on the DASS-21 with *normal* mood at baseline *mild* depression and stress due to medical issues during the smartphone treatment and a return to *normal* by follow up.

Table 9. *Psychometric test score descriptors across phases for S4.*

	Baseline	**Smartphone**	**Follow up**
RBMT-II	*Moderately impaired*	*Moderately impaired*	*Moderately impaired*
DASS-21			
Depression	*Normal*	*Mild*	*Normal*
Anxiety	*Normal*	*Normal*	*Normal*
Stress	*Normal*	*Mild*	*Normal*

Summary of S5

S5 was keen to learn to use the smartphone instead of the notebook on the basis that it was more portable. Despite this, from the outset he found learning to use the smartphone difficult. It took 6 weeks before he was comfortable enough to swap his mobile phone number over to the new phone. Prior to this, as he was not using the smartphone as his primary phone it was often left at home and so he had less opportunity to benefit from it. Even when he had transferred to the smartphone he frequently took the SIM out and reinserted it in his previous mobile as he found this easier to use. Despite this, S5 began reducing the level of reliance he had on his diary. The memory task improvements indicate that if he were to make more use of the smartphone in his daily life he would likely benefit from it. At follow up S5 reported he did not have his smartphone as he had loaned it to someone else and was in the process of getting it back.

Discussion

This study demonstrates that a smartphone can be effectively used by an individual with TBI to manage prospective memory difficulties. All participants were able to learn to use the smartphone, and six were willing to use it as a memory aid. Performance on the assigned memory tasks generally improved. In the scheduled *message task* participants were able to perform the task closer to the assigned *time* and the *content* was more likely to be relevant to the assigned question. This indicates a calendar on a smartphone with reminders and the ability to add notes to a task improves prospective memory performance. Whilst the unscheduled *postcard* task was more variable this may have been due to difficulties with a post based task than the unscheduled nature of the task. The improvements observed demonstrated that individuals with TBI are better able to manage prospective memory tasks if these tasks are entered into their calendar or To Do list on their smartphone.

Due to limitations in group numbers the memory notebook and smartphone cannot be directly compared. However, some tentative conclusions can be drawn based on the two participants who received both memory aids. One participant made a large improvement and found the memory notebook invaluable. This supports the idea that consistently using a structured memory notebook can compensate for prospective memory difficulties, as is the consensus in the literature. The improvements using a smartphone over and above those already accrued with the memory notebook for this participant suggests that audible reminders as well as greater portability affords even greater benefit. The one participant who did not benefit from the memory notebook had been provided one previously and was known to “hate” diaries. Additionally, two participants were included in the study having previously made systematic and consistent use of a diary. Both demonstrated improvement over this when using the smartphone. This again suggests additional features of smartphones, particularly alarms, make them more effective than a memory notebook/diary.

These findings are in line with previous research demonstrating individuals with TBI are able to learn to use an external memory aid to compensate for prospective memory difficulties. It adds to the limited research on smartphones as a memory aid, particularly as it utilises more advanced smartphone technology including touch screens, than used in previous research (such as Svoboda et al., 2012). It further extends the research of McDonald et al. (2011), demonstrating not only is a cloud-service backed Calendar beneficial as a memory aid, but that individuals can learn to use it on a smartphone—and therefore do not need to rely on owning a home computer—and can access and edit it at any time.

The characteristics of the participants in this study differ from other similar studies of the use of memory aids. Firstly, all participants were community dwelling and there was no inclusion criteria of having a family member involved. The study was limited to individuals with TBI and did not include others with acquired brain injury. Unlike McDonald et al. (2011), not all participants reported using a memory aid to compensate prior to the study. Further, initial recruitment excluded those who made systematic and consistent use of either memory aid, with this study only later including those who had made used of a diary but not smartphone. Training with the memory aids took an errorless learning approach (see Cicerone et al., 2011; Sohlberg & Mateer, 2001 for reviews) but did not rely on more complicated training methods such as fading of cues as in other studies (e.g., Svoboda et al., 2012). This implies that it can be expected that individuals in the community are able to learn to use a smartphone as a memory aid irrespective of prior memory aid experience. A relatively simple training method of errorless learning is sufficient for these individuals to learn to make use of a smartphone as a memory aid.

At follow up the majority of participants maintained their improved performance on the memory tasks. However, the actual use of the smartphone in the intervening two months was variable as three of the six participants who initially benefitted from the smartphone had chosen to reduce or stop using the smartphone as a memory aid. Two were participants who had previously used a diary, one returning to use the diary. The other had not bought a new diary for the year and intended to use the smartphone, although he had lent it to someone else at the time. The third participant reported the smartphone was helpful but found it frustrating and time consuming to find his glasses in order to be able to see the screen. There are clearly many factors to successful long term implementation of a memory aid, beyond mere efficacy.

Future research could increase sample size and directly compare the memory notebook and smartphone. This was intended for the current study if sufficient numbers had been able to be recruited. Further, it would be of interest to investigate whether specific cognitive or other abilities and difficulties are related to ability to learn to use the smartphone. In this study qualitative and observational information suggests individuals who are tangential, and inexperienced with technology may struggle the most. Additionally, these participants were some of the older participants in the study, and more time had passed since their injuries. More in-depth research could investigate what combination of cognitive and other factors makes it easy to learn to use a smartphone successfully and independently.

This research could be extended to examine other populations with memory difficulties. For example enlisting a caregiver to enter reminders for individuals with degenerative memory disorders such as Alzheimer's disease could have the potential to prolong independence in these individuals. Further, additional functions of the smartphone have potential therapeutic benefit, such as the ability to GPS track the smartphone allowing individuals with early memory disorders to be independent in the community, whilst caregivers know that should the individual become disoriented they can be found with GPS. Participants in this study reported having recommended both the memory notebook and the smartphone to others with memory disorders, this includes some who are likely to have had multiple mild head injuries, alcohol and drug related memory difficulties including foetal alcohol syndrome, and intellectual disability. Clinical research investigating these avenues would be valuable to determine whether these groups also could benefit from training with notebook or smartphone memory aids. With an aging population there may be an increased need for supports for individuals with disabilities and age related degenerative memory disorders in the future. Therefore, the use of relatively inexpensive memory aids such as smartphones, which people with memory difficulties can be trained to use independently is of high importance.

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Chapter 4: Supplementary Results

This chapter presents the supplemental results which were not the primary findings of interest, and thus for the purpose of space were not presented in detail in the paper presented in Chapter 3.

Visual inspection of changes in mood across time demonstrated little consistent change from baseline to treatment. Therefore the ratings of various moods taken each week (see Appendix 7) were collapsed into a mean score for each week to investigate overall changes across time. Negative items on the mood likert ratings (e.g., *I feel like a burden*) were reversed scored so 10 was the more positive outcome (in this example less of a burden). Mean mood ratings for each week are presented for each participant.

Ratings of helpfulness of the memory aid across treatment weeks are also presented for each participant. The ratings taken at end of treatment and at follow up of overall helpfulness of the memory aid, self rated improvement in remembering using the memory aid, and likelihood that the participant would recommend the memory aid to someone else with prospective memory difficulties after TBI are also shown.

The mean score for CAPM section A (CAPM-A; *frequency* of forgetting), and CAPM section B (CAPM-B; perceived *importance* of forgetting) are presented. CAPM section C (CAPM-C) was originally developed to assess agreement with reasons for forgetting and remembering, and a high mean score indicates greater agreement with reasons for forgetting and memory (Shum & Fleming, 2012). For this project, total scores were calculated that indicated endorsing greater forgetting, where necessary by reverse coding some items. This resulted in reverse scoring four items which endorsed ways of remembering (e.g., "If something is very important to me I usually remember to do it"). Mean scores were presented with higher scores indicating greater agreement with *reasons* for forgetting. The CIQ total score is also presented.

Efforts were made to collect informant versions of both the CAPM and CIQ, however a full set of informant measures was not able to be obtained for any participant and are therefore not shown. Just two of the participants lived with someone who could provide scores on the informant measures. The informant (mother) of one of these participants completed the baseline and treatment measures but not follow-up, and in one case it appeared to be the participants writing. For the other participant who lived with others, the measures were completed by two different people at baseline and treatment, making comparison unlikely to be valid, no follow up measure was returned. Some other participants attempted to return an informant measure from others who knew them well, in most cases the participant and informant (in writing) reported they could not accurately report on the persons memory since they did not live with the participant. In each of these cases just one measure was returned and so therefore comparisons could not be made even had the informant version been accurate.

N1

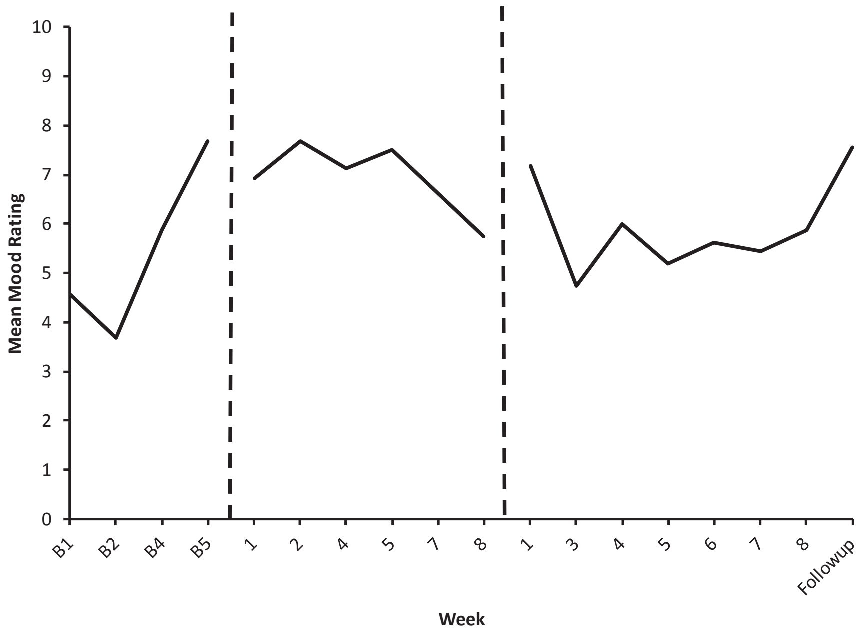

Figure 21. Mean mood rating across weeks during baseline, memory notebook and smartphone for N1.

The mean mood ratings across weeks are shown in Figure 21. Mood appeared to improve during baseline, then vary across weeks throughout the study. This is interesting given N1 improved from *severe* depression on the DASS-21 to *mild* depression with the provision of the smartphone (See results Chapter 3).

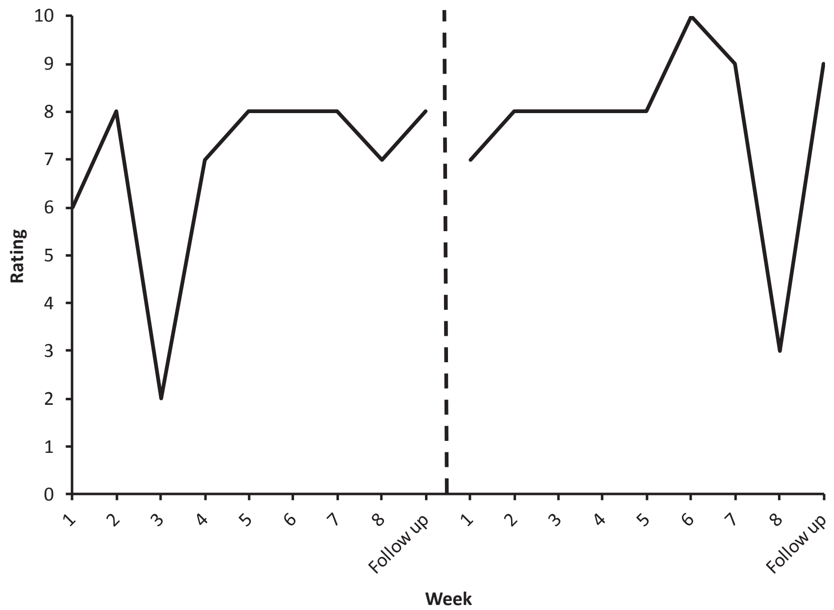

Figure 22 Ratings of helpfulness of the memory notebook and smartphone across treatment weeks for N1.

The helpfulness of the memory notebook and smartphone are demonstrated in Figure 22. It can be seen that N1 generally found both the memory notebook and the smartphone helpful aside from the occasional week (usually where a memory aid of any kind were not required). At the end of the memory notebook N1 rated the overall helpfulness as an 8/10, his perceived improvement in ability to remember tasks as a 7/10, and his rating of likelihood to recommend the memory aid to others with similar difficulties a 10/10. At follow up ratings were similar, with 7/10 overall, 8/10 for improvement and 10/10 for likelihood to recommend the memory aid to others with similar difficulties. At this point N1 mentioned he had already tried to help friends who "probably had head injuries or foetal alcohol syndrome" to implement a memory notebook. At the end of the smartphone N1 rated it less highly, giving ratings of 3/10 for overall helpfulness, overall improvement and his likelihood to recommend the memory aid to others with memory difficulties after TBI. N1 reported that his ratings of helpfulness and improvement were in comparison to the memory notebook (therefore reflecting a small improvement) but were not large as it was at times difficult to use. He reported his likelihood to recommend the memory aid to others with similar difficulties as being low because he did not think he, or others would have been able to implement it without help, and he was himself unsure how he would go without assistance in the future. Ratings had greatly improved at follow up, with N1 reporting 10/10 for overall helpfulness, improvement and his likelihood to recommend the memory aid to others with memory difficulties after TBI. This appears to reflect greater confidence in use of the smartphone with time and independent use. N1 again reported that he had already recommended it to people he knew who may benefit from a memory aid.

Table 10. *Mean prospective memory (CAPM) scores and total community integration (CIQ) score across phases for N1.*

	Baseline	**Notebook**	**Follow up**	**Smartphone**	**Follow up**
CAPM					
Section A(max 5)	2.9	2.6	2.8	2.8	2.4
Section B (max 5)	2.7	-	2.8	-	2.8
Section C (max 4)	3.2	2.7	2.6	2.7	2.7
CIQ (max 29)	21	23	22	22	23

Scores on the CAPM and CIQ are shown in Table 10. There was little variation in CAPM-A scores, with *mild-moderate* prospective memory difficulties throughout. Similarly, there was little change in CAPM-B. Measures of CAPM-B were not taken at all time intervals due to participant time constraints where the session ran well beyond the expected time and the participant had to leave for a following appointment. The decision to not complete the CAPM-B was based on prioritising measuring CAPM-A and CAPM-C as more likely to change using a memory aid. There was little change in CAPM-C across time, with a small decline from baseline to memory notebook and no further change. There was little change on the CIQ total score. However, N1 scored in the high end of the CIQ scale and due to his brain injury and physical injuries he had been unable to secure a job, and had financial difficulties which were restrictive of further increases.

N2

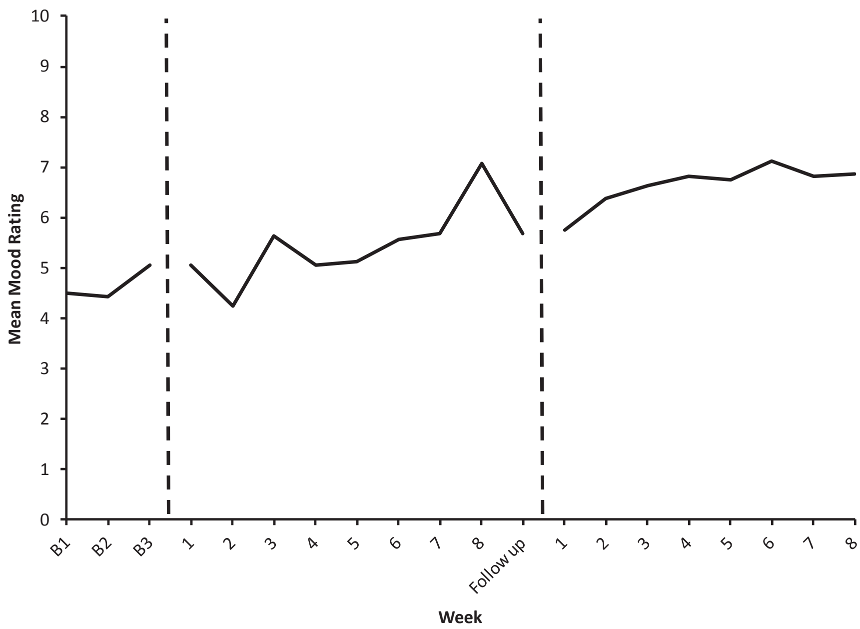

Figure 23. Mean mood rating across weeks for baseline, memory notebook and smartphone for N2.

The mean mood ratings across weeks are shown in Figure 23. While a trend for improvement in mood can be seen across both the memory notebook and smartphone treatment, this may have been due to the passage of time as improvements possibly began during baseline. This is particularly likely given that

N2 did not show an improvement using the memory notebook during this time but improvement in mood. Other improvements appeared to occur during this time such as a reduction in fatigue evidenced through reportedly fewer and shorter naps. Mood ratings at follow up were not completed due to participant time constraints as he had booked another appointment immediately following this session.

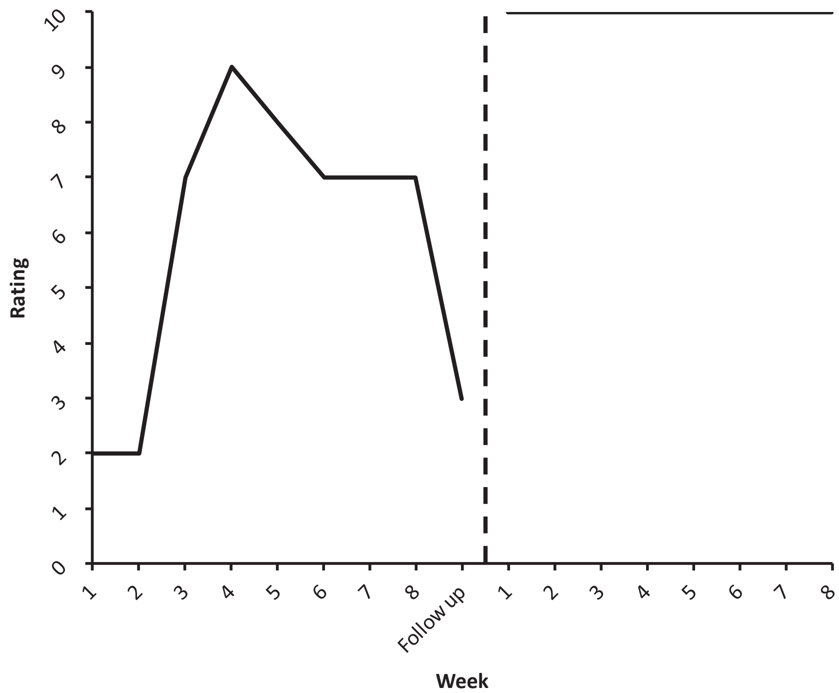

Figure 24. Ratings of helpfulness of the memory notebook and smartphone across treatment weeks for N2.

The helpfulness of the memory notebook and smartphone is shown in Figure 24. It can be seen that after the initial set-up weeks with the memory notebook N2 was positive about the helpfulness of the memory notebook but this declined substantially after a few weeks, consistent with his reports and limited use of the memory notebook. Despite a lack of use of the memory notebook N2 rated overall helpfulness, perceived improvement and likelihood to recommend the memory aid to others with similar difficulties all as 10/10. This may indicate social desirability effects given observable use and improvement did not match these ratings. Follow up ratings were lower, and likely more realistic for N2. He rated helpfulness as 5/10, improvement as 3/10. He still reported 10/10 for recommending to others, reporting it could be useful for them. A possible reason for the drop in numbers is reduced social desirability effect as N2 was aware at this time that he would be receiving a second memory aid and therefore that his memory notebook may not have been the better memory aid (participants had been told during informed consent that if one memory aid was more effective than the other they would be offered the better memory aid).

In line with N2's positive reports and evidence of independent use and improvements using the smartphone he consistently rated this as 10 for helpfulness from the first week (and he had started using it as a memory aid immediately upon provision of the smartphone). Similarly at both the end of the smartphone treatment, and at follow up N2 provided 10/10 ratings for overall helpfulness, improvement in ability to remember tasks and likelihood to recommend the memory aid to others with similar difficulties. N2 reported that he had recommended the present study to others he knew with a TBI (who had not been referred by the locality organisation he attended, or had been assessed and excluded from the study). Further, he reported he had been trying to help others use their existing smartphones as a memory aid, as well as showing family members without brain injury how to use their smartphones for normal memory difficulties.

Table 11. *Mean prospective memory (CAPM) scores and total community integration (CIQ) score across phases for N2.*

	Baseline	**Notebook**	**Follow up**	**Smartphone**	**Follow up**
CAPM					
Section A(max 5)	1.5	1.8	2.1	1.8	2.0
Section B (max 5)	3.3	2.1	2.7	3.4	2.6
Section C (max 4)	3	3	3.2	2.7	2.9
CIQ (max 29)	13	18	17	20	17

Scores on the CAPM and CIQ are shown in Table 11. CAPM-A scores were relatively stable across time, despite performance on memory tasks and participant report. At baseline and the end of each treatment prospective memory difficulties were categorised as *no problem* but were on the border, and at both follow up's were in the range of *mild-moderate problem*. CAPM-B scores tended to vary across time being highest at baseline and the end of the smartphone treatment. CAPM-C scores were relatively stable. N2 demonstrated an increase in community and household integration (CIQ) after the memory notebook and further increase after the smartphone; this had partially declined at follow up. The decline seen at follow up after the smartphone was due to Christmas and school holidays which reduced both his work and voluntary activities. The level of community and household integration he could achieve was limited by inability to drive and poor access to public transport.

S1

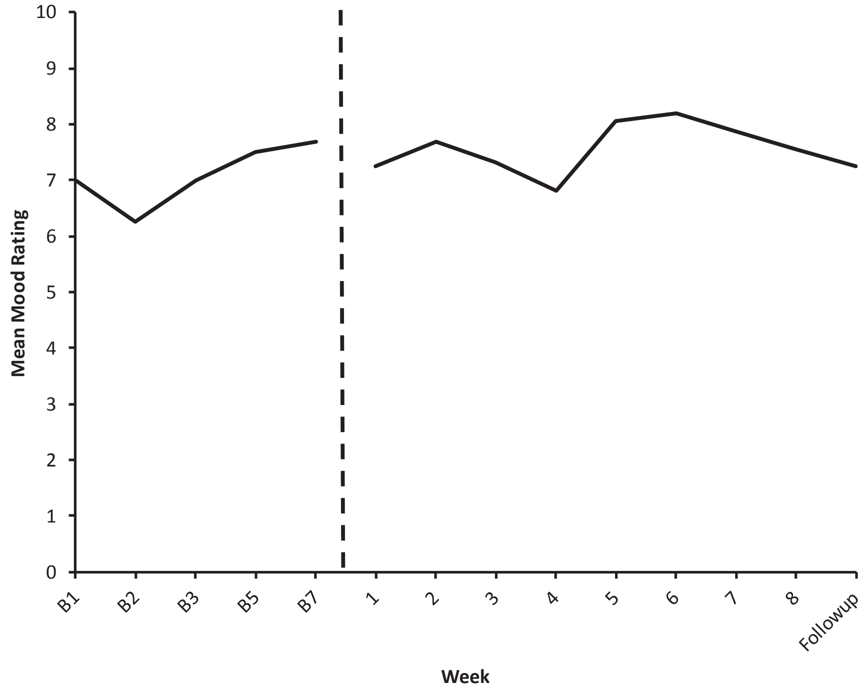

Figure 25. Mean mood ratings across weeks for baseline and smartphone for S1.

The mean mood ratings across weeks are shown in Figure 25. Mood appears to have remained relatively stable across the study.

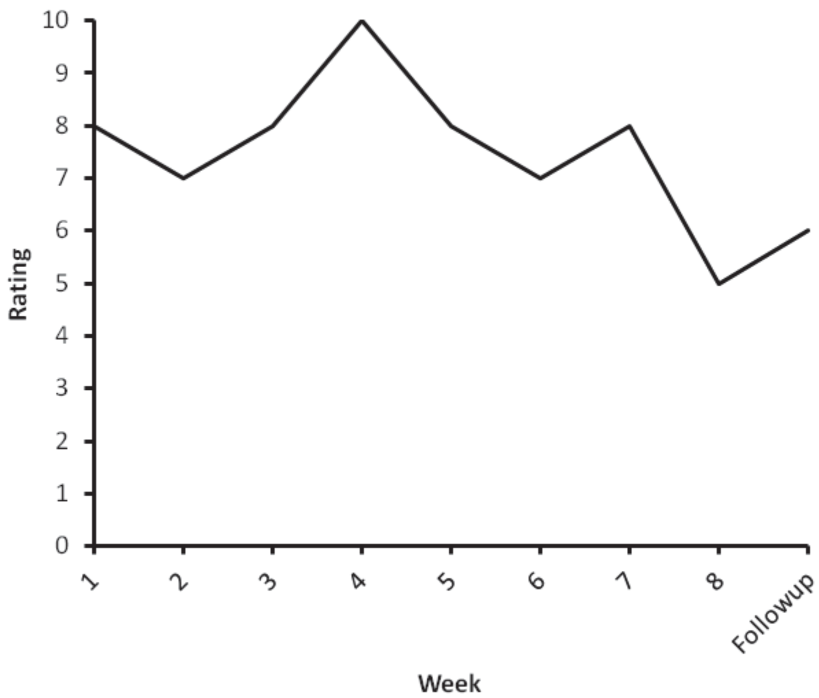

Figure 26. Ratings of helpfulness of the smartphone across treatment weeks for S1.

The helpfulness of the smartphone is demonstrated in Figure 26. It can be seen that S1 appeared to find the smartphone less helpful over time, (although it varied across weeks). At the end of the smartphone treatment S1 rated both the overall helpfulness and perceived improvement in ability to remember tasks as an 8/10, he rated his likelihood to recommend the memory aid to others in a similar situation as 5/10. He reported this was because he and others with similar difficulties due to TBI would not be able to learn to use the smartphone without appropriate assistance. At follow up he rated overall helpfulness of the smartphone higher with 10/10 but improvement lower with 5/10. He reported that he knew the smartphone was helpful but had been using it less, therefore improvement was lower. Likelihood of recommending the smartphone to others with TBI declined slightly to 4/5.

Table 12. *Mean prospective memory (CAPM) scores and total community integration (CIQ) score across phases for S1.*

	Baseline	**Smartphone**	**Follow up**
CAPM			
Section A (max 5)	3.5	3.1	3.0
Section B (max 5)	2.7	2.5	2.0
Section C (max 4)	3.2	3.3	2.9
CIQ (max 29)	16	14	14

Scores on the CAPM and CIQ are shown in Table 12. CAPM-A scores remained stable and *mild-moderate* across the study. CAPM-B declined slightly. CAPM-C remained relatively stable. S1 scored in the mid range for total CIQ score, and declined slightly with the smartphone.

S2

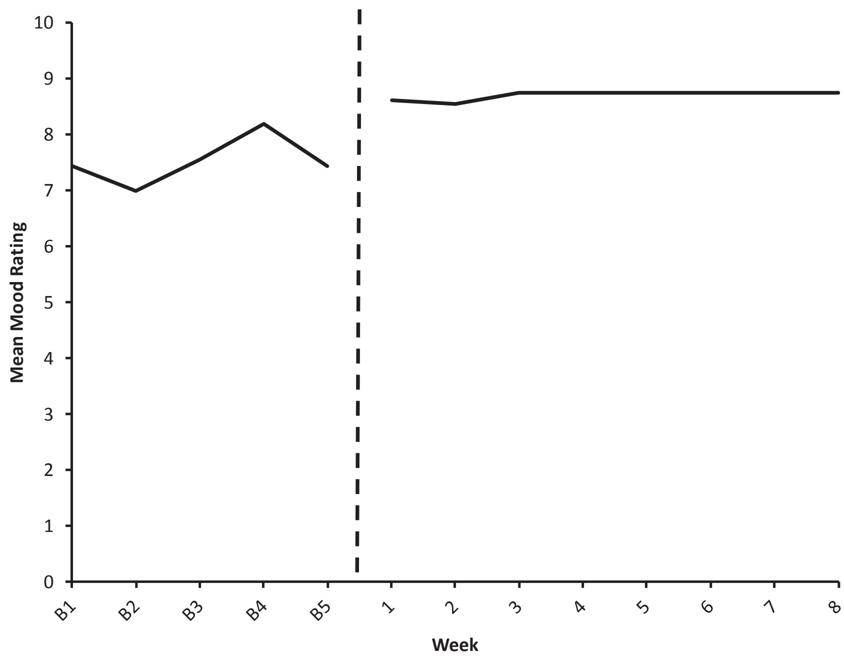

Figure 27. Mean mood rating across weeks for baseline and smartphone for S2.

The mean mood ratings across weeks are shown in Figure 27. S2 disliked the smartphone and appeared to be frustrated with the study in general (although he was willing to continue). The change in mood rating and steady ratings throughout treatment can be explained by S2 deciding that all ratings were either a 0 (usually he described the mood as "irrelevant") or 10. Follow up ratings were not completed due to participant time constraints as the session ran over the agreed time and he had another meeting to attend.

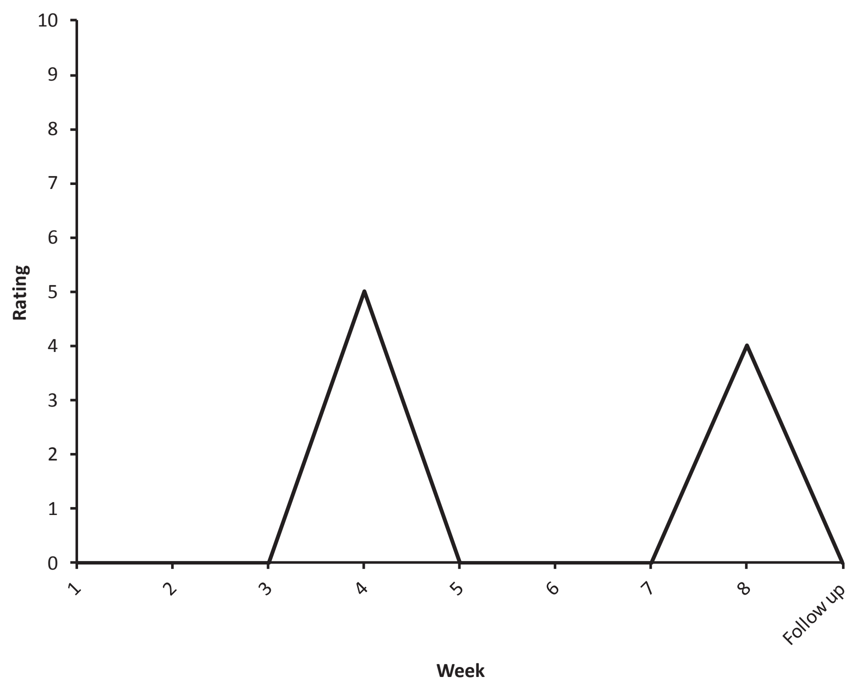

Figure 28. Ratings of helpfulness of the smartphone across treatment weeks for S2.

The helpfulness of the smartphone is demonstrated in Figure 28. It can be seen that S2 consistently disliked the smartphone with the weeks where ratings were above zero being those where the smartphone was particularly useful for "phone functions). At the end of the smartphone S2 rated 5/10 for overall helpfulness, improvement in ability to remember tasks, and his likelihood to recommend the memory aid to others with similar difficulties. S2 reported that he gave these ratings because the smartphone was helpful for "phone functions", additional focus on his memory had improved his memory, and because he "could see the smartphone could be useful for others.....but not for me". Follow up ratings were not completed due to participant time constraints as mentioned above.

Table 13. *Mean prospective memory (CAPM) scores and total community integration (CIQ) score across phases for S2.*

	Baseline	**Smartphone**	**Follow up**
CAPM			
Section A(max 5)	1.7	1.5	1.5
Section B(max 5)	1.6	1.9	1.9
Section C (max 4)	2	1.8	1.9
CIQ(max 29)	19	14	15

Scores on the CAPM and CIQ are shown in Table 13. CAPM-A remained relatively stable across time and these were in the range of *no problem* with prospective memory. This finding may be in part explained by S2's decision not to rely on memory, and so he always did everything immediately (irrespective of time). CAPM-B and CAPM-C scores both were fairly stable across time. S2 demonstrated a reduction in level of community and household integration on the CIQ reflecting withdrawal from activities out of frustration with some groups and a decision (which was unable to be fulfilled) to move overseas.

S3

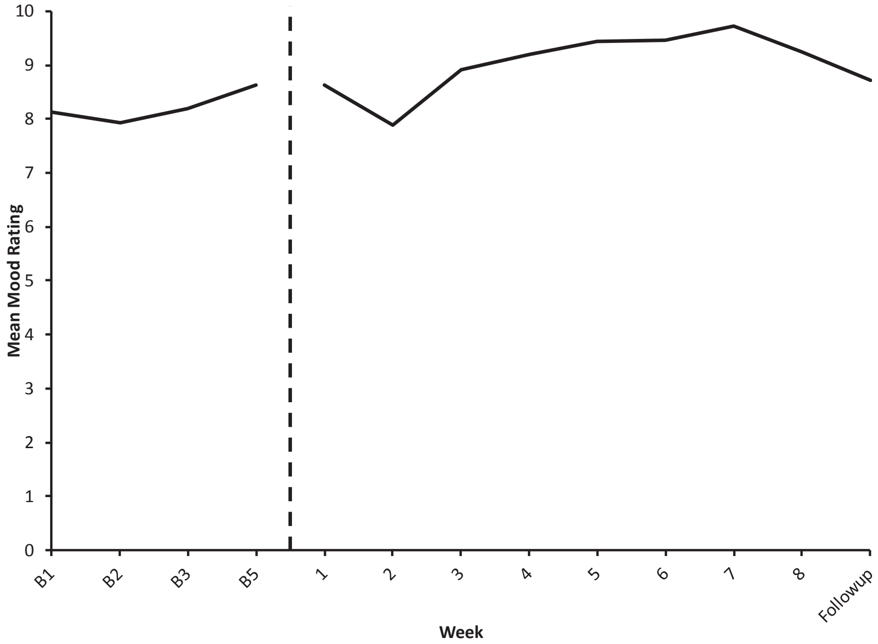

Figure 29. Mean mood rating across weeks for baseline and smartphone for S3.

The mean mood ratings across weeks are shown in Figure 29. Mood appears to have remained relatively stable and positive across the study.

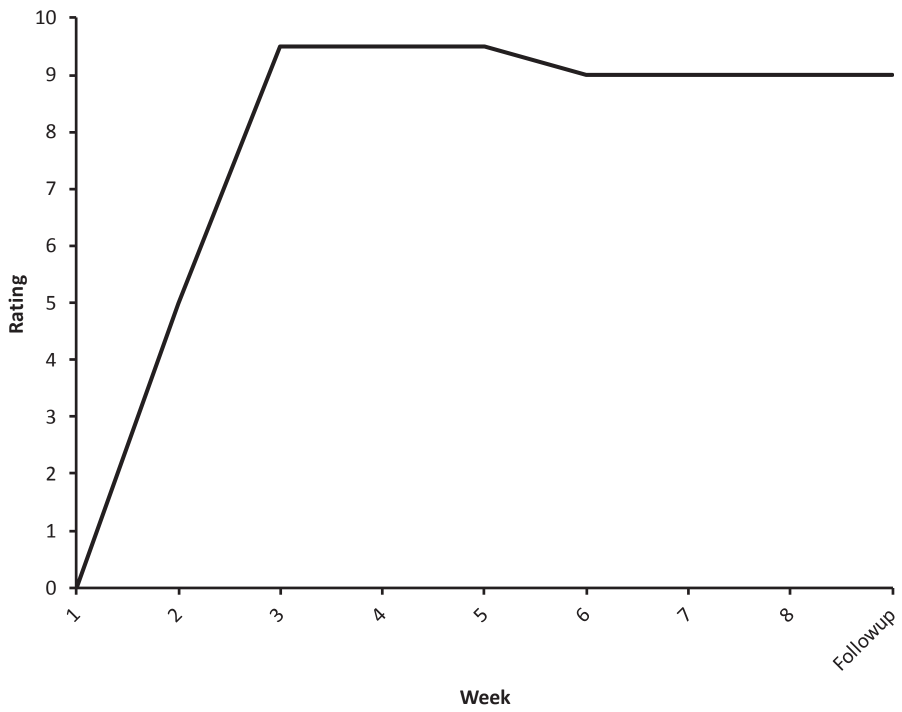

Figure 30. Ratings of helpfulness of the smartphone across treatment weeks for S3.

The helpfulness of the smartphone is demonstrated in Figure 30. It can be seen that S3's rating of helpfulness greatly increased from low rating of helpfulness to consistently high ratings for the remainder of the treatment. This is in line with the time it took S3 to learn to use the smartphone as a memory aid. It should be noted that although S3 had difficulty using the smartphone for the majority of the treatment period, he still rated it as helpful. At the end of the smartphone treatment S3 rated the overall helpfulness as 10/10, his perceived improvement in ability to remember tasks as an 8.5/10, and likelihood to recommend the memory aid to others in a similar situation 9/10—he reported he did not rate it as a 10 as he had not recommended it to anyone so far. At follow up ratings were similar, with 9/10 overall, 8.5/10 for improvement and 9/10 for likelihood to recommend.

Table 14. *Mean prospective memory (CAPM) scores and total community integration (CIQ) scores across phases for S3.*

	Baseline	**Smartphone**	**Follow up**
CAPM			
Section A (max 5)	2.1	1.9	1.9
Section B (max 5)	2.8	2.5	2.6
Section C	2.6	2.7	2.6
CIQ (max 29)	24	24	24

Scores on the CAPM and CIQ are shown in Table 14. Overall CAPM-A scores remained relatively stable, with a small decline after the smartphone which was maintained at follow up. Due to scores being on the borderline this resulted in a categorical change from *mild-moderate* prospective memory difficulties at baseline to *no problem* with prospective memory difficulties after the smartphone. CAPM-B were fairly stable with a slight decline after the smartphone. CAPM-C remained stable across the study. There was no change in community and household integration (CIQ) across the study, which reflected the high level of independence on entry to the study.

S4

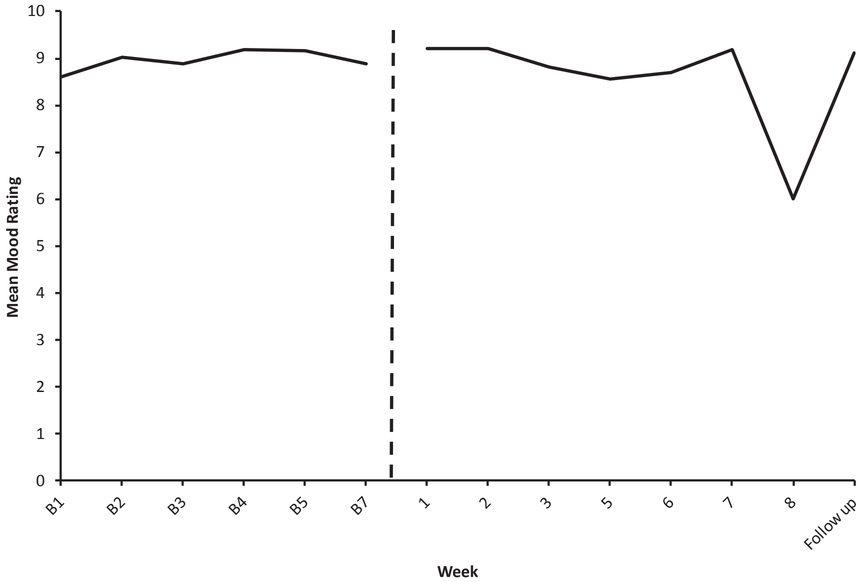

Figure 31. Mean mood rating across weeks for baseline and smartphone for S4.

The mean mood ratings across weeks are shown in Figure 31. Mood appears to have remained relatively stable and positive across the study with a dip in mood on the final week of treatment.

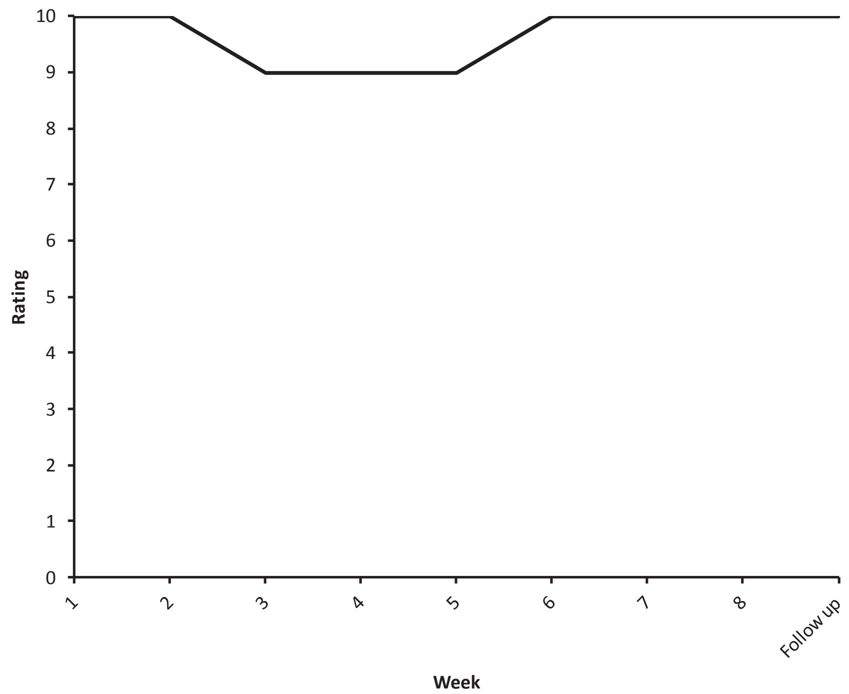

Figure 32. Ratings of helpfulness of the smartphone across treatment weeks for S4.

Helpfulness of the smartphone is shown in Figure 32. This showed reasonably consistent high ratings of the smartphone with a slight decline associated with technical difficulties which occurred with the smartphone. At the end of the smartphone treatment S4 rated the overall helpfulness as a 10/10, his perceived improvement in ability to remember tasks as a 9/10, and likelihood that he would recommend the memory aid to others in a similar situation 10/10. At follow up S4 rated overall helpfulness as 10/10 but improvement as 5/10 which he reported was due to rarely using it as a memory aid. He rated likelihood to recommend the memory aid to others with similar difficulties as 10/10, and reported that he did not know of anyone otherwise that he would have recommended it to already.

Table 15. *Mean prospective memory (CAPM) scores and total community integration (CIQ) score across phases for S4.*

	Baseline	Smartphone	Follow up
CAPM			
Section A (max 5)	1.4	1.6	1.8
Section B (max 5)	3.4	3.4	3.4
Section C (max 4)	2.5	2.1	1.9
CIQ(max 29)	23	24	21

Scores on the CAPM and CIQ are shown in Table 15. CAPM-A scores remained relatively stable and *no problem*, over time. CAPM-B scores did not vary across the study. CAPM-C declined slightly across the study. There was no change in community and household integration (CIQ) across the study, which reflected a reasonably high level of independence throughout the study.

S5

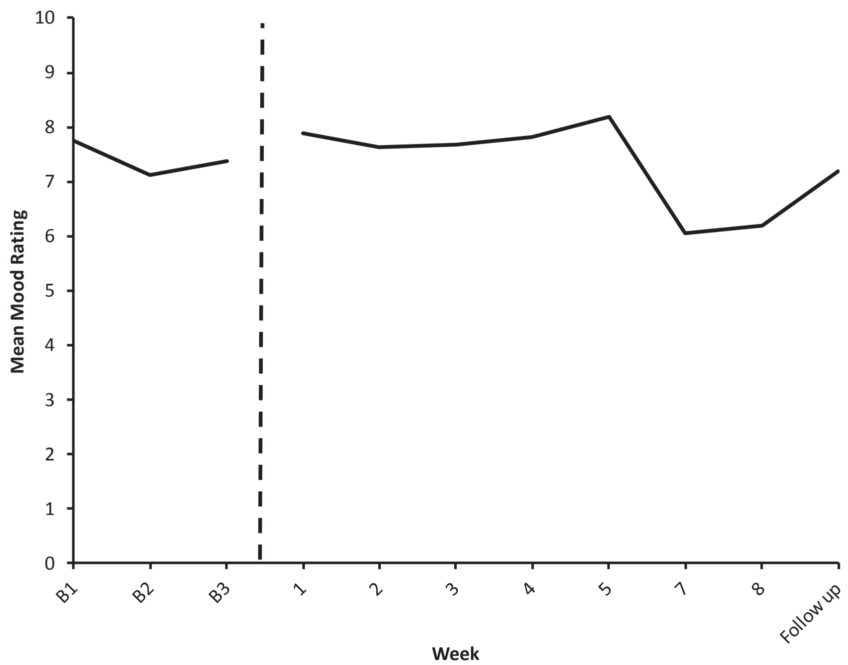

Figure 33. Mean mood rating across weeks for baseline and smartphone for S5.

The mean mood ratings across weeks are shown in Figure 33. Mood tended to be relatively stable across time with a decline in the final weeks associated with pain due to physical injuries awaiting surgery.

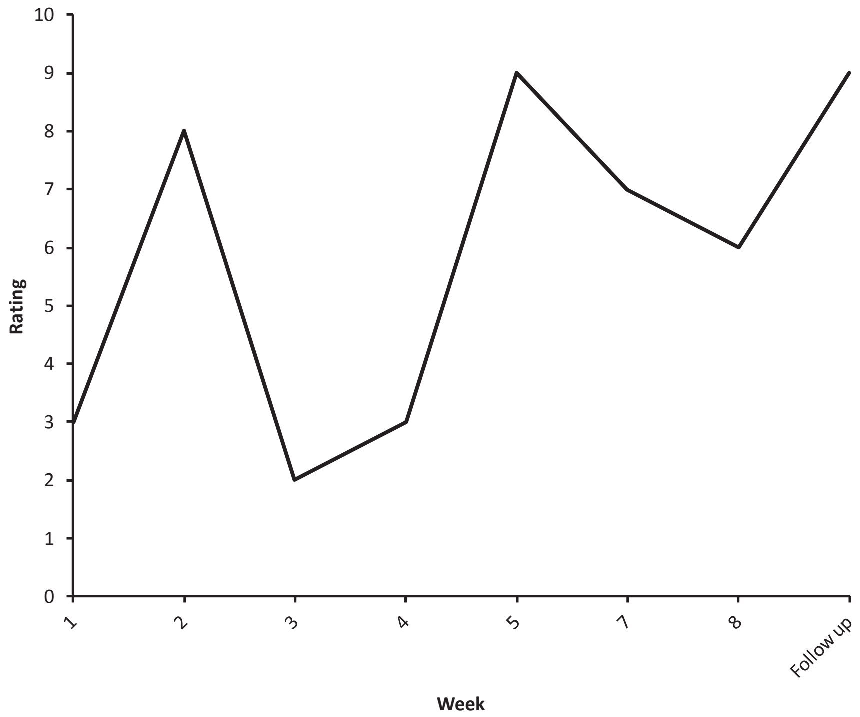

*Figure 34. R*atings of helpfulness of the smartphone across treatment weeks for S5.

Helpfulness of the smartphone is shown in Figure 34. There was considerable variation week to week, with a trend for an increase across time. The variation reflects the difficulties and variation in level of use of the smartphone. At the end of the smartphone treatment S5 rated the overall helpfulness as an 8/10, his perceived improvement in ability to remember tasks as an 8/10, and his likelihood to recommend the memory aid to others in a similar situation 9/10. At follow up S5 reported helpfulness as 9/10, level of improvement as 7/10 and likelihood to recommend to others as 9/10. It is likely that there is an element of social desirability bias in these ratings given that S5 was not using the smartphone at follow up and had given it to someone else who needed a mobile phone.

Table 16. *Mean prospective memory (CAPM) scores and total community integration (CIQ) score across phases for S5.*

	Baseline	**Smartphone**	**Follow up**
CAPM			
Section A(max 5)	1.7	1.9	1.6
Section B (max 5)	2.6	2.4	2.4
Section C(Max 4)	2.7	2.6	2.7
CIQ(max 29)	24	28	23

Scores on the CAPM and CIQ are shown in Table 16. CAPM-A scores were in the *no problem* range throughout and relatively stable. CAPM-B scores declined slightly after the smartphone and remained so at follow up. CAPM-C scores remained stable across time. There was slight variation on the level of community and household integration (CIQ) across time, with an increase with the smartphone and return to baseline at follow up. Overall level of independence was high throughout and variation may have been due to physical injuries and pain associated with these injuries.

Discussion

Contrary to expectations, mood did not appear to change over time for most participants. In general where mood changes did occur these were related to events occurring outside of the study. Where improvements in mood were seen (e.g., N2 and S3) it is not clear the extent, if any, of which this related to involvement in the study. This does not support the hypothesis that mood would improve alongside expectation of improvements in ability to manage memory difficulties.

As expected, for the most part, participants rated the memory notebook and smartphone as helpful and rated their likelihood of recommending their memory aid to others with TBI high. Perceived level of improvement was more variable. In some cases there appeared to be some social desirability bias as some participants who were not making use of their memory aid reported high levels of helpfulness and improvement. While it is plausible that perceived levels of helpfulness and improvement may be higher than observable levels, the cases where social desirability may be occurring are those in which actual use of the memory aid was limited or non-existent. Of those who received the smartphone only, two (S3 and S4) reasonably consistently reported it to be highly helpful, one had variable ratings with a trend for improvement across time (S5), one gradually found it less helpful (S1), and one immediately disliked it (S2). Overall, this finding provides conflicting evidence towards the hypothesis that participants would rate the memory aids as helpful, as having improved their ability to complete memory tasks, and being useful for others with memory difficulties after TBI. It is interesting that in some cases where reports of helpfulness were relatively low, they would still recommend it to others with similar difficulties after TBI.

Direct comparisons between helpfulness of the memory notebook and smartphone cannot be made due to small sample size. However two participants N1 and N2 received both memory aids, and so some tentative information can be drawn from their ratings. N1 demonstrated improvements using both memory aids (see Chapter 3) with some variation due to external factors for both memory aids. Ratings of the smartphone on a weekly basis tended to be higher than that of the memory notebook. Overall ratings of helpfulness and improvement with the memory notebook were relatively high both immediately after treatment and at follow up. With the smartphone low ratings were given immediately but at follow up ratings were higher than for the memory notebook. Overall, this suggests that in the long-term the smartphone was more beneficial, but perhaps more time was required for him to see the benefits or to be confident in the use of the smartphone. Weekly ratings of helpfulness of the memory notebook gradually increased for N2 but dropped at follow up, the overall ratings were high at the end of the memory notebook but likely reflect social desirability bias and declined at follow up. N2 spoke positively of the smartphone and made immediate use of it. Ratings of helpfulness both weekly and overall were consistently 10/10 as were perceived improvement and likelihood to recommend the memory aid to others with TBI, and this fitted with his use of the smartphone. A difference between N1 and N2 was in the ability to learn to use the memory aids. N1 was able to grasp the memory notebook quickly while it was more foreign to N2. When provided the smartphone N1 was able to use it, but this took longer and he was less confident in his ability. N2 was able to use it with little training, quickly grasped the use of the calendar for making appointments, and he was confident in his ability to use it.

Community and household integration as measured on the CIQ did not appear to be altered by improved ability to manage prospective memory difficulties. This appears to be an accurate representation based on participant reports. This finding may be in part due to the sample involved in this study. Overall the participants tended to be individuals who were relatively independent, with just one moving in with others as a result of his injury, and one effectively going into early retirement. Living independently meant they were both capable and required to complete tasks within the household and in the community. Their scores tended to be reasonably high on the CIQ at baseline and remain so throughout the study. Further, some were limited on their ability to improve CIQ scores due to financial constraints, difficulties accessing transport and management of fatigue or physical injuries resulting from their accidents. It was observed subjectively that whilst actual level of integration did not alter, the ability to manage the tasks was improved. There were fewer times that the person initially forgot a task and then returned to complete it (no change in actual completion). This resulted in reports of days which were more structured, rather than featuring multiple trips in and out of the home as tasks were remembered.

Contrary to expectations, individuals did not report improvement on prospective memory self-report questionnaires even when they showed improvement in assigned memory tasks and reported improvement. There are a few possible explanations for the lack of change on the CAPM. Firstly, many items on the CAPM, while potentially able to be modified using an external memory aid (e.g., remembering to shower or bath) were items which participants did not include in their memory aid. While provided cues during the research to add items identified as difficulties on the baseline CAPM-A measure, it was at the participant's discretion whether they chose to do so. Participants predominantly scheduled important events in their calendar and were willing to include reminders for medication, but not other more routine tasks which may be forgotten. Few of the CAPM-A items were selected by any participant to be used as a reminder on their memory aid. Those items which were included were appointments, prescription medications, messages, birthdates, phone calls, chores, and bills. However, most participants applied their smartphone to just a few of these items. This resulted in overall small changes in mean scores on the CAPM-A as few items changed. A further potential explanation was verbalised by some participants; this was the tendency to rate their memory as if they were not using their memory notebook or smartphone on treatment and follow up measures. This was despite reminders from the researcher that they were to score based on their memory with the memory aid.

Chapter 5: Clinical and Research Recommendations Paper

This chapter takes the format of a paper prepared for submission to a journal.

The data presented reflect recommendations for clinicians and researchers in this area. Information is drawn from clinical interview and observation. To aid in reading in the format of a thesis, page numbers are continued from previous sections. In-text references have been included for the overall thesis reference list and are also shown for this paper alone. References have been made in some places to other Chapters in the thesis, this would be removed or replaced with an appropriate citation to a publication (e.g., of the paper presented in Chapter 3 if it is to be published). For completeness of the current paper there will be some duplication of introduction and methods from chapters 1-3 of this thesis.

DRC 16

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GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION TO DOCTORAL THESIS CONTAINING PUBLICATIONS

(To appear at the end of each thesis chapter/section/appendix submitted as an article/paper or collected as an appendix at the end of the thesis)

We, the candidate and the candidate's Principal Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of Candidate: Hannah Bos

Name/Title of Principal Supervisor: Dr Duncan Babbage, Senior Lecturer

Name of Published Research Output and full reference:

Memory aids after Traumatic Brain Injury: Recommendations for Clinicians and Researchers
(to be submitted for publication

In which Chapter is the Published Work: Chapter 5

Please indicate either:

- The percentage of the Published Work that was contributed by the candidate:

  and / or

- Describe the contribution that the candidate has made to the Published Work:

  The candidate prepared the full draft of the manuscript and supervisors' comments and input into the version of the manuscript in the thesis have been to the same extent as the usual thesis chapter supervision input.

Hannah Bos — Candidate's Signature — 16/07/2013 (Date)

Principal Supervisor's signature — 17/07/2013 (Date)

GRS Version 3 – 16 September 2011

Memory aids after Traumatic Brain Injury: Recommendations for Clinicians and Researchers

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Abstract

Evidence based practice will lead a growing number of clinicians working in rehabilitation of memory difficulties to implementation of a memory aid. Having established the likely efficacy of potential memory aids clinicians are faced with a somewhat daunting task of working out how to select the most appropriate memory aid, how to go about setting up and training an individual to use the memory aid, and establishing what the role of the clinician will be. This paper provides data driven recommendations, based on clinical interview and observations from a series of single treatment cases, to guide clinicians in the implementation of a memory aid and researchers working in this area.

Why a Memory Aid has Potential

Based on Ellis's (1996) model of prospective memory, difficulties in prospective memory can arise at several levels. This includes during initial encoding, during the delay between encoding and retrieval, and during the retrieval and execution of the task. Compensatory strategies such as memory notebooks and electronic devices may assist prospective memory at varying levels (Thöne-Otto & Walther, 2003). Specifically, encoding may be improved through the active recording of the task into the memory aid. Compensating for the delay between encoding and retrieval is the main purpose of the memory aid through recording what and when tasks are to be completed. Electronic aids with alarms compensate for difficulties with retrieval by alerting attention to the aid (Thöne-Otto & Walther, 2003), whilst memory notebooks do not have this benefit. Although more difficult, it is possible to use a memory aid to assist in execution of the task through the addition of notes to a task reminder. While having all these functions the aid must also be flexible enough to allow postponement if a task cannot be completed immediately (Thöne-Otto & Walther, 2003). Arguably a reminder which repeats until a response is made could compensate in part for execution difficulties by continually alerting the person towards the task to be completed, with the task only dismissed when completed. Additionally a flexible snooze function on an electronic aid would allow postponement for tasks that cannot be completed immediately but without risk to forgetting the task altogether (Thöne-Otto & Walther, 2003).

Efficacy of various external memory aids have been demonstrated and reviewed elsewhere but generally electronic memory aids show (see Cicerone et al., 2000;

Cicerone et al., 2011; de Joode et al., 2010; Gillespie et al., 2012; Kapur et al., 2004; LoPresti et al., 2004, for reviews).

Acceptability

Memory aids are likely to be more acceptable and therefore utilised more if they are normalising, whereby the aid itself does not identify the person as having a memory difficulty (Fluharty & Priddy, 1993). Acceptance can also be improved through increasing the discreetness (e.g., reducing size) of the memory aid (Fluharty & Priddy, 1993). Mobile and smartphones have been suggested as being more socially acceptable as a memory aid than other electronic devices (Culley & Evans, 2010; Svoboda & Richards, 2009; Wade & Troy, 2001) with a large proportion of the population making regular use of them. The use of cognitive aids such as diaries and mobile or smartphones to assist in managing time and keep track of important information is in common use in the general public (de Joode et al., 2010).

Features of a suitable memory aid

A disadvantage of memory aids such as Neuropage is that the individual cannot enter their own reminders, and therefore cannot benefit from increased encoding achieved by recording an event (Thöne-Otto & Walther, 2003). Memory aids easily accessible via retail channels have the potential to reach a wider proportion of individuals with TBI than specific systems such as Neuropage which are not widely and internationally available (Thöne-Otto & Walther, 2003). There needs to be a balance between general availability of an aid and the ability for it to be easily used by an individual with TBI.

The requirement of cognitive orthotics (devices which assist in supporting weak cognitive functions) in general is that it should be an integrated device with software which is easy to use and provides practical support to assist the person with TBI complete relevant tasks (Bergman, 2002). The ability to enter and edit a task is important in terms of assisting encoding the information (Thöne-Otto & Walther, 2003) and is more suited for individuals living independently within the community.

When designing complex computer programmes to assist individuals with cognitive deficits Cole et al., (1994) identified that was usability of the system was a primary issue involving key components; the ability to improve task completion time (or ability to complete the task at all), the time to train to use the system, and errors which may be made when using the system and the ease of fixing errors when they occurred. Although this concept was intended for individualised complex software to help with specific tasks, the principles apply to any cognitive aid.

Training to use a memory aid

Evidence suggests errorless learning is the most effective when training individuals with TBI to learn to use an external memory aid (see Cicerone et al., 2011, for a review). Other research has combined errorless learning techniques with more complicated fading of cues and multiple phases of training programmes and had positive results (e.g., Powell et al., 2012; Sohlberg & Mateer, 2001; Svoboda et al., 2010; Svoboda et al., 2012). The training method is an important consideration for clinicians.

Importance of data driven study

As the implementation of memory aids, and increasingly of electronic memory aids becomes evidence based practice in neurorehabilitation, clinicians will increasingly be looking to implement these aids in their practice. A clinician new to this area may find the process of beginning to implement a memory aid a daunting task. Having selected a broad form of memory aid (e.g., a smartphone) questions arise as to the best handset for the individual, setting up and preparation for training as well as training and expectations for use of the memory aid. A data driven study is important as it provides clinicians with a guideline on how to go about implementing a memory aid and their role in the process, based on real experiences and feedback from those who have received training in the use of a memory aid.

Method

A full description of the methods can be found elsewhere (see Chapter 3). Briefly, seven community dwelling individuals living with moderate- severe TBI and reporting every day memory difficulties (prospective memory) completed the study. Based on randomisation procedures explained in Chapters 2 and 3, two participants received a memory notebook and after follow-up also received a smartphone. Five others received the smartphone alone. The majority of training was conducted in 4 - 8 hours of errorless learning with the clinician, over a 2 week period. However, with a further 6 weeks of treatment there was opportunity for more training if necessary.

Instructions on the use of the memory notebook were included within the notebook and step-by-step instructions with screen shots were provided with the smartphone.

Alongside quantitative measures (discussed in Chapter 3), the clinician noted clients experiences using a semi structured interview and observation. The interview broadly asked about memory and memory aid use in general, as well as specifically asking for examples of both positive and negative experiences with the memory aid. At the end of treatments and at follow up the interview specifically asked about what participants would like to be different about their memory aid, the study more generally and what aspects of the study was helpful.

Data driven opinions are provided in the current paper to guide clinical and research use of memory aids. Quantitative performance is reported in Chapters 3 and 4.

Results—Recommendations for Clinicians

Acceptability

Assess for the initial reaction to the proposed memory aid.

In the current study participants were blind to the treatments for research purposes. Upon receiving their assigned memory aid, two participants objected to their memory aid immediately. Memory performance in both cases declined and there was little independent use of the memory aid.

One of these participants was randomly assigned to the memory notebook. He had previously been provided a diary in neurorehabilitation, and was known to “hate it” and make no use of it. He reported preferring the memory notebook from this study over his previous diary as it was more inconspicuous without a “neurorehabilitation-related” logo on the cover. He reported the memory notebook had a place for everything he needed and seemed designed to fit his needs. However, despite these positive reports, and initial attempts at using the memory notebook, he made little independent use of it. He thought it might be useful in the future, but not at that time. When this participant was later provided a smartphone he commented it was an improvement on the memory notebook—“after all it’s the 21st century”—that it was more portable than the memory notebook, and that people would assume he was texting when he was actually using it as a memory aid and he was willing to allow this, even though “they probably think I’m rude”. This underscores the importance for some clients to not be identified as using a memory aid. He made excellent use of the smartphone and for the first time since his injury began managing his own schedule. He requested all agencies working with him to text him appointment times, and reported entering verbal appointments into his smartphone immediately.

Another participant took an immediate dislike to his memory aid, in this case the smartphone. When provided a smartphone he immediately stated that he would not use the smartphone for anything other than “phone functions”. Although capable of using the smartphone, on most weeks he refused to enter tasks into his smartphone. Performance declined likely due to frustration and loss of interest in the research. When tasks were entered into the smartphone he was unlikely to check or respond to notifications. As he stated, he used the smartphone only for “phone functions”. Efforts to increase the use of the smartphone by installing a sleep recording application (as his primary concern seemed to be lack of sleep) were to no avail. This strengthens the conclusions that acceptability of a memory aid is crucial as he simply refused to use it other than for phone functions.

These two cases underscore the importance of assessing a client's view on any potential memory aids before implementing them. The fit and therefore acceptance of a memory aid to the individual may be of more practical importance than which of two effective memory aids has the stronger evidence base.

Assess for insight into memory difficulties.

After initial assessment and inclusion in the trial, three participants reported few memory difficulties through the remaining baseline and treatment. Two of these participants showed improvements on memory task performance and attending appointments without reminders from the researcher. However, they did not maintain use of the smartphone after the main research was completed, and by follow up were not using their smartphone as a memory aid.

The first of the three was reported previously, he refused to use his smartphone as a memory aid entirely. While this may be entirely due to his dislike of the smartphone, the clinical impression was that he would have been unlikely to accept any memory aid. This was based primarily on his reports that whilst his memory was "poor" he did not see himself as having memory difficulties because he never relied on his memory. Whilst he willingly admitted that this severely impacted on his sleep as he completed tasks at all hours of the night, he seemed unwilling to change this after 6 years of using this strategy to compensate for poor memory.

The second participant learnt to use the smartphone independently. However, by follow up he had given his smartphone to someone else to use (for several weeks) and returned to his older mobile phone. This demonstrates the smartphone was not seen as an important memory aid, despite his reports. The third participant made somewhat sporadic use of the smartphone as a memory aid during the treatment, but was able to competently use it and reported preference over his previously difficult-to-follow diary. However, at follow up he had bought a new diary for the New Year and was using this instead of the smartphone as a memory aid. As he had during baseline, he requested a reminder text message for his appointment. He was known to have missed an appointment with a colleague who did not send the text reminder. This indicates that had he had sufficient insight into his memory difficulties he may have better assisted his memory with the smartphone.

The finding of lack of ongoing use of the memory aid where the individual does not feel they need a memory aid, is in line with other researchers findings (e.g., H. Kim et al., 2000). However, in the current research these findings may in part be an artefact of the recruitment process for research. All three of these participants were those who had previously completed research in the same location and had indicated they would be interested in future research. First contact in all three cases was the researcher inviting them to be involved in the research if they were interested. The implications for researchers are outlined later in this article. For clinical purposes, it is important that candidates for a memory aid are not selected based on clinical or family observations alone, but that the individual sees a need for a memory aid themselves.

Use meaningful activities where possible to increase usage.

Some participants, who were capable of making use of the smartphone, reported it was helpful but did not necessarily consistently use it. For example, one participant never used the To Do list on either the memory notebook or the smartphone. Most items that were appropriate were chores, which he did not want to undertake. Therefore, his rationale was if they were not on the To Do list then he didn't have to do them. Tasks that were personally meaningful for him like organising and packing for a trip, were added into the Calendar with an assigned time. Similarly three participants primarily used the To Do list and reserved the Calendar only for important meetings, typically involving medical appointments which were required in order to continue receiving financial assistance.

Features to assist usability of a memory notebook

The conclusions reported below are tentative based on the reports of the two participants who received the memory notebook in the current research.

Use non-identifying cover to increase acceptability.

Both participants reported that they liked the memory notebook covers being plain as it did not label them as having impairment. Each of these participants did not wish to openly tell others of their injury and difficulties. Whether either participant was comfortable using their memory notebook in front of others is questionable, as neither carried it, reportedly due to lack of portability and concern of losing or damaging it.

Include Schedule and To Do list on adjacent pages.

Both participants with the memory notebook reported finding it helpful having both the Schedule and To Do list adjacent. Both tended to leave the notebook open on the table and could therefore refer to it regularly without changing pages, and could quickly add tasks. Both participants had difficulty with orientation to the correct date, so having both on the same page meant most of the time they only needed to find out the correct day once and then leave the Calendar open to that day's date. Additionally, they could plan how to fit tasks from the To Do list in around scheduled appointment. Finally, one reported that in the types of tasks he did he often had dirty hands and therefore it was good he did not have to touch the book when he came in to refer to it.

Use tab section dividers.

Both participants reported the tabbed section dividers were helpful. They liked being able to see what other information was in their memory notebook as they often forgot the contents beyond the Schedule. One participant made frequent use of the differing sections and found it particularly helpful. The other made little use of the memory notebook overall and had little content in the additional sections to refer to.

Include instructions on section dividers.

The two participants both reported it being helpful having reminders of how to use the section on the tabbed section divider. This reduced the "embarrassment" of having forgotten multiple times, and meant they knew they were using the memory notebook correctly. One reported he liked the instructions as it felt like his memory difficulties were understood and normal through inclusion of this reminder page.

Features of a smartphone

The conclusions below are drawn from the seven participants who received a smartphone. Selection and set-up of the smartphone was completed by the researcher prior to provision of the smartphone to participants.

Select a touch screen smartphone.

A number of advantages to a touch screen were identified. Firstly the icons clearly indicated the program which they related to, and cued use of this programme. Further, to open the program the icon could simply be touched, rather than memory loading steps with key presses through a menu. Participants reported that in an older style menu they would have had difficulty using complicated features such as the Calendar (or difficulty finding them in the first place). The icons acted as a cue to use aspects of the smartphone as the icon reflected the program's use. Participants reported they liked not having the clutter of icons and features which they did not use on the home screens (since the researcher was able to customise and remove additional features from the home screens).

However, the touch screen was not a perfect user interface. A primary difficulty with the touch screen was that buttons were often too small for the participants. This resulted in additional buttons being pressed, icons moving or being deleted and settings accidentally changed. This was a source of frustration for the majority of participants. However, each participant felt the advantages of the touch screen outweighed the difficulties. When other options were discussed, all participants preferred the touch screen over a slide out screen as buttons were larger on touch screens. At follow up, two participants reported they would like a physical keyboard such as on old style mobile phones as they could use that without looking but liked the touch screen for navigating through programmes.

Setup:

Elements of the setup for which participants reported as being helpful are discussed below. Clinicians and researchers alike should first investigate the applications and settings available on the smartphone. The applications outlined are those used in the current research and were deemed most suitable at the time but clinical judgement should be used when selecting applications in the future. For example, the contacts manager on the smartphone used in this research did not include a grouping feature, as is now available on other models and newer versions of the operating system.

Include a cloud-based calendar.

During the short course of the research the importance of cloud-based Calendar event storage became apparent. Firstly, one participant inadvertently reset his smartphone handset to factory settings. This deleted all personal information, including his Calendar events and To Do list. Since this information was deleted from the handset only, the information was easily restored to the smartphone through a simple sign-in and synchronisation.

A second participant made extensive use of his smartphone as a reminder service. Part of his day to day lifestyle included a large involvement in the lives of his grandchildren. Instead of contacting him to inform him of activities and tasks that needed to be done, his teenage granddaughter would directly enter items into the Calendar. This would include events such as netball game times and tasks which the family would like him to do. He was happy with this system—although at first he was mystified as to how she was doing it. One other participant primarily used the Calendar to schedule times to pick up and drop off family from work. A roster was supplied for several weeks. He had stopped entering these tasks into his smartphone as he found it laborious. He thought entering it online would be quicker, either for himself or a family member.

Another important advantage of the cloud-based Calendar is that events can be automatically transferred to a replacement smartphone should the current one be broken or lost. Fortunately this was not required during the current research, but participants reported they were pleased to know this as efforts to enter repeating reminders such as birthdays would not be lost. The current research involved android smartphones, and therefore the cloud-based calendar Google Calendar comes automatically installed and was utilised for this research.

Have the ability to repeat and snooze reminders.

The repetition of Calendar reminders until an action was made was a key feature of the Calendar as a memory aid. Participants did not have to continually check their smartphones in case they had missed a reminder as it would reoccur. It was not uncommon for participants to either not notice or not have the smartphone on hand when an initial reminder occurred; however, repetitions meant it virtually could not be missed. This further reduces the memory load as participants do not have to remember to check their smartphones. The current smartphone model and version of operating system did not have this as an inbuilt feature and so CalendarSnooze (Bitfire-development, 2011) which accesses Google Calendar was utilised.

Participants also reported the option to snooze notifications was particularly beneficial. Using CalendarSnooze, several snooze times were easily accessible alongside the notification (e.g., 5 minutes, 10 minutes, 15 minutes, and 30 minutes). This gave the participant flexibility to allow enough time to complete a current task without distraction. This reduces cognitive load as participants are not required to keep a second task in mind while they complete the first task. All participants who made use of the smartphone reported this was a useful feature. Two participants reported that for tasks that would take some time to complete they would snooze the reminder to ensure they were bought back to the task at hand should they become distracted. This ensured that tasks were completed as the reminders were only dismissed once the task had been completed.

Use a simple cloud-based To Do list.

The benefits of a cloud-based To Do list are largely the same as those outlined for the Calendar. A To Do list which works in with the Calendar is most useful to decrease the number of online applications required, particularly if the individual with TBI plans to use them. In the current research GTasks (Dato, 2011) was selected on this basis. The To Do list was used for brief notes of jobs and things to remember. Those who used it tended to do so extensively and often would enter a list of items in one go. As participants with memory difficulties need to quickly record items a simple and fast entry method is important.

Display the calendar and To Do list on the home screen.

Four of the six participants who made use of the smartphone as a memory aid reported that having an overview of the contents of their Calendar and To Do list for the day on the home screen was valuable. Reasons for the value of this screen varied. Reasons included: a reminder to use the smartphone as a memory aid, a quick day-planner, and reorientation to what they were meant to be doing when they became distracted. To combine both the Calendar and To Do list into a single display, Simple Calendar Widget (MYCOLOURSCREEN, 2011) was installed. Both the Calendar and To Do list applications came with their own widgets (home screen display) but Simple Calendar Widget combined the two onto one screen in a clear display of the day's events and tasks.

Use a contacts list with grouping and 'favourites'.

Three participants made use of the grouping feature for contacts. The suggested groupings were *Friends*, *Family* and *Services*, and all three participants were happy with these categories. They found it useful being able to separate these distinct groups to make finding contacts easier. The *Favourites* option was used by all six participants who utilised the smartphone. This allowed for quick access to contact details and for calling and texting for frequently used numbers.

Install a smartphone locating application.

Giving a relatively costly memory device to individuals who know they have memory difficulties did provoke some anxiety from most receivers. This anxiety was reduced by knowing that should they lose their smartphone, it could be remotely activated to override the current settings to produce a loud ringtone, and if need be a location could be sent to a remote smartphone. For this purpose *Where's My*

Droid (Alienman Tech, 2011) was installed. When a keyword is texted to the lost smartphone the settings are overridden and loud white noise produced. An alternative keyword can be texted which sends the GPS location of the smartphone to the sender. One participant who was particularly concerned about losing his smartphone customised the keywords and tested them out. No participant required this application during the current research, but it was reported as useful to have in case given their memory difficulties.

Teach the use of the camera as a memory aid.

In the current research the use of the camera was considered an additional feature which could be shown to participants if they desired. Three of the participants in their own exploration began using the camera as a memory tool. All three used it whilst completing mechanical or other construction based work—photographing a work piece either as a reminder of how it was, a reminder of the steps they have completed, or as a reminder of work to be done. One also used the camera to take pictures of books which he wanted to read, and would show a librarian to reserve the books.

Role of the clinician

The role of the clinician was not directly asked about in interviews. However the majority of participants reported part of what had been helpful in the study was the clinician. There are a number of ways in which the clinician can assist clients:

Clinicians should use a similar memory aid

To assist in acceptance of the memory aid the clinician was also seen to be utilising the appropriate memory aid. Initially the clinician was relying on memory notebook for appointments, during the study for a time the clinician used both a memory notebook and a smartphone. Later in the study the clinician moved to the smartphone as a primary memory aid. The clinician always arranged future appointments and recorded them in session on their matching memory aid.

The majority of participants commented that if the memory aid was good enough for the clinician to manage a busy schedule then it would be good enough for them. This is likely to have increased acceptability through normalising the memory aid. In this study the memory notebook exactly matched the memory aids received by participants (i.e., one of the memory notebooks and the same model of smartphone with the same basic set-up).

Be prepared to be the smartphone technician

Having implemented a memory aid clinicians need to be prepared for a variety of questions, and prepared to resolve problems, in part because the clinician may be seen as an expert having recommended the device, but also because individuals with TBI may have difficulty getting adequate help from other sources. Three participants reported attempting to resolve technical issues at retail outlets. They felt overwhelmed with the speed at which technicians explained things and generally reported being frustrated and more confused. One participant was willing to explain his injury and the effects, but despite the retailers best efforts still came away confused. The clinician is a non-judgemental person who can help resolve technical issues without distress to the client. Clinicians need to be prepared for this to occur. The most suitable preparation is likely to personally use a similar memory aid and so be familiar with how they work and have potentially encountered similar difficulties personally. Friends of individuals with TBI, despite good intentions were prone to confuse and also to alter the set-up of the smartphone, usually resulting in the client returning and asking for the settings to be returned to the way in which they had learnt them.

Select and teach just one way of using a programme

For most applications there are multiple ways in which the programme can be accessed or used (e.g, access via home screen icon, menu icon, or through another programme). Given the memory difficulties and subsequent difficulties learning to use the smartphone, participants found it beneficial if at least at first one method was taught repeatedly. At a later stage the clinician would sometimes demonstrate other ways an application could be used, or ways to skip steps where this would be of benefit to the participant. For example, participants were at first shown how to enter a Calendar event by moving through each step in series so maximum information could be entered. Some participants needed only a title to remind them of the task and so were taught how to skip the additional steps for quicker (and less frustrating) use of the Calendar.

Clinicians may need to assist with a change in mobile plans

When first moving to a smartphone the clinician needs to be aware that features such as the internet are easily switched on, and are in fact beneficial (e.g., for cloud-based storage), but can be costly if paid for at a casual rate. An appropriate plan was discussed with all participants. In all but one case, who had previously owned a smartphone, moving to a new prepay bundle (which avoids running up large bills) came with a financial benefit. Participants previously tended to pay on a casual basis or be on out-of-date plans on standard mobile phones and pre-pay bundles resulted in more airtime and less cost. Understanding what pre-pay meant was confusing for two participants, with one feeling at first that he was being taken advantage of (if he didn't use all of what he paid for). Two participants attempted to further clarify in retail stores and became highly aggravated when they did not understand the explanation. To reduce distress it is important the clinician thoroughly explains the plans.

Training techniques

The standard "user guide" supplied with a smartphone has very little content to teach a person how to use the smartphone. The primary clinician coming to the technology for the first time, found it relatively complicated to learn to use initially. Learning was through trial and error, asking others and through online forums and videos. Months into the use of the smartphone new and apparently simple features would be revealed by others. As reviewed elsewhere, trial and error learning is not the most suitable method of acquiring a new skill after TBI. All but one participant (who had owned a smartphone before) reported they would not have purchased one as it was too difficult to learn to use. When inevitably settings were accidentally altered, or updates occurred and changed applications set-up, participants either waited for the next session for it to be fixed, or contacted the clinician for instructions. All participants who made use of the smartphone reported it was useful having the smartphones set up to work specifically for their memory, and without additional features to distract or confuse them.

Develop a step-by-step manual with screenshots

The current research included a step-by step instruction sheet including screenshots and written instructions for basic and memory related tasks. Four of the six participants who made use of the smartphone as a memory aid made use of this instruction sheet. Two participants set aside time at home to sit and go through the manual with their smartphone. The remaining two referred to it when they could not remember on their own. Given that errorless learning is recommended, a manual is important, as whilst impossible to prevent individuals making errors on their smartphone, they were encouraged to refer to the manual rather than guess to avoid learning mistakes.

Errorless learning is a useful approach to learn to use smartphones

As mentioned above, errorless learning is considered a key learning technique after TBI. Efforts were made to adhere to an errorless approach throughout training, and through encouraging the use of the manual outside of the clinical setting. The clinician loosely reduced the level of cueing as participants became more competent with the smartphone but did not incorporate a strict fading of cues. Learning was not split into stages. Instead individuals were taught in session how to complete a task through instruction with the researcher, and encouraged on their own not to guess but to refer to the manual. All participants were able to become competent before the end of the treatment, and most within the first two weeks using this simple approach. There was no generalisation stage as functional use was supported from the start, with participants immediately encouraged to enter upcoming appointments and events into their Calendar and To Do list, to incorporate it into their everyday life. This demonstrates practice, with errorless learning alone is sufficient to learn to use a memory aid.

The majority of participants required at least some aspects of their smartphone to be explained multiple times. Sometimes it would appear the participant had learnt the correct steps, but would forget some time later. No participant thought it would have occurred to them to use a smartphone for their memory. Even the participant who owned one had not considered it. Further, no participant thought they would have been able to figure out how to use the smartphone to assist their memory on their own. All reported the training was critical to the successful use of their smartphone.

The trainer should be a clinician who understands TBI

When asked in general what was helpful in the study, all six of the participants who had benefited from the use of memory aids commented the training with the clinician was important. Individuals felt that other non-clinicians did not understand their difficulties. Participants recalled stories of times where they had asked for (or been offered) help by friends and professionals and being shown something with multiple steps too quickly for it to be retained. This resulted in not understanding, making errors, or not wanting to try again. Participants reported it was different working with a clinician. They reported valuing the slow pace, being able to see each step on the clinician's smartphone but complete it themselves on their own smartphone. They did not feel judged when they asked to be shown how to do something on their smartphone when they knew they had been shown several times previously. Three participants were very pleased to report they had since assisted a friend or family member in using a smartphone.

Expectations for use of the memory aid

The long term use of a memory aid is difficult to predict. Those who were competent and made good use of their smartphone during the study did not necessarily continue independently. Similarly, a person who struggled to use the smartphone independently went on to rely heavily on it and make extensive use of the memory aid over the follow up period. Clinicians also need to consider the clinical value of entered tasks, rather than just the volume of use.

When followed up between two and four months after the main trial, ongoing smartphone use was variable. One participant had never used it, one had returned to a diary system, and another had lent his smartphone to someone else. One other participant wanted to use the Calendar but had become frustrated at the need to put on reading glasses to see the screen.

One participant who had made extensive use of the smartphone (and previously the memory notebook) continued to use both the Calendar and To Do list extensively. Another used only the Calendar, and never the To Do list, as he had throughout the study with both the smartphone and memory notebook.

A final participant had struggled to learn to use the smartphone, but continued to make extensive use of the To Do list. He was able to respond to daily repeated reminders to take anticonvulsant medication and could add appointments into the Calendar when he considered them important. Although he did not usually enter new events in the Calendar, responding to the Calendar had great clinical and personal significance as if he were to suffer a further seizure he would lose his driving license and hence independence. Prior to the smartphone it was not unusual to miss up to three doses in a row, but since given the memory aid he estimated two missed doses in a period of approximately five months. Similar findings occurred for another client with daily medication, who was never sure whether he had taken his medication. As the adverse side-effects of taking a double dosage of the medication could be serious, if he was unsure if he had taken the medication he would not take another dose. He suspected that this meant he often missed doses. By taking his medication with the Calendar reminder, and making it a habit to never completely dismiss a reminder until he took the tablet he could always be sure if he had taken the medication.

Recommendations for Researchers

A task log is not a suitable measure in a community setting.

Task logs have been utilised in many studies investigating memory aids for prospective memory difficulties (e.g., DePompei et al., 2008; McDonald et al., 2011; Wade & Troy, 2001; Wilson et al., 2001; Zencius et al., 1990) and therefore were selected for the current research. In an attempt to reflect actual memory difficulties encountered in everyday life of community dwelling individuals participants were given instructions each week (and instructions were supplied on the task log) to fill in ahead of time memory tasks that needed to be completed. They were then instructed to put the task completion log away throughout the day and at the end of the day mark whether items on the task list were completed. In this manner both routine items which had to remembered, and importantly, non-routine items which would be more prone to being forgotten would be recorded on the task completion log. As with previous research it was recommended that a family/caregiver would assist in the completion of the task log. Task logs however were discarded as the primary measure of prospective memory performance for the following reasons:

Firstly, a high percentage performance was seen at baseline making it appear that participants had relatively few memory difficulties. However, this was at odds with the memory difficulties reported during interviews. The primary issue was that participants had forgotten the tasks before they had been written down on the task log. When completing the task log they had effectively forgotten what they had forgotten. A second issue was that participants used the task completion log as a memory aid despite the researcher's emphasis to put it aside and not refer to it during the day. The majority of participants at some point during baseline mentioned the task completion log helping their memory.

Thus, the baseline memory performance recorded reflected only items which participants had remembered to record in the first place, and the memory performance using a basic memory aid with little instruction. Other studies have not reported this issue to such an extent. The likely reason for this finding is that unlike the current research, target tasks in previous research were preselected i.e., generally more routine and often could be objectively measured by someone else working with the individual (e.g., whether the participant remembered to attend an appointment). A reasonable proportion of research has taken place in rehabilitation settings where objective measures for most activities are possible as the persons activities are well observed by many members in a team responsible for the care of residents. Community-based studies tend to have a caregiver willing to assist in collecting information about memory in order for participants to meet inclusion criteria. The current research aimed to reflect the TBI community within the wider population and hence efforts were made to be as inclusive as possible in a research context. Of the sample in the current research all but two participants lived mostly alone and independently. Arguably, the most important memory tasks for these individuals to continue an independent lifestyle are to be able to remember non-routine memory tasks, and to do so independently. Therefore the design of the task completion log was to record these tasks. The reality was that the task completion log could not capture these memory difficulties for participants who lived independently.

A further difficulty arose because as soon as an individual began training with their memory aid they stopped completing the task log, despite being asked to continue its use. The researcher then only had information about tasks that were entered into the memory aid, which generally resulted in completion. Making use of the memory aid was the primary concern and it had already been established baseline measures were not accurate; therefore the task completion log was removed as a measure.

Future researchers need to be aware that task completion logs are only of use for capturing set tasks that can be objectively measured. However, with this method the true nature of memory impairments will be missed. Insisting on a caregiver being able to validate information eliminates a large proportion of the community dwelling population, for whom a memory aid to continue to manage their lives independently would be helpful. How to accurately record memory failures as well as occasions where memory was successful remains an open question.

Sending a postcard is no longer a relevant prospective memory task.

Performance on the *postcard* task (based on other studies including Kinsella et al., 1996; J. Mathias & Mansfield, 2005) was more variable than the text or phone *message task*.

Most participants reported rarely, if ever, posting mail. Some had difficulty finding a post box. The performance on this task then did not reflect naturalistic unscheduled prospective memory tasks as intended. Perhaps a more suitable task would be to send an email or visit a website during the week. This however, relies on individuals having access to a computer and internet. Two participants in this study did not have this access until provided with the smartphone. Perhaps future research could offer a choice of task, as those participants not making use of the internet naturally tended to still utilise the postal service.

Performance on formal measures may not change.

Performance on the memory tasks and subjective reports of memory performance in day to day life were not reflected well in formal measures of prospective memory and community integration. In terms of prospective memory performance, this may be in part due to the smartphone not being able to improve all areas of prospective memory easily. (For example, while remembering to mention a point in conversation could be recorded in the Calendar, this would be difficult to time correctly and would be intrusive. No participant chose to record this information, even when it may have been beneficial.)

A further hypothesis to explain the lack of change on measures of prospective memory performance was based on clinical impression alone. This hypothesis was that much of the time participants completed the questionnaires according to what their memory was like if they did not use their memory aid. This was despite repeated instructions to reflect on the specified time period, during which they had their memory aid.

Community integration did not show great change for most participants. Aside from the real possibility that no change occurred in community integration, there are other plausible considerations. Firstly, although the Community Integration Questionnaire was selected in part because emphasis was not on physical disability, other injury-related factors could prevent greater community integration. One participant was unable to become more active in the community due to severe fatigue and the requirement to nap each morning and afternoon limiting his ability to access paid or voluntary work. Others had physical- and pain-related difficulties which limited ways in which they could improve integration. Disorientation and difficulties with access to public transport meant the range of activities which the individual could become involved in was limited as it depended on others to supply transport. Many participants were content with their current functioning as they lived independently. Likewise, community and household integration was often relatively high at baseline.

Clinical interviews revealed an important finding which should be considered in future research. Community and household integration tended to remain relatively stable. What changed was the ability to manage the current activities. For example, participants became more self reliant for remembering their own tasks and arranging their own schedules. Completion of tasks was more efficient as the day could be planned around the tasks. Getting through a day with many prospective memory components was less anxiety-provoking as participants left on time for appointments, usually brought the appropriate items with them and were less flustered. The increased organisation and reduction in anxiety made busy days less exhausting for the busier participants. The research implication of this is that apparent lack of improvement is not necessarily reflective of the clinical outcomes. Therefore, either a formal measure of these changes should be designed and included in future research or alternately, like this research, interviews may be used to detect these changes.

Living, loving and doing—the role of research.

Some participants lack of use of the smartphone either in the trial or at follow up can be in part explained by their reasons for participating in the research. Some participants failed to continue using their memory aids, and two others withdrew from the study. Each of these participants reported they valued being able to contribute to research or “give back” for the help they received after their injury. Their motives for completing the research were to help research, rather than to help themselves. This fits with the living, loving and doing model of meaningful spheres of life and connectedness (Willer & Babbage, 2013). Participants both had something to do, and felt like they were contributing to society. Similarly, these participants were more likely to consider the research a voluntary activity when completing the Community Integration Questionnaire as part of the research. This is not to say memory performance did not improve or that they had no need for the memory aid (and they may also have lacked insight into this issue, as mentioned earlier). These participants were all participants who had completed other research in the area of brain injury and had indicated that they were willing to be contacted again. They were committed to attending the appointments, but less committed to trying out the memory aids in their own time. Two began participation in another research area before they had finished the current research.

Implications for research into clinical efficacy are that there needs to be an awareness of whether participants are being involved in the study out of a desire to make an improvement in their own lives. For those participants who become involved out of a desire to contribute to knowledge, whilst their motives were helpful this can in fact lead to less positive results or reduced maintenance of change compared to those who wished to make an improvement in themselves. On the other hand, individuals living with TBI may be both willing to participate, and also personally benefit through adding to the *doing* in the living, loving and doing model.

Discussion

Appropriate memory aids have been described in the theoretical literature and there is a growing body of quantitative studies and case reports demonstrating the efficacy of various paper-based and electronic memory aids. Based on the literature clinicians are able to select a memory aid with evidence base suggesting it may be useful. The majority of studies look primarily at quantitative change in memory performance. Having identified a client as having prospective memory difficulties and studied which memory aids have evidence to support efficacy, clinicians may be left somewhat in the dark about what to do next. This article has provided data-driven information to guide clinicians around potential difficulties. The opinion presented is based on semi-structured interviews and observations collected throughout a quantitative trial. As always, clinical judgement and adjusting to individual needs of clients should be the primary guiding factor for clinicians. However, this article provides a guideline to assess:

- The likely acceptance of a memory aid.
- What to look for when selecting and setting up memory notebook or smartphone as a memory aid.
- The role that the clinician will take in training a person living with TBI to use the memory aid.
- Ways to assist the training process.
- Expectations for how the memory aid will be used, immediately and independently.

It is hoped these recommendations will assist clinicians to provide the best possible memory assistance for their clients, as well as add to the research body for future improvements.

The current research had a particular focus on smartphones as a memory aid and opinions for appropriate set up were based around a smartphone. With ever changing technology, clinicians need to keep the client's needs in mind and individualise the memory aid to meet their need. This paper makes suggestions and provides data-driven evidence for choices in set up. Overall, it is hoped this research provides some insight into what to expect both as a clinician and as a researcher when implementing a memory aid, particularly a smartphone, with individuals with a TBI. Research can continue to build on the knowledge base and look for solutions to difficulties in measuring prospective memory and in our understanding of what helps a person with TBI compensate for their memory difficulties.

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Chapter 6: Discussion

This chapter briefly discusses the overall research, relation to the hypotheses and limitations of the study. As discussions relating to specific components of the research are presented in chapters 3-5 this chapter is kept minimal to reduce duplication.

Outcomes and hypotheses

This research had three main objectives. Firstly, this was to assess the efficacy of smartphones as memory aids after moderate-severe TBI and compare them to the efficacy of the memory notebooks. The second objective was to use qualitative descriptions and observations to make recommendations for clinicians and researchers regarding changes which may occur using a memory aid, features of the memory aid and training which was helpful for participants, and where difficulties may occur. The final objective was to investigate wider changes which may occur as a result of better management of memory difficulties, including changes in mood and involvement in the household and community. The overall findings relating to each research question are presented below:

1. *Is the smartphone an effective memory aid for individuals living with memory difficulties after TBI?*

As expected, it was found that for most participants the smartphone was an effective memory aid to compensate for memory difficulties after moderate-severe TBI. All but one participant (S2), demonstrated improvements on the weekly assigned memory tasks during treatment with the smartphone. However, maintenance of these improvements without clinician input was variable (see Chapter 3). All participants were able to learn to use the smartphone, enter tasks into the calendar and To Do list and respond to reminders for tasks. The one participant who did not demonstrate improvements using the smartphone objected to the use of the smartphone as a memory aid, and although capable of entering tasks into the calendar and To Do list for the most part chose not to do so. Change in performance on the formal measure of prospective memory, the Comprehensive Assessment of Prospective Memory (CAPM), was minimal (see Chapter 4). Overall, most participants showed stable or minimal changes on the CAPM subscales. Possible explanations for the lack of changes on this measure despite participants showing improvement on the assigned memory tasks, rating the memory aid as helpful, and reporting benefits of the memory aid are discussed in Chapter 4.

2. *Is the smartphone more effective than a paper-based memory notebook?*

Due to recruitment challenges there were insufficient group sizes to perform group comparisons. Tentative conclusions can be drawn by looking at the two individual cases that received the memory notebook and went on to receive the smartphone. In both cases performance on the assigned memory tasks improved using the smartphone for the scheduled *message tasks* (See Chapter 3). Ratings of helpfulness tended to be higher for the smartphone (See Chapter 4). Additionally, both participants reported a preference for the smartphone and benefits particular to the smartphone such as audible reminders, discreteness and portability (see Chapter 4). In addition, those subjects (S4, S5 and S6) who were using a memory notebook/diary at baseline and were assigned to the smartphone intervention also demonstrated an improvement. While this limited information cannot be taken as evidence of greater efficacy of the smartphone over the memory notebook it does provide some additional support to the literature regarding this hypothesis.

3. *Do participants living with TBI find the smartphone helpful, irrespective of measured changes in ability to manage memory difficulties?*

Ratings of helpfulness were overall reasonably high (see Chapter 4). Four of the seven participants consistently provided high (8/10 and above for the majority of weeks) ratings for helpfulness of the smartphone. One participant provided variable ratings but with a pattern of increasing helpfulness, another also had variable ratings but with a pattern of declining helpfulness. One participant objected to the smartphone and did not find it at all helpful. The majority rated their likelihood of recommending a smartphone for someone else with similar difficulties as being high. Even those who had rated a smartphone less helpful throughout the study indicated a smartphone could be useful for others with memory difficulties after TBI.

The secondary objective was assessed through semi-structured interview and observations on a weekly basis throughout the study, the majority of findings are presented in Chapter 5.

4. *What changes do participants report using a memory aid?*

Changes observed and reported were in a number of areas and varied according to the person. Changes commonly reported by participants were greater organisation of their time, remembering to get items at the store, greater ability to leave on time for appointments and improved confidence in taking prescription medications.

5. *What features of the memory aid and training are helpful?*

There were several features of the memory aid that were particularly helpful (discussed in Chapter 5). Briefly, some features of the memory notebook were having the calendar and To Do lists on adjacent pages within a section, tabbed section dividers with instructions printed on them and a plain cover. Features of the smartphone that were helpful included the touch screen, cloud based calendar and task list, repeating reminders which can be snoozed, a display of the days tasks on the home screen, grouping in the contacts list and being taught some additional features of the smartphone.

6. *What difficulties with the memory aid and training are likely to occur?*

The primary difficulties with the memory notebook were participants not being sure of the date, not wishing to carry their notebook with them, and not remembering to check in the memory notebook.

Various difficulties occurred with the smartphone. These included being unable to turn on the smartphone, moving or deleting icons, and accidental changing of settings. In most cases this seemed to be related to common difficulty of buttons/icons being too small so additional buttons were touched. For the most part participants reported that they did not know how to resolve these difficulties. The clinician is likely to become a smartphone technician as well as trainer in the use of the smartphone. The smartphone was also more difficult for the clinician to teach and for the individual to learn to use due to the larger number of features and requirement for understanding of the basic use of the smartphone before use of the calendar and task lists. Suggestions for training methods are outlined in Chapter 5 and include step-by step manual and taking an errorless learning approach.

7. *Does mood improve with potential changes in ability to manage prospective memory difficulties after TBI?*

Overall there was little change in mood across the study. DASS-21 scores tended to remain relatively stable and where changes occurred these were mostly clearly associated with external events (see Chapter 3). In general weekly likert ratings of moods did not show particular improvement with provision of memory aids and tended to be related to external events. This was contrary to hypothesised improvements in mood with better management of memory.

8. *Does provision of a memory aid to manage memory difficulties after TBI result in improved integration in the household and community?*

This was assessed with the Community Integration Questionnaire (CIQ) and results presented in Chapter 4. The level of household and community integration did not appear to be altered by provision of a memory aid and better management of memory. This was contrary to expectations. However, as discussed in Chapter 5 this may reflect the population included in the study being relatively independent at baseline and that while the actual involvement in the household and community did not change, the way in which the person was able to do these tasks changed, which is not reflected in the measure.

Summary of findings

This study provided evidence that individuals with moderate-severe TBI are able to learn to use, and benefit from the use of a smartphone as a memory aid. Participants showed improvements in completion of assigned memory tasks, reported improvements outside of the study, and rated the smartphone as helpful. Participant numbers recruited meant direct comparisons of the memory notebook and smartphone could not be made, however tentative findings from two participants who received the memory notebook and later the smartphone suggest that the smartphone may be more effective as a memory aid. Helpful features and potential difficulties were identified and discussed. Overall provision of a memory aid did not translate to improvements in mood or measured integration in the household and community or formal prospective memory measures.

Relationship to Previous Literature

The findings of the current study are consistent with the findings of previous research. While participant numbers were limited, one of the two participants demonstrated an improvement in memory performance with the memory notebook, providing partial support for the efficacy of the memory notebook seen in the literature (Ownsworth & McFarland, 1999; Zencius et al., 1990; Zencius et al., 1991). The other participant, who did not demonstrate an improvement in memory was previously known to dislike diaries and after being given the smartphone reported dislike and embarrassment about the memory notebook, in line with Fluharty and Priddy's (1993) suggestion that acceptability is a common difficulty with the memory notebook.

A previous survey suggested the clinicians experience with technology and confidence in ability to train a person with the technology is important (Hart et al., 2003). The importance of experience and confidence are reflected in the findings (Chapter 5) that participants found it difficult to gain suitable external assistance to deal with the inevitable difficulties which arose with the smartphone. Participants relied on the clinician to solve the problem, and through the clinicians understanding of their memory difficulties, teach them a way to avoid or solve the problem in the future.

The use of a smartphone to send reminders accompanied by an audible alert has close similarities to Neuropage. It is therefore not surprising that the current study supports the Neuropage literature (Wilson et al., 2009; Wilson et al., 2001; Wilson et al., 2005; Wilson et al., 1997) that an electronic aid that provides audible reminders at the appropriate time is an effective memory aid.

More specifically, the current research confirms and adds to literature that mobile phones are useful memory aids (Wade & Troy, 2001), that individuals with TBI can respond to reminders on mobile phones (Mackie, 2008; Stapleton et al., 2007) and can make use of a scheduler on a smartphone (Svoboda & Richards, 2009; Svoboda et al., 2010). Like McDonald et al. (2011) this study demonstrated that a cloud based calendar such as Google Calendar in combination with a mobile phone to receive reminders is useful as a memory aid, and more effective than a memory notebook. The current study extends this research by demonstrating that participants are able to use a smartphone to enter and edit their own tasks on the calendar, whilst also identifying factors that can interfere with use of a smartphone as a memory aid.

The effective use of errorless learning in the current study supports previous findings that errorless learning is an effective approach when training a person with TBI in a new task (see Cicerone et al., 2011 for a review). Participants were able to learn to use both the memory notebook and the smartphone effectively without additional learning techniques such as fading of cues and multiple phased training programmes (such as Powell et al., 2012; Sohlberg & Mateer, 2001; Svoboda et al., 2010; Svoboda et al., 2012).

Previous literature suggests acceptability of a memory aid is important for its utilisation (Fluharty & Priddy, 1993). The current research provides qualitative support for this suggestion. One participant, initially provided the memory notebook and later the smartphone, reported willingness to use the smartphone in public but would not carry the memory notebook. He reported that he liked being able to use the smartphone as a memory aid without others knowing this was what he was doing—which he could not do with the memory notebook. In relation to the memory notebook he reported a preference for the plain covered one used in this research over a previous diary with a “Neurorehabilitation” logo printed on the cover. Increased acceptability of the smartphone is in line with suggestions of greater social acceptability (Culley & Evans, 2010; Svoboda & Richards, 2009; Wade & Troy, 2001) and general public use (de Joode et al., 2010).

Limitations

Sample size and characteristics

Recruitment was a challenge. Despite best efforts a sample of just seven participants completed the study. As outlined in Chapter 2 the study was designed as a between groups comparison of the memory notebook and smartphone, with an awareness that recruitment may be an issue so single subject methods were incorporated into the research design. As just two participants received the memory notebook no group comparisons could be made. However, the single case experimental design does allowed extensive comparison on an individual level between baseline performance and performance with the smartphone. In the cases of the two who received both treatments improvement beyond performance with the memory notebook when the smartphone was provided contributes to the limited research in this area.

It must be acknowledged that individuals with TBI who volunteer for research may differ to others with TBI in the community. There could be differences in level of difficulty resulting in continued contact with agencies providing assistance for people with TBI. There could also be differences in level of insight into their difficulties and motivation for change (either more or less). Some participants indicated a motivation to “give back” for the care they had received after their injury and could potentially see less personal benefit (helping others rather than themselves).

Being a community based study, participants may have less functional impairment and greater ability to manage daily life independently than those who remain in residential or family care. This suggestion is supported by reasonably high CIQ scores (see Chapter 5) at baseline and relatively spared impairment on the Rivermead Behavioural Memory Test-II (see Chapter 3). It would be of interest to investigate the efficacy of memory aids and smartphones in particular in a population which included more individuals who were under residential or family care who perhaps lacked the motivation for change or involvement in the research.

Self report after TBI

Attempts were made to overcome limitations of self-report questionnaires on memory functioning after TBI. This was primarily to include a significant other to complete reports on the person's memory performance. However, since most participants lived independently, all participants either did not have a suitable informant, or for various reasons did not provide a full set of informant measures. Restricting the inclusion criteria to individuals with a caregiver would reduce the ability to generalise the results (not to mention may have resulted in an extremely small sample).

Accuracy of baseline measures

There are a number of reasons to suspect that measures taken during the baseline are an overestimation of general memory performance. The tasks being novel, and individuals perceiving them as "testing" their memory suggested a more conscious effort to remember may have been applied than would be for usual tasks. Cues may have inadvertently been provided through text reminders to attend appointments (not considered a memory task), which may result in higher (although likely late) completion of assigned tasks.

The task completion log itself was not a suitable measure of daily memory (as discussed in Chapter 5). It seems likely the task completion log captured tasks that were remembered but not the tasks forgotten. Use of the task completion log may also have assisted encoding of tasks, resulting in better recall of the tasks.

Limitations in ability to complete the assigned measures

There were some limitations in the ability to complete the assigned memory tasks. This included not sending other mail and lack of nearby post boxes. Financial difficulties meant some participants did not regularly have phone credit or landline access during baseline or with the memory notebook treatment (credit was provided during the smartphone treatment).

Future research

This study was initially conceptualised as a between-group comparison of efficacy of the memory notebook and smartphone. However, despite extensive efforts over a long period few participants could be recruited for the study. As yet there remains no large scale randomised controlled trial comparing the memory notebook with a smartphone as a memory aid after TBI, and this therefore remains a topic for future research. Further, with just two participants receiving the memory notebook future research could add to the information gained in the present research by assessing more individuals first with a memory notebook and then with a smartphone, to investigate further improvement with the smartphone beyond that achieved with the memory notebook. A more full assessment taking this approach would be a randomised cross-over design in which participants who are assigned the smartphone would then receive the memory notebook. For the current study the focus was on efficacy of the smartphone. Additionally, it was thought that after teaching participants to make use of a smartphone as their primary mobile phone that it could not ethically be removed. A further consideration was that a true washout period with removal of either memory aids may not be effective as participants would likely make an attempt to continue to compensate due to high motivation for improvement in memory management.

The current research could be extended to include individuals with memory difficulties of various aetiologies other than a moderate-severe TBI. For example one participant already recommended it to friends with likely multiple less severe brain injuries or with memory difficulties due to possible foetal alcohol syndrome. Other potential groups include acquired brain injury due to stroke, tumour or toxin/infection exposure, alcohol induced memory disorders, and progressive memory disorders such as mild cognitive impairment and dementia. It is likely that individuals with memory disabilities due to a variety of causes would be able to utilise errorless learning to manage memory difficulties with a smartphone. This poses a relatively affordable approach to reduce disability and level of care required for these individuals. This could be particularly important with the current aging population.

Future research could also examine ways to more accurately measure an individual's prospective memory performance. As seen in the current research, use of a task log in a community setting is limited. Psychometric measures such as the CAPM do not necessarily reflect the changes reported by participants and seen on assigned memory tasks. Whilst assigned tasks such as the *message task* and *postcard* task have been used with success in this and previous research this alone does not capture the important changes in memory which may happen for an individual as they learn to use a memory aid.

This thesis adds to the growing consensus within the research literature and clinical practice that while further research needs to examine the details of best implementation, it appears that mobile computing technology shows promise as an aid to memory functioning and self-organisation for people with cognitive impairment. Mobile computing technology may provide a cost-effective way to increase the degree of independence and thus quality of life for many people with brain injuries.

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Appendices

Appendix 1: Information Sheets and Consent Forms

Participant Information Sheet

MASSEY UNIVERSITY

Information Sheet

Memory aids after traumatic brain injury

You are invited to take part in a voluntary study which is designed to compare the effectiveness of two memory aid strategies to compensate for memory difficulties after a brain injury

Taking part in this study is voluntary.
It is your choice whether you take part or not. You do not have to take part in this study. If you agree to take part, you can stop taking part at any stage without having to give a reason and this will not affect your continuing health care or rehabilitation.

Please feel free to talk with a friend or whānau/family member if you need help to make the decision about whether to take part or not. Also, you are welcome to have a support person to be with you when we meet. You can ask questions about the study at any time.

What does taking part involve?
If you choose to take part in this study you will be randomly assigned to one of two memory aid groups. More information about the memory aid will be provided after randomisation. You will be provided with a memory aid, and receive training in how to use it. If you complete this study you will be allowed to keep the memory aid.
You will be involved in the study for 11-15 weeks, plus one week follow-up 2-4 months after the main study and an initial interview prior to commencing the study. We may ask you to continue in the study for a further 11-15 weeks with the memory aid you did not initially receive, and attend another 2-4 month follow-up interview.

What will people in the study be asked to do?
If you choose to take part, here are the things that you will be doing when you meet with the researchers.

- You will be asked to meet with the researcher and complete some memory tests and pencil and paper tasks. You will also be interviewed about your current memory strategies, and about what tasks you find difficult to remember to do in your daily life. This will take up to 3 hours.
- Each day you will need to complete a log of the tasks you needed to remember, whether you remembered, and what strategy you used to remember.
- You will have a one hour interview with the researcher up to once per week.
- Each week you will be assigned one task to be completed by placing a phone call.
- You will be given, and trained in the use of a memory aid. How long this takes varies between individuals but will take at least 4 hours and up to 8 hours across the entire study period. These will be in one hour sessions—up to four sessions per week for up to two weeks.
- In addition a member of the research team will ring you once per week at a prearranged time to check everything is working ok with your memory aid, collect information from your task completion log and to ask you some questions about the

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22nd September 2011

memory aid. This is expected to take approximately 15 minutes for each call.

- You will be asked to complete a follow-up week where you log your tasks and complete an assigned task through a phone service. This will occur between two and four months after the intervention ended.
- At the end of the study, we may invite you to continue in the research completing the same tasks, but after training in the use of a different memory aid to the one you initially received. This is entirely optional and you do not need to decide at this time. This would occur over an additional 11-15 weeks.
- At the conclusion of the research you are able to keep any memory aids which you trialled so you can continue to benefit from them after the study.
- During the study the researcher may have access to details about tasks you need to complete, and be able to collect data about your usage and location of the memory aid. This is subject to confidentiality regulations and will be terminated at the end of the intervention.

You do not have to complete the study if you do not wish to. You can return the memory aid and withdraw at any time.

Are there any benefits or risks?

Each of the memory aids are shown to be effective for many people who have difficulties remembering tasks they need to complete after having sustained a brain injury (We are interested in which is the most effective).You will be provided with a memory aid, trained in the use of it, and able to keep it at the end of the study, providing you with a tool to assist you with memory difficulties in the future. You will also assist health practitioners in establishing the best possible treatment for others who have memory difficulties after a brain injury. The procedures used in this study have no known risks or harmful effects.

What will happen to the information collected in the study?

The things you say, or the information we gather about you, will be kept confidential and used for research purposes only. No material that identifies you will be used in any report on this study. We will store your information in a secure location, and only those involved in this research programme will be able to see it. We will store your information for at least 10 years after the end of the study, after which time our records will be securely destroyed. Any researcher access to information in your external memory aid will be terminated when you end the study.

Compensation for Injury

In the unlikely event of a physical injury as a result of your participation in this study, you may be covered by the Accident Compensation Corporation (ACC) under the Injury Prevention, Rehabilitation and Compensation Act. ACC cover is not automatic and your case will need to be assessed by ACC according to the provisions of the 2002 Injury Prevention Rehabilitation and Compensation Act. If your claim is accepted by ACC, you still might not get any compensation. This depends on a number of factors such as whether you are an earner or non-earner. ACC usually provides only partial reimbursement of costs and expenses and there may be no lump sum compensation payable. There is no cover for mental injury unless it is a result of physical injury. If you have ACC cover, generally this will affect your right to sue the investigators.

If you have any questions about ACC, contact your nearest ACC office or the investigator.

Finding out about the results of the study.
If you would like to find out the results of the study, please circle the YES box on the consent form. After the study is completed, we will mail you the results. There may be a long delay between when you take part and when the results are known. If you would like more information about the study, feel free to contact one of us:

- Hannah Bos
  Telephone: 04 8015799 Ext. 620609
  Email: hbos.massey@gmail.com
- Dr. Duncan Babbage
  telephone: 04 801 5799 Ext. 62039

Our postal address is: Freepost 181246, Hannah Bos, School of Psychology, Massey University.

If you have any queries or concerns about your rights as a participant in this research study you can contact an independent health and disability advocate. This is a free service provided under the Health and Disability Commissioner Act.

Telephone: (NZ wide): 0800 555050
Free Fax (NZ wide): 0800 27877678 (0800 2 SUPPORT)
Email: advocacy@hdc.org.nz

This study has received ethical approval from the Central Regional Ethics committee.

Hannah Bos
Doctoral Candidate

Duncan Babbage, PhD
Senior Lecturer

Participant Consent form

MASSEY UNIVERSITY

Consent Form

Memory aids after traumatic brain injury

English	I wish to have an interpreter	Yes	No
Maori	E hiahia ana ahau ki tetahi kaiwhakamaori/kaiwhaka pakeha korero	Ae	Kao
Cook Island	Ka inangaro au I tetai tangata uri reo	Ae	Kare
Fijian	Au gadreva me dua e vakadewa vosa vei au	Io	Sega
Niuean	Fia manako au ke fakaaoga e taha tagata fakahokohoko kupu	E	Nakai
Samoan	Out e mana'o ia I ai se fa'amatala upu	Ioe	Leai
Tokelaun	Ko au e fofou ki he tino ke fakaliliu te gagana Peletania ki no gagana o na motu o te Pahefika	Ioe	Leai
Tonga	Oku ou fiema'u ha fakatonulea	Io	IKai

I have read and I understand the information sheet for volunteers taking part in this study. The nature and purpose of the study have been explained to me. I understand that this study is designed to help compare the efficacy of two memory aids, and is not designed to sell these memory aids. I have had the opportunity to discuss this study and ask questions about it. I am satisfied with the answers I have been given. I have had the opportunity to use family/whanau support or a friend to help me ask questions and understand the study. I have had the time to consider whether to take part.

I understand the following:

- Taking part in this study is voluntary (my choice). I may withdraw from the study at any time and this will in no way affect my continuing health care.
- I will be in control of what I do and what happens to me. I can ask questions or have a break when I need one.
- By participating I agree that the clinical team and my GP may provide the researchers with information from my healthcare records regarding the nature and severity of my brain injury.
- My participation in this study is confidential and material which could identify me will not be used in any reports on this study.

I .... (full name) hereby consent to take part in this study.

My GP is: ....

Signature: .... Date: ....

I would like to receive a copy of the results YES / NO

Please send the results to (email or postal address): ....

....

(There may be a long delay between when you take part and when the results are known).

I have had this project explained to me by ....

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May 30, 2011

If you would like more information about the study, feel free to contact one of us:
Hannah Bos
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Dr. Duncan Babbage
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Our postal address is: Freepost 181246, Hannah Bos, School of Psychology, Massey University, Wellington.
This study has received ethical approval from the Central Regional Ethics committee.

Whānau/Family Information Sheet

MASSEY UNIVERSITY

Information Sheet—Whānau/Family

Memory aids after traumatic brain injury

You are invited to assist in a voluntary study which your whānau/family member with brain injury is participating. This study is designed to compare the effectiveness of two memory aid strategies to compensate for memory difficulties after a brain injury.

Taking part in this study is voluntary.
It is your choice whether you take part or not. You do not have to take part in this study. If you agree to take part, you can stop taking part at any stage without having to give a reason and this will not affect your whānau/family member's eligibility to participate. You can ask questions about the study at any time.

You will provide consent to participate verbally during phone calls. Alternatively, return of written questionnaires by post will imply your consent.

What does taking part involve?
If your whānau/family member chooses to take part in this study they will be randomly assigned to one of two memory aid groups. More information about the memory aid will be provided after randomisation.

They will be provided with a memory aid, and receive training in how to use it. If they complete this study they will be allowed to keep the memory aid.

Your whānau/family member will be involved in the study for 11-15 weeks, plus one week follow-up 2-4 months after the main study and an initial interview before commencing the study. We may ask them to continue in the study for a further 11-15 weeks with the memory aid you did not initially receive, and attend another 2-4 month follow-up interview.

What will people in the study be asked to do?
If you choose to take part, here are the things that you will be doing. While any information you can provide us is valuable you are not obligated to do all of these tasks.

- We would like to gain your perspective on your whānau/family member's memory abilities and involvement in the home and community. This will involve you completing two questionnaires which your whānau/family member will also complete. Generally we would do this through a scheduled phone call. This is expected to take up to an hour. We will post you a copy of the questionnaires in advance so you can read along as we work through them during the interview. Alternatively, if it is more convenient, you may complete the questionnaire in writing and return it to us before the scheduled phone call, in which case the call will not be required.
- We would like these questionnaires to be completed on three occasions, once before your whānau/family member receives their memory aid, when they have been using their memory aid, and at a follow-up 2-4 months after the main trial.
- Your whānau/family member will be attending one hour interviews up to once a week. You are welcome to attend any of these. There are a few sessions in which your assistance would be particularly valuable, such as when initially identifying memory tasks. However, attending these sessions is always optional for you.
- Your whānau/family member will be completing a log of tasks which they needed to remember. If both your whānau/family member and yourself work together to record this, the information may be more accurate.

Are there any benefits or risks?

Each of the memory aids have been shown already to be effective for many people who have difficulties remembering tasks they need to complete after having sustained a brain injury (We are interested in which is the *most* effective). Your whānau/family will be provided with a memory aid, trained in the use of it, and able to keep it at the end of the study, providing them with a tool to assist with memory difficulties in the future. The information collected during the study will assist health practitioners in establishing the best possible treatment for others who have memory difficulties after a brain injury. The procedures used in this study have no known risks or harmful effects.

What will happen to the information collected in the study?
The things you say, or the information we gather about you, will be kept confidential and used for research purposes only. No material that identifies you will be used in any report on this study. We will store your information in a secure location, and only those involved in this research programme will be able to see it. We will store your information for at least 10 years after the end of the study, after which time our records will be securely destroyed. Any researcher access to information in your external memory aid will be terminated when you end the study.

Compensation for Injury
In the unlikely event of a physical injury as a result of your participation in this study, you may be covered by the Accident Compensation Corporation (ACC) under the Injury Prevention, Rehabilitation and Compensation Act. ACC cover is not automatic and your case will need to be assessed by ACC according to the provisions of the 2002 Injury Prevention Rehabilitation and Compensation Act. If your claim is accepted by ACC, you still might not get any compensation. This depends on a number of factors such as whether you are an earner or non-earner. ACC usually provides only partial reimbursement of costs and expenses and there may be no lump sum compensation payable. There is no cover for mental injury unless it is a result of physical injury. If you have ACC cover, generally this will affect your right to sue the investigators.

If you have any questions about ACC, contact your nearest ACC office or the investigator.

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If you would like to find out the results of the study, please circle the YES box on the consent form. After the study is completed, we will mail you the results. There may be a long delay between when you take part and when the results are known.

If you would like more information about the study, feel free to contact one of us:

- Hannah Bos
  Telephone: 04 8015799 Ext. 62609
  Email: hbos.massey@gmail.com

- Dr. Duncan Babbage
  telephone: 04 801 5799 Ext. 62039

Our postal address is: Freepost 181246, Hannah Bos, School of Psychology, Massey University, Wellington.

If you have any queries or concerns about your rights as a participant in this research study you can contact an independent health and disability advocate. This is a free service provided under the Health and Disability Commissioner Act.

Telephone: (NZ wide): 0800 555050
Free Fax (NZ wide): 0800 27877678 (0800 2 SUPPORT)
Email: advocacy@hdc.org.nz

This study has received ethical approval from the Central Regional Ethics committee.

Hannah Bos
Doctoral Candidate

Duncan Babbage, PhD
Senior Lecturer

Whānau/Family Assent Form

MASSEY UNIVERSITY

Assent Form—Whānau/Family

Memory aids after traumatic brain injury

I have read and I understand the information sheet for volunteers taking part in this study. I understand that this study is designed to help compare the efficacy of two memory aids, and is not designed to sell these memory aids. I have had the opportunity to discuss this study and ask questions about it. I am satisfied with the answers I have been given. I have had the time to consider whether my whānau/family should take part.

I understand the following:

- Taking part in this study is voluntary. My whānau/family member may withdraw from the study at any time and this will in no way affect their continuing health care.
- My whānau/family member will be in control of what they do and what happens to them. They may ask questions or have a break when they need one.
- By participating my whānau/family member has agreed that the clinical team and their GP may provide the researchers with information from their healthcare records regarding the nature and severity of their brain injury.
- My whānau/family member's participation in this study is confidential and material that could identify them will not be used in any reports on this study.

I .... (full name)

hereby assent to my whānau/family member..(full name) with brain injury taking part in this study.

Signature: .... Date: ....

I would like to receive a copy of the results YES / NO

Please send the results to (email or postal address):

....

....

(There may be a long delay between when you take part and when the results are known).

I have had this project explained to me by ....

If you would like more information about the study, feel free to contact one of us:
Hannah Bos
telephone: 04 8015799 Ext 62609
email: hbos.massey@gmail.com
Dr. Duncan Babbage
telephone: 04 801 5799 Ext. 62039

Our postal address is: Freepost 181246, Hannah Bos, School of Psychology, Massey University, Wellington.
This study has received ethical approval from the Central Regional Ethics committee.

Te Kunenga ki Pūrehuroa

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Version 1.0
28 November 2011

Appendix 2: Media Release

News release

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA

Paul Mulrooney
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news.massey.ac.nz

Monday, July 9, 2012

Memory aid research to help brain injury sufferers

Memory aids have long been identified as a way for people with traumatic brain injuries to remember everyday tasks, and a study by psychology researcher Hannah Bos wants to determine which could be best.

The clinical psychology doctoral candidate would like to hear from people who suffered a moderate or severe brain injury to join her study measuring one traditional memory aid with one using new technology.

Participants will be randomly assigned one of the two memory aids and will be provided with training in how to use them, she says. Throughout the study participants will be asked to keep a short record of their memory, and will be asked to complete two brief memory tasks each week.

Ms Bos says the randomised controlled research trial means none of the participants are allowed to know in advance which memory aid they will be testing to ensure their responses are not compromised by using a different kind of device to that assigned to them.

Prospective memory deficits, which are the ability to remember to perform a planned action at the intended time, are a common result of traumatic brain injury, she says. "Deficits in prospective memory have devastating effects on a person's ability to be independent and may increase their care burden.

"Research demonstrates compensating by using memory aids is best practice in rehabilitation. While research has investigated several types of memory aids there have been little direct comparisons between [these] two."

To date Ms Bos has already completed the testing of three respondents who have suffered a traumatic brain injury through either car accident or fall. Another five are currently being tested but she would like another 10 respondents to join the study before issuing her findings early next year. One requirement is that the brain trauma experienced by participants needed to have happened at least a year ago to have allowed the brain tissue to heal.

Participants in the study range in age from their teens to over 60 says Ms Bos whose main research subject for her PhD is in the field of neuro-psychology. "Because memory functions can interrupt so much in everyday life I wanted to do my research in an area that can be a focus of treatment at the same time."

The research is being supported through a small project grant from the Neurological Foundation as well as the Massey University Psychology Fund.

To sign up for her study contact Hannah Bos at 04-801-5799 x 62609 or email hbos.massey@gmail.com

Appendix 3: Task Completion Log

NAME: WEEK:

TASK COMPLETION LOG

You need to complete TWO pages for each day:

Appointments and Scheduled Tasks—Tasks that needed to be completed at a <u>certain time</u>

Other Tasks—Tasks that can be completed at <u>any time</u>

<u>Contact information:</u>

If you need to contact Hannah:

(04) 801 5799 extension number 62609

Email: hbos.massey@gmail.com

To call voicemail service (this will go straight to voicemail):

(04) 801 5799 extension number 62623

Text: 02102619451

1

NAME: WEEK:

HOW TO USE MY TASK COMPLETION LOG

- I can fill my task completion log out on my own, or with someone else to help: I circle whether I did it on my own or with someone else helping me.
- I can fill in tasks that I need to do in advance, the night before, or in the morning.
- I fill in whether I did the tasks, whether I did them on time, and how I remembered at the end of the day.
- I can look at my Target Task List for ideas about what tasks I could do.
- I can always add tasks that are not on my Target Task List.
- Each day I should try to add 2 tasks that are not part of my every day routine.

- **Task:** This is where I write what I need to remember.
- **Completed?** At the end of the day I circle whether I did the task or not.
- **How I remembered:** This is where I explain how I remembered the task (e.g. I remembered on my own, someone else reminded me, I looked at my memory aid).

Appointments and Scheduled tasks

- **On time?** I need to say whether I did the task at the right time, I circle yes or no.
- **Explain why not on time:** If I did an appointment or scheduled task out of schedule I explain why (e.g. I remembered late, I got a phone call, I had extra time so did it early).

2

NAME:

WEEK:

TARGET TASK LIST

Appointments and Scheduled tasks		Other Tasks	

3

NAME: WEEK:

FRIDAY

Appointments and Scheduled Tasks
Tasks which I need to complete at a CERTAIN time

I completed this form: (circle one)
On my own
With someone else

Task	Completed?	On time?	How I remembered	Explain why not on time
	Yes No	Yes No		
	Yes No	Yes No		
	Yes No	Yes No		
	Yes No	Yes No		
	Yes No	Yes No		
	Yes No	Yes No		
	Yes No	Yes No		
	Yes No	Yes No		
	Yes No	Yes No		
	Yes No	Yes No		
	Yes No	Yes No		
	Yes No	Yes No		
	Yes No	Yes No		

4

NAME: WEEK:

FRIDAY

Other Tasks—Tasks I can complete at ANY time

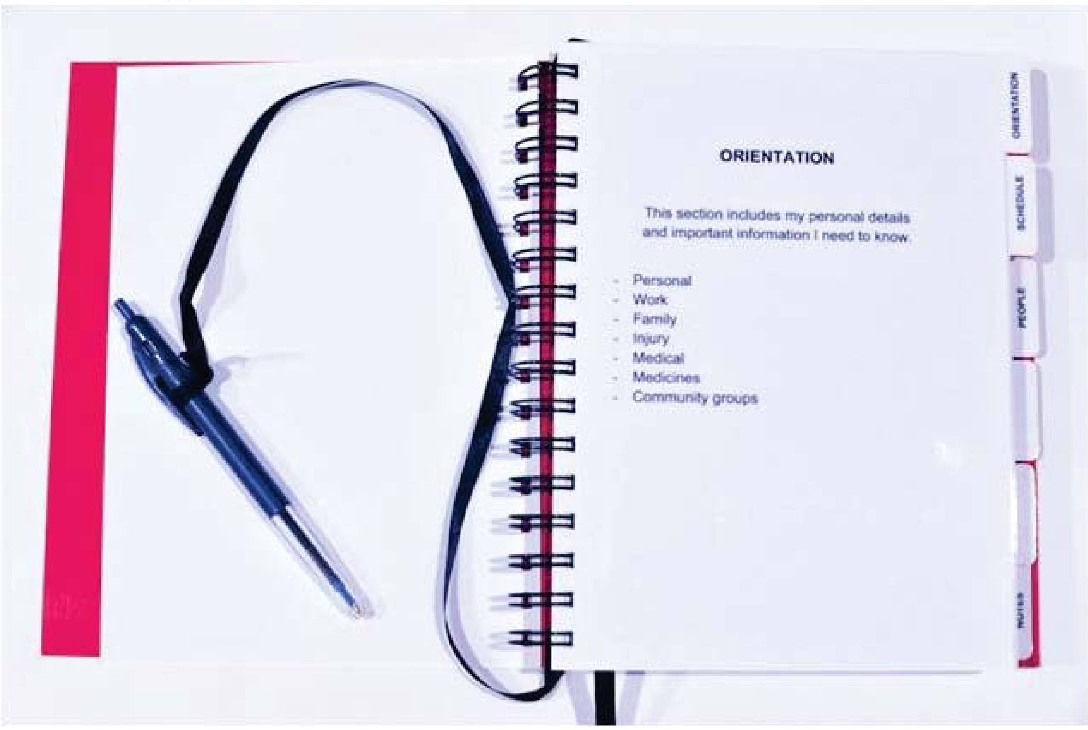
Task	Completed?	How I remembered
	Yes No	
	Yes No	
	Yes No	
	Yes No	
	Yes No	
	Yes No	
	Yes No	
	Yes No	
	Yes No	
	Yes No	
	Yes No	
	Yes No	
	Yes No	

I filled in most of these tasks: (circle) In advance Morning of During the day End of day More than a day later Same time as completion section	**I filled the completion section for most of these tasks: (circle)** During day End of day Next Day More than a day later

5

Appendix 4: Memory Notebook

Image of the Memory Notebook



Introduction Page

This Belongs to:

....

This notebook is to help me with my memory.
I should carry it with me at all times.

When there is something I need to remember
I should write it down straight away.

I need to look in my notebook often.

The sections in my notebook are:

Orientation: This is important information about me.

My schedule: Where I write down things I have to do on a particular day at a particular time.

My To Do list: Where I write down things I have to do, but it doesn't matter when I do them.

Names: This helps me remember people's names and how I can contact them.

Orientation Section

ORIENTATION

This section includes my personal details and important information I need to know.

- Personal
- Work
- Family
- Injury
- Medical
- Medicines
- Community groups

PERSONAL INFORMATION:

Name:

Birth date:

Home phone:

Mobile:

Address:

Email:

Other:

WORK INFORMATION

I work at:

Phone:

Address:

Email:

My position is:

What I do:

Boss's name:

Secretary's name:

Other:

1

FAMILY INFORMATION:

Name:

Birth date:

Relationship to me:

Phone:

Mobile:

Email:

Address:

Work/School:

Work phone:

Address:

Other:

FAMILY INFORMATION:

Name:

Birth date:

Relationship to me:

Phone:

Mobile:

Email:

Address:

Work/School:

Work phone:

Address:

Other:

2

INJURY INFORMATION

What happened:

When:

The injury:

The effects:

MEDICAL INFORMATION

Doctors Name

Medical centre:

Phone:

Address:

My medical conditions:

OTHER MEDICAL PROFESSIONALS

Profession:

Name:

Medical centre:

Phone:

Address:

Profession:

Name:

Medical centre:

Phone:

Address:

IN AN EMERGENCY DIAL 111

MY MEDICATIONS:

Name of medication:

What it is for:

When do I take it?

Instructions:

Name of medication:

What it is for:

When do I take it?

Instructions:

Name of medication:

What it is for:

When do I take it?

Instructions:

Name of medication:

What it is for:

When do I take it?

Instructions:

COMMUNITY GROUPS

Group:

What the group is:

When meet:

Things to take:

Contact person:

Address:

Phone:

Email:

Other:

Schedule and To Do Section

SCHEDULE & TO DO LIST

A Schedule and a current To Do list
are on the pages beside each other.

My Schedule is for writing down things I have to do at a certain time. I use this to write down things I need to do in the future and to know what I am doing today.

My To Do list is for writing down things I need to do, but it doesn't matter what time I do these things. I will use this to remember what I need to do, and will look at it to decide what jobs I can do.

When I have finished a task I will tick the ☐ DONE box.

SCHEDULE—MONDAY 2 JANUARY

TIME	WHAT	WHERE/NOTES	☑
			☐
			☐
			☐
			☐
			☐
			☐

TUESDAY 3 JANUARY

TIME	WHAT	WHERE/NOTES	☑
			☐
			☐
			☐
			☐
			☐
			☐

WEDNESDAY 4 JANUARY

TIME	WHAT	WHERE/NOTES	☑
			☐
			☐
			☐
			☐
			☐
			☐

THURSDAY 5 JANUARY

TIME	WHAT	WHERE/NOTES	☑
			☐
			☐
			☐
			☐
			☐
			☐

2

☑	TO DO—MONDAY–THURSDAY
☐	Copy unfinished tasks to this page
☐	
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☐	
☐	
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☐	

3

People Section

PEOPLE

This section is where I
write the names of people I know.

I write down their phone numbers
and other information about the person.

The people section is organised into
three sections to help me find people.

I can use these sections to group together people—
e.g. from one context or by relationship.

GROUP:

Places I might meet these people:

PHOTO	**Name:**
	Birthday:
	Phone:
	Mobile:
	Work Phone:
	Email:
	Address:

Description:

PHOTO	**Name:**
	Birthday:
	Phone:
	Mobile:
	Work Phone:
	Email:
	Address:

Description:

1

Notes Section

NOTES

1

Appendix 5: Smartphone

Image of Smartphone

(actual size)

Use of the Smartphone Instruction Sheet

Using Your Smartphone

This sheet shows you the items purpose and location of main parts of your phone and briefly describes how to use it.

Hard buttons are physical buttons located on the phone body rather than the screen.

Button	Name of application	What it is for	Where the button is	Instructions
	Power button	Turn on/off phone, lock screen	Hard button. Top of phone	Long press when phone is unlocked opens menu to power off, silence or airplane mode Short press locks screen
	Home button	Returns you to home screen	Hard button centre left on phone	From any other application pushing this will return you to the main home screen. Applications will still be running but out of sight
	Back button	Takes you back one step	Hard button centre right on phone	Takes you back to the previous screen. If keep pushing until a application closes the application will no longer be running
	Options menu	Gives options and settings	Hard button left of phone	Pushing within any application gives extra options and settings menu for the application
	Search	Searching	Hard button right of phone	Push and type what you would like to search for within an application
	Screen unlock	Unlocking the screen	Lower half of screen on the left	When phone in standby touch any hard button to turn on screen. Touch padlock and slide to the right to unlock the screen.
	Sound control	Switching between sound on and off	Lower half of screen on the right	When phone in standby touch any hard button (bottom of phone) to turn on screen. When the screen is locked touch and slide to the left to switch between sound on/silent

	Notifications bar	Information	Top line of screen	Information about connections. Notification and missed call icons go here. Touch and slide down to show notifications. Touch any notification to open. Push clear to clear all.
	Menu button	Menu	Centre bottom of screen	Opens menu showing all available applications
	Calendar	Opens your calendar	Bottom left of screen top of main menu	To enter my meetings, appointments and events which I need to do at a particular time
	Contacts	Opens your contacts	Bottom centre left	Opens contacts application, where information about people and how they can be contacted. Can start calls, texts and emails from here.
	Tasks	Opens your task list	Bottom right of screen	Opens task list for things you need to do but it doesn't matter when you do it. Cross off completed tasks.
	Messaging	Opens your text inbox	Bottom centre right	Opens your text message inbox to read and send text messages

Your Homescreens- Press any hard button to turn screen on

Unlocking

Touch the padlock and drag to the right

Homescreen

Today's tasks are displayed

Other homescreens

Swipe sideways to see other homescreens.

Your keyboard

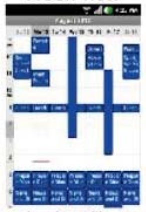
Drag your finger across the screen to spell a word. Lift finger to leave a space and start new word. Suggested words appear in the bar. Touch to select one. The word displayed in blue will automatically insert when you start a new word

Touch the :-) on the bottom right of alphabet view to change to smiley face view. Touch a face to insert into message.

Touch the ?123 on bottom left of alphabet view to change to numbers and symbols. ¼ displays more symbols. Touch ABC on the bottom left to return to the alphabet view

Your Calendar – Touch to open.

Week view



The calendar will open on whatever was the last screen you had open. This is the week view. Swipe across to move through time on calendar.

Changing Views

To change views press and select view. Today brings you to today's date in whichever view you are in

Day View

Select day view. The red line is current time

Month View

Select month view. Blue dots indicate an event is scheduled that day

Adding a new event

Select the time and hold finger to bring up menu

→

New event menu

Touch "event name" to enter event

→

Event name

Use keyboard to write event. Hold down the arrow bottom right to hide keypad afterwards

→

Event time

Change start and end times and dates by touching the time/date and selecting a new one.

→

Enter location of event

Touch "Where" and write the location of event

Regular events

If this is a regular event touch "Repetition" and select appropriate option

Reminders

Touch the reminder time to alter. Touch the + to add more, the – to remove. A popup screen and tone will remind you at this set time

Save, view & edit event

Touch done to save. Touch an event to show details. To edit, delete or add a new event hold finger on event to bring up menu

Your notifications

Notification pop-up screen

If respond touch dismiss. To snooze either select default snooze bar or other snooze option. To keep popup on screen but silence alarms touch mute.

Selecting a time to snooze event for

You can choose your own snooze time by touching the "For" snooze option and selecting your time. Touch ok to save

Selecting a day to snooze until

You can select a new day and/or and time to receive the reminder by touching "until" Select the day you wish to receive the reminder on. Touch Set

Selecting the time on that day to snooze until

You can then select the time you wish to receive the reminder at touch "Done" to save.

To Do List- Touch to open

Task list

Tasks with a date will be displayed under the date. All others will be listed under "No Date"

Ticking completed task

Touch the check box on the left to mark off a completed task. The item will be crossed out and go to "Completed" at the bottom. To bring it back touch the tick box.

Add a new task

Touch the "Quick add new task" bar at the bottom. enter the task

You can select if the task is for Today, Tomorrow or next week by touching the option above the task. Save by touching the tick button to the right of the task.

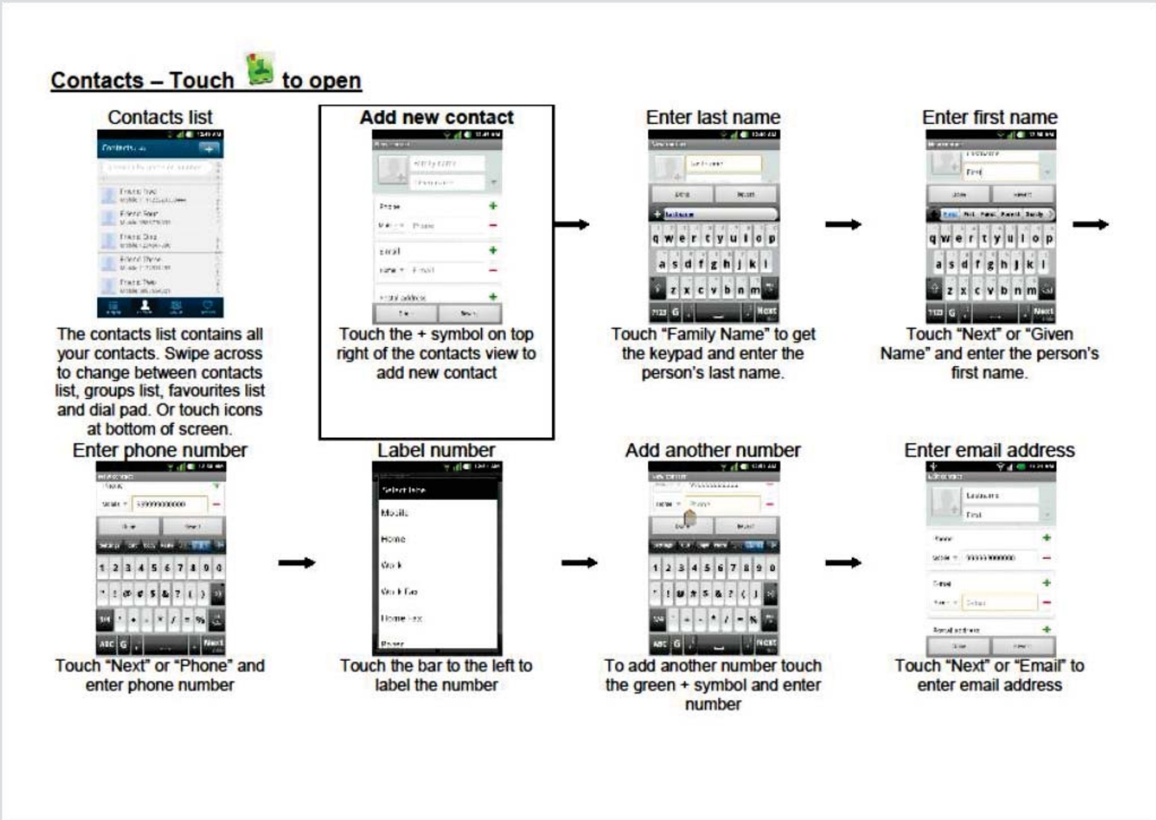
Selecting a task date

After entering a task touch the task text, this allows you to edit the text. Touch "Due date and Priority" at the top right to open a calendar. Select a date then touch OK

Clear completed tasks

In the main task window press

This brings up options. Then touch "Clear Done"


Contacts – Touch to open
Contacts list
The contacts list contains all your contacts. Swipe across to change between contacts list, groups list, favourites list and dial pad. Or touch icons at bottom of screen.
Add new contact
Touch the + symbol on top right of the contacts view to add new contact
Enter last name
Touch "Family Name" to get the keypad and enter the person's last name.
Enter first name
Touch "Next" or "Given Name" and enter the person's first name.
Enter phone number
Touch "Next" or "Phone" and enter phone number
Label number
Touch the bar to the left to label the number
Add another number
To add another number touch the green + symbol and enter number
Enter email address
Touch "Next" or "Email" to enter email address

Enter postal address

Touch the keyboard minimise button (where "Next" was previously) or Touch "Postal Address". Enter each part in the appropriate box by touching the box to enter text

Label address

Touch the bar beside the address to select a label for the address

Enter organisation

To enter where the person works touch "Organisation" and enter in the box. You can enter their work title below.

Add to a group

To add the person to a group touch the drop-down bar below "Groups" and tick the box for group you want to add them to. Touch OK

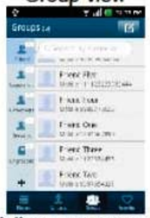
Add a photo

Touch the head silhouette to the left of the person's name, select whether you wish to take a photo or choose from one you have already taken in your Gallery

View a contact

From either the Contacts view or Groups view ouch the name of any contact you want to see the details for

Group view



Touch the group name on the left side of the screen to open group

Adding to favourites

Touch the grey box with the + inside. Touch tick boxes on right hand side of contacts names to add to favourites. Touch OK to save. This gives you quick options to contact the person by touching name

Phone dialpad

Swipe from contacts or touch the dialpad icon on the bottom of the screen.

Dialling a number

As you type in the number matching contacts numbers appear, at any time touch the contact name to call. Press call to start the call.

Call log

To view the full call log push the hide the keypad by touching the dialpad icon the bottom left of the screen.

Clearing call log

From the call log you can delete the list by pressing  to bring up the menu, select Clear call log.

Messaging-  to open

New message

Touch "New Message" at top of screen. Touch "To" and write person's name

→

Select number

A list of numbers will appear. Select the persons number by touching the name, ensure you select their mobile number to send a text

Alternatively, reply to a message you have received from the contact before. Touch message to open, then touch "Type to Compose"

Appendix 6: Acquisition Charts

Memory notebook

Acquisition Chart- Notebook

Questions	Training Dates							
What is your notebook for? *To help me with my memory*	1 /1	1 /1	1 /1	1 /1	1 /1	1 /1	1 /1	1 /1
What are the sections of in your notebook? *Orientation, Schedule & todo(2), People, Notes*	/5 /5	/5 /5	/5 /5	/5 /5	/5 /5	/5 /5	/5 /5	/5 /5
What is the orientation section for? *My personal details and important information I need to know*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
What is the Schedule & to do section for? *Writing down things I have to do*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
What is the People section for? *Writing the names of people I know*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
What is the notes section for? *Recording any other information of my choice*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
Where is your current to do list? *Inside the schedule section on the page beside today's date*	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2
What are the Schedule pages for? *Writing down things I have to do at a certain time*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
What are the To Do pages for? *Writing down things I need to do but it doesn't matter what time I do these things*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
When should you look at your Schedule? *First thing in the morning, and whenever I need to know what to do next*	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2
Where should you record information about appointments, meetings or events with particular days and times? *On the Schedule pages in the Schedule section*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
What should you do when you have completed something on your to do list? *Tick the done box*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
How is your People section arranged? *Into three groups*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
If you need to find out information about your medications, your injury or your community groups where would you look? *Orientation Section*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
Total Correct	/20 /20	/20 /20	/20 /20	/20 /20	/20 /20	/20 /20	/20 /20	/20 /20
% correct 1: % correct 2: % correct total								

Smartphone

Acquisition Chart- Smartphone

Questions	Training Dates							
What is your phone for? *To help me with your memory*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
What are the main applications in your phone? *Calendar, Tasks, Contacts, Inbox, (memo)*	/4 /4	/4 /4	/4 /4	/4 /4	/4 /4	/4 /4	/4 /4	/4 /4
How do you open the calendar *Bottom left of screen*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
What are the calendar and tasks for? *Writing down things I have to do*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
What is Contacts for? *Writing the names and contact information for people I know*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
How do you open the tasks list? *On the bottom right- the tick box, and in main menu*	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2
What is the calendar for? *Storing information about things I have to do at a certain time*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
What is tasks for? *Storing information about things I need to do but it doesn't matter what time I do these things*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
When should you look at your Schedule and to do lists? *First thing in the morning whenever I need to know what to do next and whenever a notification is received*	/3 /3	/3 /3	/3 /3	/3 /3	/3 /3	/3 /3	/3 /3	/3 /3
Where should you record information about appointments, meetings or events with particular days and times? *In the calendar*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
What should you do when you have completed something on your task list? *Tick the done box*	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
How are your contacts arranged? *Into groups base on where I would meet them*	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2	/2 /2
What other applications are important?	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1	/1 /1
Total Correct	/20 /20	/20 /20	/20 /20	/20 /20	/20 /20	/20 /20	/20 /20	/20 /20
% correct % correct 2: % correct total								

Tasks

Calendar

- Everyday reminder to put phone on charger overnight
- Put in the current schedule for the appointment

Appendix 7: Weekly Semi-Structured Interviews and Likert Ratings

Initial Interview- Memory compensatory strategies

1. How do you remember the time of appointments you need to keep?
2. How do you remember things you have to do today (When it doesn't matter what time it is done)?
3. How would you remember something you need to do tomorrow?
4. How would you remember something you need to do next week?
5. If a friend invited you to dinner at 6.30pm Wednesday next week, how would you remember?
6. How do you remember when your friends or family's birthdays are?
7. Do you need to take any medication? (if yes) how do you remember?
8. Do you own a..........Please explain how you use it, and how often:

- Home computer or laptop
- Wall chart or notice board
- PDA or palm pilot
- Notebook or notepad
- Mobile phone or smartphone
- Calendar or wall planner
- ipad or something similar
- Appointment diary or scheduler
- Pager
- Lists or sticky notes

First baseline interview- Target task Identification

If you run through a typical day – is there anything you have difficulty remembering to do?

Is there anything which don't currently do, but would like to remember to do

CAPM items- any items which were scored as frequently forgotton which could be added as a target task

Possible tasks:

Making breakfast /lunch/ dinner	Medications	Shopping
Meeting a friend	Social groups	Work tasks
Pick up children from school	Exercise	Posting letters
Take children to activities	Going to movie/show	Bills
Doctor appointments	Getting to bus stop at correct time	Organising a social event
Other appointments	Calling someone	Picking up/return an item to someone
	Groceries	

Interviews

Weekly Interview (all phases)

1. How have you gone in terms of remembering things you needed to do in the last week?
2. What sorts of things have you had difficulty remembering to do?
3. Were there any times you were particularly good at remembering or where you remembered something you wouldn't have expected to be able to remember?

Treatment Questions (additional)

4. How have you gone using your memory aid this week?
5. Have you had any difficulties with your memory aid this week?
6. Has there been any times this week where it has been particularly useful?
7. How often would you say you have added something into your memory aid?
8. How often would you say you refer to your memory aid?
9. Have you scheduled anything in advance?
10. Have you used it for anything aside from scheduling and tasks?

End of study Questions (additional)

11. Can you describe for me your experiences in this study, from before you had a memory aid, learning to use it, and now that you have been using it for a while?
12. What has been helpful?
13. What has been unhelpful?

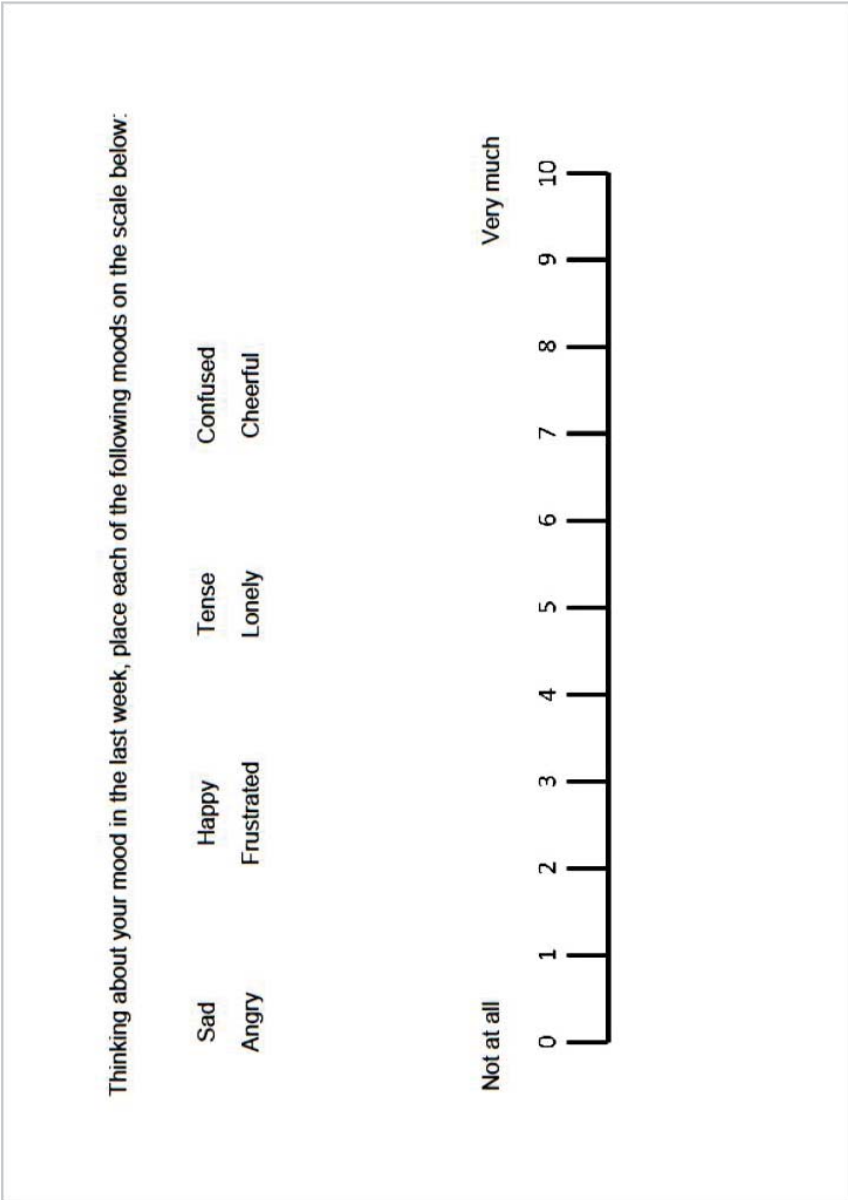
14. Have you noticed any differences in your ability to manage with your memory difficulties?
15. Have you noticed any changes other than memory? E.g. changes in mood, motivation.
16. If you were to imagine what you could be doing in your future if you didn't have your memory aid, and imagine what you could be doing in your future now that you have a memory aid- would there be any differences?
17. Is there anything you would recommend be changed about your memory aid?
18. Anything you would change about the study?
19. Overall, has this study helped you, made no difference, or been unhelpful? (explain)
20. Any other comments?

Follow up

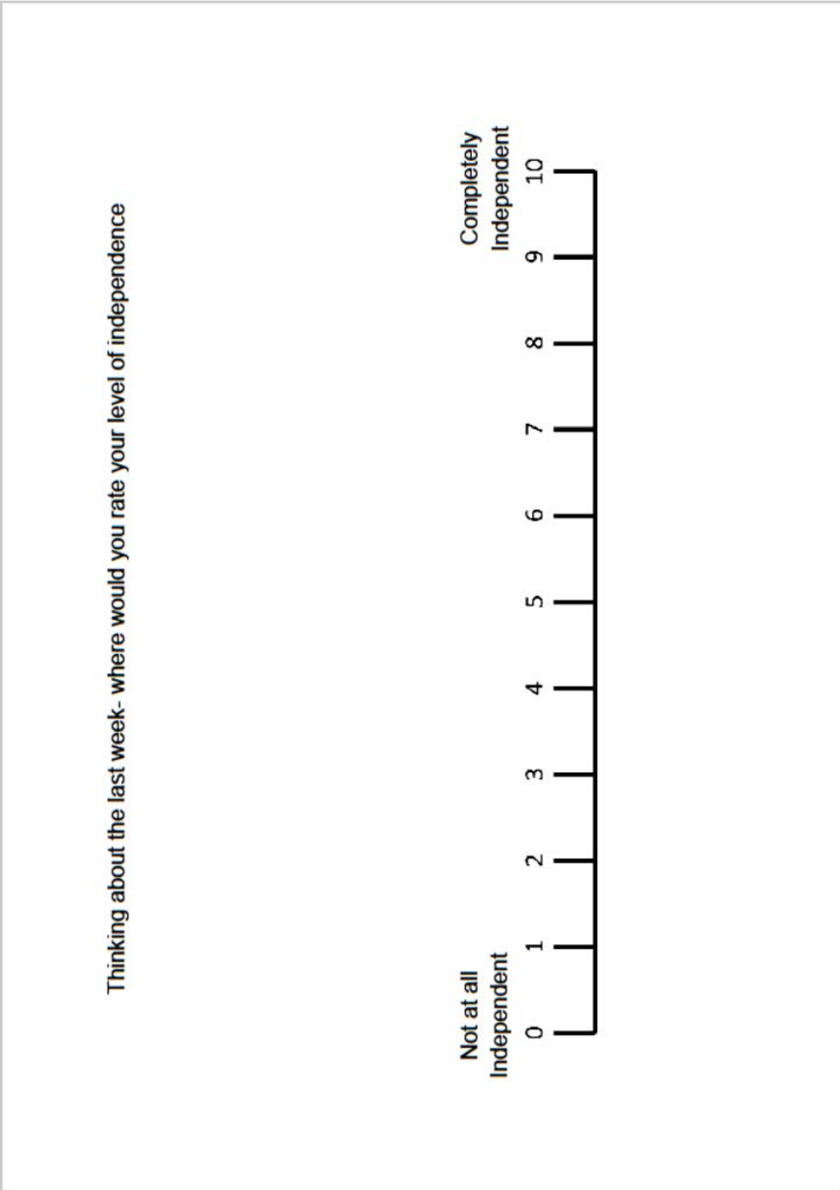
1. How have you gone in terms of remembering things you needed to do since I saw you last?
2. How have you gone using your memory aid since I saw you last?
3. Have you noticed any differences in your ability to manage your memory difficulties when using your memory aid?
4. Have you had any difficulties with your memory aid?
5. Has there been any where it has been particularly useful?
6. How often would you say you have added something into your memory aid?
7. How often would you say you refer to your memory aid?

8. Do you carry your memory aid with you?
9. Have you used it for anything aside from scheduling and tasks?
10. Has the amount that you use the memory aid changed since I saw you last?
11. In your opinion has the memory aid been helpful on your own?
12. Have you noticed any changes other than memory? E.g. changes in mood, motivation.
13. Is there anything you would recommend be changed about your memory aid?

Likert Ratings



Administered weekly throughout the study



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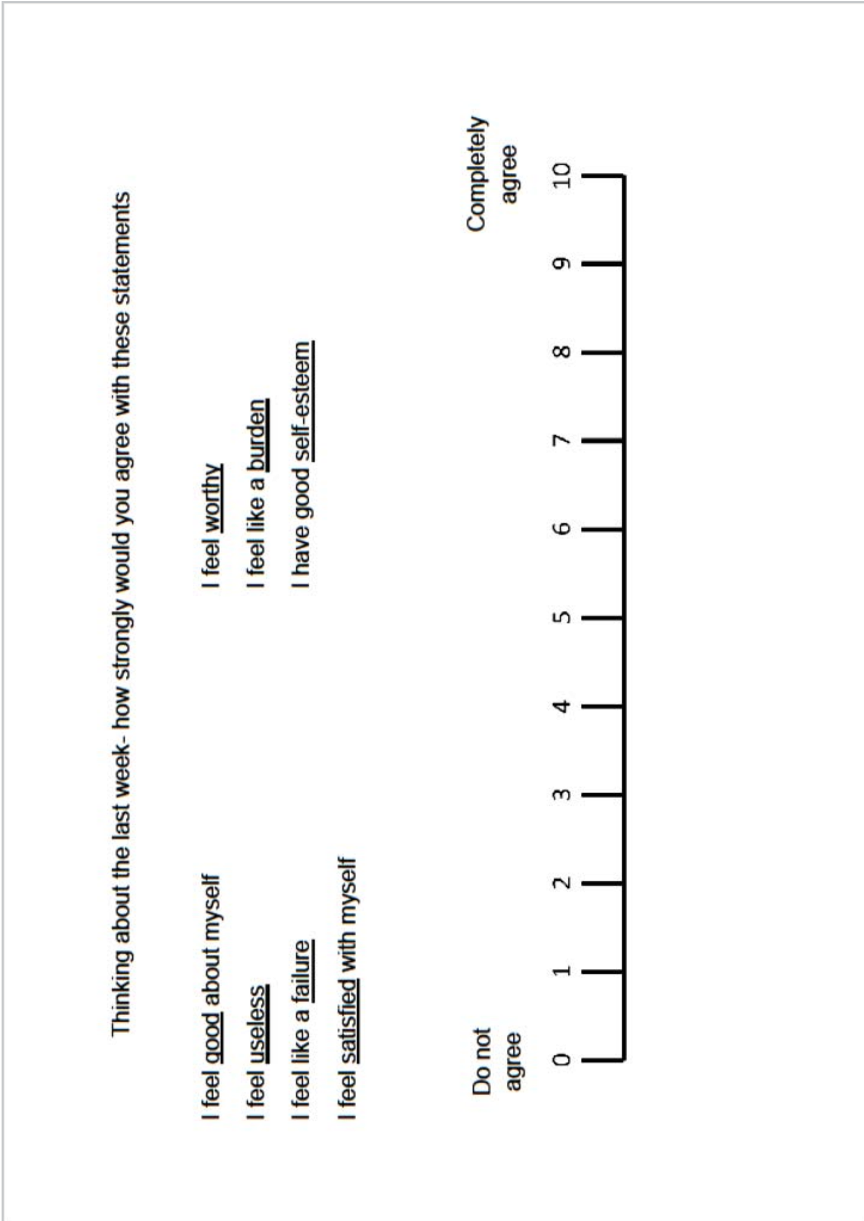

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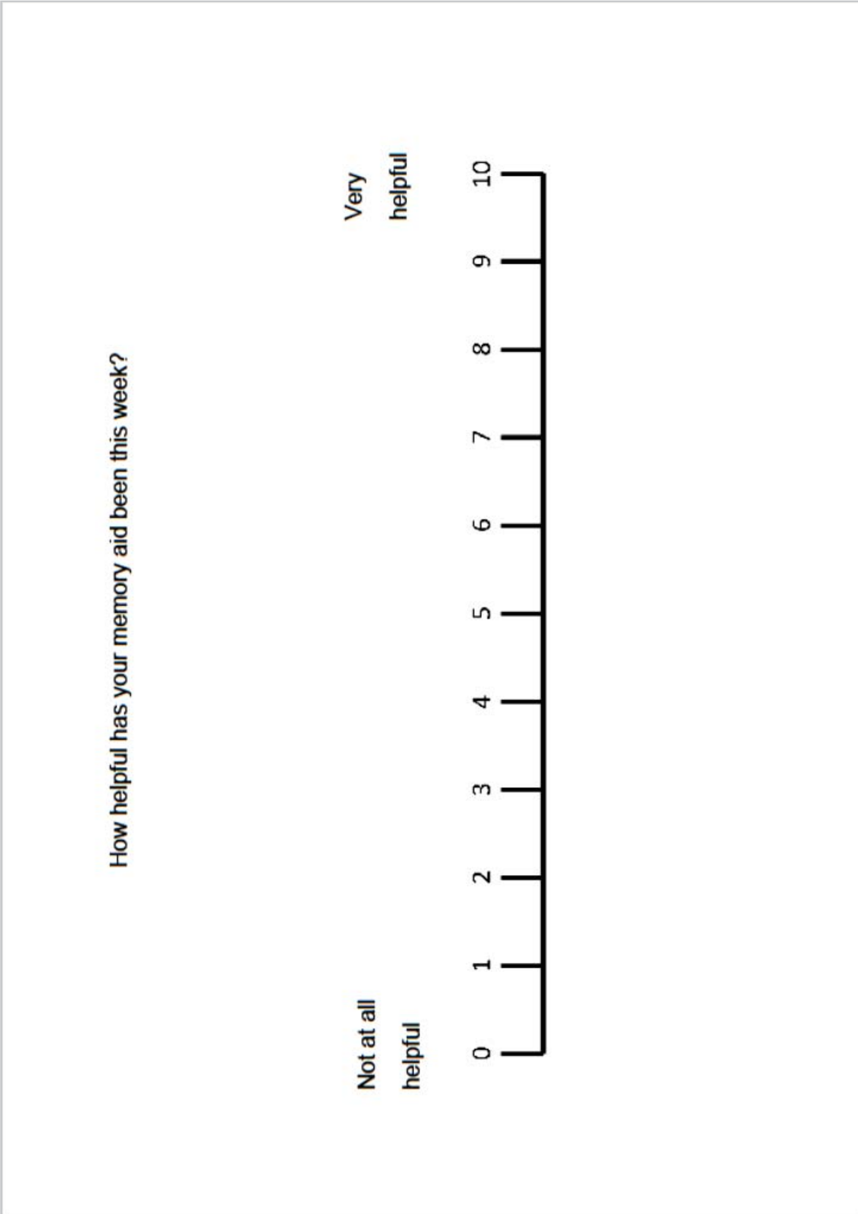
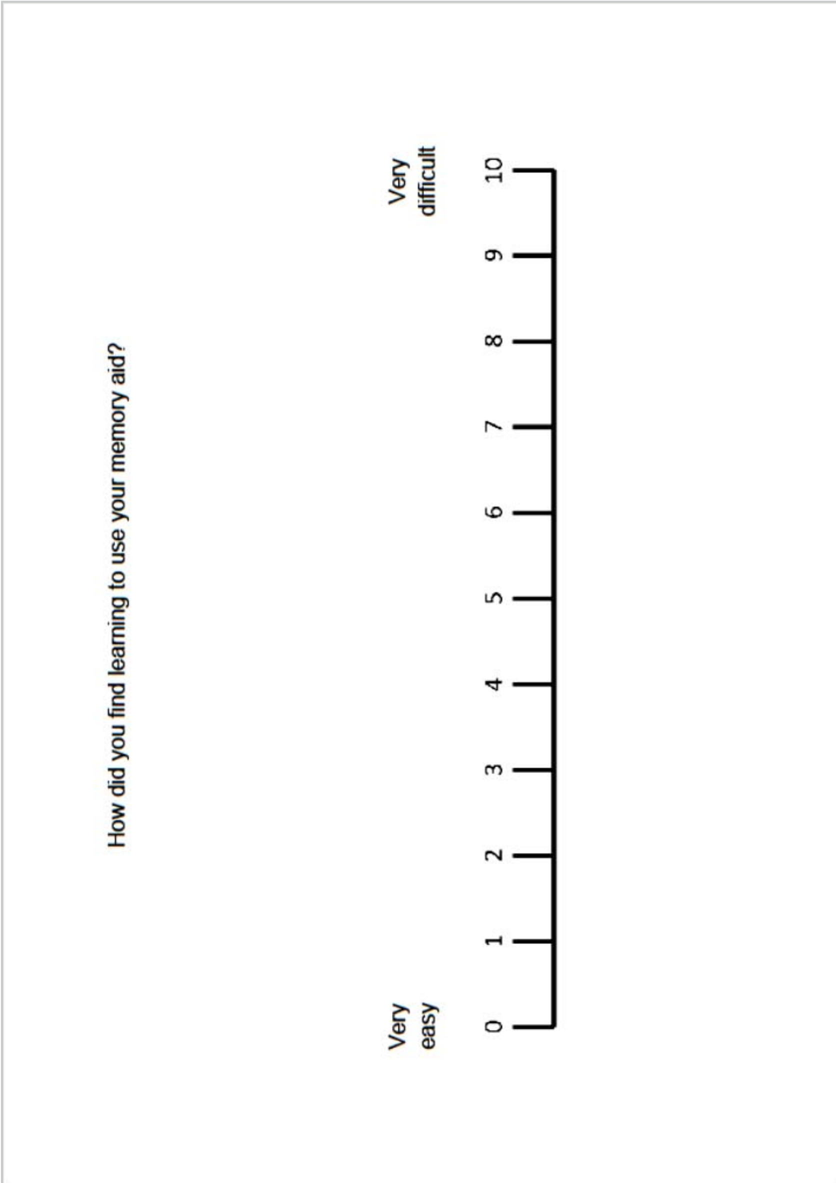
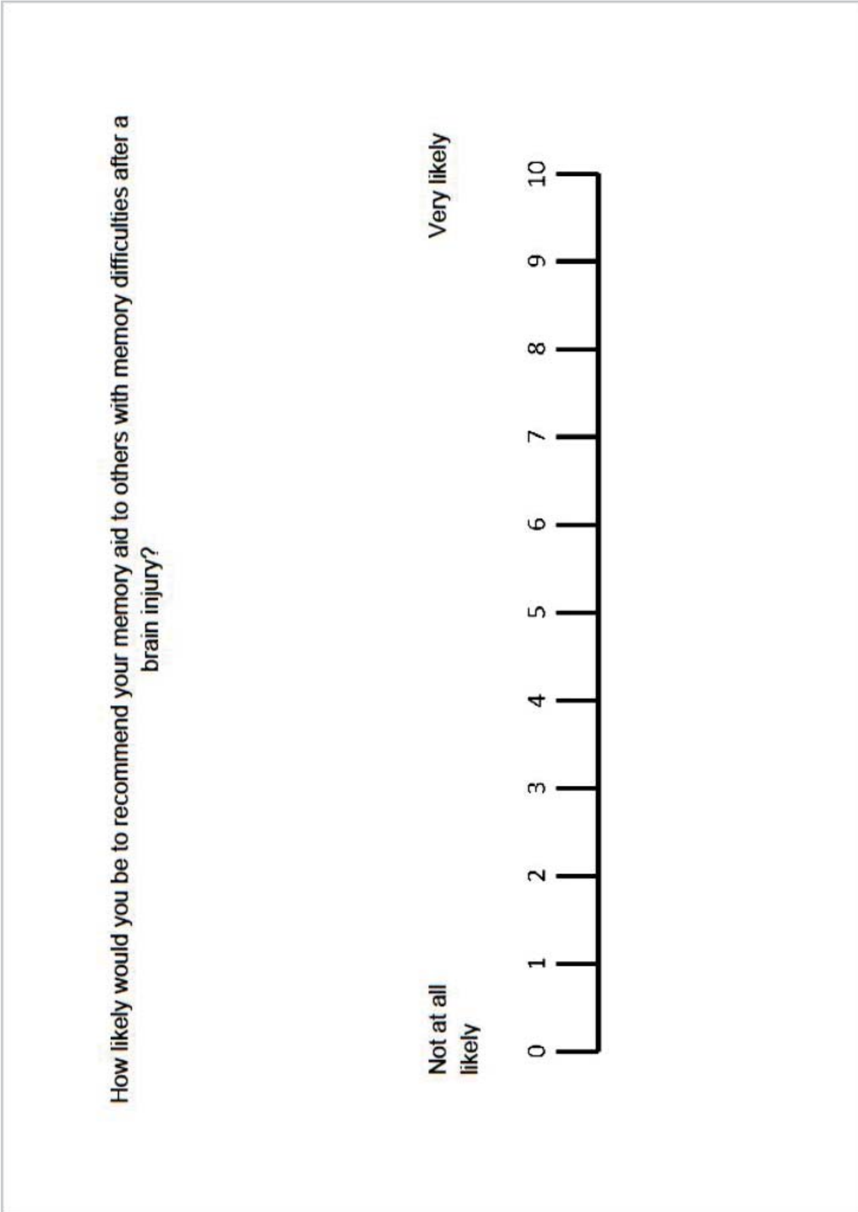


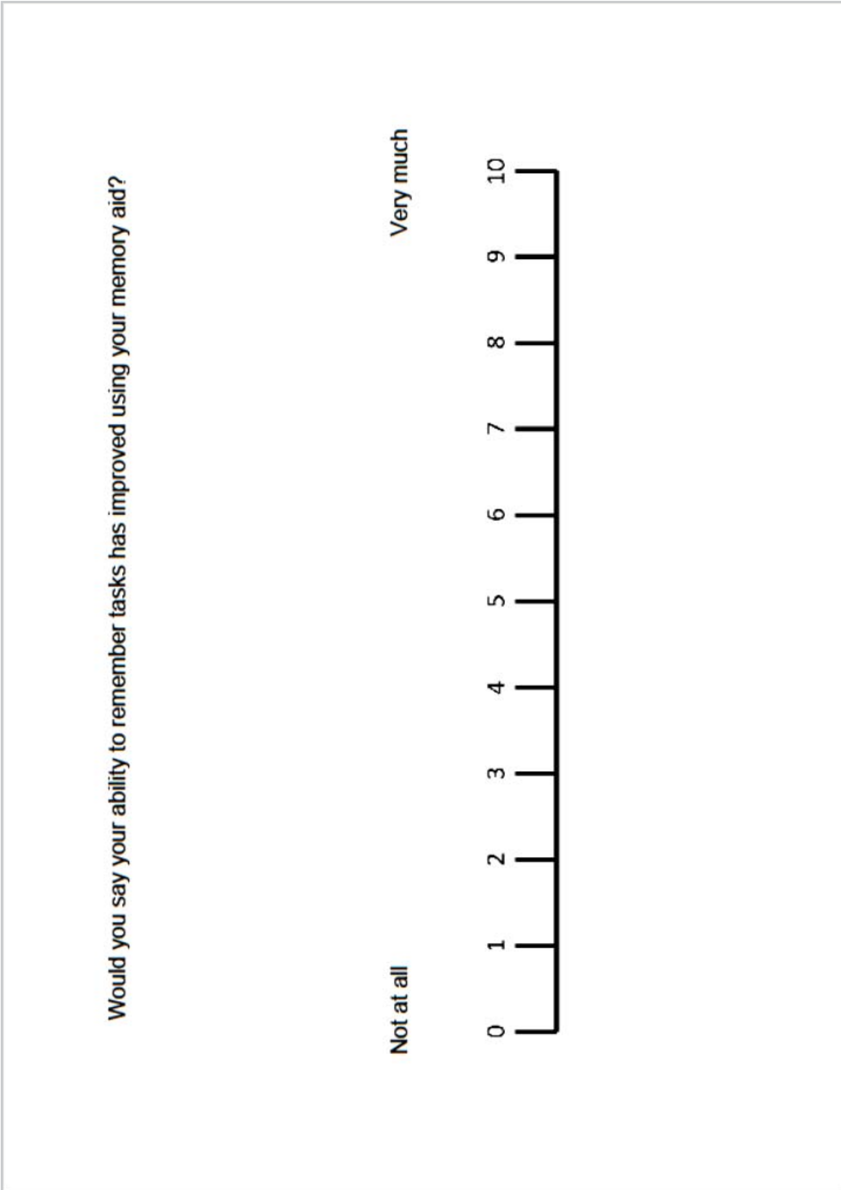
Administered throughout treatment and follow up



Administered during training



Administered at the end of treatment and at follow up



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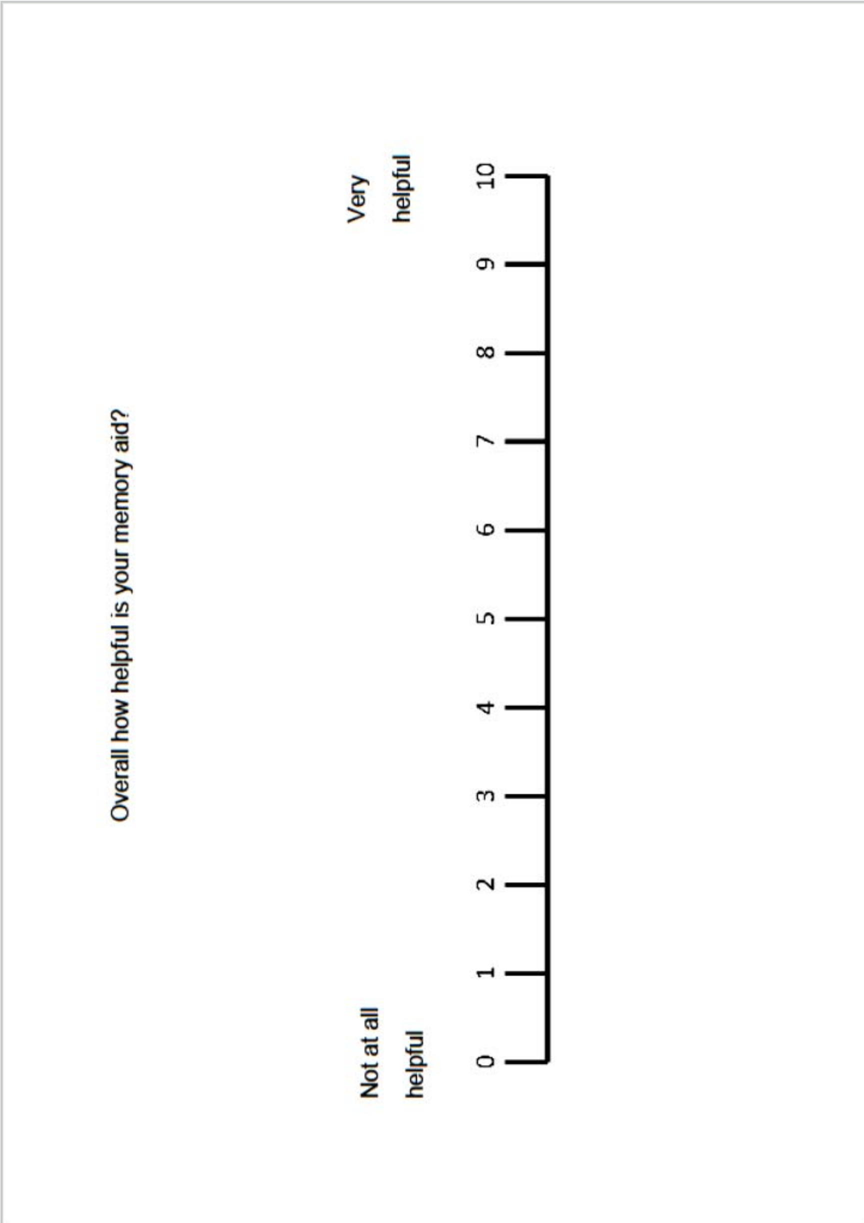

Administered at the end of treatment and at follow up

Appendix 8: Memory Tasks

Baseline Questions:

Questions were provided in order for the required number of baseline recording weeks dependent on assigned length and stability

1. Tell me what you think will be good about having a memory aid
2. Tell me what you think will be bad about having a memory aid
3. Tell me what you think might help you use a memory aid
4. (optional) Tell me what you think might stop you using a memory aid
5. (optional) Tell me about a time this week you remembered what you were meant to do
6. (optional) Tell me About a time this week where you forgot about something you were meant to do

Treatment Questions

All participants had an eight week baseline and therefore were asked all questions.

1. Tell me what parts of your memory aid are easy to learn to use
2. Tell me what parts of your memory aid is difficult to learn to use
3. Tell me something good about your memory aid
4. Tell me something bad about your memory aid
5. Give me an example of a time where your memory aid was particularly useful
6. Give me an example of something going wrong with your memory aid

7. Tell me if you have forgotten to take your memory aid with you at all this week
8. Tell me if your memory aid has helped you do something you wouldn’t have remembered without it

Postcard Task

Front

MASSEY UNIVERSITY

Back

Please write your name and post this week

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