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Implementing a Neuropsychological Rehabilitation Program Using a Single Case Experimental Design with an Adult Patient Following Severe Traumatic Brain Injury in Cape Town

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Implementing a Neuropsychological Rehabilitation Program Using a Single Case Experimental Design with an Adult Patient Following Severe Traumatic Brain Injury in Cape Town

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Abstract

Traumatic brain injury (TBI) is one of the largest contributors to death and disability in millions of individuals globally each year. In South Africa, the prevalence of TBI is elevated largely owing to high rates of interpersonal violence and motor-vehicle accidents. TBI has multiple potential cognitive, psychological and behavioural sequelae that can severely impact on individuals' daily lives. Thus, methods of remediation are essential to their continued health and functional capacity. In this pre- and post-test single case experimental design, we implemented a neuropsychological rehabilitation program for an individual with severe TBI, aimed at improving his capacity for activities of daily living. The intervention utilised principles of Goal Management Training (GMT) and external memory aids, with reliance on procedural memory and errorless learning, to target the patient's impairments in executive functioning and memory. Matched control participants were included to control for potential practice effects. Data collected pre- and post-intervention, on formal neuropsychological measures, demonstrated no significant change in cognition in the intervention participant. However, observational data and qualitative feedback indicated notable improvement in performance on everyday tasks. In the context of severe TBI, neuropsychological rehabilitation can facilitate gains in independent functioning. This single case experimental design provides support for the value of neurorehabilitation and should serve as impetus for further such research in the South African context, where neuropsychological rehabilitation and infrastructure is lacking.

Keywords: traumatic brain injury, neuropsychological rehabilitation, GMT, errorless learning, compensatory memory aids, single case experimental design

It is estimated that globally 69 million people sustain traumatic brain injuries (TBI) each year (Dewan et al., 2018). Such high prevalence is indicative of TBI's status as a major public health concern (Frost, Farrer, Primosch, & Hedges, 2013). Whilst a global issue, TBI incidence and distribution is largely overrepresented in low- to middle-income countries (LMICs), such as South Africa - with prevalence rates being three times higher in proportion to high-income countries (HICs) (Dewan et al., 2018). Further, context-specific factors also contribute to the increased burden of TBI in some LMICs. For example, in South Africa, TBI is primarily attributed to high rates of both interpersonal violence and road traffic accidents (Naidoo, 2013). Ironically, it is also within such countries, with higher rates of TBI, in which provision and access to neuropsychological rehabilitation is most limited. This speaks to the need to establish reliable and effective neurorehabilitation efforts upon which further research and interventions can be built.

Definition, Classification and Common Sequelae of TBI

TBI is a type of acquired brain injury in which an external force causes damage to the brain - commonly by means of the acceleration, deceleration and rotational forces of such impact (Frost et al., 2013). In terms of severity, TBIs are classified as mild, moderate or severe with severity most often determined as a function of degree and duration of loss of consciousness and post-traumatic amnesia (period of confusion following TBI) (Hawryluk & Manley, 2015; O'Neil et al., 2013). There is a dose-response relationship between TBI and outcomes – the more severe the injury, the poorer the outcome. TBI can result in deficits across multiple domains including psychological, physical and emotional spheres (Mar et al., 2011; Rabinowitz & Levin, 2014). Furthermore, cognitive impairments post-TBI are observed, broadly, in attention, memory and executive functioning, which often require neuropsychological rehabilitation to facilitate possible remediation (Zimmermann, Mograbi, Hermes-Pereira, Fonseca, & Prigatano, 2017).

Neuropsychological Rehabilitation

Post-TBI deficits can severely impact on individuals' daily lives and methods of remediation are essential to improving their functional capacity.

Definition and approaches. Neuropsychological rehabilitation is a process in which patients and health-care professionals work together to restore premorbid levels of functioning as best as possible (Wilson, 2008). Two major approaches towards rehabilitation can be adopted – restorative or compensatory. The former aims at cognitive retraining in which neural pathways can be reconnected to restore premorbid functioning. In contrast, compensatory approaches focus on methods that bypass impairments and find alternative, often external, aids (Koehler, Wilhelm, & Shoulson, 2012). In the context of severe TBI, damage is regularly irreversible, thus, compensatory rather than restorative strategies are more often appropriate and frequently applied (Barman, Chatterjee, & Bhide, 2016; Wilson, 2008). Furthermore, there is a greater evidence base for the efficacy and generalisability of compensatory techniques to activities of daily living (ADLs) in rehabilitation literature (Nadar & McDowd, 2010; Withiel et al., 2019). This preference for compensatory interventions is also demonstrated in our own review of the literature concerning single case experimental designs in neuropsychological rehabilitation (Dewar & Wilson, 2005; McKerracher, Powell, & Oyebode, 2005; Pitel et al., 2006; see Appendix A for our summary of previous single case experimental designs in neuropsychological rehabilitation). Of the main domains affected post-TBI, executive functioning and memory, lend themselves to compensatory type approaches.

Interventions for executive dysfunction. A popular method for treating executive dysfunction, demonstrated in our summary table (see e.g., Levine et al., 2000; Schweizer et al., 2008; Appendix A), is Goal Management Training (GMT) which focuses on reducing goal neglect through providing individuals with new schemas that encourage a more systematic, self-aware approach towards accomplishing tasks (see e.g., Schweizer et al., 2008). Based on Duncan's (1986) theory of goal neglect, GMT is a useful tool for teaching patients to hold goals in mind and self-monitor their progress while carrying out tasks – this, in turn, can translate to improved capacity for completing ADLs and enhanced everyday functioning (Krasny-Pacini, Chevignard, & Evans, 2014; O'Connor et al., 2011).

Interventions for memory. In terms of memory deficits, interventions are largely reliant on patients receiving cueing (Desbois, Strong, Kuipers, Ownsworth, & Fleming, 2008; Destreri et al., 2002; see Appendix A) – whether by caregivers or electronic devices, such as mobile and smart devices (Baldwin & Powell, 2015). While memory aids are becoming increasingly technological, the option of more traditional aids, like notebooks, still remain and selection should be based on patient preference and resource availability (Pino, 2015).

Reliance on procedural memory. Research suggests that, following TBI, explicit memory is more vulnerable to damage while implicit memory is typically spared (Brayer et al., 2015). As such, while the explicit memory system may be dysfunctional, learning that relies on spared, implicit forms of memory, such as procedural memory, can still occur in the context of severe TBI. Thus, it is often argued that strategies utilising implicit memory are preferable to methods that recruit explicit memory systems in TBI populations (Skidmore, 2015).

Errorless learning. Training through errorless learning is often used in rehabilitation of patients with memory impairments and executive dysfunction (Bertens, Kessels, Fiorenzato, Boelen, & Fasotti, 2015; Roberts et al., 2018). This approach describes a focus on minimising the possibilities for participants to make mistakes during training. This limits confusion during encoding and continued error repetition (Campbell, Wilson, McCann, Kernahan, & Rogers, 2007; Wilson, 2017).

Methodological considerations. In the studies reviewed in Appendix A, real-world goal outcomes are often elected to ensure the real-life applicability of rehabilitation efforts (Levine et al., 2000; Turkstra & Flora, 2002). Notably, all studies targeted only one domain (either executive functioning or memory) rather than multiple domains for a single patient. Furthermore, none of the studies reviewed, except Dewar, Kapur and Kopelman (2018), included control participants in their design.

Tailoring intervention to the individual. Characteristic of TBI is the heterogeneity of functional outcomes, patient resources and environmental demands (Figaji, Fieggen, Mankahla, Enslin, & Rohlwink, 2017). Given this, multiple authors stress the importance of tailoring interventions to the individual (see e.g., Dewar et al., 2018; Nadar & McDowd, 2010). Health professionals should involve the patient in identifying relevant treatment goals and types of intervention, thereby increasing patient motivation for participation. It is essential that treatment aids the individual in a comprehensive and practical manner, with direct application to their ADLs (Duval, Coyette, & Seron, 2008; Wilson, 2008).

Rationale for single case experimental designs (SCEDs). Given the diversity of TBI cases, no single treatment can be effectively applied to multiple individuals. SCEDs, however, in answering this call for individualised intervention, offer a fitting research design – as indicated by its popularity in our summary table (see e.g., Cheung et al., 2006; Appendix A). While generalisability is an area of concern for SCEDs, its relevance can be argued given that neuropsychological rehabilitation is founded on interventions being tailored to individual specifications and, thus, generalisability is not sought after nor can it be considered a measure of research validity. Indeed, in contrast to larger group studies, a strength of SCEDs is that they enable more detailed inspection allowing for a more in-depth understanding of the variability in a patient's post-treatment outcomes (Krasny-Pacini & Evans, 2018).

Neuropsychological rehabilitation in HICs versus LMICs. Lastly of note, is the marked lack of neuropsychological rehabilitation research in LMICs. Notably, of the 13 cases reviewed in our summary table (see Appendix A), the majority emanated from HICs. Indeed, there exists a clear gap in this field of research regarding neurorehabilitation within LMICs, such as South Africa (Schrieff-Elson & Thomas, 2017), and it is this cause to which our research intends to contribute.

Neuropsychological rehabilitation in South Africa. The need for cognitive rehabilitation services within South Africa is made clear by the country's particular burden of disease (Schrieff-Elson & Thomas, 2017), as well as high rates of interpersonal violence and motor vehicle accidents (Naidoo, 2013), which all result in long-term neurocognitive sequelae that place heavy strain on families and communities. While the demand for such services is undoubtedly apparent, the supply thereof falls distinctly short. This stems largely from neuropsychology's status as an emerging discipline in the country, and the subsequently limited local research and infrastructure for neuropsychological rehabilitation (Schrieff-Elson & Thomas, 2017).

Conclusion and Rationale

In conclusion, the effects of TBI are present worldwide – however, particularly severe in LMICs, such as South Africa. Furthermore, owing to the infancy of neuropsychology in the country, neurorehabilitation efforts are limited. A review of the literature indicates GMT, external memory aids, reliance on procedural memory and errorless learning as prominent strategies for ameliorating deficits of executive functioning and memory following TBI. Few studies, however, apply multiple intervention strategies aimed at different domains for a single patient. Additionally, these studies generally lack controls. Our research addressed these caveats thereby contributing towards the currently limited field of neuropsychological rehabilitation in South Africa.

Aims and Objectives

This research study explored the implementation of neuropsychological rehabilitation strategies following severe TBI in a single case experimental design. These strategies included principles of GMT and an external memory aid, mediated by errorless learning and reliance on procedural memory. There were no specific hypotheses for this explorative study. The objective was to investigate if a neuropsychological rehabilitation intervention would produce improvements in a patient's capacity for everyday functioning.

Method

Design and Setting

This is a mixed-methods, exploratory study using both quantitative and qualitative descriptive data. We used a single case experimental design with pre- and post-testing of both an intervention participant and controls. A battery of cognitive and behavioural assessments was administered, as specified below. Between testing occasions, a 10-week neurorehabilitation intervention was conducted in the intervention participant's home.

The study also included four matched, no-intervention control participants. Controls were used to ensure that any changes in the intervention participant's scores on neuropsychological tests were due to the effects of the intervention, rather than practice effects. We tested our control participants twice on the cognitive measures, spaced the same amount of time as the pre- and post-assessments for our intervention participant. To rule out experimenter bias, all testing was conducted by independent neuropsychology interns from the University of Cape Town (UCT).

Both pre- and post-testing of the intervention participant were conducted at his house for his convenience and to reduce testing anxiety. The setting was Cape Town, Western Cape. Control testing was conducted at UCT in the Department of Psychology.

Participants

TBI participant. This patient will be referred to as FS – a 33-year-old male from a medium to high socioeconomic background who lives in Cape Town, Western Cape. His first language is Afrikaans, but he is also fluent in English. He was referred to Dr Schrieff by a neuropsychologist from Mediclinic Constantiaberg, who initially assessed FS. FS was involved in a motor vehicle accident (MVA) in November 2016, where he was the driver. His Glasgow Coma Scale score (eight on site and five upon hospital admission) classified the injury as severe (Teasdale & Jennett, 1974). FS' neuropsychological reports indicate a TBI with diffuse axonal injury, which resulted in severe executive dysfunction and memory impairments. FS' dysexecutive syndrome was characterized by deficits in attention, planning, strategising, inhibition, processing speed and problem solving. Regarding his memory, FS had both encoding and retrieval deficits. While FS' explicit memory systems were impaired, his implicit memory appeared relatively preserved.

Notably, most of his adult life was spent as a professional athlete. He retired a few years before the accident and had started a new job in packaging sales a few months before the MVA. At the time of the study, he was unable to participate in meaningful work.

Control Participants. Community sampling was achieved through word-of-mouth to recruit four control participants with a similar age, socioeconomic status, language and sporting background as FS.

Inclusion criteria for control participants. These included: (a) being of the male sex, (b) being between 28 and 38 years at the time of testing (c) no prior TBIs that resulted in loss of consciousness, and d) no prior or current diagnosed psychiatric illnesses, learning disabilities, or neurological disease.

Measures

Each measure is summarised below. All measures were chosen based on their psychometric properties, previous use as reported in brain injury literature and where possible, previous use in South Africa, (full description in Appendix B).

Demographic data.

Demographic questionnaire and asset index. This measure (see Appendix C) examined the demographic and socioeconomic information of each participant including annual household income, material resources, education and vocation (Myer, Ehrlich, & Susser, 2004; Myer, Stein, Grimsrud, Seedat, & Williams, 2008).

Sporting history. We drew up an informal self-report measure asking participants to comment on their sporting history including type, duration and level of participation (see Appendix D).

Behavioural Measures.

Patient-Reported Outcome Measurement Information System - 29 version 2.0 (PROMIS-29). This is a self-report measure used to assess general health of the participant, across seven health domains (pain interference, depression, anxiety, physical functioning, fatigue, sleep quality and social activities) (Cella et al., 2010).

Dysexecutive Questionnaire - revised version (DEX-R). This measure assesses the impact of dysexecutive syndrome on daily living (Simblett & Bateman, 2011).

Self-Concept Questionnaire (SCQ). This measure is aimed at determining the overall affect and self-esteem of the participant (Robson, 1989).

Quality of Life after Brain Injury (QOLIBRI). This measure assesses general quality of life after sustaining TBI, including cognition, emotions, daily and physical functioning, personal and social life (von Steinbüchel et al., 2010).

Caregiver Strain Index (CSI). The CSI is used to measure areas of concern or challenges, experienced by family and caregivers, caused by the patient's care demands (Robinson, 1983).

Patient Competency Rating Scale (PCRS). This is a self-report measure that assesses participants' deficits, and their awareness thereof (Prigatano et al., 1986).

Cognitive measures.

Wechsler Adult Intelligence Scale - third edition (WAIS-III). In the current study, we used three subtests of the WAIS-III - Digit Span to assess attention and working memory and Symbol Search and Digit Symbol Coding to assess processing speed (WAIS; Wechsler, 2008).

Wechsler Abbreviated Scale of Intelligence - second edition (WASI-II). The WASI-II was used to assess general intellectual functioning (WASI-II; Wechsler, 2011) in the current study. There are four subtests within WASI-II including Verbal IQ tests, namely Vocabulary and Similarities, and Performance IQ tests, namely Block Design and Matrix Reasoning.

Delis-Kaplan Executive Function System (D-KEFS). The D-KEFS was used to assess FS' executive functioning (Delis, Kaplan, & Kramer, 2001). Two subtests were utilised. We used the Tower test to assess problem solving, spatial planning abilities, perseverative responding and ability to follow instructions and learn rules, and the Verbal Fluency test to assess verbal retrieval and recall, cognitive flexibility, inhibitory control and self-monitoring.

Wide Range Assessment of Memory and Learning - second edition (WRAML-2) We used tests from the Verbal Memory Index. A list of 16 words is given verbally, with immediate recall over four trials, followed by delayed recall and recognition trials (Sheslow & Adams, 2003).

Materials

Visual Schedule Planner. The Visual Schedule Planner is an iOS application that allows for a visual representation of an individual's daily calendar that is customisable to the user (Good Karma Applications Incorporated, 2015). Features include an activity inventory, reminders and checklists. Our intervention made use of the activity inventory and checklist functions specifically.

Google Calendar. Google Calendar is an online calendar service available on smart devices (Google LLC, 2019). Events can be added to the calendar along with programmed visual and auditory reminders.

Procedure

Participants.

FS. Prior to the intervention, FS and his fiancé completed a demographic questionnaire and asset index (see Appendix C). FS was assessed on the cognitive and behavioural tests outlined in our measures. Thereafter, the 10-week intervention program commenced. We met with FS weekly, for approximately 2 hours per session, accompanied by Dr Schrieff. The program included the components detailed in The Brain Injury Rehabilitation Workbook (Wilson, 2017), as described below. We held regular discussions in-between sessions regarding what worked, our plan for the next session, and whether any changes were required from session to session. Further, Dr Schrieff engaged in online discussions with Dr Jill Winegardner about the content of the sessions and such adjustments, given her expertise in the area of neuropsychological rehabilitation. Post-intervention – approximately three months after pre-testing – FS again completed all behavioural and cognitive measures – except the WASI-II. Literature demonstrates the stability of IQ over time and therefore the WASI-II, measuring IQ, was only administered at pre-testing (Schneider, Niklas, & Schmiedeler, 2014).

Control participants. Control participants were tested twice, using the same cognitive measures as FS, spaced 3 months apart. The WASI-II was only completed at pre-testing. Notably, controls did not complete behavioural measures as these were specific to individuals who have sustained TBIs and their caregivers. Inclusion criteria (see Appendix E), sporting history (see Appendix D), and demographic data (see Appendix C) were confirmed at testing.

Pre-intervention steps.

Assessment. Before the intervention could begin, assessment was necessary to provide insight into FS' impairments, cognitive strengths and challenges (Wilson, 2017). As noted, we thus implemented standardised neuropsychological cognitive and behavioural measures (see measures).

Formulation. The formulation is a summary of potential factors influencing FS' level of functioning and current psychological state (see Appendix F). The formulation also includes information regarding the participant's personality, occupation and support structures. Furthermore, it considers the cognitive, emotional and behavioural consequences of the participant's brain injury, and how these can impact his identity and adjustment to injury outcomes. This information was gathered through cognitive and behavioural measures, and via discussion with FS, his fiancé, parents and caregiver.

Selection of intervention tasks. On the basis of his cognitive profile and formulation, executive functioning and memory were identified as target areas of the intervention and subsequent intervention tasks were chosen. These comprised five tasks of daily living with which FS and his fiancé indicated they would like assistance – namely, making coffee, making a sandwich, making the bed, shaving FS' face and cutting his fingernails.

Psychoeducation. The Brain Injury Rehabilitation Workbook (Wilson, 2017) recommends that steps be taken to improve the family's insight into the patient's condition. As such, we conducted psychoeducation – the provision of information regarding the patient's condition, mechanism of injury and outcomes, as well as management and treatment options. Research suggests that such interventions are effective in improving family functioning and adjustment to TBI, and can help reduce levels of distress and burden (Robertson & Schmitter-Edgecombe, 2015).

Intervention strategies and implementation.

Checklists. Applying the principles of GMT, we constructed a checklist of steps for each intervention task selected by FS and his fiancé (see Appendix G).

*Developing checklists***.** We broke each task down into explicit and manageable steps. These were programmed into the Visual Schedule Planner application installed on FS' iPad which allowed him access to step-by-step instructions for each programmed task. Custom images could also be included as icons for steps in the checklist - such as photographs of items and locations from FS' environment that corresponded with particular steps. For example, we included a photograph of the pantry cupboard where the bread was kept. This addressed FS' memory difficulties as it provided a prompt for where to find necessary items.

In session one, we observed FS' performance without intervening in order to gauge how he carried out these tasks on his own. Because the tasks were everyday activities that FS performed regularly prior to sustaining his injury, he retained some level of residual procedural memory for these actions and his own natural way of ordering steps. Unless this was inefficient or non-contributory, we did not want to interfere with pre-existing schemas for these tasks, and thus matched our checklists as close as possible to his habitual ways of completing these tasks.

Implementing checklists.

The checklists on the application were introduced in session two. Thereafter, during intervention sessions, FS used the checklists to complete the intervention tasks. We supervised FS such that we could prompt him to refer back to the checklist steps if he appeared confused or uncertain during tasks.

Reviewing and editing checklists. After each session, we reviewed the checklists for each task, altering steps which proved difficult or confusing for FS. For example, after the milk ran out and FS needed to locate a new carton, we decided to include a step that instructed him to ask for help should this occur (see Appendix G). Because we needed to make alterations to the application after each session, and we did so between sessions, we could not leave the iPad with FS until session 10. As such, during the week, we left paper versions of the checklists with FS and asked his caregiver to practice these tasks with him, monitoring his performance and providing prompting if needed. This did not seem to impact his use of the application within sessions. He continued, fluidly, from session to session in terms of accessing the application and finding his tasks on the application's homepage.

Memory aid. To target FS' memory impairments, we programmed alert notifications into the Visual Schedule Planner application on his iPad. These notifications served as reminders to perform intervention tasks at particular times during the day – when the alert sounded. The notifications instructed FS to make use of the checklists on the Visual Schedule Planner application to complete the specified tasks. These notifications were introduced in session six. However, the in-built notification sounds on the Visual Schedule Planner application were too soft to capture FS' attention. As such, we decided to use the Google Calendar application instead that offered louder, more attention-grabbing alert sounds to prompt FS to use his Visual Schedule Planner. These Google Calendar alerts were introduced in session seven. During intervention sessions FS practiced responding to the notifications and completing the task it indicated. We also consulted with FS' fiancé and programmed reminders into Google Calendar for tasks outside of the intervention, such as taking medication. This was implemented from session 10 when the iPad was left with FS.

Errorless learning. Regarding the checklists, during our intervention sessions, we monitored FS when using them, offering verbal prompts to guide his actions and prevent him from deviating from the task steps and making errors. Regarding the memory aid, we also provided verbal prompts during our sessions to ensure FS attended to the Google Calendar notifications, and subsequently completed the relevant task.

Awareness. Decreased self-awareness is a common outcome following TBI (Tate et al., 2014; Wilson, 2017). A lack of insight has been shown to limit the extent to which patients benefit from rehabilitation as it leads to unrealistic goal setting and decreased motivation for participation (Robertson & Schmitter-Edgecombe, 2015). Research suggests that improving patients' awareness of their impairments, can thus optimize gains from rehabilitation (Beatriz et al., 2001; Wilson, 2017). In light of this, we asked FS to rate himself on his performance of each intervention task conducted in the intervention sessions. He used a scale ranging from zero to five - with higher scores reflecting better execution. This activity encouraged self-reflection and monitoring, targeting FS' awareness of his capabilities. Furthermore, using the same scale, we also rated FS' execution and drew his attention to any discrepancy between his rating and our own in order to improve his insight.

Intervention tasks. The intervention tasks for each session are outlined in Table 1 (detailed notes of each session available upon request). The intervention tasks included in initial sessions were making coffee, making a sandwich, making the bed, shaving his face and cutting his fingernails. Once FS became familiar with these tasks, we introduced additional activities in later weeks – these being brushing his hair and making tea.

The tasks completed from week to week varied according to whether it was necessary to perform these or not (e.g., whether or not FS needed to cut his fingernails or shave his face), and whether FS wanted to complete specific activities (e.g., making coffee). In later weeks, the tasks performed were based on whether FS had already completed the tasks by the time we had arrived (e.g., he started making his own sandwich for breakfast prior to our arrival).

Table 1

Intervention Tasks Completed Per Session (N=1)

Session number	Coffee	Sandwich	Bed	Shaving	Nails	Hair	Tea
1	X	X		X	X		
2	X	X	X				
3	X	X		X	X		
4	X	X					
5	X	X	X	X	X		
6	X	X	X	X		X	
7	X		X	X	X	X	
8	X		X	X	X	X	
9		X	X	X		X	X
10	X			X	X	X	X
Follow-up	X	X		X		X	

Note. X represents an activity present during a session. Intervention begins at session two as session one was observational. Coffee = making coffee; sandwich = making a sandwich; bed = making the bed; shaving = shaving his face; nails = cutting fingernails; hair = brushing hair; tea = making tea.

Evaluation of the intervention.

Statistical Analysis. First, we present the demographic information and test scores for both FS and controls, descriptively. To assess whether the change in scores, from pre- to post-intervention testing, for FS and the control participants were statistically significant we used the Reliable Change Index (RCI). Differences at the 68.26%, 95% and 99% confidence interval are recorded with change at the 95% confidence interval being considered clinically significant (Jacobson & Truax, 1991). This outcome was calculated using a reliable change generator, relying on the following RCI formula:

SEd = √2p(Se)2, where *Se = s(√1- rxx),*

Where *s* stands for the standard deviation and *rxx* stands for the test-retest reliability coefficient (Jacobson & Truax, 1991).

FS' results were compared against changes in the control participants' scores.

Within-intervention assessments. After obtaining FS' verbal consent, we video recorded him performing the intervention tasks in every session. In order to assess FS' task performance throughout the intervention, we reviewed these recordings and retrospectively coded the number of errors he made, as well as prompts he received during each task's completion.

Errors. Errors included any obvious deviations from the checklist (for example, retrieving water instead of milk from the fridge), incomplete steps (only retrieving bread but not peanut butter when a step instructed he fetch both), pre-emptive selection (checking off a step before completing it), location-based errors (looking in the incorrect cupboard for items), or non-contributory actions (opening the peanut butter jar and closing it again without putting any on the bread).

Prompts. Prompting describes any action (visual or verbal) taken to refocus FS' attention on the task at hand (e.g., "check your steps"), to alert him to an error that needed correction (pointing to an incomplete step) and to remind him to use the photos as cues for the location of items.

Execution ratings. Using the same six-point scale described above (under 'Awareness'), our own ratings of FS' task execution also served as a proxy for his mastery of tasks. After we scored FS five out of five for execution of a task, for two consecutive sessions, a new task could be introduced, and the mastered task dropped. That said, the tasks that FS did master we continued to complete each week, as these formed part of his daily routine and their completion was thus beneficial. For example, while we scored FS five for brushing his hair in both session six and seven, we continued this task in later sessions.

Additionally, the difference between our own and FS' ratings served as an indication of FS' awareness across the intervention. This was calculated using the following formula: Difference = Our rating – FS' rating.

Response to alert notifications. We recorded qualitative assessments of FS' responses to the Google Calendar alert notifications on his iPad.

Qualitative feedback. After the completion of the intervention program, we scheduled a feedback session with FS and his family in order to obtain their qualitative evaluation of the intervention. Several days prior to this session, we asked FS (see Appendix H), his parents, fiancé (see Appendix I) and caregiver (see Appendix J) to complete a feedback form reflecting on the intervention process. Questions were worded such that they would elicit open-ended responses and not prompt answers in favour of our research. These were then collected and discussed at the session. FS and his parents, fiancé, and caregiver, all attended the feedback session.

Dr Schrieff started the session with an overview of the intervention process, detailing the events of each session. She further explained the intervention strategies utilised and how these targeted FS' memory and executive functioning difficulties. Additionally, we explained the iPad application FS had learnt to use, and how to effectively prompt him during tasks. Further recommendations included limiting distractions during tasks and refraining from intervening too quickly, when it seemed that FS was taking time to complete a task. Those in attendance were encouraged to ask questions and comment if they wished to throughout the session.

Additionally, we compiled a step-by-step guide with instructions on how to program the Visual Schedule Planner application and Google Calendar notifications on the iPad (see Appendix K). This was given to FS' fiancé to whom we demonstrated the programming of the application.

Ethical considerations. We obtained ethical clearance for this study from the UCT Psychology Department's Research Ethics Committee – reference number PSY2019-018 (see Appendix L).

Consent, voluntary participation and confidentiality. Lack of insight is common following TBI which makes obtaining informed consent from such patients an ethical challenge (Dreer, DeVivo, Novack, Krzywanski, & Marson, 2008). As such, common practice is to request consent from the primary caregiver or significant other (Johnson-Greene, 2010). We requested written consent from FS' fiancé (see Appendix M) for his participation in the study and asked FS to give written assent (see Appendix N). Additionally, at each session, verbal assent was sought, and FS was reassured of his right to voluntary participation and withdrawal without penalty.

We also obtained written consent from four control participants (see Appendix O) to participate in two assessments and to use the records of their performance. FS, his fiancé and controls, were informed that any information obtained from them would be kept confidential and would not be used for any purpose other than that of the study. Further, no identifying information was used in the study write-up.

Limitations, risks and benefits. There were no known risks to the participants of which the researchers are aware, although they may have experienced fatigue during testing and were thus given time to rest during assessments. Benefits of the study could include improvements in FS' everyday functioning if the intervention proved efficacious. Controls did not directly benefit from participating.

Study Significance

TBI is one of the leading causes of brain injury as well as contributors to global mortality and morbidity (Dewan et al., 2018). Given the profound and far-reaching cognitive, emotional and psychological impairments following TBI (Rabinowitz & Levin, 2014), the need for intervention appears most relevant and justified. Research into neuropsychological rehabilitation emanates predominantly from HICs with little to no rehabilitation efforts reported in LMICs. This is of concern given that the prevalence of TBI appears largely overrepresented in LMICs (Dewan et al., 2018). In South Africa, elevated levels of TBI are primarily accounted for by high rates of interpersonal violence and road traffic accidents (Naidoo, 2013). Despite the country's clear need for neuropsychological rehabilitation, the field is still in its infancy. The significance of our research thus lies in its contribution to the currently limited database for neuropsychological rehabilitation in South Africa.

Results

Demographic Characteristics

FS and control participants were matched on sex (male) and were of similar age (within four years of FS). All participants were fluent in English and had at least basic conversational linguistic ability in Afrikaans. Further, all controls had a sporting background. Regarding IQ, all controls were within 1.50 standard deviations (*SDs*) of each other (see Table 2). Notably, FS' full scale IQ is markedly lower (4.50 *SDs*) than that of the mean of control participants. It is important to note that FS' TBI deficits, in particular memory and attention, represent large confounds to his neuropsychological testing.

Scores on the demographic questionnaire and asset index were similar between FS and control participants (Table 3). However, three controls had tertiary education, whereas FS and control three had grade 12 as their highest level of education. FS, of course, was a professional sportsman for several years after completing school. FS and controls were, however, carefully matched on socioeconomic status – all fell within the same annual household income bracket and reported asset indices in the same range.

Table 2

Age and General Intellectual Functioning of the Sample (N = 5)

	Participants						
	FS	Control 1[b]	Control 2	Control 3	Control 4	Control Average (N = 4)	
Variable						*M (SD)*	Range
Age[a] at assessment (in months)	398	429	407	431	384	412.75 (22.04)	384 - 431
Verbal IQ	78	103	96	109	105	103.25 (5.44)	96 - 109
Performance IQ	60	114	112	125	124	118.75 (6.70)	112 - 125
Full Scale IQ	67	109	104	119	116	112.00 (6.78)	104 - 119

Note. [a]Age at testing is in months. [b]Control one was tested using the WASI-I, while FS and the other controls were tested on the WASI-II. That said, these versions are reported to be highly correlated (Wechsler, 2011). Thus, the IQ score of control one can still be compared to the other participants' scores.

Table 3
Demographic Questionnaire and Asset Index Data (N = 5)

	Participants				
	FS	Control 1	Control 2	Control 3	Control 4
Household income per year[a]					
0	0	0	0	0	0
1 - 5 000	0	0	0	0	0
5 001 - 25 000	0	0	0	0	0
25 001 - 100 000	0	0	0	0	0
100 000 +	X	X	X	X	X
Education (participant: spouse)					
0 years (no formal education)	0	0	0	0	0
1 - 6 years (incomplete primary	0	0	0	0	0
education)	0	0	0	0	0
7 years (primary education)	0	0	0	0	0
8 - 11 years (incomplete secondary education)	0	0	0	0	0
12 years (secondary education)	X: 0	0	0	X: 0	0
13 + years (tertiary education)	0: X	X: X	X: 0	0	X: X
7 (don't know)	0	0	0	0	0
Employments (participant: spouse)					
Higher executives, major professionals	0	0	0	0	0
Business managers of medium businesses, lesser professions	0	0	X: 0	X: 0	X: X
Administrative personnel, managers, minor professionals	0: X	X: 0	0	0	0
Clerical and sales, technicians, small businesses	0	0	0	0	0
Skilled manual (with training)	0	0	0	0	0
Semi-skilled	0	0	0	0	0
Unskilled	0	0	0	0	0
Homemaker	0	0	0	0	0
Student, no occupation	X: 0	0: X	0	0	0
Material and financial resources (Asset Index)					
0 - 5 assets (low)	0	0	0	0	0
6 - 12 assets (medium)	0	0	0	0	0
13 - 17 assets (high)	X	X	X	X	X

Note. [a]Presented in South African Rands (ZAR).

Pre-intervention Steps

Formulation. As outlined in the method, we compiled a formulation for FS (see Figure 1). The formulation includes the key points from his neuropsychological reports and an interview with FS and his fiancé about strengths and weaknesses in various areas in FS' life. Notably, FS had a strong support structure and his participation in rehabilitation efforts was encouraged, as evidenced by his involvement with multiple health professionals. Further strengths included FS' positive mood, and good self-esteem. Likewise, rehabilitation efforts could capitalise on his intact procedural memory. FS' most notable challenges included his severe memory and executive functioning impairments that impacted his capacity for personal care, everyday tasks and opportunities for social interaction.

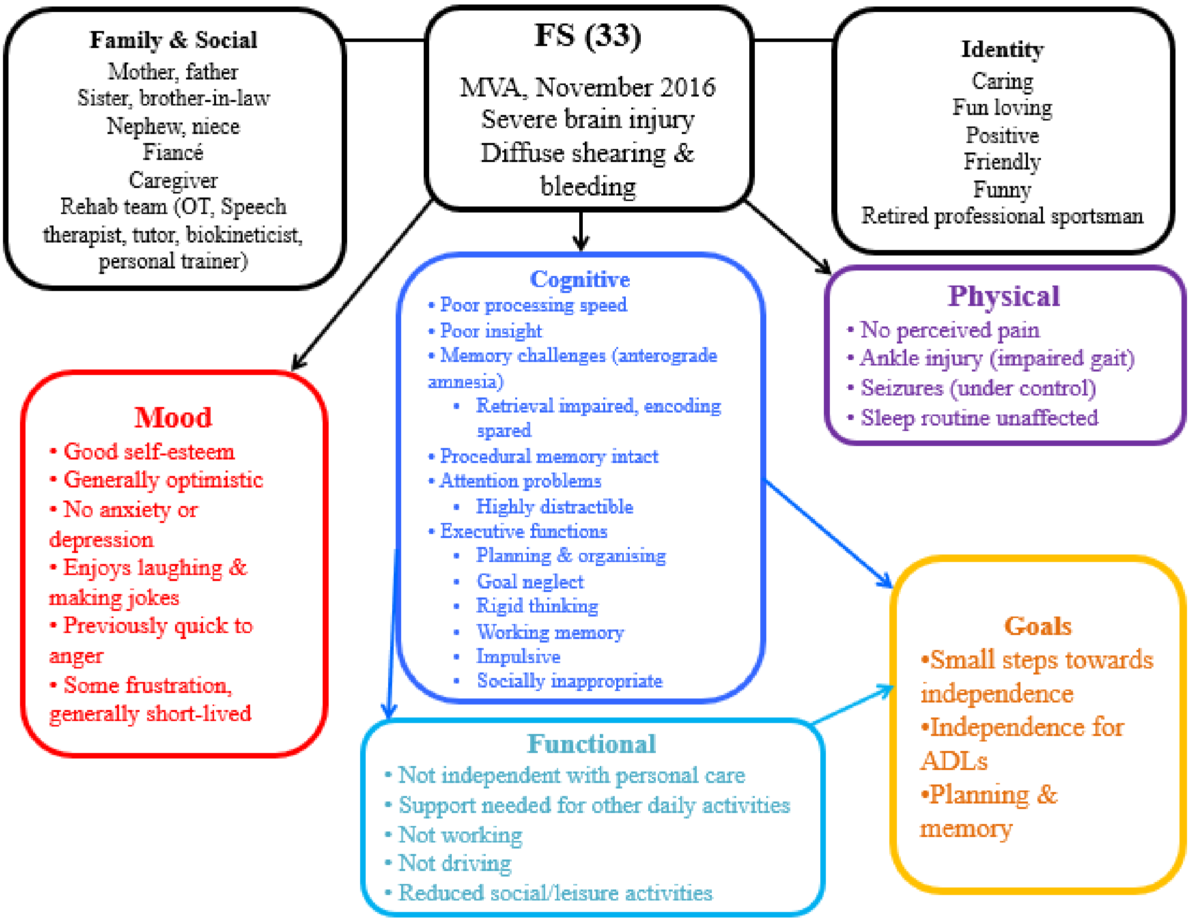

Figure 1. Formulation (*N*=1).

Evaluation of the Intervention

Cognitive measures. Table 4 shows the scaled scores for the subtests of the cognitive measures for both FS and the controls, as well as the results of their RCI analyses. FS' scaled scores fell predominantly within the extremely low range, while the controls' scaled scores largely fell within the average to high average ranges. There were no clinically significant changes on the cognitive measures for FS. That said, his Digit Span score showed minimal negative change at the 68.26% confidence interval. In contrast, the Digit Span score of Control two demonstrated positive change at the 68.26% confidence interval, and that of Control one showed clinically significant positive change at the 99% confidence interval. On average, there was little change on the cognitive measures for the controls. There were 4 subtests – namely, Digit Span, Move Accuracy Ratio, Letter Fluency and Verbal Learning – where a positive change at a confidence interval of 68.26% was demonstrated, which may suggest the presence of minor practice effects.

Table 4

Scaled Scores and RCI Results on Cognitive Measures (N = 5)

	Participants																	
	FS			Control 1			Control 2			Control 3			Control 4			Average controls (*N=4)*		
	Pre	Post	**Change**	Pre	Post	**Change**	Pre	Post	**Change**	Pre	Post	**Change**	Pre	Post	**Change**	Pre	Post	**Change**
WAIS-III																		
Digit Span	6.00	4.00	**(-)Δ**	7.00	12.00	**ΔΔΔ**	11.00	13.00	**Δ**	13.00	13.00	**None**	11.00	11.00	**None**	10.50	12.25	**Δ**
Symbol Search	4.00	3.00	**None**	14.00	13.00	**None**	12.00	10.00	**(-)Δ**	10.00	12.00	**Δ**	12.00	12.00	**None**	12.00	11.75	**None**
Coding	3.00	3.00	**None**	9.00	9.00	**None**	12.00	11.00	**None**	12.00	13.00	**None**	13.00	15.00	**Δ**	11.50	12.00	**None**
D-KEFS																		
Tower Test																		
Move accuracy	2.00	4.00	**None**	7.00	8.00	**None**	3.00	8.00	**ΔΔ**	6.00	3.00	**(-)Δ**	3.00	9.00	**ΔΔΔ**	4.75	7.00	**Δ**
Rule violations	8.00	10.00	**None**	11.00	11.00	**None**	10.00	11.00	**None**	11.00	11.00	**None**	11.00	11.00	**None**	10.75	10.75	**None**
Letter Fluency	1.00	1.00	**None**	9.00	11.00	**None**	5.00	6.00	**None**	10.00	13.00	**Δ**	12.00	15.00	**Δ**	9.00	11.25	**Δ**
Category Fluency	1.00	1.00	**None**	13.00	10.00	**(-)Δ**	10.00	7.00	**(-)Δ**	11.00	11.00	**None**	14.00	13.00	**None**	12.00	10.25	**None**
WRAML-2																		
Learning	1.00	1.00	**None**	9.00	16.00	**ΔΔΔ**	10.00	10.00	**None**	12.00	13.00	**None**	9.00	11.00	**None**	10.00	12.25	**Δ**
Delay	1.00	1.00	**None**	9.00	15.00	**ΔΔΔ**	7.00	7.00	**(-)Δ**	10.00	11.00	**None**	11.00	14.00	**Δ**	9.25	11.75	**None**
Recognition	1.00	1.00	**None**	11.00	13.00	**None**	11.00	11.00	**None**	10.00	13.00	**Δ**	11.00	13.00	**None**	10.75	12.25	**None**

Note. WAIS-III = Wechsler Adult Intelligence Scale – third edition. Coding = Digit Symbol Coding. D-KEFS = Delis-Kaplan Executive Function System. Move accuracy = move accuracy ratio. Rule violations = rule violations per item ratio. WRAML = Wide Range Assessment of Memory and Learning – second edition. **Δ** = a positive change of at least 1.00 standard deviation with a confidence interval of 68.26%; **ΔΔ** = a positive change of at least 1.96 standard deviations with a confidence interval of 95%; **ΔΔΔ** = a positive change of at least 2.58 standard deviations with a confidence interval of 99%. (-) = negative change. None = no significant change.

Behavioural measures. As indicated by the RCI analyses, there was no significant change on the following measures for FS: DEX-R, QOLIBRI and CSI (see Table 5). Likewise, no significant changes were observed on several subtests of the PROMIS completed by FS. Of the subtests that did change, anxiety increased, and fatigue decreased, although these changes were minimal and significant only at the 68.26% confidence interval. Ease of physical functioning decreased significantly, with a confidence interval of 95%, indicating greater difficulty in this domain.

Further, FS demonstrated a significant change, at the 95% confidence interval, on the Robson SCQ, indicative of increased levels of self-esteem. On the PCRS (measure of patient competency), only FS' fiancé showed significant change – this being at the 95% confidence interval.

Table 5
RCI Results on Behavioural Measures (N = 2)

	FS	Fiancé
PROMIS		
Anxiety	**Δ**	
Depression	None	
Fatigue	**Δ**	
Pain intensity	None	
Pain interference	None	
Physical function	**ΔΔ**	
Sleep disturbance	None	
Social role	None	
DEX-R (Executive functioning)	None	None
SCQ (Self-esteem)	**ΔΔ**	
QOLIBRI (Quality of life)	None	
CSI (Caregiver strain)		None
PCRS (Daily functioning)	None	**ΔΔ**

Note. PROMIS = Patient-Reported Outcomes Measurement Information System. DEX-R = Dysexecutive Questionnaire – revised version. SCQ = Self-concept Questionnaire. QOLIBRI = Quality of Life after Brain Injury. CSI = Caregiver Strain Index. PCRS = Patient Competency Rating Scale. **Δ** = a positive change of at least 1.00 standard deviation with a confidence interval of 68.26%; **ΔΔ** = a positive change of at least 1.96 standard deviations with a confidence interval of 95%; **ΔΔΔ** = a positive change of at least 2.58 standard deviations with a confidence interval of 99%. Blank cells indicate responses for the measure were not required from the participant. None = no significant change.

Within-intervention assessments.

Errors. The number of errors per session, for each task, are recorded in Figure 2. Given that the number of tasks completed per session varied, an average number of errors per task, per session, was added to illustrate the general trend of errors over the course of the intervention. An average thus offers a more representative reflection of task performance than a comparison of the sum of errors per session.

The average line depicts a gradual decrease in errors across sessions. Notably, the number of errors made during the follow-up session for all activities were lower than the number of errors made during FS' first completion of each task. As depicted in Figure 2, the declining trend observed across intervention sessions thus extended one month beyond the intervention period.

Notably, the nature of errors committed changed across the intervention period. In referring to the checklist, FS became less prone to completing actions that did not serve his goal for a specific task, i.e., retrieving incorrect items or looking in the wrong location. For example, in session two, FS retrieved water when instructed to retrieve milk from the fridge. These errors differed from those committed in later sessions which related more to incomplete (but logical) actions. For example, in session 10, FS retrieved peanut butter but not bread when instructed to retrieve both items.

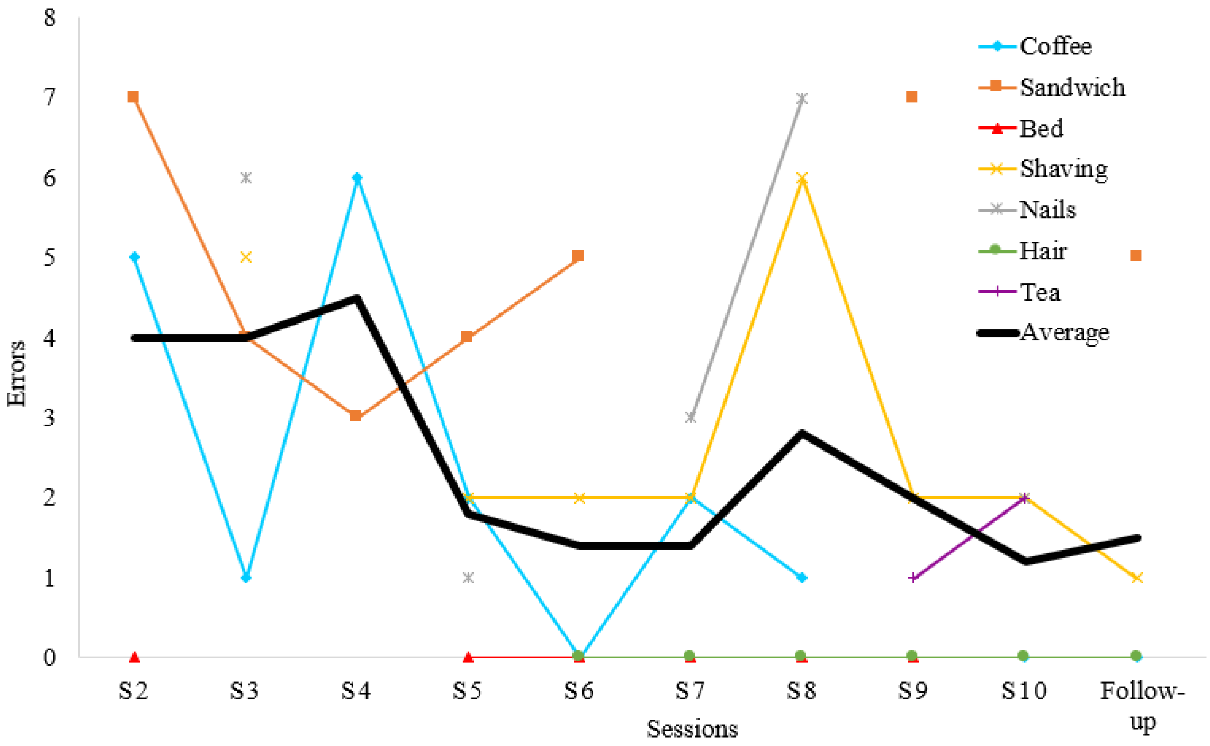

Figure 2. Number of errors committed by FS per task, per session (*N*=1).

Prompting. Number of prompts given per task, per session are recorded in Figure 3. The average number of prompts required by FS decreased from session two to 10. At the follow-up session, the number of prompts per task was lower compared to FS' first completion of each task. This declining trend, depicted in Figure 3, thus held in the one month following the intervention period.

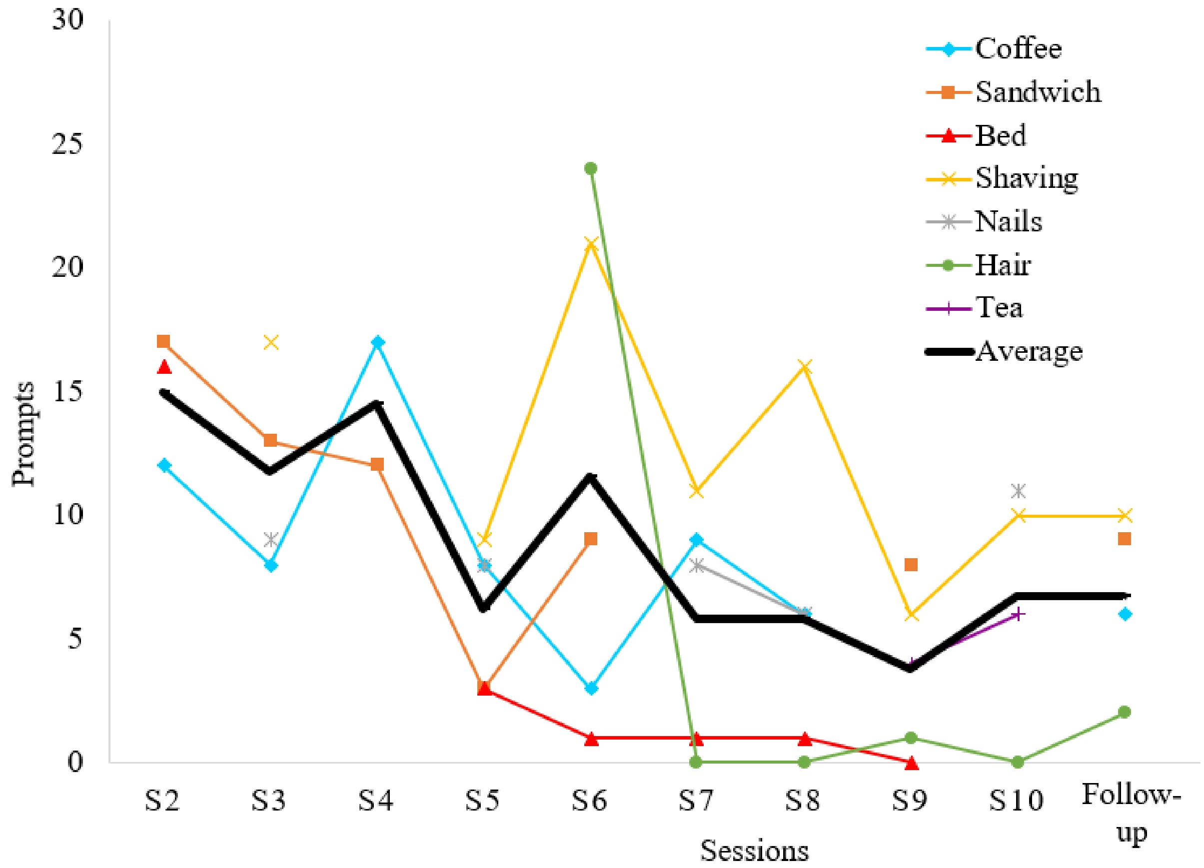

Figure 3. Number of prompts required by FS per task, per session (*N*=1).

Execution ratings. Figure 4 depicts the difference in execution ratings between FS and us, in terms of how well he performed a task (this is also depicted in a matrix in Appendix P). In early sessions, there are more negative ratings, suggesting FS rated himself higher than us, compared to later sessions where there are more positive ratings suggesting FS rated himself lower than us. Notably, this trend is held in the follow up session with FS one-month post-intervention.

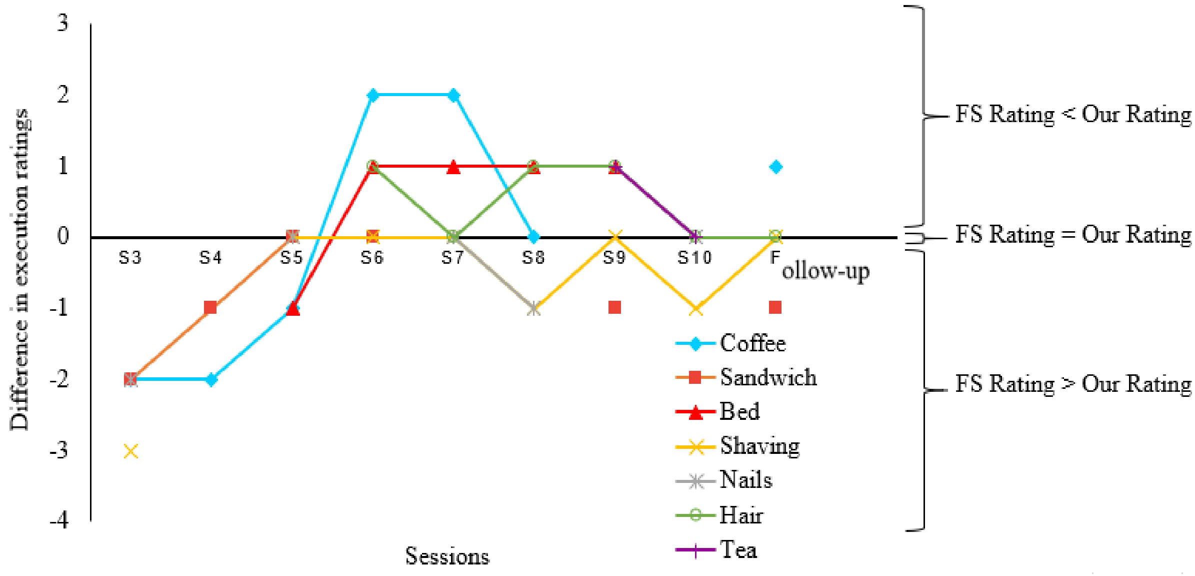

Figure 4. Difference in execution ratings of task performance per task, per session (*N*=1). Formula: difference in execution ratings = our rating – FS' rating.

Response to alert notifications. The auditory alert notifications were introduced in session six using the Visual Schedule Planner application. As noted, these alerts were, however, too soft to capture FS' attention such that he would not attend to them or dismiss the notification without reading the accompanying instructions. Once we changed to Google Calendar in session seven, which provided much louder and commanding alerts, FS was noticeably more attentive. He began reading the notification aloud, before turning off the alarm and promptly proceeding to perform the task that it instructed by making use of the checklists on the Visual Schedule Planner application.

Qualitative feedback. During the feedback session, FS was distractible and gave limited input regarding his opinion on the intervention. Likewise, on the feedback form, FS offered little beyond commenting that the intervention was *"good"* and *"professional".*

His family and caregiver reported several meaningful changes in their daily lives. Notably, FS' fiancé and caregiver indicated that, after the completion of the intervention, FS began to use the iPad to complete daily tasks. For example, at post-testing, FS' caregiver informed us he had used his application to make his bed as well as sandwich for breakfast that morning, before we arrived. This reduced the amount of assistance needed by FS for such tasks. Furthermore, they stated that previously, FS was reluctant to complete activities if asked. However, since the intervention, if he is prompted by Google Calendar on his iPad, FS performs the tasks indicated by the reminders without hesitation. This helped decrease frustration and conflict around completing daily tasks - as noted by FS' fiancé, *"He basically* *helps himself a lot more than before and this in turn helps me and [caregiver]. No more 'fighting' to do a task or some personal tasks."* Given this, FS' fiancé expressed her intention to program a new activity (tying shoelaces) into the Visual Schedule Planner application. At the follow-up session one month later, we noted that she had indeed done so.

Both of FS' parents gave examples of FS' increased cooperation and willingness to assist family members with small tasks. His mother recounted how he had recently offered to pack the groceries into and out of the car. FS' father explained how he had volunteered to carry firewood from outside and pack it away. It was stressed that FS had done so without having to be asked – which, following his brain injury and prior to the intervention, was not his custom.

Discussion

In this research study, we implemented a neuropsychological rehabilitation program for an individual with severe TBI, aimed at improving his capacity for activities of daily living. The intervention made use of task checklists (based on Goal Management Training) and an external memory aid, mediated by errorless learning and reliance on procedural memory. Data collected, pre- and post-intervention on formal neuropsychological measures demonstrated no significant change in cognition. However, observational data and qualitative feedback indicated notable improvement in performance on everyday tasks - suggesting the intervention was effective in its aim of increasing the participant's capacity for everyday functioning.

Evaluation of the Intervention

Cognitive outcomes. FS demonstrated no clinically significant change on the cognitive measures. While this may be a function of the severity of his injury, it may also be related, in part, to the compensatory methods of remediation utilised. Both the checklists and Google Calendar served as means of bypassing (rather than restoring) FS' executive function and memory impairments. As such, the lack of change on the cognitive measures of these functions is relatively unsurprising. Further, it is acknowledged that standardised assessment tools, while useful for gathering information regarding patients' cognitive strengths and challenges, may not reflect their real-life functioning (Wilson, 2017).

The purpose of including control participants was to control for practice effects. On average, the controls' cognitive scores demonstrated little significant change suggesting the presence of minimal practice effects. That said, scaled score comparison of FS to controls still provides an indication of FS' performance relative to other males of a similar age and background – further highlighting the severity of his impairments.

Behavioural outcomes. There was minimal change observed on the behavioural measures completed by FS. The nature of FS' impairments should be considered as potential confounds to these self-report measures. For example, the PROMIS requires the participant to think back to their experiences within several days preceding, when answering questions. FS' profound memory impairments, may have thus influenced the accuracy of his responses (Roessler-Górecka, Iwański, & Seniów, 2013). Furthermore, the DEX-R asks participants to rate their capacity for everyday tasks. For tasks which participants do not perform as part of their personal routine, they are asked to rate their *perceived* capacity for the task. This requires abstract and hypothetical thinking – functions that are impaired in FS, and which may have thus impacted his responses (Roessler-Górecka et al., 2013).

The results of FS' fiancé on the Caregiver Strain Index (CSI) suggested no significant change post-intervention. While, in her qualitative feedback, she expressed her appreciation of improvements in FS' capacity for daily tasks, these changes, in the context of her greater care responsibilities, may not have reflected on the formal measure of caregiver strain. The CSI has been criticised as it indicates either the absence or presence of caregiver strain, but does not capture varying levels of burden (Sullivan, 2007).

That said, there was a marked increase on FS' fiancé's PCRS response post-intervention. Given that the PCRS is a measure of patient competency in daily functioning, it is encouraging that these results correspond with the feedback given by FS' fiancé and parents post-intervention, as well as our own qualitative assessment of his task performance (discussed below).

Within-intervention assessments.

Errors. Results indicated a decline in the number of errors across the intervention sessions. This reflects FS' increasing ability to complete the intervention tasks in a logical, ordered manner. It is important to note that there are small fluctuations in the number of errors committed across the intervention sessions. However, it is unrealistic to expect a near-perfect linear trend as literature reports fluctuating performance levels are consistently observed in individuals with TBI (Hill, Rohling, Boettcher, & Meyers, 2013). This is indeed reflected in the pattern of peaks and valleys of our own data (see Figure 2). Nonetheless, on average, FS committed fewer errors as the intervention progressed. This serves as support for the success of the intervention in improving FS' ability to complete tasks of daily living.

Prompting. Results indicated a decline in the level of prompting required by FS across the intervention sessions (see Figure 3). Once again, minor fluctuations are evident as expected (Hill et al., 2013). Prompting is noticeably higher in the earlier sessions. In keeping with the errorless learning tradition, we may have been more inclined to prompt FS to prevent him from learning the incorrect procedure when the task was still new. In later sessions, due to his increased familiarity with tasks, FS completed steps with greater certainty and confidence thus requiring less prompting – and reducing the level of assistance required for such tasks.

Reliance on procedural memory. What the decrease in both errors and prompting suggests, is FS' increasing reliance on procedural memory for completing intervention tasks. Through repetition, FS could consolidate procedural memories for each activity. This allowed him to perform tasks without having to recruit executive functions, such as careful planning and sequencing, which were markedly impaired in FS.

Initially, the manner in which FS completed tasks was disordered and inefficient and he appeared uncertain about what step to perform next. As the intervention progressed, FS became increasingly familiar with making use of his checklist. He began referring back to the application on his iPad much more frequently during tasks - reflecting how this action became procedural in nature. The checklist reduced the extent to which he needed to recruit executive functions by providing him with a detailed list of the necessary steps. This eliminated some of FS' uncertainty and his actions became increasingly fluid, ordered and familiar, suggestive of the procedural manner in which he began to carry out these tasks. As these actions were consolidated into procedural memory, FS could perform tasks without as much conscious effort as initially required.

Our research thus demonstrates the potential of implicit memory strategies as a means of compensating for executive dysfunction. These findings are consistent with a large body of literature that promotes reliance on procedural memory as an effective intervention strategy for facilitating learning in patients with severe TBI (Brayer et al., 2015; Skidmore, 2015).

Discrepancy between cognitive measures and actual task performance. This increasing reliance on procedural memory also helps explain the marked discrepancy between FS' executive functioning as indicated by traditional neuropsychological measures (see Table 4) and his demonstrated capacity for everyday tasks. Results on the formal neurocognitive measures showed no significant change in executive functioning post-intervention. However, the observational data described provides convincing support for his improved performance on everyday tasks – tasks that typically require the recruitment of executive functions. Ironically, it is FS' decreased reliance on such functions and increased dependency on procedural memory that enabled his improved functioning. This, then, may also account for the lack of significant change observed on neuropsychological tests of executive functioning.

***Memory aid*.** The use of Google Calendar as an external memory aid was successful. We propose that this was, in part, related to its reliance on FS' preserved implicit memory. The sound of the alert became paired with performing the task indicated in the alert notification. This response was reinforced during intervention sessions, such that responding to the alerts became conditioned and occurred outside of intervention sessions, thus translating into FS' everyday life. Similar findings have been found in recent research promoting the use of technology, such as smartphones, for memory rehabilitation in TBI populations. For example, Baldwin and Powell (2015), as well as McDonald and colleagues (2011) made use of Google Calendar with a sample of patients with TBI, utilising the application's alert notifications to improve participants' prospective memory for tasks of daily living. Our study thus contributes to the growing research promoting the use of assistive technology as compensatory memory aids in rehabilitation. Our results also demonstrate how external prompting can provide gains in independence for patients with TBI, by reducing need for reminders from family members which can cause strain (Fish, Manly, & Wilson, 2008).

Awareness. FS has markedly limited awareness concerning his impairments. Efforts to improve his insight were thus important. In early sessions, FS' execution ratings were consistently higher than our own but became increasingly equivalent to or lower as the intervention progressed – reflective of a more realistic (if not critical) assessment of his own performance. This suggests that FS' insight into his capabilities improved across the intervention. Our results indicate that even in the context of severe TBI, improvements in awareness, albeit modest ones, can be made. This is notable given that increased insight is known to aid rehabilitation efforts (Robertson & Schmitter-Edgecombe, 2015; Wilson, 2017).

Real-life applicability of the intervention. When asked to comment on the intervention, FS' fiancé, parents and caregivers all referred to his increasing willingness to complete tasks - both those he learned in the intervention and other household tasks. One possible explanation for this could be FS' increased confidence to perform intervention tasks independently, making him more willing to assist with other, similar everyday tasks outside of the intervention sessions.

This increased willingness to perform tasks may have been facilitated by the use of external prompting. Family members noted how, prior to the intervention, FS resisted responding to their requests to complete tasks that formed part of his everyday routine. They then noted a change when FS began receiving reminders to complete tasks, on his iPad. He responded promptly and, without reluctance, performed the activity. It is plausible that since the reminder originated from his own calendar, on his own iPad - FS felt an increased sense of autonomy and personal choice. This change in the source of prompting may have played a role in FS' increased willingness to complete tasks if viewed as being his own choice, and not the directive of others. Additionally, FS' conditioned response to the alert notifications was effectively applied to other tasks of daily living not specifically targeted during intervention sessions. For example, we programmed daily notifications reminding FS to take his medication. This further enhanced the real-life applicability of our intervention strategies in aiding daily living.

Furthermore, both the decrease in number of errors made and decreased need for prompting in intervention sessions reflected positive real-world impacts, speaking to the ecological validity of the intervention. Namely, FS was more capable, and more likely, to complete tasks of daily living independently. Literature indicates that fostering an increased sense of autonomy in patients with TBI is beneficial for the development of positive self-image and outlook on adjustment to injury outcomes (Knox, Douglas, & Bigby, 2017). Although monitoring is still required when FS completes tasks, there is a decreased need for intensive supervision, thereby decreasing caregiver and family strain and promoting an increased sense of independence for FS.

Sustainability

The fact that the decline in errors and prompting, observed at the conclusion of the intervention, still held at the one-month follow-up speaks to the sustainability of the intervention's effects. This outcome may have been bolstered by the family's role in practicing the intervention tasks with FS between sessions as well as post-intervention – which, in and of itself, is a positive outcome as it demonstrates how the intervention strategies were incorporated into their lives. Similarly, the sustained (and real-life) usefulness of the intervention is evidenced by FS' fiancé's decision to program a new activity into the application. The family's continued use of the intervention strategies is encouraging as it increases the likelihood that the changes observed post-intervention will endure.

Limitations and Recommendations

Our intervention consisted of 10 weekly sessions. Given that procedural memory is known to benefit from rehearsal (Ellmore, Stouffer, & Nadel, 2008), FS could benefit from more frequent practice on the intervention tasks. Potential solutions to this include lengthening the duration of the intervention. Likewise, the other health professionals that currently work with FS on a weekly basis, could be consulted and encouraged to incorporate into their sessions, our intervention tasks and strategies.

Furthermore, our intervention focused exclusively on compensatory methods of remediation. While executive functioning and memory do not lend themselves to restorative type approaches, there is literature supporting the efficacy of attentional skills training for improving attention in TBI populations (Bogdanova, Yee, Ho, & Cicerone, 2016). Given FS' prominent distractibility, he could have benefitted from such restorative attentional strategies. As in our own study, rehabilitation interventions commonly adopt either a compensatory or restorative approach. We propose that patients with TBI may stand to benefit from both types of intervention strategies and suggest that future neuropsychological rehabilitation research investigate the efficacy of combined compensatory and restorative methods.

Summary and Conclusion

In conclusion, the intervention was successful in improving FS' capacity for tasks of daily living. Our study thus demonstrates the value of neuropsychological rehabilitation efforts that, even in the context of severe TBI, can facilitate gains in independent functioning. This research serves as further support for the use of Goal Management Training principles (checklists), external memory aids, errorless learning and reliance on procedural memory as effective intervention strategies following severe TBI.

While executive functioning and memory impairments commonly occur together following TBI, previous research demonstrates that neuropsychological rehabilitation interventions target these independently. Our study is unique as it implemented strategies targeting both domains in one intervention program, thus addressing the combined impact of these impairments and enhancing the intervention's real-life applicability.

Furthermore, our research contributes to the currently limited body of research concerning neuropsychological rehabilitation within LMIC contexts. Like the majority of LMICs, neuropsychological rehabilitation services and infrastructure is extremely limited in South Africa. That said, our study demonstrates the potential for conducting effective neurorehabilitation in such a setting and should serve as impetus for further such efforts.

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References

Atkinson, T. M., Konold, T. R., & Glutting, J. J. (2008). Patterns of memory: A normative taxonomy of the Wide Range Assessment of Memory and Learning – Second Edition (WRAML-2). *Journal of the International Neuropsychological Society, 14*(5), 869-877. doi:10.1017/S1355617708081137

Azouvi, P., Vallat-Azouvi, C., Millox, V., Darnoux, E., Ghout, I., Azerad, S., . . . Jourdan, C. (2015). Ecological validity of the Dysexecutive Questionnaire: Results from the Paris-TBI study. *Neuropsychological Rehabilitation, 25*(6), 864-878. doi:10.1080/09602011.2014.990907

Baddeley, A., & Wilson, B. A. (1994). When implicit learning fails: Amnesia and the problem of error elimination. *Neuropsychologia*, *32*(1), 53–68. doi:10.1016/0028-3932(94)90068-X

Baldwin, V. N., & Powell, T. (2015). Google Calendar: A single case experimental design study of a man with severe memory problems. *Neuropsychological Rehabilitation*, *25*(4), 617–636. doi:10.1080/09602011.2014.956764

Barman, A., Chatterjee, A., & Bhide, R. (2016). Cognitive impairment and rehabilitation strategies after traumatic brain injury. *Indian Journal of Psychological Medicine, 38*(3), 172–181. doi:10.4103/0253-7176.183086

Beatriz, C., Seale, G., Scheibel, S., Huddleston, N., Zhang, L., & Ottenbacher, K. (2001). Levels of self-awareness after acute brain injury: How patients' and rehabilitation specialists' perceptions compare. *Archives of Physical Medicine and Rehabilitation*, *82*(1), 49–56. doi:10.1053/apmr.2001.9167

Bertens, D., Kessels, R. P. C., Fiorenzato, E., Boelen, D. H. E., & Fasotti, L. (2015). Do old errors always lead to new truths? A randomized controlled trial of errorless Goal Management Training in brain-injured patients. *Journal of the International Neuropsychological Society*, *21*(08), 639–649. doi:10.1017/s1355617715000764

Bogdanova, Y., Yee, M. K., Ho, V. T., & Cicerone, K. D. (2016). Computerized cognitive rehabilitation of attention and executive function in acquired brain injury: A systematic review. *The Journal of Head Trauma Rehabilitation, 31*(6), 419-433. doi:10.1097/HTR.0000000000000203

Brayer, S. W., Ketcham, S., Zou, H., Hurwitz, M., Henderson, C., Fuletra, J., . . . Wagner, A. K. (2015). Developing a clinically relevant model of cognitive training after experimental traumatic brain injury. *Neurorehabilitation and Neural Repair, 29*(5), 483-495. doi:10.1177/1545968314550367

Campbell, L., Wilson, F. C., McCann, J., Kernahan, G., & Rogers, R. G. (2007). Single case experimental design study of carer facilitated errorless learning in a patient with severe memory impairment following TBI. *NeuroRehabilitation, 22*(4), 325–333. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17971624

Canali, F., Brucki, S. M., Bertolucci, P. H., & Bueno, O. F. (2011). Reliability study of the behavioral assessment of the dysexecutive syndrome adapted for a Brazilian sample of older-adult controls and probable early Alzheimer's disease patients. *Brazilian Journal of Psychiatry, 33*(4), 338-346. doi:10.1590/S1516-44462011005000015

Cassimjee, N., & Motswai, P. K. (2017). Neuropsychological profiles of adults and older adults with HIV. *South African Journal of Psychology, 47*(1), 35-45. doi:10.1177/0081246316646296

Cella, D., Riley, W., Stone, A., Rothrock, N., Reeve, B., Yount, S., … PROMIS Cooperative Group. (2010). Initial adult health item banks and first wave testing of the Patient-Reported Outcomes Measurement Information System (PROMIS™) network: 2005–2008. *Journal of Clinical Epidemiology, 63*(11), 1179-1194. doi:10.1016/j.jclinepi.2010.04.011

Cheung, W., Yip, B., Hui-Chan, C. W. Y., Tam, S.-F., Lau, A., & Man, W. K. (2006). Evaluating the efficacy of tele-cognitive rehabilitation for functional performance in three case studies. *Occupational Therapy International*, *10*(1), 20–38. doi:10.1002/oti.175

Cockcroft, K., Alloway, T., Copello, E., & Milligan, R. (2015). A cross-cultural comparison between South African and British students on the Wechsler Adult Intelligence Scales Third Edition (WAIS-III). *Frontiers in Psychology*. doi:10.3389/fpsyg.2015.00297

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis-Kaplan Executive Function System (D-KEFS) examiner's manual.* San Antonio, TX: The Psychological Corporation.

Desbois, J., Strong, J., Kuipers, P., Ownsworth, T., & Fleming, J. (2008). A metacognitive contextual intervention to enhance error awareness and functional outcome following traumatic brain injury: A single-case experimental design. *Journal of the International Neuropsychological Society, 12*(1), 54–63. doi:10.1017/s135561770606005x

Destreri, N. D., Farina, E., Calabrese, E., Pinardi, G., Imbornone, E., & Mariani, C. (2002). Frontal impairment and confabulation after herpes simplex encephalitis: A case report. *Archives of Physical Medicine & Rehabilitation, 83*(3), 423-426. doi:10.1053/apmr.2002.29646

Dewan, M. C., Rattani, A., Gupta, S., Baticulon, R. E., Hung, Y., Punchak, M., . . . Park, K. B. (2018). Estimating the global incidence of traumatic brain injury. *Journal of Neurosurgery, 1*(1), 1-18. doi:10.3171/2017.10.JNS17352

Dewar, B., Kapur, N., & Kopelman, M. (2018). Do memory aids help everyday memory? A controlled trial of a memory aids service. *Neuropsychological Rehabilitation, 28*(4), 614-632. doi:10.1080/09602011.2016.1189342

Dewar, B., & Wilson, B. A. (2005). Cognitive recovery from encephalitis lethargica. *Brain Injury, 19*(14), 1285-1291. doi:10.1080/02699050500309536

Donald, K. A., Mathema, H., Thoomas, K. G., & Wilmshurst, J. M. (2011). Intellectual and behavioral functioning in a South African cohort of boys with Duchenne muscular dystrophy. *Journal of Child Neurology, 26*(8), 963-969. doi:10.1177/0883073811399149

Dreer, L. E., DeVivo, M. J., Novack, T. A., Krzywanski, S., & Marson, D. C. (2008). Cognitive predictors of medical decision-making capacity in traumatic brain injury. *Rehabilitation Psychology*, *53*(4), 486–497. doi:10.1037/a0013798

Duncan, J. (1986). Disorganisation of behaviour after frontal lobe damage. *Cognitive Neuropsychology*, *3*(3), 271-290. doi:10.1080/02643298608253360

Duval, J., Coyette, F., & Seron, X. (2008). Rehabilitation of the central executive component of working memory: A re-organisation approach applied to a single case. *Neuropsychological Rehabilitation*, *18*(4), 430-460. doi:10.1080/09602010701573950

Ellmore, T. M., Stouffer, K., & Nadel, L. (2008). Divergence of explicit and implicit processing speed during associative memory retrieval. *Brain Research, 10*(1), 155-166. doi:10.1016/j.brainres.2008.07.011

Figaji, A. A., Fieggen, A. G., Mankahla, N., Enslin, N., & Rohlwink, U. K. (2017). Targeted treatment in severe traumatic brain injury in the age of precision medicine. *Child's Nervous System*, *33*(10), 1651–1661. doi:10.1007/s00381-017-3562-3

Fish, J. (2018). Patient Competency Rating Scale. In *Encyclopedia of Clinical Neuropsychology,* 2598-2600. doi:10.1007/978-3-319-56782-2_1827-2

Fish, J., Manly, T., & Wilson, B. A. (2008). Long-term compensatory treatment of organizational deficits in a patient with bilateral frontal lobe damage. *Journal of the International Neuropsychological Society*, *14*(1), 154–163.

doi:10.1017/S1355617708080120

Fleming, J. M., Strong, J., & Ashton, R. (1998). Cluster analysis of self-awareness levels in adults with traumatic brain injury and relationship to outcome. *Journal of Head Trauma Rehabilitation, 13*(5), 39-51. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/9753534

Frost, R. B., Farrer, T. J., Primosch, M., & Hedges, D. W. (2013). Prevalence of traumatic brain injury in the general adult population: A meta-analysis. *Neuroepidemiology, 40*(3), 154-159. doi:10.1159/000343275

Good Karma Applications Incorporated. (2015). Visual Schedule Planner (Version 2.6) [Mobile application software]. Retrieved from https://apps.apple.com/us/app/visual-schedule-planner/id488646282

Google LLC. (2019). Google Calendar (Version 6.0.54-271933864) [Mobile application software]. Retrieved from https://apps.apple.com/il/app/google-calendar/id909319292

Hawryluk, G. W. J., & Manley, G. T. (2015). Classification of traumatic brain injury: Past, present, and future. *Handbook of Clinical Neurology, 127*(1), 15–21. doi:10.1016/b978-0-444-52892-6.00002-7

Hays, R. D., Spritzer, K. L., Schalet, B. D., & Cella, D. (2018). PROMIS-29 v2.0 profile physical and mental health summary scores. *Quality of Life Research*, *27*(1), 1885-1891. doi:10.1007/s11136-018-1842-3

Hill, B. D., Rohling, M. L., Boettcher, A., & Meyers, J. E. (2013). Cognitive intra-individual variability has a positive association with traumatic brain injury severity and suboptimal effort. *Archives of Clinical Neuropsychology, 28*(7), 640-648. doi:10.1093/arclin/act045

Hoogenhout, M., & Malcolm-Smith, S. (2016). Theory of mind predicts severity in autism. *Autism, 21*(2), 242-252. doi:10.1177/1362361316636758

Huang, W., Rose, A. J., Bayliss, E., Baseman, L., Butcher, E., Garcia, R.-E., & Edelen, M. O. (2019). Adapting summary scores for the PROMIS-29 v2.0 for use among older adults with multiple chronic conditions. *Quality of Life Research, 28*(1), 199-210. doi:10.1007/s11136-018-1988-z

Jacobson, N. S., & Truax, P. (1991). Clinical significance: A statistical approach to defining meaningful change in psychotherapy research. *Journal of Consulting and Clinical Psychology*, *59*(1), 12-19. doi:10.1037/0022-006X.59.1.12

Johnson-Greene, D. (2010). Informed consent issues in traumatic brain injury research: Current status of capacity assessment and recommendations for safeguards. *Journal of*

Head Trauma Rehabilitation, *25*(2), 145-150. doi:10.1097/HTR.0b013e3181d8287d

Knox, L., Douglas, J. M., & Bigby, C. (2017). “I’ve never been a yes person”: Decision-making participation and self-conceptualization after severe traumatic brain injury. *Disability and Rehabilitation, 39*(22), 2250-2260. doi:10.1080/09638288.2016.1219925

Koehler, R., Wilhelm, E. E., & Shoulson, I. (2012). *Cognitive rehabilitation therapy for traumatic brain injury: Evaluating the evidence.* Washington, DC: National Academies Press.

Krasny-Pacini, A., Chevignard, M., & Evans, J. (2014). Goal Management Training for rehabilitation of executive functions: A systematic review of effectiveness in patients with acquired brain injury. *Disability and Rehabilitation*, *36*(2), 105–116. doi: 10.3109/09638288.2013.777807

Krasny-Pacini, A., & Evans, J. (2018). Single-case experimental designs to assess intervention effectiveness in rehabilitation: A practical guide. *Annals of Physical and Rehabilitation Medicine*, *61*(3), 164–179. doi:10.1016/j.rehab.2017.12.002

Levine, B., Robertson, I., Clare, L., Carter, G., Hong, J., Wilson, B., … Stuss, D. (2000). Rehabilitation of executive functioning: An experimental–clinical validation of Goal Management Training. *Journal of the International Neuropsychological Society*, *6*(3), 299–312. doi:10.1017/s1355617700633052

Mahmoud, G. A., Rady, H. M., & Mostafa, A. M. (2018). Cross cultural adaptation and validation of an Arabic version of selected PROMIS measures for use in rheumatoid arthritis patients. *The Egyptian Rheumatologist*, 1110-1164. doi:10.1016/j.ejr.2018.09.003

Mar, J., Arrospide, A., Begiristain, J. M., Larranaga, I., Elosegui, E., & Oliva-Moreno, J. (2011). The impact of acquired brain damage in terms of epidemiology, economics and loss in quality of life. *BMC Neurology, 11*(46), 11-46. doi:0.1186/1471-2377-11-46

McCrimmon, A. W., & Smith, A. D. (2013). Review of Wechsler Abbreviated Scale of Intelligence Second Edition (WASI-II). *Journal of Psychoeducational Assessment, 31*(3), 337-341. doi:10.1177/0734282912467756

McDonald, A., Haslam, C., Yates, P., Gurr, B., Leeder, G., & Sayers, A. (2011). Google Calendar: A new memory aid to compensate for prospective memory deficits following acquired brain injury. *Neuropsychological Rehabilitation, 21*(6), 784-807. doi:10.1080/09602011.2011.598405

McKerracher, G., Powell, T., & Oyebode, J. (2005). A single case experimental design comparing two memory notebook formats for a man with memory problems caused by traumatic brain injury. *Neuropsychological Rehabilitation*, *15*(2), 115–128. doi:10.1080/09602010443000056

Myer, L., Ehrlich, R. I., & Susser, E. S. (2004). Social epidemiology in South Africa. *Epidemiologic Reviews*, *26*(1), 112-123. doi:10.1093/epirev/mxh004

Myer, L., Stein, D. J., Grimsrud, A., Seedat, S., & Williams, D. R. (2008). Social determinants of psychological distress in a nationally-representative sample of South African adults. *Social Sciences & Medicine, 66*(8), 1828-1840. doi:10.1016/j.socscimed.2008.01.025

Nadar, M. S., & McDowd, J. (2010). Comparison of remedial and compensatory approaches in memory dysfunction: A comprehensive literature review. *Occupational Therapy in Health Care, 24*(3), 274–289. doi:10.3109/07380577.2010.483269

Naidoo, D. (2013). Traumatic brain injury: The South African landscape. *South African Medical Journal*, *103*(9), 613. doi:10.7196/samj.7325

O'Connor, C., Schweizer, T. A., Turner, G., Stuss, D. T., Levine, B., Robertson, I. H., … Gillingham, S. (2011). Rehabilitation of executive functioning in patients with frontal lobe brain damage with Goal Management Training. *Frontiers Human Neuroscience, 5*(9), 1–9. doi:10.3389/fnhum.2011.00009

O'Neil, M. E., Carlson, K., Storzbach, D., Brenner, L., Freeman, M., Quiñones, A., . . . Kansagara, D. (2013). *Complications of mild traumatic brain injury in veterans and military personnel: A systematic review.* Washington, DC: Department of Veterans Affairs. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK189784/table/appc.t1/

Othman, Z., & Wong, T. S. (2014). Validation of Malay Caregiver Strain Index. *Eastern Journal of Medicine*, *19*(2), 102-104. doi:10.5281/zenodo.2596359

Pino, O. (2015). Memory impairments and rehabilitation: Evidence-based effects of approaches and training programs. *The Open Rehabilitation Journal*, *8*(1), 25–33. doi:10.2174/1874943720150601e001

Pitel, A. L., Beaunieux, H., Lebaron, N., Joyeux, F., Desgranges, B., & Eustache, F. (2006). Two case studies in the application of errorless learning techniques in memory impaired patients with additional executive deficits. *Brain Injury*, *20*(10), 1099–1110. doi:10.1080/02699050600909961

Ponsford, J., Kelly, A., & Couchman, G. (2014). Self-concept and self-esteem after acquired brain injury: A control group comparison. *Brain Injury, 28*(2), 146-154. doi:10.3109/02699052.2013.859733

Prigatano, G. P., Fordyce, D. J., Zeiner, H. K., Roueche, J. R., Pepping, M., & Wood, B. C. (1986). *Neuropsychological rehabilitation after brain injury.* Baltimore, MD: John Hopkins University Press.

Rabinowitz, A. R., & Levin, H. S. (2014). Cognitive sequelae of traumatic brain injury. *Psychiatric Clinics of North America*, *37*(1), 1–11. doi:10.1016/j.psc.2013.11.004

Roberts, J. L., Anderson, N. D., Guild, E., Cyr, A. A., Jones, R. S. P., & Clare, L. (2018). The benefits of errorless learning for people with amnestic mild cognitive impairment. *Neuropsychological Rehabilitation*, *28*(6), 984–996. doi:10.1080/09602011.2016.1216000

Robertson, K., & Schmitter-Edgecombe, M. (2015). Self-awareness and traumatic brain injury outcome. *Brain Injury*, *29*(0), 848–858. doi:10.3109/02699052.2015.1005135

Robinson, B. C. (1983). Validation of a Caregiver Strain Index (CSI). *Journal of Gerontology*, *38*(3), 344-348. doi:10.1093/geronj/38.3.344

Robson, P. J. (1989). Development of a new self-report questionnaire to measure self-esteem. *Psychological Medicine, 19*(1), 513-518. doi:10.1017/S003329170001254X

Roessler-Górecka, M., Iwański, S., & Seniów, J. (2013). The value of self-report methods in neuropsychological diagnostics of patients after brain injury. *Psychiatria Polska*, *47*(3), 465-474. Retrieved from http://www.psychiatriapolska.pl/uploads/images/PP_3_2013/Eng_ver_RoesslerGorecka.pdf

Schneider, W., Niklas, F., & Schmiedeler, S. (2014). Intellectual development from early childhood to early adulthood: The impact of early IQ differences on stability and change over time. *Learning and Individual Differences, 32*, 156-162. doi: 10.1016/j.lindif.2014.02.001

Schrieff-Elson, L., & Thomas, K. (2017). Rehabilitation in South Africa. In B. A. Wilson, J. Winegardner, C. M. van Heugten, & T. Ownsworth, *Neuropsychological Rehabilitation: The International Handbook* (1st ed., pp. 526-529). London: Routledge. doi:10.4324/9781315629537

Schweizer, T. A., Levine, B., Rewilak, D., O'Connor, C., Turner, G., Alexander, M. P., … Stuss, D. T. (2008). Rehabilitation of executive functioning after focal damage to the cerebellum. *Neurorehabilitation and Neural Repair*, *22*(1), 72–77.

doi:10.1177/1545968307305303

Sheslow, D., & Adams, W. (2003). *Wide Range Assessment of Memory and Learning* (2nd ed.). Lutz, FL: Psychological Assessment Resources, Inc.

Simblett, S. K., & Bateman, A. (2011). Dimensions of the Dysexecutive (DEX) Questionnaire examined using Rasch analysis. *Neuropsychological Rehabilitation, 21*(1), 1-25. doi:doi:10.1080/09602011.2010.531216

Simblett, S. K., Ring, H., & Bateman, A. (2017). The Dysexecutive Questionnaire Revised (DEX-R): An extended measure of everyday dysexecutive problems after acquired brain injury. *Neuropsychological Rehabilitation, 27*(8), 1124-1141. doi:10.1080/09602011.2015.1121880

Skidmore, E. R. (2015). Training to optimise learning after traumatic brain injury. *Current Physical Medicine and Rehabilitation Reports, 3*(1), 99-105. doi:10.1007/s40141-015-0081-6

Sullivan, M. T. (2007). Caregiver Strain Index (CSI). Urologic Nursing: *Official Journal of the American Urological Association Allied, 27*(3), 251-252. doi:10.1097/00004045-200303000-00024

Swanson, J. (2005). The Delis-Kaplan Executive Function System: A review. *Canadian Journal of School Psychology, 20*(2), 117-128. doi:10.1177/0829573506295469

Tate, R., Kennedy, M., Ponsford, J., Douglas, J., Velikonja, D., Bayley, M., & Stergiou-Kita, M. (2014). INCOG recommendations for management of cognition following traumatic brain injury, part III. *Journal of Head Trauma Rehabilitation, 29*(4), 338–352. doi:10.1097/HTR.0000000000000068

Teasdale, G., & Jennett, B. (1974). Assessment of coma and impaired consciousness. A practical scale. *Lancet, 304*(7872), 81-84. doi:10.1016/S0140-6736(74)91639-0

Thornton, M., & Travis, S. S. (2003). Analysis of the reliability of the Modified Caregiver Strain Index. *The Journals of Gerontology: Series B, 58*(2), 127-132. doi:10.1093/geronb/58.2.S127

Turkstra, L. S., & Flora, T. L. (2002). Compensating for executive function impairments after TBI: A single case study of functional intervention. *Journal of Communication Disorders, 35*(6), 467-482. doi:10.1016/S0021-9924(02)00118-1

Vanotti, S., & Caceres, F. J. (2014). Cognitive and neuropsychiatric disorders among MS patients from Latin America: Results of the RELACCEM study. *Multiple Sclerosis and Related Disorders, 3*(3), 335-340. doi:10.1016/j.msard.2013.10.007

von Steinbüchel, N., Wilson, L., Gibbons, H., Hawthorne, G., Höfer, S., Schmidt, S., . . . QOLIBRI Task Force. (2010). Quality of Life after Brain Injury (QOLIBRI): Scale development and metric properties. *Journal of Neurotrauma, 27*(7), 1167-1185. doi:10.1089/neu.2009.1076

Wechsler, D. (1999). *Wechsler Abbreviated Scale of Intelligence* (2nd ed.). San Antonio, TX: The Psychological Corporation.

Wechsler, D. (2008). *Wechsler Adult Intelligence Scale* (4th ed.). San Antonio, TX: Pearson.

Wechsler, D. (2011). *Wechsler Abbreviated Scale of Intelligence–Second Edition (WASI-II).* San Antionio, TX: Pearson.

Wilson, B. A. (2008). Annual review of clinical psychology. *Neuropsychological Rehabilitation, 4*(1), 141-162. doi:10.1146/annurev.clinpsy.4.022007.141212

Wilson, B. A. (2017). General Introduction. In R. Winson, B. A. Wilson, & A. Bateman (Eds.), *The brain injury rehabilitation workbook* (pp. 1-14). New York, NY: Guilford Press.

Withiel, T., Wong, D., Ponsford, J., Cadilhack, D., New, P., Mihaljcic, T., & Stolwyk, R. (2019). Comparing compensatory and restorative approaches to memory rehabilitation following stroke: A phase II randomised controlled trial. *Journal of Rehabilitation Medicine, 51*(1), 25-33. doi:10.2340/16501977-2540

Zimmermann, N., Mograbi, D. C., Hermes-Pereira, A., Fonseca, R. P., & Prigatano, G. P. (2017). Memory and executive functions correlates of self-awareness in traumatic brain injury. *Cognitive Neuropsychiatry, 22*(4), 346-360. doi:10.1080/13546805.2017.1330191

Appendix A:

Summary of Single Case Experimental Designs in Neuropsychological Rehabilitation Interventions

Authors	Design	Client	Treatment Narrative	Outcome Measures	Findings
Levine et al., 2000	SCED with pre and post testing	35y/old female[a]. Attentional and executive deficits Self-reported diminished capacity for meal preparation	Goal Management Training. Principles first applied to paper-and-pencil tasks, followed by graded tasks to assist transfer to real-life situations	Paper-and-pencil tasks Observation of meal preparation Self-report diary	Significant improvement on paper-and-pencil tasks. Naturalistic observation and self-report diary confirm lasting improvements in meal preparation efficiency.
Turkstra et al., 2002	SCED with pre and post testing	49y/old male[b] Planning and organisation deficits, impacted on ability to conduct interviews and complete reports as part of profession (chemical dependency counsellor)	Trained in using S.O.A.P format for note-taking and report writing. Skills practiced in timed simulation interviews.	Inter-rater reliability for report accuracy, spelling and discourse cohesion. Observation of interview and report writing Client comments Employment outcome	Significant improvements in report accuracy. Observations and self-reports indicate improved functional performance. Managed to secure desired employment with assistance.
Fish et al., 2008	SCED with pre and post testing	60 y/old female[c] Initiation deficits and goal neglect impacted on ability to complete ADLs timeously.	Outlined pertinent goals with subject and their spouse. Following baseline periods, implemented use of a checklist, NeuroPage and combination of both checklist and NeuroPage.	Completion of ADLs recorded by spouse Statistical analysis of time series data Subject and collateral comments	Statistical analysis indicated NeuroPage as most effective treatment with significant reductions in time taken to complete ADLs. Improved functional capacity supported by subject and spouse self-reports.
McKerracher et al., 2005	Multiple baseline SCED.	46y/old male[b]. Deficits in language, attention and concentration,	Compared two different diary formats Sohlberg & Mateer “standard” Donaghy & Williams “modified”	Rehabilitation staff recorded completion of the assigned prospective memory tasks	“Modified” diary was significantly more effective in assisting completion of assigned memory tasks. ○ “standard” – carried out 1/20 tasks ○ “modified” – 15/20

		planning and impaired prospective memory.			
Desbois et al., 2008	SCED with pre and post testing	32y/old male[b]. Deficits in self-awareness and error self-regulation.	Rehabilitation specific to functional goals – meal preparation and return to employment. Practiced tasks with systematic feedback and external prompting. Education for psychosocial supports.	Observation of meal preparation with inter-rater reliability for frequency of error behaviour.	Mild functional gains across home and work settings. Subject secured paid employment with assistance. Significant decrease in error frequency during meal preparation.
Campbell et al., 2007	Multiple baseline SCED	24y/old male[b] Deficits in memory impacted on functional independence	Through errorless learning, taught to respond to different levels of (patient-generated) prompts issued by mother (NB caregiver) for tasks selected as important: Use of notebook Walking the dog	Mother recorded daily completion of specified tasks.	Significant reduction in memory lapses. 18 months post-intervention notebook use maintained and walks the dog daily without prompting.
Schweizer et al., 2008	SCED with pre and post testing	41y/old male[c] Deficits in language, information processing speed, organisation and self-monitoring.	7 weekly 2-hour sessions of GMT	Clinical neuropsychological tests of executive functioning and attention. Dysexecutive Questionnaire (DEX) Self-Assessment and Significant Other versions Cognitive Failures Questionnaire (CFQ)	Modest therapeutic gains on neuropsychological tests. Significantly improved functional capacity indicated by self and spouse reports as well as return to demanding job within weeks of intervention.
Pitel et al., 2006	Two SCEDs with pre and post testing	17y/old male[b]. Moderate memory impairment and severe executive dysfunction (inhibition, organization flexibility and categorization)	Errorless learning technique for ecological semantic information Procedural learning for using electronic organiser ○ VoiceMate ○ Navytech	Customised tasks assessing retention of semantic information	Learning of semantic information and complex procedures mediated by severity of EF profile.

		31y/old male[b]. Severe memory impairment and mild executive dysfunction (inhibition)			
Cheung et al., 2006	Three SCEDs (ABA design)	37y/old male[b]. Anomia. 20y/old male[b]. Prospective memory difficulties. 20y/old female[c]. Impaired memory, esp. semantic.	Customized tele-cognitive rehabilitation using online computer software to train cognitive skills	Visual and trend line analysis Qualitative feedback from subjects	Treatment phase showed improving trends and levels of specific cognitive performance. Qualitative feedback confirmed the efficacy of intervention. Further study into long-term effects recommended.
Duval et al., 2008	Multiple baseline SCED	23y/old male[d]. Deficits in working memory.	Cognitive rehabilitation training for 3 components of WM. Ecological rehabilitation. Assisted in transferring cognitive strategies to real-life situations. Psychoeducation concerning WM.	Compared pre and post treatment neuropsychological tests Self-assessment questionnaires	Significant improvements in specific aspects of WM Effects generalised to everyday life Self-reports confirmed efficacy of treatment
Destreri et al., 2002	SCED with pre and post testing	53y/old female[a]. Severe frontal syndrome (apathy, initiation deficits and confabulation).	Temporal and spatial re-orientation through use of memory book. Paper-and-pencil tasks training variety cognitive domains. Psychoeducation of social supports.	Neuropsychological evaluation. Observations of ecologic improvement.	Neuropsychological evaluation indicated improvements in frontal functioning. Improved functional capacity observed by relatives.
Dewar et al., 2018	Compared treatment group	Participants[e] had everyday memory problems with additional	Memory goals and aids selected according to individual specifications.	Memory diary Neuropsychological tests Problem Solving Inventory	Memory goal attainment significantly higher in treatment relative to control group. Treatment was effective for non-progressive participants, with results being maintained across time.

	and waiting list controls. Pre and post testing.	diagnosis of progressive or non-progressive neurological conditions.	3 sessions training the components and utilisation of memory aid. Additional memory strategies trained on case-by-case basis.		Treatment was not effective for progressive participants.
Dewar et al., 2005	SCED with pre and post testing	24 y/old female[a]. Memory and executive impairment.	Psychoeducation and memory diary targeting self-awareness. Training building on compensatory memory techniques already used. Education on memory strategies. Training in application of problem-solving template. Graded return to work.	Neuropsychological evaluation	Significant improvement in memory and executive functioning, mild residual impairments in non-verbal memory. Return to pre-morbid levels of work responsibilities.

Note. Pathologies: encephalitis[a] TBI[b]; CVA[c]; tumour[d]; mixed neuropsychiatric profile[e]

Appendix B:

Measures

Behavioural Measures

Patient-Reported Outcome Measurement Information System - 29 version 2.0 (PROMIS-29). This is a self-report measure used to assess general health of the participant, including seven health domains (pain interference, depression, anxiety, physical functioning, fatigue, sleep quality and social activities) (PROMIS, Cella et al., 2010).

Psychometric properties. PROMIS-29 literature reflects high internal consistency, with coefficients of .78 to .96 (Hays, Spritzer, Schalet, & Cella, 2018). Similar results have been demonstrated in other literature (Huang et al., 2019).

Cross-cultural use. Although there is no literature that we are aware of investigating PROMIS-29 use in South Africa, this measure has been used in other LMIC contexts. An Arabic version of this measure demonstrated high internal consistency with coefficients between .70 and .90 (Mahmoud, Rady, & Mostafa, 2018).

Dysexecutive Questionnaire - revised version (DEX-R). This measure assesses impacts on daily living of those with frontal lobe damage and dysexecutive syndrome (DEX-R, Simblett & Bateman, 2011). This measure is aimed at providing accurate assessment of deficits and further directs interventions for neurorehabilitation personnel (Simblett, Ring, & Bateman, 2017).

Psychometric properties. Simblett et al. (2017) conducted extensive analysis on the revised test (DEX-R). Their review found that DEX-R has high reliability and internal validity.

Cross-cultural use. DEX-R has been used in alternative ecological contexts (Azouvi et al., 2015), including LMICs (Canali, Brucki, Bertolucci, & Bueno, 2011), suggesting an applicability to a South African context.

Self-Concept Questionnaire (SCQ). This measure is aimed at determining the overall affect and self-esteem of the participant (SCQ; Robson, 1989).

Psychometric properties. Initial literature on this measure demonstrated a high split-half correlation with .89 to .96 correlation. Test-retest correlation was also determined to be significantly high, with a correlation of .87. Validity was significant, with particular reference to convergent validity with a coefficient .85.

Cross-cultural use. There is little evidence supporting the use of this measure outside of a western context. However, considering reliable and valid psychometric properties, and the global nature of self-esteem following TBI, its applicability within South Africa seems plausible (Ponsford, Kelly, & Couchman, 2014).

Quality of Life after Brain Injury (QOLIBRI). This measure assesses general quality of life after sustaining a TBI, including cognition, emotions, daily functioning, physical functioning, personal life and social life. This was the first measure to assess brain injury related health outcomes and quality of life (HRQoL) (QOLIBRI, von Steinbüchel et al., 2010).

Psychometric properties. QOLIBRI has been found to have a high internal consistency with a coefficient of .81 to .91. Research has also demonstrated a moderate to high test-retest reliability of .68 to .87 (von Steinbüchel et al., 2010).

Cross-cultural use. Versions of this measure have been translated into multiple languages including Portuguese, Chinese and Russian (von Steinbüchel et al., 2010). This demonstrates an applicability to non-western contexts.

Caregiver Strain Index (CSI). The CSI is used to measure potential areas of concern or challenges experienced by family and caregivers caused by the patient (CSI; Robinson, 1983). This helps direct rehabilitation target areas and goals.

Psychometric properties. The CSI has significantly high test-retest reliability with a coefficient of .88. Internal consistency is also particularly high with a coefficient of .90 (Thornton & Travis, 2003), compared to the original assessment with a coefficient of .86 (Robinson, 1983).

Cross-cultural use. The CSI has been used in non-western contexts. For example, a Malay study used this measure and demonstrated high internal consistency with a coefficient of .79, and high face validity (Othman & Wong, 2014).

Patient Competency Rating Scale (PCRS). The PCRS is a self-report measure aimed to assess the participant’s awareness of their deficits (PCRS; Prigatano et al., 1986). This measure is comprised of three similar measures. One is completed by the participant, one by their primary caregiver, and one by the clinician. This measure can be used to assess neurorehabilitation interventions’ efficacy for improving patients’ daily functioning (Fish, 2018).

Psychometric properties. PCRS has demonstrated high test-retest reliability with coefficients from .92 to .97 (Prigatano et al., 1986). PCRS has also demonstrated high internal consistency with a coefficient of .91 to .93 (Fleming, Strong, & Ashton, 1998).

Cross-cultural use. PCRS has been translated into languages aside from English, including Japanese, Hebrew and Norwegian, demonstrating its potential applicability outside of a western context (Fish, 2018).

Cognitive measures

Wechsler Adult Intelligence Scale - third edition (WAIS-III). The WAIS-III is an updated version of the WAIS which assesses general cognitive functioning (WAIS; Wechsler, 2008). The Working Memory Index includes the Digit Span subtest and the Processing Speed Index includes Symbol Search and Digit Symbol Coding subtests.

Digit Span. A verbal forward and backward Digit Span are tested. Numbers increase in quantity upon successful completion of two trials of successful recall. Forward recall assesses attentional capacities. Backwards recall assesses working memory abilities.

Symbol Search. Symbol search consists of recognising whether a given symbol is present in a given list of symbols, which increases in complexity.

Digit Symbol Coding. This test consists of various symbols associated with specific numbers, as given at the top of the page. The participant is given a list of symbols and needs to decode each symbol with the associated number.

Psychometric properties. WAIS-III has a high test-retest reliability of .74 to .90. WAIS-III has also demonstrated a high inter-rater reliability of .98, and a high internal reliability of .87 to .98 within testing domains (Wechsler, 2008).

Cross-cultural use. WAIS-III has been used in non-western literature (Cockcroft, Alloway, Copello, & Milligan, 2015).

Wechsler Abbreviated Scale of Intelligence - second edition (WASI-II). The WASI-II is an updated version of WASI which tests general intellectual functioning (WASI-II; Wechsler, 2011). There are four subtests within WASI-II including Vocabulary IQ tests, namely Vocabulary and Similarities, and Performance IQ tests, namely Block Design and Matrix Reasoning.

Vocabulary. Participants are asked to verbally define words which increase in difficulty. This assesses verbal conception and knowledge, which is a component of crystallised intelligence (Wechsler, 1999).

Similarities. Participants are given two words and asked to give associations between them. Associations progressively become more abstract. This test assesses abstraction and categorical reasoning.

Block Design. Participants are given several white and red blocks which have various patterns on them, varying on each side of the cube. Participants are shown a 2D picture of various blocks put together and asked to reproduce that image using the available blocks, which increases in difficulty as time progresses. Spatial reasoning, visual-motor coordination and spatial planning are assessed.

Matrix Reasoning. Participants are shown a pattern comprised of various symbols. One image is missing from completing the pattern. Participants are given various pictures and asked to pick the one that fits the missing picture in the pattern. Patterns and selection choice increase in difficulty with time. This tests assesses spatial reasoning, abstraction and nonverbal fluid intelligence.

Psychometric properties. Each subtest has a high reliability coefficient, spanning from .81 to .97. Test-retest reliability is also significantly high with a coefficient score of .92 to .95 (Wechsler, 1999) Internal and concurrent validity ranged from acceptable, .10, to very high, .92 (McCrimmon & Smith, 2013).

Cross-cultural use. The WASI has been used in South Africa (Donald, Mathema, Thoomas, & Wilmshurst, 2011; Hoogenhout & Malcolm-Smith, 2016).

Delis-Kaplan Executive Function System (D-KEFS). The D-KEFS is used to determine patients' executive functioning (Delis et al., 2001). D-KEFS has a total of nine subtests, of which two will be used in this study, namely the Tower test and Verbal Fluency test.

Tower test. This test requires the participant to move different sized discs between three wooden pegs. There are two rules that must be adhered to, namely that a larger piece cannot be put on top of a smaller piece and only one piece can be moved at a time. The aim is to reproduce the given pictorial arrangement in as few moves as possible. This test assesses problem solving, spatial planning abilities, perseverative responding and ability to follow instructions and adhere to rules (Delis et al., 2001).

Verbal Fluency test. This assessment has three subtests including phonemic fluency, semantic fluency and a category switching task. A participant is first asked to verbally give as many words they can think of starting with a specific letter. They are then asked to give as many words they can think of within a specified category. In the final assessment participants must alternate between two categories of words. This test assesses verbal retrieval and recall, cognitive flexibility and shifting, inhibitory control and self-monitoring.

Psychometric properties. A review of the D-KEFS found this measure to have a high test-retest reliability and a moderately high internal consistency coefficient. It was also found to have high intercorrelation with other tests measuring similar domains (Swanson, 2005).

Cross-cultural use. The D-KEFS has been used in multiple settings outside of a western context (Vanotti & Caceres, 2014), including within South Africa (Cassimjee & Motswai, 2017).

Wide Range Assessment of Memory and Learning - second edition (WRAML-2). This test comprises numerous subtests encompassing a wide range of memory assessments (WRAML-2; Sheslow & Adams, 2003). For the purposes of this study, only tests from the Verbal Memory Index were used. A list of approximately 20 words is given and four immediate recall trials follow, as well as one trial each of delayed recall and recognition. The primary aim is to test verbal memory of the participant.

Psychometric properties. WRAML-2 has high construct validity with a coefficient of .91. It is also reported to have high reliability (Sheslow & Adams, 2003).

Cross-cultural use. There has been research into developing non-western norms for this measure (Atkinson, Konold, & Glutting, 2008).

Appendix C:

Demographic Questionnaire and Asset Index

QUESTIONNAIRE AND ASSET INDEX

GENERAL INFORMATION

Full name:	
Telephone:	Work: ( ) Home: ( ) Cell:
Home Language:	
Gender:	M F
Date of Birth:	
Highest Education Level:	

HOUSEHOLD INCOME: (Please circle appropriate number)

Household income per year:	1. R0 2. R1 – R5 000 3. R5001 – R25 000 4. R25 000 – R100 000 5. R100 001+

EDUCATION: (Please circle appropriate number)

	Yourself	Spouse
Highest level of education reached? Mark one response for each person as follows:		
1. 0 years (No Grades / Standards) = No formal education (never went to school)	1.	1.
2. 1-6 years (Grades 1-6 / Sub A-Std 4) = Less than primary education (didn't complete primary school)	2.	2.
3. 7 years (Grade 7 / Std 5) = Primary education (completed primary school)	3.	3.
4. 8-11 years (Grades 8-11 / Stds 6-9) = Some secondary education (didn't complete high school)	4.	4.
5. 12 years (Grade 12 / Std 10) = Secondary education (completed senior school)	5.	5.
6. 13+ years = Tertiary education (completed university / technikon / college)	6.	6.
7. Don't know	7.	7.

EMPLOYMENT: (Please circle appropriate number)

Hollingshead categories:	Yourself	Spouse
1. Higher executives, major professionals, owners of large businesses)	1.	1.
2. Business managers of medium sized businesses, lesser professions (e.g. nurses, opticians, pharmacists, social workers, teachers)	2.	2.
3. Administrative personnel, managers, minor professionals, owners / proprietors of small businesses (e.g. bakery, car dealership, engraving business, plumbing business, florist, decorator, actor, reporter, travel agent)	3.	3.
4. Clerical and sales, technicians, small businesses (e.g. bank teller, bookkeeper, clerk, draftsperson, timekeeper, secretary)	4.	4.
5. Skilled manual – usually having had training (e.g. baker, barber, chef, electrician, fireman, machinist, mechanic, painter, welder, police, plumber, electrician)	5.	5.
6. Semi-skilled (e.g. hospital aide, painter, bartender, bus driver, cook, garage guard, checker, waiter, machine operator)	6.	6.
7. Unskilled (e.g. attendant, janitor, construction helper, unspecified labour, porter, unemployed)	7.	7.
8. Homemaker	8.	8.
9. Student, disabled, no occupation	9.	9.

MATERIAL AND FINANCIAL RESOURCES: (Please circle appropriate number)

Which of the following items, in working order, does your household have?

Items	Yes	No
1. A refrigerator or freezer	1.	1.
2. A vacuum cleaner or polisher	2.	2.
3. A television	3.	3.
4. A hi-fi or music centre (radio excluded)	4.	4.
5. A microwave oven	5.	5.
6. A washing machine	6.	6.
7. A video cassette recorder or DVD player	7.	7.

Which of the following do you have in your home?

Items	Yes	No
1. Running water	1.	1.
2. A domestic worker	2.	2.
3. At least one car	3.	3.
4. A flush toilet	4.	4.
5. A built-in kitchen sink	5.	5.
6. An electric stove or hotplate	6.	6.
7. A working telephone	7.	7.

Do you personally do any of the following?

Items	Yes	No
1. Shop at supermarkets	1.	1.
2. Use any financial services such as a bank account, ATM card or credit card	2.	2.
3. Have an account or credit card at a retail store	3.	3.

Appendix D:

Sporting History

Please briefly describe your sporting background (type, number of years, participation at a professional/national level, current participation)

___

___

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Appendix E:

Inclusion Criteria

I can confirm that I do not have or have not had,

- prior traumatic brain injuries that resulted in loss of consciousness,
- prior or current diagnosed psychiatric illnesses,
- prior or current learning disabilities,
- prior or current neurological disease.

Name of control participant: ___________________________

Signed: _________________________

Appendix F:

Formulation Template (based on literature by Wilson (2017)

HANDOUT 1.1

Formulation Template

Key Relationships	**Brain Pathology**	**Social/Medical Factors**	**Cognition**
Communication	**Mood**	**Sensory/Perceptual Factors**	**Physical Factors**
	Insight	**Functional Consequences**	**Losses**

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Appendix G:
Checklists

Brush your hair

1. Untick all your steps
2. Fetch hairbrush from drawer
3. Brush your hair
4. Put hairbrush back in drawer

Cut your nails

1. Check all steps are UNTICKED
2. Get a towel from bathroom
3. If not, ask [caregiver] for help
4. Get the nail clippers
5. Put towel on the counter
6. Cut all 10 nails
7. Check all nails have been cut
8. Put towel in the bath
9. Put nail clippers away
10. Wipe down counter

Make a peanut butter sandwich

1. Check all steps are UNTICKED
2. Get a bread board
3. Get peanut butter from cupboard
4. Get bread from the cupboard
5. Get jam from the fridge
6. Get a knife
7. Put on the peanut butter
8. Put on the jam
9. Close the sandwich and cut it
10. Get a plate
11. Put sandwich on the plate
12. Put knife in the sink
13. Pack away bread board
14. Put jam in the fridge
15. Put away bread in cupboard
16. Pack away peanut butter
17. Wipe the counter

Make Coffee

1. Check all steps are UNTICKED
2. Check the water level in the kettle
3. Fill the kettle if needed
4. Boil the kettle
5. Get mugs from the cupboard
6. Get coffee from the cupboard
7. If not enough, ask [caregiver]
8. Get teaspoon from the drawer
9. Put coffee in the cups
10. Add the water
11. Get milk from the fridge
12. Add the milk
13. Stir the coffee
14. Put teaspoon in the sink
15. Pack away coffee
16. Put milk back in the fridge
17. Wipe counter if necessary

Make Tea

1. Check all steps are UNTICKED
2. Check the water level in the kettle
3. Fill the kettle if needed
4. Boil the kettle
5. Get mugs from the cupboard
6. Get tea from the cupboard
7. If not enough ask [caregiver]
8. Put teabag in the mug
9. Add the water to the mug
10. Get milk from the fridge
11. If not enough milk ask [caregiver]
12. Add milk to the mug
13. Put milk back in the fridge
14. Pack tea back into cupboard
15. Get teaspoon from the drawer
16. Stir the tea
17. Take out teabag & throw away
18. Put teaspoon in sink
19. Wipe counter if necessary

Make the bed

1. Check all steps are UNTICKED
2. Take pillows off the bed
3. Take duvet off the bed
4. Straighten the sheet
5. Put duvet back on the bed
6. Straighten the duvet
7. Put pillows neatly on the bed

Shave

1. Check all steps are UNTICKED
2. Get the box with the razor
3. Take vest out of box
4. Put on shaving vest
5. Take out electric razor
6. Take out aftershave
7. Take razor to bathroom
8. Attach vest to suction cups
9. Shave
10. Check that face is shaven cleanly
11. Shake hair off vest in toilet
12. Wipe toilet seat
13. Rinse the sink
14. Take off shaving vest
15. Pack vest into box
16. Apply aftershave
17. Put razor & aftershave in box
18. Pack away box

Tie your laces

1. Untick all the steps
2. Put your shoes on
3. Tighten the laces
4. Tie the laces into a bow
5. Make sure both shoes laces are tied

Appendix H:

Feedback form for FS

We have so enjoyed working with you these past few months. Thank you for your time and hard work. We would really appreciate any thoughts or feedback you might have. Could you please take some time to answer the following questions?

Overall, how would you describe the sessions with us (Leigh, Taryn and Alexa)?

Have you found our sessions helpful? How?

Have you noticed any changes in your daily life in your:

Routine:____

____

____

_

Emotions:____

____

____

Memory:____

____

____

Any other thoughts or comments, critiques or recommendations?

____

____

____

____

____

____

____

____

Appendix I:

Feedback Form for Parents & Fiancé

Feedback

We have so enjoyed working with your family. Thank you for your time and cooperation. We would really appreciate any thoughts or feedback you might have. Could you please take some time to answer the following questions?

Name: ___________________________

Relation to [FS]: ________________

Overall, how did you find the experience?

Have you observed any noticeable changes in [FS]? Speech, behaviour, emotions or personality?

Have there been any meaningful changes in your daily routine or life in general?

Have these sessions raised any concerns or brought your attention to anything new?

Any other thoughts or comments, critiques or recommendations?

Appendix J:

Feedback Form for Caregiver

Terugvoering

Dit was ‘n plesier om saam met u te werk. Dankie vir u tyd en samewerking. Ons sal dit waardeer as u enige idees of terugvoering vir ons het. Kan u asseblief hierdie vorm vir ons invul?

Naam: ____

Hoe het u hierdie ervaring ondervind?

____

____

____

____

____

Het u enige veranderinge in [FS] waargeneem in terme van spraak, emosies, gedrag of persoonlikheid?

____

____

____

____

____

____

____

Was daar enige noemenswaardige verandering in u daaglikse roetine of lewenskwaliteit oor die algemeen? Gee asb voorbeelde indien van toepassing.

____

____

____

____

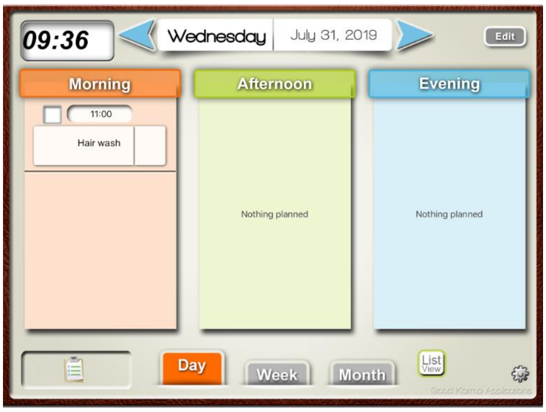
____

Het hierdie sessies enige kommerwekkende kwessies aan die lig gebring of beklemtoon of dalk iets nuuts onder u aandag gebring?

Het u enige verdere kommentaar, kritiek of aanbevelings wat u met ons wil deel?

Appendix K:
Visual Schedule Planner – How to Guide

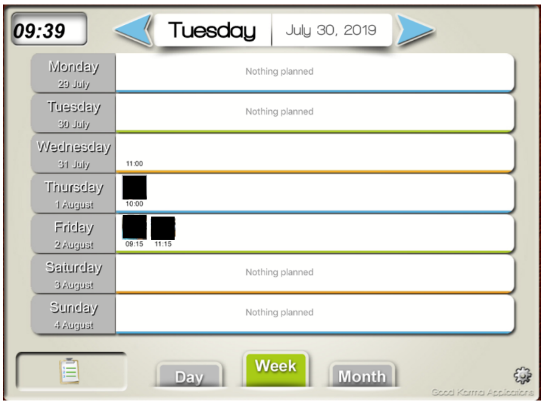
VISUAL PLANNER: Homepage

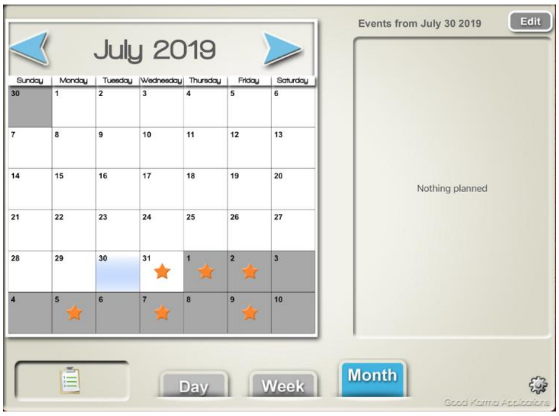


DAY VIEW

*You can ask [FS] to check the date and time using this app

WEEK VIEW

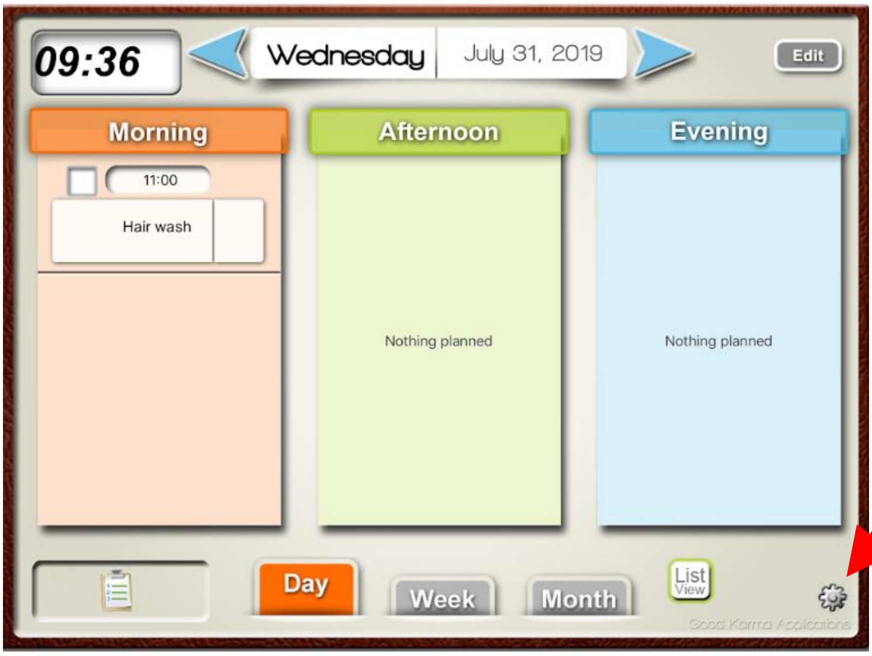




MONTH VIEW

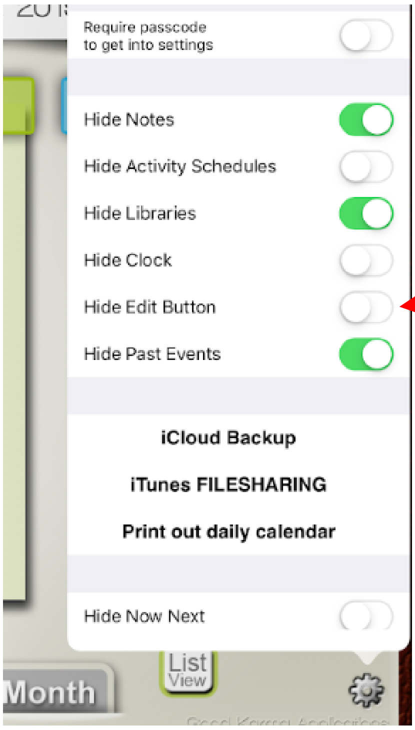
*A star will show if there is an event/activity planned for that day

EDITING ON THE APP



Step 1

Click on the settings button on the bottom right hand corner



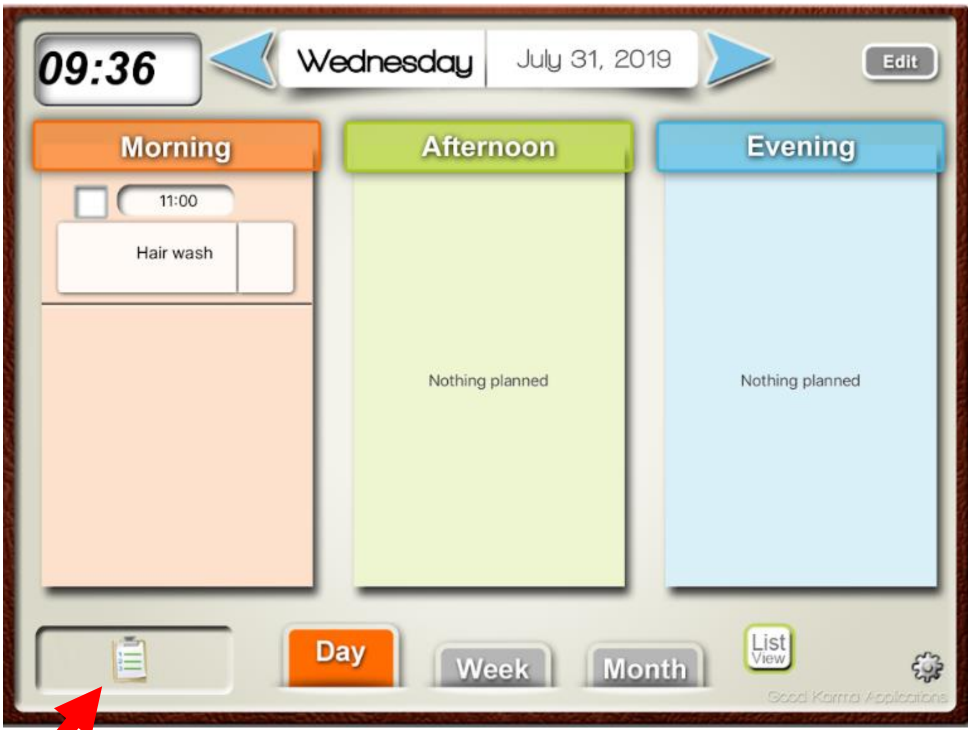
Step 2

Ensure that the "Hide Edit Button" is unselected

You will want to select this button before handing it back to [FS]

If you would like, you can set up a passcode at the top of the settings page

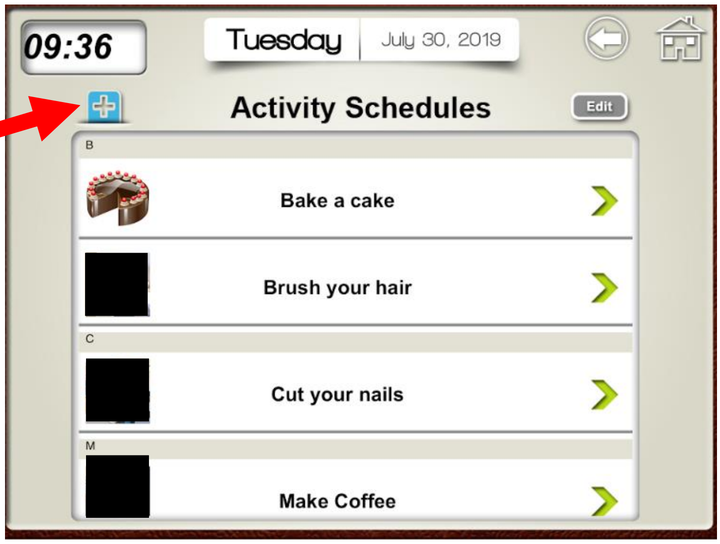
<u>ACCESSING HIS ACTIVITIES</u>



You can access a list of his activities using this button

You will see what is displayed below:

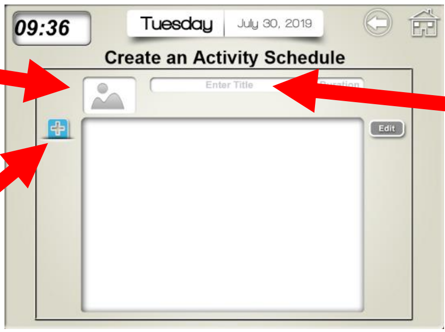
You can **add a new activity here**



You can return to the homepage using this button

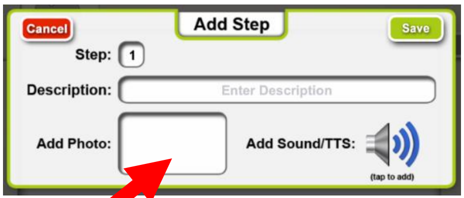
ADDING A NEW ACTIVITY

Add a **picture** of the activity
(e.g. a cup of coffee that [FS] has made)



Add the **title** of the activity here

Add a new step(s) here

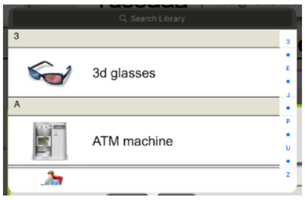


You can enter the title of the step here

Make it as descriptive as possible but notice that it won't display if it's more than 5 or 6 words

You can add a photo here

You can add an image by searching from an inbuilt list here ("Icon Library")

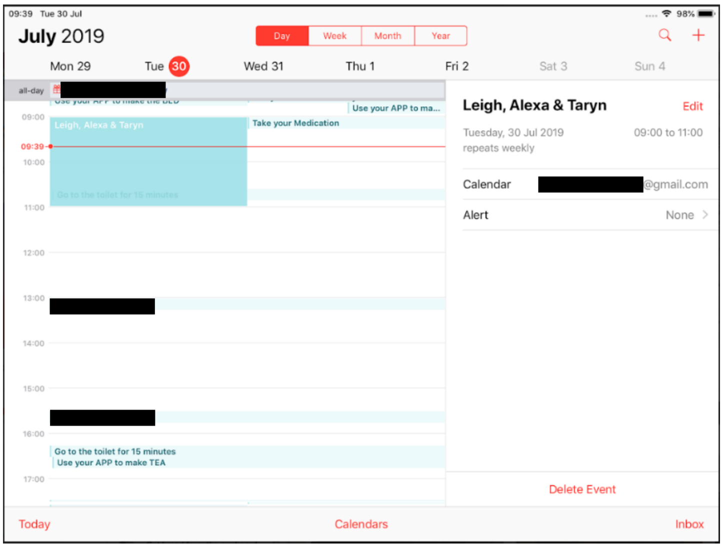


You can add an image from the internet or from your camera roll here ("Add a new image")

It is better to take photos in your environment (e.g. of the kettle in your kitchen) as it will help prompt [FS] where to look if he is unsure

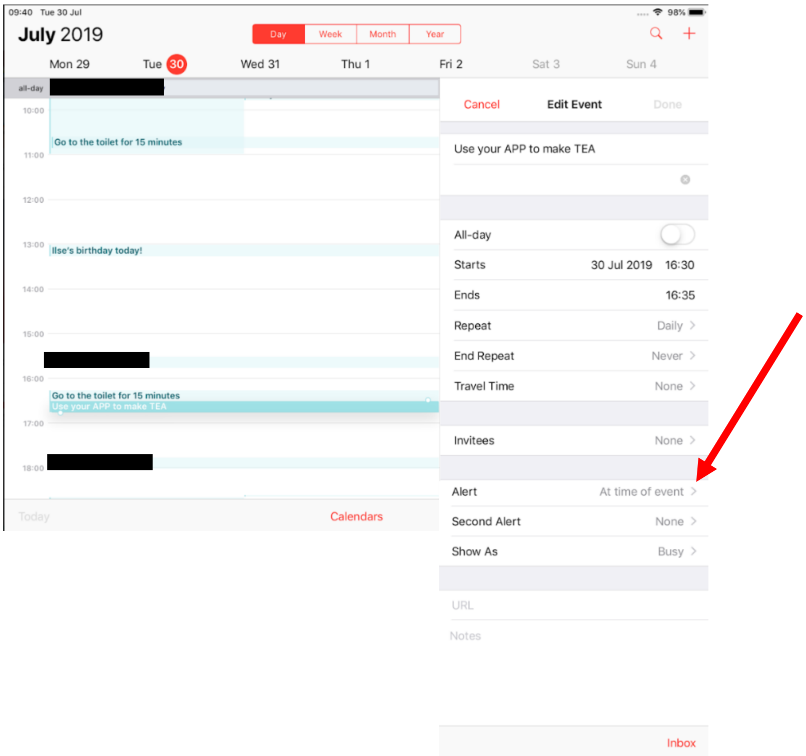
CALENDAR APP

*Used for notifications & reminders



It is important to include all events here that [FS] needs a reminder for

e.g. taking his medication



Give it a descriptive title
(e.g. say use your app if it's a programmed activity)

Make sure the **"Alert"** is programmed **"At time of event"**

*Chosen noise for alert has been pre-programmed through the phone's settings. Although loud, we have tested this with [FS] and this appears to be the best alert sound for him.

Ensure that iPad volume is as loud as possible to ensure he hears it and responds

Appendix L:
Ethical Clearance

UNIVERSITY OF CAPE TOWN

Department of Psychology

University of Cape Town Rondebosch 7701 South Africa
Telephone (021) 650 34[illegible]7
Fax No (021) 650 4104

03 May 2019

Alexa Leach and Taryn Christie- Taylor
Department of Psychology
University of Cape Town
Rondebosch 7701

Dear Alexa and Taryn

I am pleased to inform you that ethical clearance has been given by an Ethics Review Committee of the Faculty of Humanities for your study, *Implementing a neuropsychological rehabilitation program using a single case experimental design with an adult patient following severe traumatic brain injury in Cape Town.* The reference number is PSY2019 -018.

I wish you all the best for your study.

Yours sincerely

University of Cape Town
ΨPSYCHOLOGY DEPARTMENT
Upper Campus
Rondebosch

Lauren Wild (PhD)
Associate Professor
Chair: Ethics Review Committee

Appendix M:
Primary Caregiver Consent Form

Informed Consent to Participate in Research and Authorization for Collection, Use and Disclosure of Cognitive Performance and Other Personal Data

Your partner is being asked to take part in a research study. This form provides you with information about the study and requests your permission for your partner to participate in the research study. Consent is also asked for the collection of questionnaire data, as well as other information necessary from you. Signing this form also gives permission to the researchers for the collection, use and sharing of your partner's cognitive performance data, as well as other information necessary for the study. The Principal Investigators or a representative of the Principal Investigators will also describe this study to you and answer all of your questions. Your partner's participation is entirely voluntary. Before you decide whether or not he may participate, please read the information below and ask about anything you do not understand. By declining participation in this study, you or your partner will not be penalized or lose any benefits to which you would otherwise be entitled.

1. **Name of participant** ____
2. **Title of research study**

   Implementing a Neuropsychological Rehabilitation program Using a Single Case Experimental Designs with Adult Patients Following Severe Traumatic Brain Injury in Cape Town
3. **Principal Investigators and Telephone Numbers**

   Dr Leigh Schrieff (Supervisor)
   Department of Psychology
   University of Cape Town
   021 650 3708

   Alexa Leach (Honours Student)
   Department of Psychology
   University of Cape Town
   079 517 4932

   Taryn Christie-Taylor (Honours Student)
   Department of Psychology
   University of Cape Town
   071 895 6608
4. **What is the purpose of this research study?**

   The aim of this study is to investigate whether neuropsychological interventions (Goal

Management Training and Memory Aids) will improve everyday functioning in an individual with executive and memory deficits following severe traumatic brain injury. The research also aims to contribute to studies on conducting neuropsychological intervention in a low-to-middle-income country setting like South Africa.

5. **What will be done if you provide consent for your partner to take part in this research study?**

   During this study, you will be asked to complete some questionnaires to obtain information about your demographics and relationship with your partner, and his behavioural and emotional state. In addition, we will also test your partner's thinking (their attention, memory, and how fast they think) and problem-solving abilities. Once a week, we will also visit your partner in your home, during which we will teach him compensatory strategies aimed at assisting him with his memory and planning and forming manageable goals around everyday tasks.

6. **If you choose to allow your partner to participate in the study, how long will he be involved in the research?**

   The study is expected to span 3 months including the pre- and post-intervention assessments. The intervention program itself is proposed to last approximately 2 months.

7. **What are the possible discomforts and risks to you and your partner?**

   There are no known risks associated with participation in this study. Should you or your partner get tired during the study, you will be allowed to rest. If you would like to discuss the information above or any discomforts you may experience, you may ask questions now or alternatively, call one of the Principal Investigators listed in #3 of this form.

8. **What are the possible benefits to you and your partner?**

   The aim of the study is to explore possible intervention strategies to assist your partner with his memory and planning and forming manageable goals around everyday tasks. Should these strategies prove effective, your partner may benefit from employing such strategies which could promote further independence in the focus areas of the intervention.

9. **What are the possible benefits to others?**

   The study hopes to contribute to research in neuropsychological rehabilitation in low-to-middle-income countries like South Africa. We hope that the research will shed light on the effectiveness of the proposed intervention strategies for people who have sustained traumatic brain injury.

10. If you choose to allow your partner to participate in this study, will it cost you anything?

Participating in this study will not cost you or your partner anything.

11. Can you or your partner withdraw from this research study?

You or your partner may withdraw your consent or assent and stop participation in this study at any time without penalty. If you have any questions regarding your own and your partner's rights in this research, you may phone Rosalind Adams in the Psychology Department offices at +27 21 650 3417.

12. If you or your partner withdraw, can information about you still be used and/or collected?

Information already collected may be used.

13. Once personal and performance information is collected, how will it be kept confidential in order to protect your privacy?

Only certain people have the right to review these research records. These people include the researchers for this study and certain University of Cape Town officials. Your research records will not be released without your permission unless required by law or a court order.

14. What information about you may be collected, used and shared with others?

The information gathered from you and your partner will be demographic information, records of your partner's performance on neuropsychological (thinking, problem solving and memory) tests and questionnaires on their emotional and behavioural state, and the intervention outcomes. Your and your partner's identities will not be revealed and all the information you give will be kept confidential. We will only use the results of this study for academic research purposes; such as in a research report or a journal article, but it will not include your names.

15. Signatures

As a representative of this study, I have explained to the participant the purpose, the procedures, the possible benefits, and the risks of this research study; and how the participant's performance and other data will be collected, used, and shared with others:

____ ____________________

Signature of Person Obtaining Consent and Authorization Date

I have been informed about this study's purpose, procedures, possible benefits, and risks; and how my partner's performance and other data will be collected, used and shared with others. I have received a copy of this form. I have been given the opportunity to ask questions before I sign, and I have been told that I can ask other questions at any time.

I voluntarily agree for my partner to participate in this study. I hereby authorize the collection, use and sharing of their performance and other data. By signing this form, I am not giving away any of my legal rights.

____ ____________________

Signature of Person Consenting and Authorizing Date

Appendix N:

Participant Assent Form

We are inviting you to take part in our research study. We would like to learn more about neuropsychological rehabilitation and how it can help people who have sustained brain injury.

If you agree to take part, we will meet with you in your home, once a week for two hours. This will take place for about three months. During these sessions, we would like to do some tasks that will test the way you think (memory, planning and problem-solving skills). We would also like to ask you some questions about your mood and emotions. Later on, we would like to teach you some strategies we think might assist you with your memory and might make it easier to do some everyday tasks.

Taking part in this study will not place you at risk in any way. These activities will not harm you, but some of them may be long and you may feel tired at times. If you do, you can stop and rest at any time. There will be no penalty if you choose not to be part of this study or if you choose to stop being part of it. We will ask you each time we meet you whether you would like to continue or not.

We hope the study will help you understand some of your strengths and how to use these to help you in areas in your life you might find challenging after your injury.

Your identity will not be revealed and all the information you give will be kept confidential. We will only use the results of this study for academic research purposes; such as in a research report or a journal article, but it will not include your name.

If you sign this paper it means that you would like to take part in this study. If you would not like to take part in this study, you do not have to sign this form. It is up to you. Before you say whether you want to be part of this study or not, I will answer any questions that you may have. If you have a question later that you didn't think of now, you can ask me next time.

I would like to take part in this study:

Signature of Participant ____________________ Date _________

Signature of Investigator ____________________ Date ________

Appendix O:

Control Participant Consent Form

Informed Consent to Participate in Research and Authorization for Collection, Use and Disclosure of Cognitive Performance and Other Personal Data

You are being invited to take part in a research study. This form provides you with information about the study and requests your consent for your participation. Consent is also requested for the collection of information necessary from you. The principal investigators or a representative of the principal investigators will also describe this study to you and answer all of your questions. Your participation is entirely voluntary. Before you decide whether or not to take part, and whether you would like to participate, please read the information below and ask about anything you do not understand.

1. **Title of research study**

   Implementing a neuropsychological rehabilitation program to assist a patient following traumatic brain injury.

2. **Principal Investigators and Telephone Numbers**

Dr Leigh Schrieff (Supervisor)
Department of Psychology
University of Cape Town
021 650 3708
leigh.schrieff@gmail.com

Alexa Leach (Honours Student)
Department of Psychology
University of Cape Town
079 517 4932
LCHALE003@myuct.ac.za

Taryn Christie-Taylor (Honours Student)
Department of Psychology
University of Cape Town
071 895 6608
tchristietaylor@gmail.com

3. **What is the purpose of this research study?**

   The aim of this study is to investigate whether neuropsychological interventions (Goal Management Training and Memory Aids) will improve everyday functioning in a participant with a severe traumatic brain injury. The research also aims to contribute to studies on conducting neuropsychological intervention in a low- to middle-income country setting like South Africa. Because most neuropsychological tests (including those commonly used in South Africa) have been developed and normed in the United Kingdom and the United States, we need healthy control participant data against which to compare our intervention participant's neuropsychological outcomes.

4. **What will happen if you decide to take part in this research study?**
   During this study, you will be asked to complete some questionnaires to obtain information about your demographics. We will also ask you to participate in neuropsychological assessments that test your thinking (memory, attention and problem-solving skills). We will ask you to do so twice, with the two sessions spaced about 2 months apart.
5. **If you choose to participate in the study, how long will you be involved in the research?**
   You will be tested twice, about 2 months apart. Each testing session should last about 2-2.5 hours.
6. **What are the possible discomforts and risks to you?**
   There are no known risks associated with participation in this study, although testing can be tiring. Should you get tired at any point, you will be allowed to rest and refreshments will be provided. If you would like to discuss the information above or any discomforts you may experience, you may ask questions now or alternatively, call one of the Principal Investigators listed in #3 of this form.
7. **What are the possible benefits to you?**
   You will not personally benefit from the research study.
8. **What are the possible benefits to others?**
   The study hopes to contribute to research in neuropsychological rehabilitation in South Africa. We hope that the research will shed light on the effectiveness of the proposed intervention strategies for treating people who have brain injury.
9. **If you choose to participate in this study, will it cost you anything?**
   Participating in this study will not cost you anything.
10. **Can you withdraw from this research study?**
    You may stop participation in this study at any time without penalty. If you have any questions regarding your rights in this research, you may phone, Rosalind Adams in the Psychology Department offices at +27 21 650 3417.

11. **If you withdraw, can information about you still be used and/or collected?**
    Information already collected may be used but your name and any signifying information will be kept confidential and will be anonymous.
12. **Once personal and performance information is collected, how will it be kept confidential in order to protect your privacy?**
    Only certain people have the right to review these research records. These people include the researchers for this study and certain University of Cape Town officials. Your research records will not be released without your permission unless required by law or a court order.
13. **What information about you may be collected, used and shared with others?**
    The information gathered from you will be demographic information, as well as records of your performance on neuropsychological (thinking, problem solving and memory) tests. Your identity will not be revealed and all the information you give will be kept confidential. We will only use the results of this study for academic research purposes; such as in a research report or a journal article, but it will not include your name. Any information you give will be kept in a locked filing cabinet which only the research team has access to.
14. **Signatures**
    As a representative of this study, I have explained to the participant the purpose, the procedures, the possible benefits, and the risks of this research study; and how the participant's performance and other data will be collected, used, and shared with others:

____ ____________________

Signature of Person Obtaining Consent and Authorization Date

____

Name of the Researcher

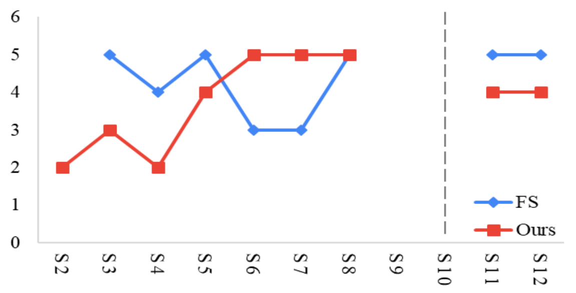
I have been informed about this study's purpose, procedures, possible benefits, and risks; and how my performance and other data will be collected, used and shared with others. I have received a copy of this form. I have been given the opportunity to ask questions before I sign, and I have been told that I can ask other questions at any time.

I voluntarily agree to participate in this study. I hereby authorize the collection, use and sharing of my performance and other data. By signing this form, I am not giving away any of my legal rights.

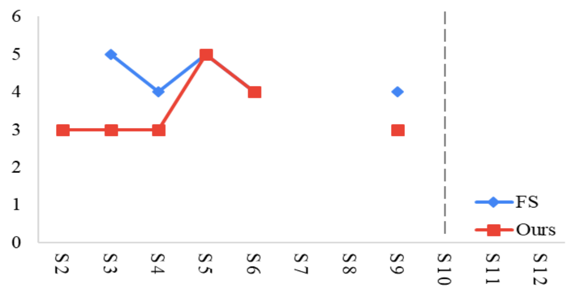
Signature of Person Consenting and Authorizing | Date

Name of Participant

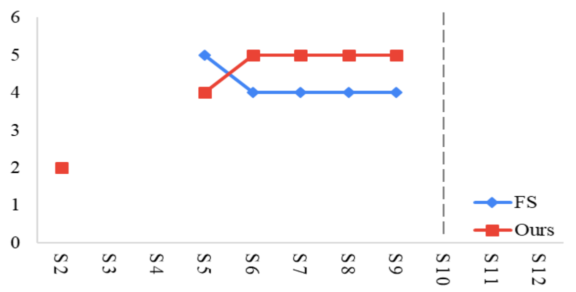
Appendix P:
Execution Ratings Matrix



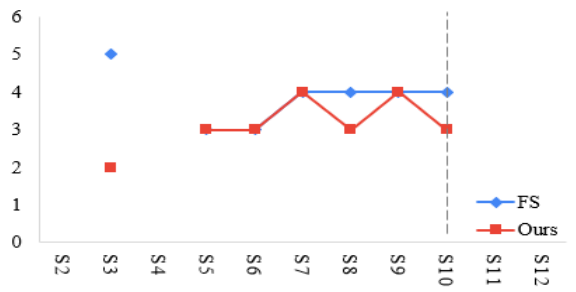
Coffee



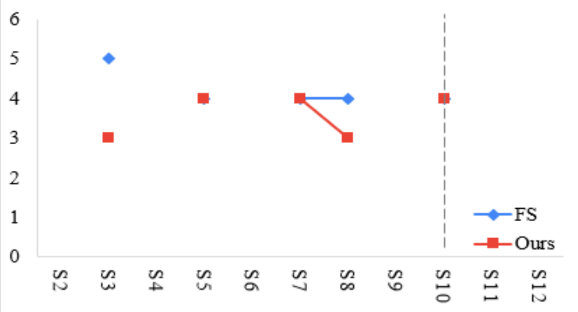
Sandwich



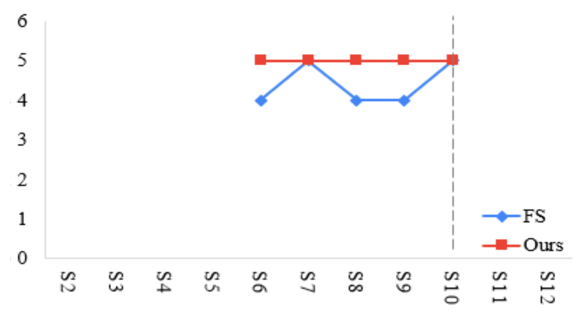
Bed



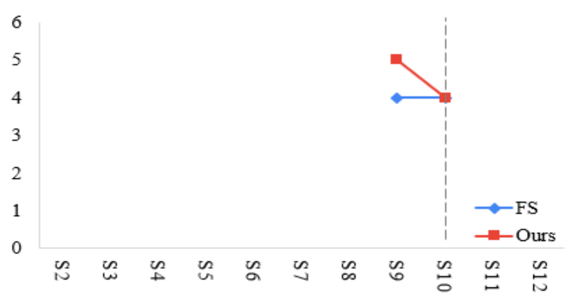
Shaving



Nails



Hair



Tea