Treating Problem Solving Deficits in Traumatic Brain Injury

by

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Abstract

Cognitive deficits following TBI are multidimensional. Current treatment programs approach problem solving training in a top-down approach with problem solving skill perceived as independent of attentional control and working memory. Also, these treatment programs lack sufficient evidence-based data to support maintenance and generalization. The purpose of the current study was to assess the applicability of the bottom-up approach targeting set-shifting (attention), updating (working memory), and inhibition to improve complex problem solving skills in individuals with moderate-severe TBI. The aims of the study were to identify if a bottom-up treatment approach improves, maintains and generalizes complex problem solving skills in familiar and novel problem solving tasks. Three participants with a history of moderate-severe TBI participated in the multiple-probe ABA design study. The multiple probe design included baseline, treatment, and generalization probes administered through the course of the study. Several cognitive measures and problem solving measures were administered to obtain pre-treatment performance. Twenty treatment sessions of 1-hour duration were conducted across five weeks to improve working memory, attention and inhibition skills using paper-pencil and computer training tasks. Post-treatment probes were obtained 1-month after treatment to assess maintenance of learned skills. Results indicate large treatment effects for all participants with significant improvement in pre-post treatment measures of problem solving, memory, attention,

and inhibition skills. Treatment probe scores for problem solving skills were higher than the baseline mean and trend for all participants. These positive trends provide preliminary data to support using a bottom-up approach to improve problem solving skills in adults with moderate-severe TBI. Targeting working memory, attentional and inhibition skills resulted in concurrent improvement in problem solving skills. Positive maintenance data and generalization results further strengthen this novel approach and paradigm shift in treating problem solving deficits.

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Dedication

This project is dedicated to my wife Purnima, my daughter Sara,
my brother Anand and my parents Neeta and Satish Kelkar.
I owe them what is best in me.

I also dedicate this project to members of the Brain Injury Support Group
Fayetteville, North Carolina.
They are a lesson in resilience of the human spirit.

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Introduction to traumatic brain injury

Traumatic brain injury (TBI) occurs when an outside force traumatically injures the brain resulting in possible death or disability; it commonly results from motor vehicle accidents, falls, or violence. Most TBIs occurring in the United States are a result of direct blunt-force trauma from falls or motor vehicle crashes. Data from the Centers for Disease Control and Prevention indicate an annual incidence of emergency department visits and hospital admissions for TBI to be 403 per 100,000 and 85 per 100,000, respectively with the cost for direct TBI medical care estimated at more than $56 billion per year (McKean, Ross, Dressler, Brotman, & Ginsberg, 2012).

Leading causes of TBI are falls –28%, motor vehicle accidents – 20%, being struck by or against objects – 19%, and assault – 11% (Langlois, Rutland-Brown, & Wald, 2006). In the United States, persons in the 15–24 and 64+ age groups are at highest risk, with males at more risk than females at a ratio of approximately 2.8:1.6. In the younger age group (15-24 years), sports related TBI is second only to MVA as a leading cause of injury with 300,000 cases annually in the United States (Gessel, Fields, & Collins, 2007; Langlois et al., 2006; Morris, 2010). In the past decade, TBI resulting from blast injury is a significant source of morbidity in military service personnel in the Iraq and Afghanistan wars (Warden, 2006).

Types of injuries

Traumatic brain injuries are classified as penetrating or closed, with different pathophysiological processes observed for each. Penetrating or open head injuries (PHI) cause fracture or breach of the skull and penetration of the meninges with laceration or destruction of

brain tissue, along with higher mortality rate. Trauma to the skull results from low-velocity bullets, puncture, everyday objects that may become embedded or from a tangential injury whereby an object strikes the skull (especially in case of blast injuries), causing bone fragments to be driven into the brain (Hannay et al., 2004; McCullagh & Feinstein, 2005; Peek-Asa, McArthur, Hovda, & Kraus, 2001). In most cases, such focal lesions cause relatively circumscribed cognitive losses; however, penetrating objects may cause damage throughout the brain depending on shock wave or pressure effects from the speed and malleability of the penetrating object (Peek-Asa et al., 2001). Secondary injuries from metabolic and physiologic processes such as edema, ischemia, or posttraumatic epilepsy can be as or more damaging than the primary injury.

Closed head injury (CHI) is the most common type of TBI in which the skull remains relatively intact and the meninges are not penetrated. Primary effects of CHI include DAI impacting particularly the orbital and polar aspects of the frontal lobes, due to the proximity of these regions to the bony surfaces of the skull. Damage to the dorsolateral prefrontal cortex and orbitofrontal cortex leads to frontal lobe dysfunctions. Potential secondary effects in CHI include development of subdural hematoma, intracerebral bleeding, increased intracranial pressure, hypoxia, obstructive hydrocephalus, and posttraumatic epilepsy (Werner & Engelhard, 2007).

Cognitive and behavioral changes are often the most salient features noted after closed head injury of any severity. The extent of impairment is reflected by the severity of the DAI, extent of generalized atrophy, and the location, depth, and volume of focal cerebral lesions (McCullagh & Feinstein, 2005; Werner & Engelhard, 2007). The nature and frequency of the cognitive and/or behavioral difficulties are due to concentration of damage in the anterior regions

of the brain. After a CHI, a person may experience any of the following symptoms: loss of consciousness (LOC), post-traumatic amnesia (PTA) dilated/unequal pupils, vision changes, dizziness, balance problems, respiratory failure, paralysis, slow pulse, slow breathing rate, vomiting, lethargy, headache, confusion, tinnitus (ringing in ears), inappropriate emotional responses, loss of bowel/bladder control, speech changes, or body numbness or tingling (McCullagh & Feinstein, 2005). Of these, LOC and PTA are considered important variables when classifying the severity and estimating the prognosis of traumatic brain injury.

LOC is the inability to perceive and respond to external stimuli. Consciousness is defined as the full state of awareness of self and one's relationship to the environment (Laureys, Perrin, & Bredart, 2006; Plum & Posner, 1983). Thus LOC may range from a few minutes to a vegetative state of coma. Coma is described as a state of unresponsiveness in which the patient lies with eyes closed and cannot be aroused to respond appropriately to stimuli even with vigorous stimulation (Iverson, Lovell & Smith, 2000; Laureys et al., 2006). It reflects loss of function in both the cortex and the brainstem reticular system and rarely lasts more than two to four weeks (Giacino & Whyte, 2005). The measure most commonly used for the purpose of grading coma is the Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974, 1976). It utilizes best eye-opening, and best verbal and motor responses, in order to regularly monitor improvement and/or deterioration over time. Responses in each category are ranked and assigned a numerical value, yielding a total score between 3 (a person showing no response on any dimension) and 15 (a person who is alert and well-oriented). Teasdale and Jennett (1974) defined coma as the absence of eye-opening, a failure to obey commands and a failure to give any comprehensible verbal response. This definition of coma corresponds to a score of 8 or less on the amended GCS.

CHIs are usually followed by a transient state of confusion and disorientation referred to as PTA, which is characterized by intellectual and behavioral disturbances. The hallmark of this state is anterograde amnesia (AA), which is the impaired ability to remember events after the onset of a condition. Although clinicians had recognized this state previously, its modern conception originated with Symonds (1940) who distinguished the `clouded consciousness' of this state from the `unconsciousness' that precedes it, and who was the first to use their combined duration as a criterion for severity of CHI. Symonds and Russell (1943) later defined the duration of PTA as the time of injury to when the patient can give a clear and consecutive account of what was happening around him by careful questioning after recovery of full consciousness and normal orientation. Russell and Nathan (1946) emphasized that to be out of PTA, patients had to demonstrate `continuous memory', or the ability to commit events to memory reliably. PTA has since become a common term of clinical usage, and its duration, which varies from minutes to months, remains one of the best predictors of outcome after closed head injury (Ellenberg, Levin, & Saydjari, 1996). Moreover, many clinical management decisions are made at the time that the patient is considered to have emerged from PTA, such as hospital discharge in less severely injured patients and commencement of formal therapies in the more severely injured (Tate, Pfaff, & Jurjevic, 2006).

Severity of TBI

Severity classification in traumatic brain injury (TBI) has been the subject of long standing interest because of its relationship to acute and post-acute medical care and social/functional outcome (Levin, 1995; Malec et al., 2007). In most research studies and often in clinical care, TBI severity is classified according to single indicators such as the GCS, duration of PTA, and duration of LOC. A TBI severity classification system should distinguish clinical

characteristics of the least as well as the most severe injuries as most cases of TBI are not severe (Malec et al., 2007). TBI may be present in cases in which none of the indicators previously reviewed are recorded. Such cases typically come to clinical attention when a patient with a history of head trauma reports "postconcussive" symptoms such as feeling dazed, dizziness, headache, or nausea (Evans, 2006; Malec, 1999).

The Mayo Classification System for TBI Severity was developed to classify cases based on available indicators that included death due to TBI, trauma-related neuroimaging abnormalities, GCS, PTA, loss of consciousness and specified post-concussive symptoms (Malec et al., 2007). This study shall utilize the Mayo Classification system for identifying participants with mild and moderate-severe deficits. According to the classification system, an individual is classified as having Moderate-Severe (definite) TBI if one or more of the following criteria apply:

1. Death due to this TBI
2. Loss of consciousness of 30 minutes or more
3. Post-traumatic anterograde amnesia of 24 hours or more
4. Worst Glasgow Coma Scale full score in first 24 hours is less than 13 (unless invalidated upon review, e.g., attributable to intoxication, sedation, systemic shock)
5. One or more of the following present:
    - Intracerebral hematoma
    - Subdural hematoma
    - Epidural hematoma
    - Cerebral contusion
    - Hemorrhagic contusion

• Penetrating TBI (dura penetrated)

• Subarachnoid hemorrhage

• Brain Stem Injury

If none of the above mentioned criteria apply, then the individual is classified to have Mild (probable) TBI if one or more of the following criteria applies:

1. Loss of consciousness of momentary to less than 30 minutes
2. Post-traumatic anterograde amnesia of momentary to less than 24 hours
3. Depressed, basilar or linear skull fracture (dura intact)

A third classifying level is also included in the severity system, which is considered if none of the criteria in moderate-severe or mild categories apply. These cases are classified Symptomatic (Possible) TBI if one or more of the following symptoms are present:

• Blurred vision

• Confusion (mental state changes)

• Dazed

• Dizziness

• Focal neurologic symptoms

• Headache

• Nausea

It is important to note that the Mayo system was structured to conservatively reflect the severity of brain trauma based on the strength of available evidence. Cases of Moderate-Severe injury are those with relatively strong evidence of definite brain trauma. Mild cases are those

with weaker evidence of probable TBI. Symptomatic cases are those with only equivocal documented evidence of the occurrence of possible TBI.

Cognitive functions

Executive functions

Over the past 50 years, executive function (EF) and its associated "frontal-executive" theories have gained significant attention of scholars of cognitive aging and neuropsychology. Several writers have attempted to define and measure executive functioning. Luria (1966, 1973, 1980) proposed the concept of EF distinguishing three functional units in the brain: (1) arousal-motivation (limbic and reticular systems); (2) receiving, processing, and storing information (post-rolandic cortical areas); and (3) executive unit for programming, controlling, and verifying activity, depending on the activity of the prefrontal cortex. Lezak (1983) referred to executive functioning to discriminate cognitive functions from the *how* or *whether* of human behaviors. According to Lezak (1983), executive functioning refers to the integration of several cognitive skills people require to adapt to novel situations and pursue their life goals, which includes planning, initiation, and regulation. The abilities of goal formation, planning, carry out goal-directed plans, and effective performance are necessary for appropriate, socially responsible and effectively self-serving adult conduct (Lezak et al., 2004).

Neuropsychologists and cognitive psychologists approach EF from different perspectives. The former focuses on executive dysfunction as an impairment in behavior or cognitive performance that is a direct consequence of neurological insult to the frontal lobe with the primary intention of confirming a diagnosis. The latter addresses EF as a range of mental control

processes associated with neuroanatomical integrity of the brain consisting of a collection of higher order functions that form a system of control processes (Luszcz & Lane, 2008; Luszcz, 2011).

Definitions for EFs are abound in the neuropsychology literature. For the purpose of this study the definition provided by Miyake, Friedman, Emerson, Witzki, Howerter, and Warden (2000) shall be considered in context for EFs. Miyake and colleagues consider EFs as encompassing cognitive control processes that include three separate subcomponents – shifting, updating, and inhibition. They chose these three functions because (1) these subcomponents are relatively circumscribed, lower level functions and can be operationally defined in a fairly precise manner, (2) these EFs can be assessed with well-studied, relatively simple cognitive tasks and (3) most importantly, the three target functions are likely to be implicated in the performance of more complex, conventional executive tests. For example, the Wisconsin Card Sorting Test has often been suggested as a test that measures set shifting (for shifting between sorting principles) as well as inhibition (for suppressing inappropriate responses) (Konishi, Nakajima, Uchida, Kameyama, Nakahara, Sekihara, & Miyashita, 1998). Detailed below are the definitions and reviews for the three lower level EFs that are the building blocks for the study.

Shifting between tasks (Shifting). The first executive function concerns the ability to shift back and forth between multiple tasks, operations or mental sets (Miyake et al., 2000; Monsell, 1996). Also known as task/attention switching, this ability appears to be crucial not only in disengaging an irrelevant or low priority task and shifting to a more relevant or higher priority task but also for overriding proactive interference from recently performed task (e.g., subtracting "3" from a list of two-digit numbers which were recently added by "3" causing negative priming

effect) (Allport & Wylie, 2000, 2001). Executive-oriented shifts may be regulated primarily by the frontal lobes, including the anterior cingulate (Miyake et al., 2000; Posner & Raichle, 1994).

Updating and monitoring of working memory representations (Updating). This second EF is related to monitoring and coding of incoming information for relevance to the task at hand and then appropriately revising the items held in working memory by replacing old, non-relevant information with newer, more relevant information (Miyake et al., 2000; Morris & Jones, 1990). This updating process is closely related to working memory and may involve temporal mapping to track which information is old and non-relevant (Smith & Jonides, 1997, 1999). This temporal tracking is not a passive storage of information but rather an active manipulation of relevant information in working memory. The dorsolateral prefrontal cortex has been associated with the Updating functions of temporal sequencing and monitoring (Smith & Jonides, 1997, 1999).

Inhibition of prepotent responses (Inhibition). The third EF concerns one's ability to deliberately inhibit dominant, automatic, or prepotent responses when necessary. A typical inhibition task would be the Stroop task, in which one needs to inhibit the tendency to produce a more dominant or automatic response (e.g. read the word instead of its color). Inhibition is constrained to the deliberate, controlled suppression of prepotent responses and it does not refer to reactive inhibition that occurs due to negative priming (Logan, 1985; Miyake et al., 2000)

It is important to note that these EFs are lower level functions with no supervisory control over higher level metacognitive functions such as problem solving, abstracting, planning, strategy development, and implementation (Ardila, 2008; Fuster, 2001, 2002; Happaney, Zelazo & Stuss, 2004). Miyake et al. (2000) considered these executive functions as a non-exhaustive conceptualization of control processes, at a relatively low level of analysis, which proved to be

appropriate for reaching a better understanding of the relationship between control processes and complex cognitive tasks. This definition of EF is used to support the idea that three capacities - *shifting, updating* and *inhibition* - are correlated yet separate. Accordingly, several studies have identified that the three mechanisms share substantive variance and overlap in subserving brain regions (Huizinga, Dolan, & van der Molen, 2006; Tabibnia et al., 2011). Moreover, in support of the notion that cognitive capacity has a limited resource reservoir, acting on one executive mechanism temporarily reduces the ability to exert executive control in the same or in the other two domains (Hofmann et al., 2012; Schmeichel, 2007). The present study tries to relate executive functions and problem solving, two important processes in the realm of higher order cognition. Proposed is the notion that these three skills form the foundational basis upon which higher EF of problem solving processes are layered. Though executive functions and problem solving are usually considered to be tightly connected, the relationship between executive control and problem solving processes has not been articulated in a hierarchical paradigm.

Problem solving

Problem solving has been defined as a goal-directed cognitive activity that arises in situations for which no response is immediately apparent or available (Luria, 1966). ‘‘Being confronted with a problem’’ simply means that we want to achieve a certain goal, whereas the steps to solve this problem are uncertain, unknown, or need to be performed in a particular order (Unterrainer & Owen, 2006). Problems therefore have three general characteristics: (1) an initial state, or the state in which the problem solver sorts out the givens; (2) a goal state, or the solution state that the problem solver tries to achieve; and (3) the steps that the problem solver takes to

transform the initial state into the goal state that initially may not be obvious (Sternberg & Ben-Zeev, 2001).

Situations requiring problem solving have in common the requirement to take some precautions in order to meet the goals. Resolution of problems requires completion of three critical steps (1) goal directedness (the behavior is clearly organized towards a goal); (2) sub-goal decomposition (the original goal is divided into sub-tasks or sub-goals); and (3) operator application[1]. In order to accomplish these steps one needs to (a) create a mental representation of both the current situation and the goal and (b) link these representations by establishing which actions need to be completed in order to transform the current state into the goal state. Effective problem solving requires the individual to plan a series of complex steps in a particular sequence. In this sequence, the initial step is for the individual to be able to label or identify the task demands accurately (Kennedy & Coelho, 2005). Once this is accomplished, the individual must:

- Identify the goal
- Identify all the potential strategies that could be used
- Compare and contrast the strategies to decide which would be the optimal one for this particular problem
- Prioritize strategies in order of preference and likelihood of success; include alternative strategies as a backup
- Create steps of action that are necessary, including identifying and gathering the necessary materials

[1] The term operator refers to an action that transforms one problem state into another problem state. The solution of the overall problem is a sequence of these known operators (Anderson, 2000; Channon & Crawford, 1999).

- Initiate the action steps
- Self-monitor/check the action steps as they are performed
- Modify the steps as necessary, implementing alternative strategies if needed
- Continue with action steps, modifying as needed until goal is achieved
- Retrospectively review what worked and what did not and why

Not all these steps are required in every problem solving situation. However, it is critical to be able to identify these steps when encountered with a problem that requires extensive planning. The ability to problem solve is considered as a higher level, metacognitive EF that 14is easily disrupted by and commonly associated with TBI. For the purpose of this study, the two concepts of problem solving and planning are used interchangeably and refer to the ability to resolve a potential or evident conflict.

Executive dysfunction in TBI

Attentional control and working memory deficits

Recently, researchers found that participants with severe TBI demonstrated a significant dual-task decrement. Severe TBI impairs the ability to deal simultaneously with two different tasks, when the tasks put a significant load on working memory and/or inhibition (Azouvi et al., 2004; McDowell, Whyte, & D'Esposito, 1997; Vilkki, Virtanen, Surma-Aho, & Servo, 1996). Park, Moscovitch, and Robertson (1999) investigated the interaction between divided attention and working memory load, and found that dual-task performance of participants with severe chronic TBI was significantly impaired under significant working memory load conditions,

requiring controlled processing. Convergent findings have been reported in additional studies, where participants with severe TBI had to perform dual tasks under different conditions, using different difficulty levels, or different degrees of dependency between the subtasks (Brouwer et al., 2001, 2002; Withaar, Brouwer, & van Zomeren, 2000). A divided attention deficit was found only in the more demanding conditions. Additionally, dual-task measures under the most difficult condition evinced the highest correlations with performance in daily-living activities, thus suggesting the ecological validity of divided attention performance under high time-pressure (Withaar et al., 2000). Similar results were found in divided attention studies performed by Azouvi and colleagues (1996). They found that using a dual-task paradigm performed without time-pressure and requiring little executive control, showed no disproportionate dual-task impairment in the TBI group. However, in two other experiments under more demanding conditions (either because of time-pressure or because of higher task complexity), participants with TBI showed a significant impairment in dual-task processing (Azouvi et al., 1996; Leclercq et al., 2000).

Sustained attention is an endogenous process, where people engage in sustained, mindful, conscious processing of repetitive, non-arousing stimuli which is susceptible to habituation and distraction to other stimuli (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). TBI participants' deficits in sustained attention are well documented. Vigilance tasks require participants to detect infrequently occurring targets over long periods of time. TBI participants have been shown to be impaired in such tasks (Whyte, Polansky, Fleming, Coslett, & Cavallucci, 1995; Wilkins, Shallice, & McCarthy, 1987). TBI participants also have difficulty with continuous performance tasks of sustained attention, which require the participant to maintain his/her response (to the go targets), but to inhibit response to certain infrequently occurring

stimuli (the no-go target) (Chan, 2001; Robertson et al., 1997). The loss of inhibitory control is discussed in the following section.

Inhibition deficits

Inhibitory control, in particular, is an important function of the frontal–subcortical executive system allowing us to suppress, interrupt, or delay an activated behavior or cognitive course of action (Aron, Robbins, & Poldrack, 2004; Starkstein & Robinson, 1997). Clinical features of TBI suggest a failure in this mechanism, with frequent reports of an inability to inhibit impulsive and habitual behavior and socially inappropriate responses such as inappropriate touching and verbal disinhibition (Rao & Lyketsos, 2000). Brain imaging findings during tasks involving cognitive control also support inhibition deficits with reduced activation in prefrontal regions in participants with mild and moderate-to-severe TBI (McAllister et al., 1999, 2001; Perlstein et al., 2004; Soeda et al., 2005). Response inhibition, typically measured as the number of inhibition failures (i.e., failure to stop a response when required), has been found to be impaired in adults with TBI compared with controls in a number of studies (e.g., O'Keeffe, Dockree, Moloney, Carton, & Robertson, 2007; Roche et al., 2004). Other measures of response inhibition include the speed of the inhibition process, termed the stop-signal reaction time (SSRT; Logan, 1994).

Examining inhibition of a prepotent response in the response inhibition paradigms separately revealed a moderate deficit in adults with TBI, as measured by SSRT. Automatic and habitual responding following TBI is common, and indeed these participants show little or no difficulty with automatic or well-learned tasks (Levin, Goldstein, High, & Williams, 1988; Loken, Thornton, Otto, & Long, 1995). Problems become evident when effortful processing is

demanded to stop a course of action that is made inappropriate by changing circumstances. Inefficient response inhibition can arise when inhibition fails to activate or is slow to activate, or if the response process is relatively too fast and/or variable (Logan, 1994). Mild to severely injured TBI adults showed overall slower response speed than controls, and the measure was unrelated to the inhibition effect; it is unlikely that response speed contributed to impaired inhibition. Consequently, this analysis suggests that the difficulty lies with inhibition itself that is, failing to activate or activating too slowly (Di Marco, McDonald, Kelly, Tate, & Johnstone, 2011).

The Stroop Color–Word Task is often used to measure a cognitive form of inhibition known as interference control (Stuss, Floden, Alexander, Levine, & Katz, 2001). This task includes subtasks involving color naming and/or word reading that measure attention and processing speed and a third subtask involving color naming when the color word and ink are incongruent. Effortful inhibition at a covert, cognitive level is required in the third subtask to suppress the competing automatic response in favor of the correct response (Nigg, 2000).

As demonstrated, there is a significant interaction between disruptions in attentional controls, working memory, and inhibition control in individuals with severe TBI. Inhibitory control along with attentional control and working memory present as important cognitive functions to focus on as they have been shown to be amenable to functional changes arising from learning and rapid plasticity of neural networks (Chambers et al., 2006; Chambers, Garavan, & Bellgrove, 2009; Kelly, Hester, Foxe, Shapner, & Garavan, 2006). From a clinical perspective, identifying deficient inhibition, attention, and working memory processes in TBI is useful for the development of targeted cognitive training to complement or replace existing rehabilitation

programs. The utility of this line of research has been identified by researchers, with a recent surge in studies examining the role of treating inhibition, attention and working memory deficits in TBI since 2000 (e.g., Felmingham, Baguley, & Green, 2004; Larson, Kaufman, Schmalfuss, & Perlstein, 2007; Perlstein, Larson, Dotson, & Kelly, 2006). Researchers are beginning to adopt theoretical frameworks that target frontal lobe-mediated top-down modulatory processes to guide cognitive training that are either specific task-based, specific impairment-based (e.g. decision making) or learning –based approaches in order to remediate higher level cognitive deficits (e.g. problem solving). However, there has been no known attempt to consolidate and remediate inhibition, shifting and updating deficits, which are the foundations of higher level EF in a bottom-up modulatory process, as proposed in the current study. The focus of the study is to develop and apply a treatment program that improves the higher-level metacognitive functions of problem solving/planning through focused training of the lower level EFs of shifting, updating and inhibition. The following sections describes problem solving deficits as a higher level EF and the shortcomings of existing cognitive training programs that approach it in a top-down modular process.

CHAPTER 2: PROBLEM SOLVING DEFICITS IN TBI

Both focal and diffuse frontal lesions after TBI disrupt activities of daily living (ADL) and EF impairments contribute to the cognitive component of ADL failure. The frontal lobe is responsible for a variety of executive functions, including inhibition. Not surprisingly, following a TBI many patients have difficulty inhibiting their behaviors, especially patients who have suffered injury with a frontal lobe focal point. It is generally understood that impaired planning might reflect damage within the prefrontal cortex, which is particularly susceptible to trauma. Neuroimaging studies of individuals with TBI identified the frontal brain, particularly the rostrocaudal region, as the most frequent lesion site (Levin, et al., 1997, Unterrainer & Owen, 2006).

Planning is a complex process that involves goal formation, development of a sequence of strategies to fulfill that goal, implementation of the devised strategies, and the ability to utilize feedback to alter unsuccessful strategies (Kaller, Unterraniner, Rahm, & Halsband, 2004). The ability to inhibit behavior, or cognitive control, is needed when a situation is ambiguous or a high probability response is not appropriate. Cognitive control is critical for completing goal directed behaviors, and a weakness in this area can have a significant impact on an individual's quality of life (Stuss, Shallice, Alexander, & Picton, 1995). Unfortunately, impairment in planning ability has significant functional consequences for individuals with TBI because this ability is essential for independent living (Burgess & Shallice, 1996; Jefferson, Paul, Ozonoff, & Cohen, 2006). Due to this deficit, patients often experience difficulties when faced with choice or ambiguity. In particular, executive abilities of planning, self-monitoring and self-correction, decision-making,

and judgment are considered critical for independent, adaptive functioning within real world settings (Eslinger & Damasio, 1985; Fortin, Godbout, & Braun, 2003).

EF deficits of inattentiveness, mental slowing, impulsivity, and lack of prospective memory can all contribute to major functional impairments after TBI. The impact of such impairments can be damaging to a complex cognitive-emotional *macrostructure* or *managerial knowledge unit* (including strategic planning, procedural memory, and working memory) that underlies most multi-step requirements of real life, such as meal preparation or recreational activity (Eslinger & Damasio, 1985; Fortin, Godbout, & Braun, 2003; Grafman, 1995). Penfield and Evans (1935), neurosurgeons at the Montreal Neurological Institute, described three cases of patients who had sustained extensive neurosurgical excisions of the frontal lobes. Of particular interest was one young woman who, following surgery, exhibited a marked failure to organize and plan her daily activities. She was unable to plan and prepare an entire family meal, but was nevertheless perfectly capable of cooking the individual dishes. Subsequently, such disabilities have usually been accounted for in terms of deficits in the cognitive processes involved in planning, although rather few studies have addressed this issue directly.

Meal preparation, managing a budget or going to a movie may well be more difficult than cognitive tasks presented during a formal clinical testing session because the former situations require an individual to develop and implement a plan and invest executive resources in accomplishing the many aspects of the task (Fortin, Godbout, & Braun, 2003; Shallice & Burgess, 1991; Levine et al., 2000). Luria (1966) noted that individuals with lesions to the frontal lobes were unable to analyze problems systematically and identify important connections and relationships. They typically had no specific plan to solve the problem, did not appear to

engage in a preliminary investigation of the nature and constraints of the problem, and evidenced impulsive actions. He described this phenomenon as an impairment in self-regulation, resulting in EF impairments involving anticipation (e.g., unrealistic expectations, failure to appreciate consequences), planning (e.g., impulsivity, poor organization), execution (e.g., perseveration, difficulty maintaining set), and self-monitoring (e.g., emotional dyscontrol, poor error recognition). Such findings once again illustrate an obstacle that individuals with TBI must face when attempting to include themselves into their community and increase their quality of life. The common weaknesses and deficits discussed above are only a small sample of many of the difficulties that individuals with TBI may need to overcome. These problems can have a significant effect on their quality of life. A longitudinal study done by Johnston and Miklos (2002) reported that life satisfaction appears to steadily decline after an individual experiences a brain injury. Cognitive rehabilitation is therefore of paramount importance for individuals with TBI to improve their quality of life.

Cognitive rehabilitation

Cognitive rehabilitation refers to a wide range of methods aimed at remediating or compensating for decreased cognitive abilities. However, in recent decades, it has been emphasized that treatment should focus on the individual rather than on the impaired cognitive function. The influence of specific contextual variables on rehabilitation plans, the emotional and social aspects associated with brain injury, and their interactions with cognitive function should be clarified for each patient, in order to precisely assess the patient's particular needs. The

goal of treatment is a functional change that results in meaningful changes in the individual's everyday life, including improved autonomy and satisfactory social relationships.

As executive functions are essential to the planning/problem solving and effective execution of all purposeful behavior, executive dysfunction leads to a variety of difficulties in daily living and represents one of the most significant barriers to post-TBI recovery and community reintegration. Cognitive rehabilitation refers to various theoretically based and empirically validated interventions that have been designed to maximize cognitive functioning and thereby minimize the functional consequences of post-TBI cognitive and behavioral impairments. In general, cognitive rehabilitation teaches individuals the cognitive skills necessary to perform tasks that they were able to do before their injury but not able to do following their injury. Treatment may focus on improving function in any or all of the following domains: attention, visual perception, memory, learning, and executive functioning (ie, organization, planning, or problem solving). Three rehabilitation programs specific to remediating problem solving deficits are critically described in the following sections.

Problem Solving Training (PST)

vonCramon et al. (1991) developed a cognitive remediation program called Problem-Solving Training (PST) and tested it in a small group study with the primary intention of providing participants with techniques to enable them to reduce the complexity of a multistage problem by breaking it down to more manageable portions. They theorized that a slowed down, controlled and stepwise processing of a given problem should replace the unsystematic and often rash approach these participants spontaneously prefer. Sixty-one participants with various etiologies of brain damage (TBI n= 32), with an average post-onset time of 6 months, were

divided into two groups-poor problem solvers (PS minus) and good problem solvers (PS plus) - using the medians of three problem-solving tasks (modified card-sorting test, tower-of-Hanoi puzzle, planning test). PS-plus and PS-minus participants did not significantly differ as to age, sex and time since lesion. However the PS-minus group had significantly lower results on all cognitive tasks measuring various aspects of attention and memory than PS-plus group.

The 37 poor problem solvers were alternately allocated (in the sequence of their admission) to either the PST (n = 20) or a memory-training (MT; n = 17) program. Two examiners delivered the PST program over a period of 6 weeks, with a mean of 25 sessions per participant in a group setting. Three group members cooperated on a given task as a team. The trainer interfered only when solution barriers occurred. Working together for an hour, participants had to adapt to their individual differences in efficiency and speed of performance. The therapeutic goals were oriented towards five aspects of problem solving behavior (D'Zurilla & Goldfried, 1971) (a) problem orientation (b) problem definition and formulation (c) generating alternatives (d) decision making and (e) solution verification. Two dimensions of assistance or cueing were followed: (1) the level of assistance ("amount of cueing"); (2) the mode of assistance ("how to cue"). A *saturated cueing* approach was used for the first dimension where on an instance a participant failed on a problem or on a particular portion of a problem, a general cue was first given to facilitate performance. If still unsuccessful, a more specific cue was given; this cueing process continued from general-to-specific until the participant was able to solve a given problem flawlessly, with the therapist's assistance. After a given criterion was attained, prompts and cues were reduced stepwise ("fading out"), passing from external control of the response to internalization (Luria, 1963). All kinds of verbal and non-verbal cues were presented in the visual and auditory modality, to provide participants with (structured) schemes, sketches,

context information, etc. The memory-training program targeted impaired memory and was of comparable intensity and duration to the PST program where participants were taught various internal memory strategies, such as visual imagery, association recall, first letter cueing, etc.

Results indicated significant pre-post treatment effects for three (reasoning, categorization, and similarities) out of five intelligence sub-tests in the PST group (analogies and proverbs being the other two). Ten of 17 PST participants showed marked improvement on the subtest "Categorizing". In contrast, no comparable effects were found for the MT group. A significant post-treatment group effect was also observed for the Tower-of-Hanoi where nine of 14 PST participants reached the predefined criterion of at least 10 moves less in the fourth and fifth trials. By comparison, only one out of 12 MT participants performed significantly better on the planning test, and two out of eight MT participants significantly improved on the tower-of-Hanoi puzzle.

The findings relevant to this study are that the pre/post comparisons of some attentional and memory functions revealed no relevant treatment effects in the PST group, even though the participants in the PS-minus group had lower (pretreatment) results in virtually all attentional and memory functions. The researchers stated poor specificity and sensitivity of "problem-solving behavior" or "executive function" as the reason for their findings. Interestingly, four out of eleven MT participants achieved better rating scores for their general "problem-solving ability". The researchers state that the positive effects on problem-solving behavior may be due to an unspecific improvement of other (more basic) cognitive functions, which could have been influenced differently by the PST or the MT. These findings reiterate the oversight in approaching problem solving skill in a top-down approach.

Goal Management Training

The Goal Management Training (GMT) was developed based on Duncan's (1986) theory of disorganization of behavior following frontal lobe lesions which states that much of the disorganized behavior seen in participants with frontal systems dysfunction (i.e., dysfunction in the frontal cortex or its interconnections) can be attributed to impaired construction and goal neglect. GMT targets the disorganization of behavior, which is commonly seen following TBI and aims to improve goal directed behavior through training in five discrete stages of goal completion. Each of the five GMT stages corresponds to an important aspect of goal-directed behavior (Levin et al., 2000). In Stage 1, orienting, participants are trained to assess the current state of affairs and direct awareness towards relevant goals. Goals are selected in Stage 2, and these are partitioned into sub-goals in Stage 3. Stage 4 concerns encoding and retention of goals and sub-goals. In Stage 5, the outcome of action is compared with the goal state (monitoring). In the event of a mismatch, the entire process is repeated.

The study comprised two phases. In the first phase participants in the GMT group were provided with repeated practice in applying GMT steps to three abstract paper-and-pencil training tasks, while a control group completed the tasks without GMT. In the second phase, GMT was applied to real life meal preparation activities in a single case study involving a postencephalitic participant. For the first part of the study, Levin et al (2000) applied GMT to participants with moderate TBI who were 3-4 years post-onset time and presented with impaired self-regulation in a randomized group trial. The group trial demonstrated the potential efficacy of GMT in real-life situations using paper-and-pencil tasks similar to many everyday activities. Thirty participants were randomly assigned to receive brief trials of GMT or motor skills training (MST). The MST included procedural processes unrelated to goal management; such as, reading

and tracing mirror-reversed text and designs. Before and after training, both groups completed everyday paper-and-pencil tasks designed to mimic unstructured situations that give rise to goal management deficits. The researchers hypothesized that participants receiving GMT would show greater improvement on the post-training tasks (relative to the pre-training tasks) than participants receiving MST. Severity indicators (GCS and PTA) indicated an overall moderate level of severity with 24 participants reporting good recovery and 6 stating moderate disability.

Their results support the notion that attention, working memory and executive functions are intimately related. However, in reality, rehabilitation of the three interrelated skills has developed separately. According to proponents of GMT, attention rehabilitation employs time constrained, simple tasks in a highly structured format, whereas executive functioning rehabilitation involves complex, unstructured tasks that are not time-limited (Levin et al., 2000; Robertson et al., 1997). However, realistically, attention rehabilitation should target unstructured, time-independent tasks because attentional skills are critical for completion of such complex tasks in a real-life setting. In summary, the findings from previous studies suggest that GMT may improve performance on tasks requiring planning and organization in healthy older adults and individuals with acquired brain injury. However, it remains unclear whether this approach can result in sustained and generalizable gains in people with severe TBI, given the severity and range of cognitive impairments often present in this population.

Executive Plus Model

In addition to theory-based intervention approaches that are either specific task-based or specific impairment based (e.g., problem-solving), researchers have proposed learning-based approaches to remediate cognitive dysfunction. For example, Gordon and colleagues' (2006)

Executive Plus model includes combining principles of top-down approaches to maximize learning so that treatment benefits generalize across a variety of life situations. The model is based on the assumptions that (a) executive dysfunction disrupts problem solving mechanism (b) role of emotions is critical to proper functioning of problem solving skills and (c) executive functioning, problem solving, emotional regulation and learning are mediated by attention (Gordon et al., 2006; Vas et al., 2012). This six-month, daily treatment, modular training program targets attention (25 sessions), problem solving (100 sessions) and emotional regulation (125 sessions) in a contextualized setting in order to improve higher order executive functioning skills. The treatment program utilizes the problem solving steps described by von Cramon and colleagues' PST (1991) in a variety of contexts and settings to improve problem solving skills. Intensive attention training was provided using the Attention Process Training Manual-II (APT – II) (Sohlberg et al., 2000) prior to initiating PST. Emotional regulation was addressed by providing participants with strategies to recognize illogical, maladaptive and inaccurate thoughts; facilitate use of positive self-talk and mental reframing; and utilize behavioral techniques such as relaxation breathing to decrease mental stress (Gordon et al., 2006).

The Executive Plus model postulates a cumulative benefit of combining different intervention principles to maximize learning. It addresses problem solving and attention training at the same hierarchical level and incorporates emotional regulation training for a holistic executive functioning training program. Although the treatment program projects a strong theoretical and empirical model, its logistical deficiencies are inherent in the length of the rehabilitation program. Six months of daily treatments lasting 4-6 hours would require a significant financial and time commitment. Further, efficacy and/or applicability of the model in an experimental or real-world setting have not been empirically investigated. It is therefore, not

possible to predict the applicability of the model to treat problem solving skills its current proposed state.

Statement of the problem

Cognitive deficits following TBI are multidimensional. Current treatment programs approach problem solving training in a top-down approach wherein the problem solving skill is perceived as independent of attentional control and working memory. A different approach is necessary to develop a treatment program that will target problem solving skill as a collective capability rather than a unitary function. Targeting shifting, updating and inhibition in an individual setting will present with a new approach to improving problem solving skills in a person with TBI with the rationale that every TBI patient presents with varying degrees of deficits in one or multiple domains. These three skills form the foundation on which higher EF such as reasoning, problem solving, and decision making are built. Unless each skill is independently assessed and treated according to severity, there won't be objective progress at the higher levels of EF, especially in the area of problem solving.

The Executive Plus Model considers attention training as crucial for improving executive functions but does not address working memory in its treatment plan. A different perspective is essential to approaching treatment models targeting lower level EFs in order to develop complex cognitive processes such as problem solving. This study proposes a bottom-up approach where set-shifting, updating and inhibition are targeted in an individual setting to improve problem solving skills in individuals with TBI. These three skills form the foundation for building higher EF; such as, reasoning, problem solving and decision-making. A bottom-up approach ensures

that participants with TBI who present with varying degrees of deficits in one or multiple areas of core executive functions is independently assessed and then treated according to severity to gain measurable progress at the higher levels of EF. This study shall test this paradigm only in the area of problem solving.

The purpose of the study is to assess the applicability of the bottom-up approach targeting set-shifting (attention), updating (working memory), and inhibition to improve complex problem solving skills in individuals with moderate-severe TBI. The aims of the study are as follows:

1. To identify if the bottom-up approach improves complex problem solving skills in individuals with moderate-severe TBI.
2. To determine if treatment effects generalize to novel, unfamiliar problem solving tasks following implementation of this approach.
3. To determine if treatment effects maintained for trained tasks over a 1-month period following completing of the treatment program.

The research questions that will be explored through this study are:

1. Are there significant differences between pre- and post-treatment measures of attention, working memory and inhibition?
2. When treating attention, working memory and inhibition is there a significant difference between pre-and post-treatment measures of problem solving skills?
3. Is there a significant difference in measures of problem solving skills 1 month post completion of treatment?

Method

Participants

Participants were approved as per the East Carolina University Institutional Review Board. They were recruited from the Fayetteville and Lumberton communities by placing advertisements in targeted areas to attract individuals with traumatic brain injury. Participants were approached independently and those who were interested began the consent process. In total, 3 participants with a mean age of 50 were recruited for the study. P1 is a 48 year old female who completed 16 years of education. She is 26 years post onset of her TBI that resulted from a motor vehicle accident (MVA). P1 was in a coma for approximately 3 months following the MVA with hemorrhagic injuries to frontal and occipital lobes. She remained hospitalized for an additional 6 months after recovering from coma. She then received speech-language therapy (SLP), occupational therapy (OT), and physical therapy (PT) for four months at an acute inpatient rehabilitation facility. Upon discharge, she did not seek further therapy services. Prior to the MVA, P1 was a recent university graduate, married and searching for a job. P1 remained unemployed following her MVA for approximately 18 years due to her significant physical and cognitive impairments. She was able to take a less cognitively-demanding part-time position at a car dealership 8 years ago in the accounting department. She is responsible for invoice processing, charting, and filing which according to her is a repetitive and rote task. She continues to work in that position now. P1 has been on Trileptal (anti-convulsion) and Cymbalta (anti-depression) medications since her MVA 26 years ago. She's married with an adult son from her first marriage.

P2 is a 53 year old female who completed 18 years of education. She is 23 years post onset of her TBI that resulted initially from blunt force head trauma following an assault with

hemorrhagic injuries to frontal, occipital and parietal lobes. She reported a loss of consciousness for approximately 6-7 hours and retrograde amnesia greater than 24 hours. She was hospitalized for 3 days for the incident and did not receive SLP, OT or PT services after discharge. Following the head trauma, she was diagnosed with left frontal lobe benign tumor, which was surgically removed 7 years ago with no remissions. She did not undergo chemotherapy or radiation therapy following the surgery. Her length of hospital stay following the surgery was approximately 1 week with SLP services at home for 1 month upon discharge. P2 was working as a counselor with the U.S. Army and quit her job following increased stress and inability to cope with complex work situations. She is currently unemployed and is seeking recertification as a counselor to return to the work force. P2 was not taking any prescription drugs related to the TBI or cancer during the time of study.

P3 is a 50 year old female who has completed 12 years of education. She is 6 years post onset of TBI that resulted from a MVA where she sustained hemorrhagic injuries to her frontal lobe and right parietal lobe. She was in a coma for 31 days with PTA for 2 years after injury. She remained hospitalized for 2 months after the MVA following which she received in-patient rehabilitation services (SLP, OT and PT) for 3 months. She is currently on daily prescription pain medications- Percocet and Tremadol (both classified as non-narcotics)- due to injuries to her lower extremities and recurrent headaches. P3 was not employed prior to her injury and remained unemployed after her MVA. She intends to pursue a cognitively less demanding job in the near future.

Once informed consent was obtained, participants complete the following measures: (1) demographic questionnaire; (2) *Trail Making* and *Color-Word Interference* subtests from the *Delis Kaplan Executive Function System (D-KEFS)* (Delis, Kaplan & Kramer, 2001) ;(3) *Letter-*

Number Sequencing and *Digit Span* subtests from the *Wechsler Memory Scale (WMS-III)* (Wechsler, 1997); and (4) *The UCSD Performance Based Skills Assessment (UPSA)(Patterson, 2001).* The cognitive measures were administered during pre-treatment and post-treatment sessions.

Measures

D-KEFS Trail Making Test

The *Trail Making Test* of the *DKEFS* is designed to isolate set-shifting from skills such as letter sequencing and visual scanning. The test accomplishes this by including four baseline conditions (Visual Scanning, Number Sequencing, Letter Sequencing, and Motor Speed) and by placing equal numbers of stimuli in the three sequencing conditions (Yochim, Baldo, Nelson, & Delis, 2007). The D-KEFS Trail Making Test involves a series of 5 conditions: visual scanning; number sequencing; letter sequencing; number-letter switching; and motor speed. In all five conditions, the stimuli are spread over an 11x 17-inch area, which provides longer trails and more interference stimuli than the traditional TMT (Delis et al., 2001). In the Visual Scanning condition, examinees cross out all the 3s that appear on the response sheet. In the Number Sequencing condition, examinees draw a line connecting the numbers 1–16 in order; distractor letters appear on the same page. The Letter Sequencing condition requires examinees to connect the letters A through P, with distractor numbers present on the page. In the Number-Letter Switching condition, examinees switch back and forth between connecting numbers and letters (i.e., 1, A, 2, B, etc., to 16, P). Last, a Motor Speed condition is administered in which examinees trace over a dotted line connecting circles on the page as quickly as possible, in order to gauge their motor drawing speed. Each condition is preceded by a short practice trial. In all conditions, examinees are told to work as quickly and as accurately as possible. In all but the visual scanning

condition, the examiner corrects mistakes by placing an "X" over a wrong connection, and examinees are asked to continue from the last correct connection. The stopwatch remains running during such corrections (Yochim et al., 2007)

D-KEFS Color-Word Interference Test

The *D-KEFS Color-Word Interference Test* (Delis et al., 2001) is a version of the Stroop Test (Stroop, 1935) that measures inhibition of verbal responses through naming dissonant ink colors. This test presents interference in the form of competing responses in which an examinee must attend to the task. The *D-KEFS* version contains four conditions, which increase in complexity: basic color naming, word reading, inhibition and inhibition/switching. These conditions are assessed across three tasks. The Word page includes color words printed in black ink and the participant reads the word, the Color page includes 'Xs' printed in color and the participant names the color, and Color-Word page includes color words in mismatching ink colors and the participant names the color of the ink rather than reading the printed word. Raw scores are obtained for each page and include the number of items read/named in 45 seconds. An Interference score provides an objective measure of inhibition, cognitive flexibility, creativity, and reaction to cognitive pressures (Lippa & Davis, 2010; Shunk, Davis, & Dean, 2006)

WMS-III: Letter Number Sequencing Test (LNS) and Digit Span Test

The *WMS-III* (Wechsler, 1997) is one of the most commonly used memory assessment tools in the clinical setting (Rabin et al., 2005). The *LNS* and *Digit Span* tests will be administered and a WM composite score will be computed for each participant. The *LNS* measure is used to assess sequencing, mental manipulation, attention, short-term auditory memory, visual-spatial imaging, and processing speed. In the *LNS* task, the experimenter read a

series of numbers and letters aloud to the participants at the approximate rate of one item per second. Participants were asked to recall each list with the numbers in numerical order followed by the letters in alphabetical order. The participant's response to each trial was recorded verbatim and scored. The complete test consisted of eight blocks with three trials in each. List length of three is used for the first block and increased by one for each successive block. Administration was terminated if participants miss all three trials within a block. For each trial of an item, 1 point is scored for each correct response, 0 points for each incorrect response. A response was scored incorrect if a number or letter was omitted or if the numbers or letters were not said in the specified sequence. The trials were added to obtain the item scores, and the sum of the item scores gives the total score ranging from 0 to 21(Rabin et al., 2005; Shelton, Elliott, Hill, Calamia, & Gouvier, 2009).

The *Digit Span Test* was administered in forward and backward span conditions. For Digits Forward, the experimenter read strings of digits aloud to the participants at the approximate rate of one number a second. The participants were asked to repeat them back in the correct order. The Forward condition consists of 8 blocks of 2 trials at each list length. The number of digits in the initial block was 2 and increased by 1 in each successive block. Administration was terminated if participants incorrectly recall the digits for both trials within the same block. For the Backward condition, the same procedure was used, except that the participants repeated the digits in reverse order and only 7 blocks were presented. Following all trials, the experimenter recorded responses as correct if all digits were recalled in the correct serial order (Shelton et al., 2009). The forward span is considered a measure of the efficiency of attention (freedom from distractibility) whereas backward span draws more upon working memory (Lezak, 1995). Additionally, it has been suggested that the reversing operation in the

backward span test is dependent upon internal visual scanning processes (Weinberg, Diller, Gerstman, & Schulman, 1972). The score on each of these subtests represented the maximum number of digits that could be recalled (max scores: Forward = 8; Backward= 7).

The UCSD Performance-Based Skills Assessment (UPSA)

The *UPSA* is a role-playing test designed to evaluate a person's functional capacity to problem solve in five selected areas of basic living skills. These areas include *Comprehension & Planning*, *Finance*, *Communication*, *Mobility*, and *Household Management*. Participants being tested used props to demonstrate how they perform everyday activities and are assessed on their actual performance. The area of *Finance* was completed first which tests one's ability to count change and write checks. In the first part of this task participants were provided with real currency (coins and bills) and asked to count out given amounts (e.g., $12.17, $6.73, $1.02) and make change from ten dollars. The second part of the task involved answering questions related to paying a utility bill. Participants were shown a real bill from a utility company (e.g., San Diego Gas and Electric) and were required to answer questions related to paying the bill. These tasks take about five minutes to complete and yield scores ranging from 0 to 11.

Next the participants were tested in the area of *Comprehension and Planning* and asked to read a short story that describes an outing to the beach on a hot sunny day. After reading the story, participants are asked a few questions to evaluate their comprehension and then requested to list five items necessary to bring or wear in order to spend the whole day at the beach. Points were given for answers deemed appropriate (e.g., swimsuit, towel, picnic lunch, sunscreen, etc. for the beach and umbrella, raincoat etc.). This part of the assessment takes about five minutes to complete and yields scores ranging from 0 to 12.

The next area tested is *Communication*. Participants were provided with an unplugged telephone and asked to role-play a number of scenarios. First they were asked to show the examiner what number they would dial if they had an emergency. The appropriate response is to dial 9-1-1. A second task involved calling information to get a specific telephone number and then dialing that number from memory. Next participants were requested to read a medical appointment confirmation letter and then role-play calling the hospital to reschedule the doctor's appointment. In addition, participants were asked to describe how the letter requested them to prepare for the medical appointment (e.g., fast for a blood draw) and what two items they need to bring with them to the doctor (e.g., insurance card and list of medications). There were a total of nine communication subtasks that require about five minutes to complete and yield scores ranging from 0 to 14.

The area of *Transportation* includes the use of public transportation. Participants were provided with bus schedule information from the San Diego Transit District and asked the following questions: cost of their fare, the telephone number for schedule information, which bus to ride to a specific destination, where they would get off the bus to transfer to another bus and the location of the trolley stations on a map. This task requires about five minutes to complete and yields scores ranging from 0 to 9.

The final task measures *Household Management* skills. Participants were provided with a recipe for rice pudding and asked to prepare a written shopping list. They are then presented with an array of 29 items that one might have on hand in one's pantry (e.g., pasta, jelly, cereal, soup, rice, canned tuna, toothpaste, canned vegetables, crackers, etc.). Participants were requested to read the recipe, check the pantry, and then prepare a list of the items they need to buy in order to

make the rice pudding. Points were given for each correct item on the shopping list. This task was timed for five minutes and yielded scores ranging from 0 to 4.

The *UPSA* was administered in approximately 30 minutes. The raw scores from each of the 5 subscales were transformed to yield comparable scores (0-20) for each scale, which then provided a summary *UPSA* score ranging from 0 – 100 points (higher scores reflect better performance). Test-retest reliability of UPSA is 0.94 and inter-rater reliability is 0.91 (Patterson, Goldman, McKibbin, Hughs, & Jeste, 2001; Twamley, Doshi, Nayak, Morlock, Leeuwenkamp, & Patterson, 2002).

Procedures

A multiple-probe ABA design replicated across each participant was used for the study. The multiple probe design included a baseline condition, treatment condition, and post-treatment condition obtained 1-month after treatment ended to assess maintenance. After the participants were identified as per inclusionary criteria and informed consent had been obtained, initial testing began by determining the severity of TBI. All testing and treatment sessions were audio and video recorded for later review as needed, and also for reliability and treatment fidelity checks.

Initial testing

Initial session included obtaining detailed case history information, screening for significant deficits in vision and hearing acuity and determining severity of TBI. The *Mayo Classification System for TBI Severity* (Malec et al., 2007) was used to identify participants as presenting with mild or moderate-severe deficits based on the Glasgow Coma Scale (GCS)

scores, duration of post-traumatic amnesia (PTA), and loss of consciousness reported in their medical records following traumatic injury event. The *UPSA, WMS-III* and *D-KEFS* subtests mentioned in the previous section were administered to obtain baseline data on problem solving skills, attention, working memory, and inhibition. Order of test administration was randomized across participants. All study activities were conducted in individual training sessions at the participant's residence.

Baseline

All probes administered during baseline, treatment and maintenance probes were selected from the Everyday Problems Test (EPT) (Willis, 1990). EPT is an 84-item standardized test used to assess an adult's ability to solve tasks of daily living. The test stimuli, used as probes for this study, are designed to assess adult cognitive competence to reason and problem solve problems associated with daily living. These items were selected as probes due to their high test-retest reliability (.91) Baseline was established over the first three to four trials for each participant. Baseline probes consisted of 30 items selected from the EPT that targeted problem solving tasks such as medication management, recipe/cooking instructions, identifying appropriate Medicare benefits, using telephone calling card, managing tax and bank information/correspondence, ordering home supplies, following accident related protocols, completing mail-order catalog, ordering prescription drugs etc (Appendix A). Participants read the items and questions related to them and responded verbally. Each item consisted of five open-ended and/or multiple-choice responses. The examiner recorded the responses. Self-corrected responses and first responses were scored one point for accuracy (total of 5 points/task). No response after a 15 second delay was scored incorrect. Each participant attempted all trials for a total of 50 possible points. Once a

stable baseline was reached, treatment was initiated.

Treatment

Treatment sessions began following initial testing. Treatment was conducted in one-hour sessions, four times a week for a total of five weeks (20 total sessions). Each week, the first three sessions focused on therapeutic activities and strategy training to address deficits in attention, working memory, and executive functions. A brief description of therapeutic tasks and strategy training is provided in the following section (see Appendix B). Treatment probes were administered once a week during the fourth session. No feedback was provided during the completion of these probes.

Memory training addressed visual and verbal working memory skills. These skills were addressed in activities such as recalling shopping lists, medication regimes, and appointments for the week, life-events, face-name association, etc. Participants were taught to use mnemonic strategies for recalling word lists and sequences of items, text material, and main ideas and details of visual and verbal information presented in paragraphs, stories, or narratives. Participants received instructions for using semantic organization/categorization strategy, face-name association, mental (visual) imagery, spaced retrieval, information chunking methods, and practice tests. For example, participants were instructed how to organize word lists into meaningful categories and to form visual images and mental associations to recall words and texts. Therapeutic activities such as recalling items on the grocery list, medication routines, appointments, event reminders, recalling a person's name, etc., were used to provide functional training for improving working memory skills in everyday tasks.

Computer-based training was utilized for addressing attention and executive function deficits. This form of instruction delivery facilitates multimodal and multi-domain training,

which is a key factor for functional improvement in co-existing skills such as attention and inhibition. Computer-based interventions enable algorithms to set the initial level of task difficulty with reference to the individual's baseline competency and then gradually increase task difficulty in a customized fashion, in effect providing an individualized intervention (Gates & Valenzuela, 2010). These features also allow effective control of ceiling and baseline effects as individuals are continually cognitively challenged. In addition, computer-based interventions enable real time monitoring of cognitive performance and the standardization of intervention (Gates, Sachdev, Singh, & Valenzuela, 2012; Gates & Valenzuela, 2010; Jak, 2012). Lumosity, a web-based computer training program will be used for the purpose of this study (Lumos Lab Inc., 2011). The training program targets the cognitive domains of attention, working memory, and inhibition through games and exercises promoting arousal, alertness, sustained attention, inhibition, visual scanning, target detection, and rapid information processing. The training program was introduced online in 2011 with reliability coefficient of 0.69 indicating moderate reliability (Sternberg, Hardy, Ballard & Scanlon, 2013). Currently, there is no validity data for the training program.

Each participant created an individual profile to monitor progress on the training program. All participants began at the same level of difficulty. The program was designed to increase difficulty on every exercise after participant was successful in clearing the level. In each domain, there was a test-train-test sequence, with the test measuring reaction time and performance score. Participants were provided simple, direct feedback about their performance and could track it over time. They typically trained for 20-25 minutes on computer-training sessions to improve cognitive skills associated with speed/inhibition/flexibility, memory, attention and problem solving. In addition to the computer training program, the remaining

treatment time was used for completing paper-pencil and functional tasks to target attentional control and inhibition. Paper-pencil tasks involved reading short stories and answering associated questions with/ without time limits, pattern drawings, copying written materials etc. These tasks were derived from Workbook for Activities for Language and Cognition-6 (WALC-6) (Bilik-Thompson, 2004). Functional tasks such as generating a shopping list based on recipes, chunking information for short stories presented verbally, noting down name and/or phone number in a voicemail excused for improving attention and inhibition skills were also derived from WALC-6 (Appendix B).

Maintenance and Generalization Probes

Generalization probes were administered immediately post treatment to identify pre-post changes in problem solving skills on a novel tasks. The post-treatment session was conducted one month following completion of training program to assess maintenance and generalization of learned skills. This session targeted participant performance on a novel problem solving task derived from EPT test items (See Appendix A) not previously completed or attempted in the training program. The *UPSA*, *WMS-III* and *D-KEFS* subtests were also re-administered to assess maintenance of learned skills.

Reliability and treatment fidelity

An independent observer, viewed 10% of randomly selected trials from each participants' treatment, baseline, and generalization trials to ensure that the examiner followed the procedures appropriately. Procedural reliability was calculated to be 80.3%. Treatment fidelity was calculated to be 85.1%. Deviation from treatment protocol occurred on instances when the participant experienced neurofatigue. On such instances, which occurred in less than 10% of all

sessions, follow-up trials to incorrect responses could not be progressed and the training task had to be discontinued. These deviations from protocol occurred with all participants and were minimized by the examiner to the least extent possible extent.

Results

Acquisition, maintenance and generalization of target skills

Performance on problem solving probes for the three participants is illustrated graphically in Figures 1-3. The Figures depict accuracy scores on 50 problem solving probes administered during baseline, treatment, and maintenance trials. The Figures also depict accuracy scores on 20 problem solving probes administered to assess generalization. The generalization probes were multiple-choice problem solving tasks derived from EPT and were similar to the treatment probes in design and level of difficulty. Effect sizes, *d*-statistic, were also calculated to examine treatment effects (Busk & Serlin, 1992). Rath, Simon, Langenbahn, Sherr and Diller (2003) conducted a study investigating treatment for problem solving skills in individuals with TBI and used Cohen's (1988), effect-size conventions for determining effect size. In the current study, the same benchmarks were followed and they include: small=0.30, medium=0.50 and large=0.80.

Participant 1. As shown in Figure 1, the first participant (P1) demonstrated a stable baseline and performed at 56% mean accuracy for total problem solving score. All data points in the treatment phase probes were at or above the baseline mean and trend lines indicate a systematic change associated with treatment. Problem solving score trended up to 86% of total problem solving score with a mean accuracy of 73.6% for the treatment phase. For the maintenance probe at four weeks after treatment ended, P1 performed with 88% accuracy. Generalization of problem solving skills is evident on visual inspection of data as all treatment and maintenance phase generalization scores are higher than baseline; however a higher number of data points are necessary to utilize CDC interpretation procedures. A large treatment effect was found for problem solving for P1, (as estimated by Cohen's *d* statistic) $d = 2.61$.

Participant 2. Participant 2 (P2) was determined to be eligible for baseline testing following initial pre-testing and inclusion criteria. As seen in Figure 2, P2 demonstrated a stable baseline and performed with a mean accuracy of 56.5%. The initial three data points in the treatment phase probes were at or near the baseline. Her performance improved in weeks 4 and 5 of the treatment phase which is reflected by the final two data points which are above the baseline mean and trend lines. P2 demonstrated higher problem solving score in the maintenance phase than the treatment phase with a mean accuracy of 84% for the maintenance phase as compared to mean accuracy of 70% for the treatment phase. Generalization of problem solving skills is evident on visual inspection of data with treatment and maintenance phase generalization scores above the baseline mean and trend lines; however, a higher number of data points are necessary to utilize CDC interpretation procedures. A large treatment effect was found for problem solving for P2, (as estimated by Cohen's *d* statistic), d=1.64.

Participant 3. Participant 3 (P3) scored the highest mean accuracy during the baseline testing. Inspection of baseline data, as seen in Figure 3, indicate a mean accuracy of 70% at baseline with less than 10% variability in baseline scores across probes. Treatment was initiated and as shown in Figure 1, all five data points are at or above the baseline mean and trend lines indicate a systematic change compared to baseline performance. Problem solving score trended up to 90% of total problem solving score with a mean accuracy of 78.2% across five treatment probes for the treatment phase. For the maintenance probe at four weeks after treatment ended, P3 performed with 86% accuracy. Generalization of problem solving skills is evident on visual inspection of data as all treatment and maintenance phase generalization scores are higher than baseline. A large treatment effect was found for problem solving for P2, (as estimated by Cohen's *d* statistic), d=1.79.

Pre- and Post-Treatment Performance on Standardized Cognitive Measures

Results of pre- and post-treatment testing are presented in Table 1. All three participants showed improvement on the *UPSA* problem solving test. Using the 95% confidence interval (CI) criteria on standard error of measurement (*SEM*) scores (1.96 x *SEM*; Harvill, 1991) all participants demonstrated significant gains on total *UPSA* score. For standardized measures of updating, inhibition, and shifting, all three participants produced higher scores on at least one task for each process. Using the 95% CI criteria on *SEM* scores (1.96 x *SEM*), P1 and P3 showed significant gains on *Letter-Number Sequencing* (LNS) and *Digit Span* (DS) subtests indicating improved recall/updating skills and P2 showed significant gains on the LNS and DS Forward subtests. On the *DKEFS-Color Word Interference* subtest, all three participants showed significant gains on the inhibition/switching task indicating improvement in inhibition skills. For the *DKEFS-Trail Making* subtest, P3 demonstrated significant gains on all tasks. P1 and P2 made significant gains on number sequencing and letter-number sequencing tasks indicating improved shifting skills.

Measures	P1 Pre	P1 Post	P2 Pre	P2 Post	P3 Pre	P3 Post	Normative Data[1] Mean (SD) 95%CI	Normative Data[1] SEM
UPSA (Max score=100)	67	**82***	75	**84***	76	**91***	92.6(5.5)	1.23
WMS-III (Scaled Scores)								
Letter Number Sequencing	9	**11***	7	**9***	8	**14***	10.3 (2.6)	0.22
Digit Span (Forward)	8	**10***	6	**7***	9	**11***	9.8(1.7)	0.27
Digit Span (Backward)	6	**8***	5	5	5	**7***	7.9(2.1)	0.34
DKEFS								
Color Word Interference (Scaled Scores)								
Color Naming	3	**4***	6	6	9	**10***	9.06(2.81)	0.48
Word Reading	8	**9***	5	3	9	9	9.91(2.94)	0.50
Inhibition completion	9	**11***	10	8	8	**9***	11.24(2.65)	0.45
Inhibition/Switching	1	**3***	11	**12***	8	**9***	11.39(2.30)	0.45
DKEFS								
Trail Making Test (Scaled Scores)								
Visual Scanning	9	9	9	7	2	**3***	10.5(2.8)	0.21
Number Sequencing	7	**8***	8	**9***	8	**9***	10.9(3.0)	0.22
Letter Sequencing	11	11	8	8	4	**6***	11.1(2.6)	0.19
Letter-Num Sequencing	6	**7***	10	**11***	7	**9***	10.9(2.6)	0.19
Motor Speed	5	5	3	**7***	5	**7***	10.9(2.2)	0.16

Note: P= participant; UPSA= UCSD Performance Based Assessment, normative data from Patterson et al. (2001); WMS-III= Wechsler Memory Scale-III, normative data for LNS from Yo et al. (2012); normative data for Digit Span tests from Grisby et al. (1994); DKEFS= Delis-Kaplan Executive Function System, normative data for Color Word Interference subtest from Aupperle et al. (2012) and for Trail Making subtest from Fine et al. (2011).
*****Pre-to Post-treatment change ≥ 2 *SEM* units (95% confidence interval)
1- Normative data for SEM from other comparative adult population studies

Table 1: Pre- and post-treatment measures on standardized measures of problem solving, updating, inhibition and shifting skills

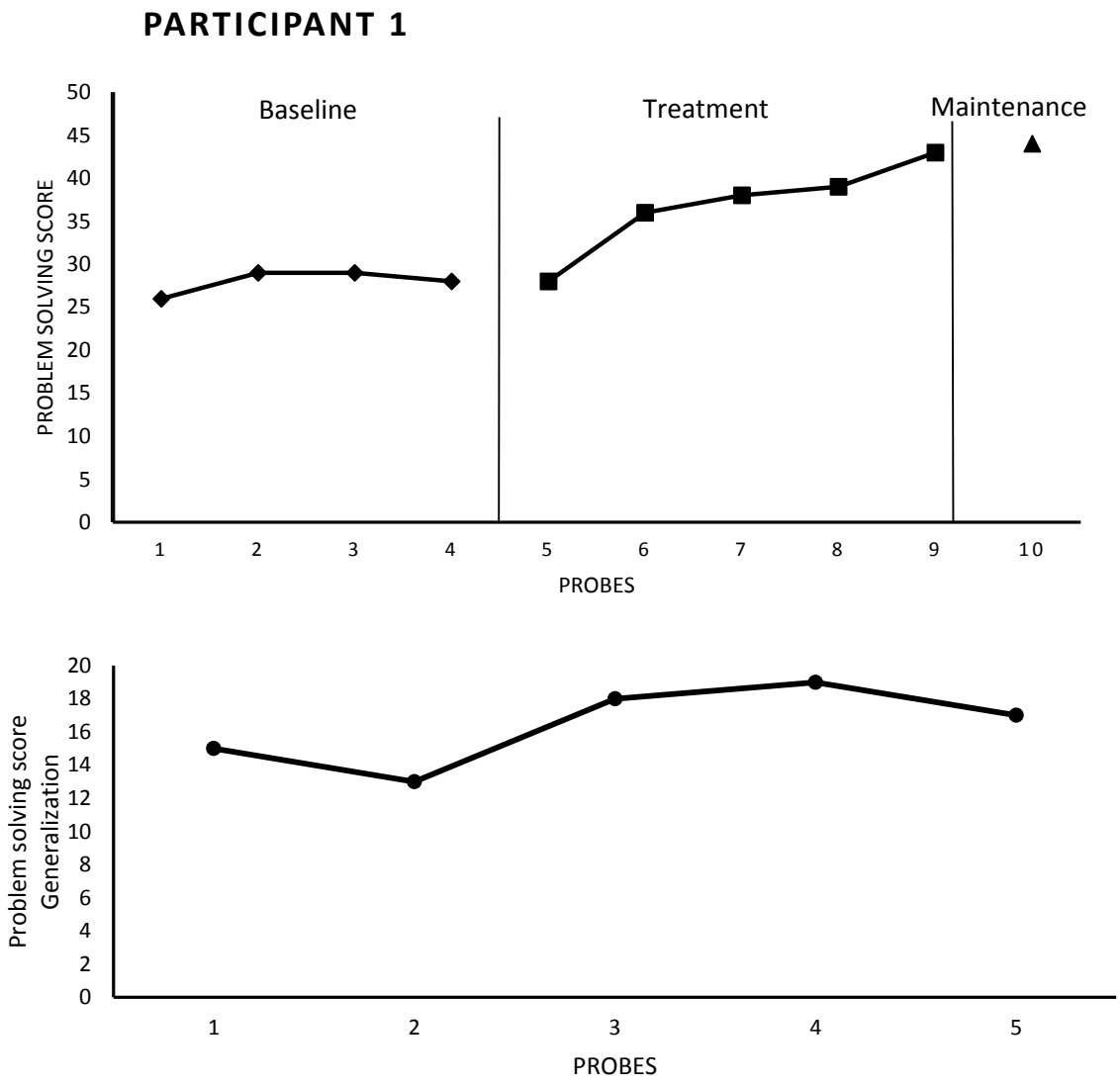

Figure 1: Problem solving scores for Participant 1 at baseline, treatment, maintenance and generalization probes.

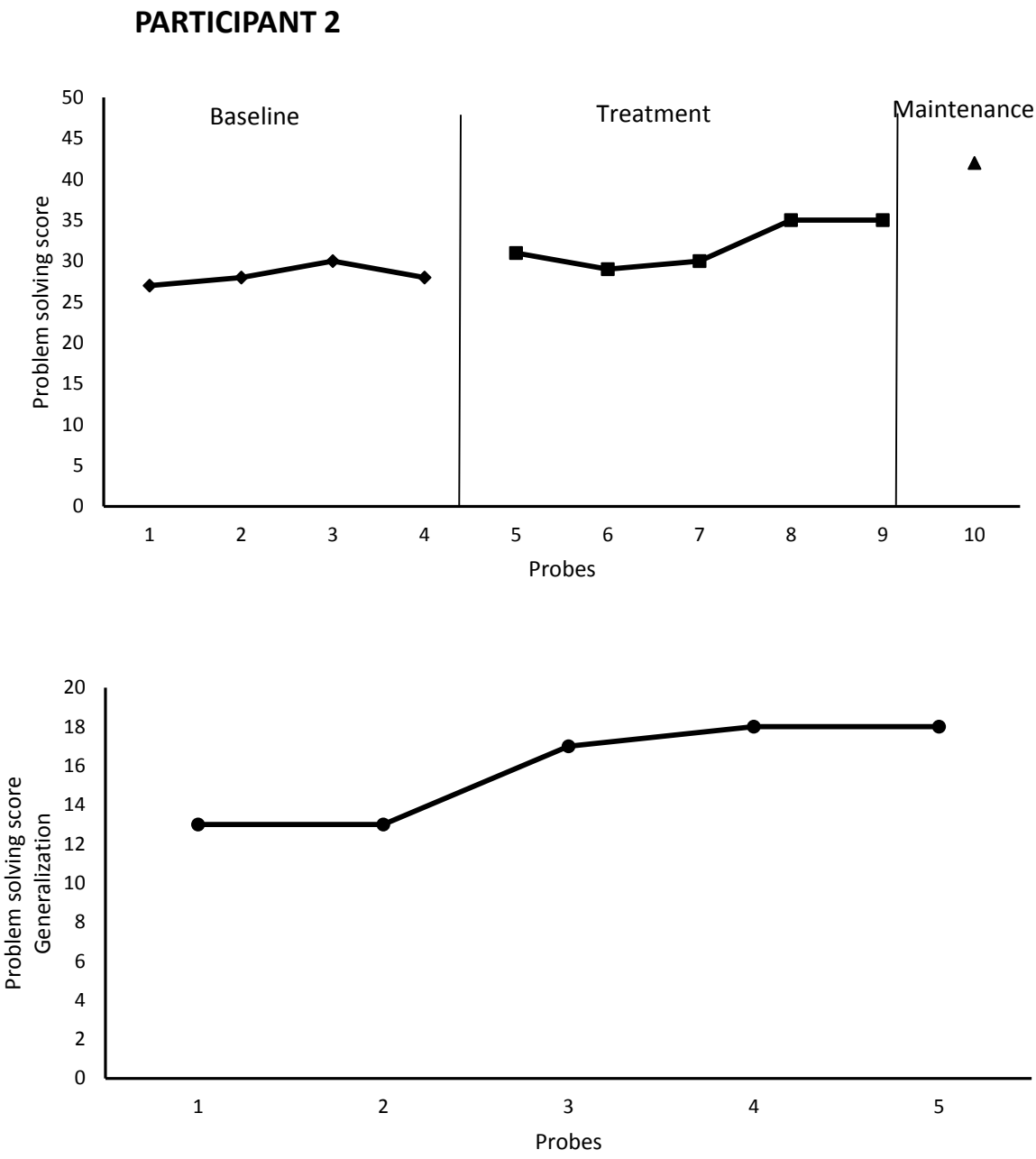

Figure 2: Problem solving scores for Participant 2 at baseline, treatment, maintenance and generalization probes.

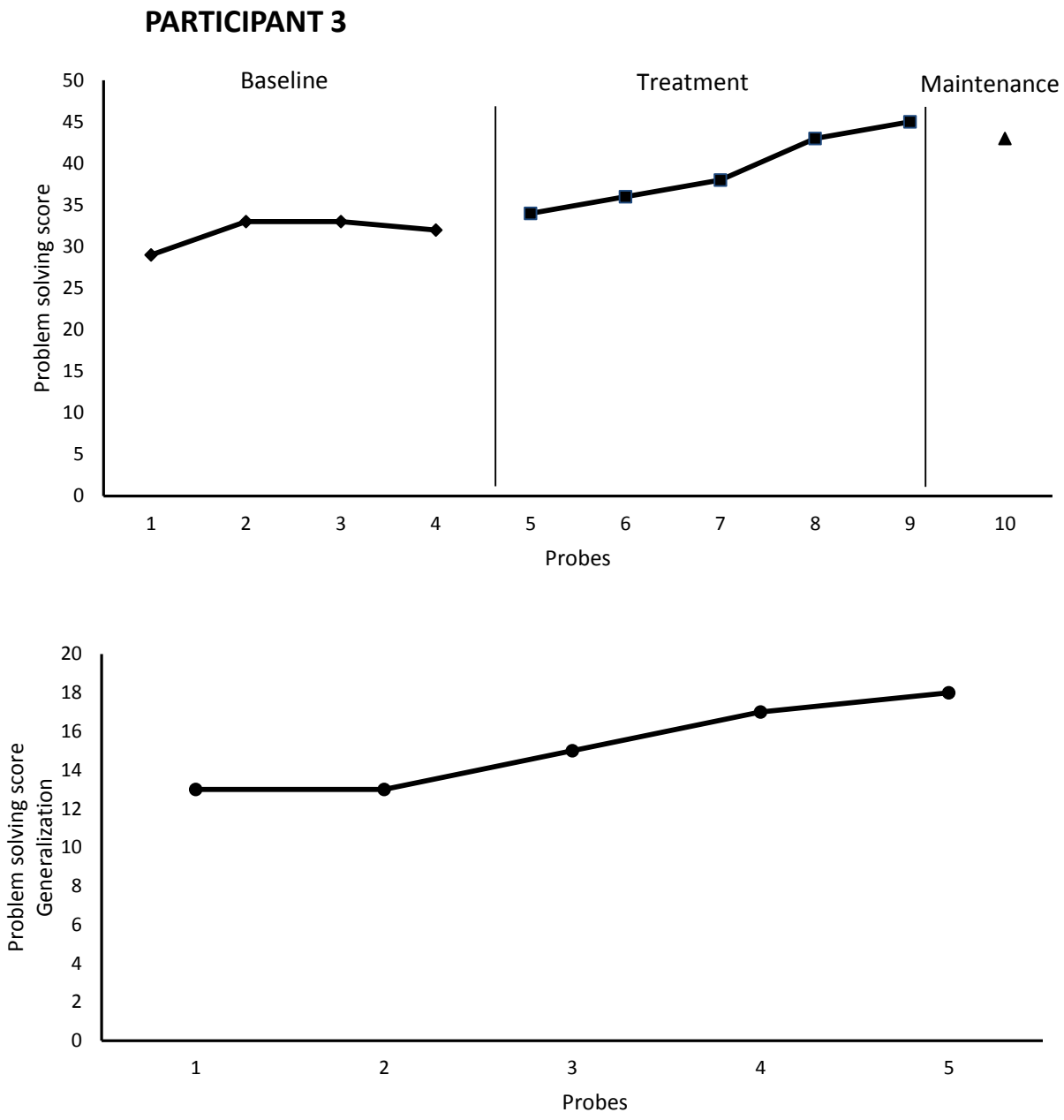

Figure 3: Problem solving scores for Participant 3 at baseline, treatment, maintenance and generalization probes.

Discussion

Problem-solving deficits have been a primary focus of executive dysfunction interventions. Cognitive rehabilitation interventions are commonly classified as either restorative or compensatory. Compensatory or 'top-down' approaches address deficits in higher-order 'executive' functions through instruction and systematic practice of strategies or rules that theoretically can be generalized across a variety of situations. Top-down interventions focus on teaching individuals with executive dysfunction, a guiding principle or rules on how to complete a higher-order task applicable across multiple-contexts, as opposed to relying on 'bottom-up' approaches to re-learn a specific lower-order task or skill. In order to optimize self-regulation, top-down intervention strategies rely on behavioral routines and internalization of 'self-talk' to address executive function deficits (Cicerone & Giacino, 1992). They can also be used to ameliorate deficits in more foundational functions by teaching executive strategies to manage environmental demands and monitor performance across different contextual setting (e.g., Time pressure management; Fasotti, Kovacs, Eling, & Brouwer, 2000 or Goal Management Training; Levine et al., 2000).

These strategies involve using external prostheses, such as a memory notebook or calendar to aid executive processes. These external tools, which may be considered a bottom-up intervention, replaces rather than restores once-intact skills. They allow an individual with injury related deficits to achieve similar functional outcomes through the systematic use of compensatory strategies (Dams O-Connor & Gordon, 2013). The goal of all top-down interventions is to allow processes that happened "automatically" prior to the TBI to become achievable through the deliberate and conscious use of structured compensatory strategies. Although top-down approaches provide generalizable strategies or guiding principles that may theoretically be applicable and relevant for 'real-world' functioning, but without adequate

attention and information processing skills, the individual will be unable to learn, remember, process and incorporate feedback from the environment.

Restorative or 'bottom-up' interventions target basic cognitive skills such as attention and information processing, and directly engage these fundamental skills through repetitive drills or graded exercises (Dams-O'Connor & Gordon, 2013; Mahncke, Bronstone, & Merzenich, 2006). Traditionally, this approach is based on the notion that by training the brain to encode, process and manipulate increasingly complex stimuli through intensive procedural learning, restoration of these basic cognitive functions may occur with repeated practice. Improvement of these foundational cognitive skills is theoretically an important prerequisite for advanced training in higher-order cognitive skills (memory, self-monitoring, executive functioning), but researchers report that restorative interventions alone are unlikely to generalize to untrained tasks (Cicerone et al., 2011).

The purpose of this study was to test a novel model for treating problem solving deficits in individuals with TBI using a bottom-up approach to treatment. In previous studies, researchers have utilized a top-down approach with limited evidence to support application and efficacy of the treatment models. Cicerone and Giacino (1992) sought to improve self-regulation in three participants with TBI. They were taught to predict their performance on the Tower of London task and to adjust their efforts to the task demand using verbal self-regulation. The procedure was effective in improving performance on the Tower of London task although treatment withdrawal resulted in a return to baseline error rate with no generalization reported. In another study, Goal Management Training (GMT) was used to instruct a post-encephalitic patient how to prepare a meal (Levine et al., 2000). The outcome measures consisted of two everyday paper-and-pencil tasks, meal preparation performance (through observation), and the patients' self-

reports of meal preparation behavior. Both observation and self-report measures revealed improved meal preparation performance after GMT, which was maintained in follow-up measurements at 1, 3, and 6 months. Apart from anecdotal information no other data on generalization to other situations and tasks were reported.

The bottom-up approach is also not thoroughly investigated for its experimental evidence in treatment of problem solving deficits. Serino and colleagues (2007) applied a quasi-bottom-up approach to study 9 participants with TBI who underwent Working Memory Training (WMT), consisting of the repeated administration of three variants of the Paced Auditory Serial Addition Test (PASAT). Comparison of performance on neuropsychological tests before and after the training revealed improvement on tests of working memory, divided attention, executive functions, and long-term memory, but not on tests of speed of processing and sustained attention (Serino, Ciaramelli, Santantonio, Malagu, Servadei, & Ladavas, 2007). No other known treatment models have been reported in the literature to address problem solving deficits for individuals with TBI.

Sohlberg, White, Evans, and Mateer (1992) sought to increase the time interval between encoding and execution of intentions to improve prospective memory in a participant with brain-injured. Results showed a steady increase in the length of time between task administration and execution. Task performance was better in the A-condition in which time levels were only slightly above the subject's prospective memory threshold, whereas execution timing was better in the B-condition, in which time levels were much greater than the patient's current measured prospective memory ability. At the beginning and in the middle of each phase of the study, generalization probes were administered, i.e., daily life prospective memory tasks and standardized recall tests. Performance on these generalization probes improved in the A-

condition, but not in the B-condition. Generalization effects to retrospective memory ability did not show a stable improvement over time. Although the training in general resulted in an improvement of prospective memory, the changes were not experimentally controlled. The authors acknowledge this is a result of flaws in the study design. Also, follow-up measurements were not included in this study.

The current study was initiated to fill this void and to test a novel approach to problem solving. This bottom-up approach assumes problem solving as a cognitive skill dependent on working memory, attention, and inhibition rather than an independent cognitive function. It is important to note that the study did not test the effects of emotional regulation, which is typically impaired in TBI population. To test the bottom-up hypothesis of problem solving, cognitive treatment was provided to three individuals with moderate to severe TBI targeting working memory, attention, and inhibition deficits with maintenance and generalization probes to monitor concurrent performance of their problem solving skills. Results associated with each of the research questions are discussed below.

Acquisition of learned skills

TBI alters cognitive functions with global effects across higher and lower order cognitive skills. With this as the guiding principle, the first aim was to identify if a bottom-up approach improves complex problem solving skills in individuals with moderate-severe TBI. Rather than conform to the traditional restorative strategy training model where progression of cognitive functions moved from lower order functions such as arousal and attention to higher-order functions such as memory; the present approach assumed working memory, attention, and inhibition as pre-requisites for problem solving skills. These three cognitive skills were targeted

in computer training and paper-pencil tasks across 20 treatment sessions with the expectation that accuracy of problem solving scores will improve concurrently as treatment progresses.

The biggest barrier participants had to overcome during the course of treatment was changing their negative central paradigm of "inability" to encode and process complex problem solving tasks independently. Through their years of personal experience all three participants showed reluctance in accepting that successful performance on working memory, attention, and inhibition tasks was directly related to the use of learned strategies rather than a chance occurrence. All three participants initiated treatment at least 5 years post-TBI event with self-reported negative experiences and poor self-esteem associated with memory, attention, and impulsivity.

Substantial treatment time was invested in counseling the participants that their success in cognitive tasks such as completing free word recall, N-back task, interference task etc. was not a chance occurrence but the result of appropriate use of treatment strategies (See Appendix C). For each participant, progression of difficulty was determined based on individual performance on attention, working memory, and inhibition tasks. Treatment time was allocated depending on level of impairment in each cognitive skill. P1 had severe deficits in inhibition and impulsivity that were observed during completion of pre-treatment testing. Initial treatment sessions were directed more towards addressing inhibition deficits with shorter treatment time allotted for working memory and attentional tasks. P2 presented with moderate deficits in sustained attention with increased cognitive processing load. Initial treatment sessions targeted teaching P2 to manage environmental distractors, decrease level of frustration associated with failure and facilitate self-talk to improve sustained attention to cognitively loaded tasks. P3 had moderate deficits in working memory for verbally presented stimuli. To address these deficits, the first few

sessions focused primarily on providing P3 with restorative strategies such as verbalization, rehearsal, repetition, and self-talk to facilitate improvement in working memory skills. This was crucial for the success of this approach, as TBI-related cognitive deficits rarely exist in isolation. Feelings of loss and sadness that can accompany recovery from TBI process can influence motivation for treatment, participation in the community and maintenance of social support networks (Levack, Kayes, & Fadyl, 2010). These participants were acutely aware of functional consequences of these deficits and self-reported experiencing feelings of anxiety, frustration, failure, and helplessness. Therefore investing treatment time on most impaired cognitive skills was crucial for motivating participants for upcoming treatment sessions and to facilitate acquisition of strategies.

Training effect on working memory, attention and inhibition skills. Pre-treatment scores of working memory, attention, and inhibition skills were lower than mean normative data for all study participants (see Table 1). Large treatment effect was evident for all participants indicating that this non-traditional bottom-up approach has potential for further investigation. Quantitative visual analysis of treatment graphs using CDC procedures demonstrated systematic change in problem solving probes for P1 and P3 as treatment and maintenance probe scores trended higher than the baseline scores. They demonstrated carry-over of learned strategies such as self-talk, verbalization, repetition, eliminating external distraction, and decreased impulsivity within two weeks of treatment. An upward trend in treatment probes may be attributed to the carry-over of learned strategies after two weeks of treatment. P1 and P3 were highly motivated to improve their cognitive skills and reported practicing learned strategies on computer training tasks in between treatment sessions. P2 was highly receptive to treatment strategies and was familiar with the computerized training modules prior to initiating treatment and applied the strategies during

completion of treatment tasks but did not demonstrate carry-over until week 3 of treatment phase. The reason for this delay may be attributed to the extent of divided attentional deficits and increased emotional dysregulation that P2 presented when encountered with failure in training tasks. Anger, frustration, and negative self-talk were frequently observed when P2 experienced a non-desired outcome to the presented stimuli. The in-the-moment experience of deficit-related failure can cause a cascade of physiological changes, thoughts and feelings that serve to overwhelm cognitive resources, resulting in cognitive 'flooding' that derails effective thinking (D'Zurilla & Goldfried, 1977). Substantial counseling and education was provided to comprehend the detrimental effects of frustration and negative self-talk on training performance following which P2 was able to identify moments of emotional disturbances in week 2 of treatment and could regulate an appropriate emotional response when encountered with performance failure. Previous researchers suggested that providing training in cognitive behavioral strategies for emotional self-regulation prior to initiating metacognitive strategy training for problem-solving disorders results in improvements in self-reported problem solving abilities and role-playing activities, which were maintained 6 months post treatment (Goverover, Johnson, Toglia and Deluca, 2007; Rath, Simon, Langenbahn, Sherr & Diller, 2003). For P2 four out of six examined data points showed scores higher than the baseline probes indicating a gradual trending towards systematic change.

Following completion of treatment, large differences between pre- and post-treatment measures of attention, working memory, and inhibition were observed in all participants indicating a significant improvement in cognitive functions. All three participants also demonstrated a significant pre-to post-treatment change on the UCSD-UPSA demonstrating that

the bottom-up approach to rehabilitating problem solving deficits was effective for these participants.

These findings support the study hypothesis and provide promise for further investigating the application of bottom-up approach to problem solving training. Even though the pilot study was completed with only three participants, large treatment effects for all participants indicate significant potential for further studies. Other than the group-intervention study conducted by Rath and colleagues (2003), no other study reported effect-sizes with maintenance and generalization data to support its applicability. In previous studies using a top-down approach comparable results were found with improvements in problem solving during the treatment phase and simultaneous improvements in attention and working memory. Cicerone (2002) aimed to improve the ability of four participants with TBI to effectively allocate attentional resources and to manage the rate of information during performance on computerized N-back tasks. Participants were taught compensatory strategies, such as self-pacing, verbal mediation, self-monitoring of their effort during performance, and the use of feedback by therapists. The results indicated that the intervention had a positive effect with improved performance on tests of attention and working memory, but no direct effect on processing speed. Generalization was assessed by means of a questionnaire that showed a significant reduction of self-reported attentional difficulties in everyday activities in the treatment group. There were no follow-up measurements. Processing speed is a skill that may be improved with extended attention training over time; however it was not considered in the current study and only speculative at this point without further investigation. Although processing speed may be a skill considered in a top-down approach, the results from the literature add support for the use of a bottom-up approach

for remediating problem solving deficits in TBI population and addressing processing speed in a bottom up approach may contribute to improved problem-solving abilities.

Von Cramon and Matthes-Von Cramon (1994) presented the case of a medical doctor who 9 years after suffering a TBI received Problem Solving Training. The training procedure was embedded in a protected work trial, so that treatment in self-regulation could be studied under real-life conditions. The PST-steps were taught using self-instruction techniques. Work performance improved, but training effects did not generalize to novel situations. The participant's awareness did not increase and when confronted with novel problem solving situations his basic incompetence continued to be present. The study was not systematically followed up and no further research was conducted to further assess or modify the treatment protocol. This study followed up on the original PST study (vonCramon, 1990). Lack of transference to novel situations exemplifies possible working memory and retention deficits, which they did not addressed. With researcher-led suggestions, all three participants in the current study attempted to use compensatory and restorative strategies outside therapeutic settings. They reported initial success with restorative strategies of self-talk and chunking for working memory tasks in novel situations. In addition to the self-motivation demonstrated by the participants, increased awareness of their existing deficits and their gradual success with use of strategies are also important for creating the need to venture outside their comfort zone and should be considered a priori in future studies. The precipice of generalization is possible when an individual makes conscious attempts to utilize the strategies outside therapeutic settings independently.

Goal Management Training (GMT) was used to instruct a post-encephalitic participant how to prepare a meal (Levine et al., 2000). The outcome measures consisted of two everyday

paper-and-pencil tasks, meal preparation performance (through observation), and the participant's self-reports of meal preparation behavior. Both observation and self-report measures revealed improved meal preparation performance after GMT, which was maintained in follow-up measurements at 1, 3, and 6 months. Apart from anecdotal information, no other data on generalization to other situations and tasks were reported. Schweizer et al. (2008) applied GMT to a participant with executive dysfunction following a right cerebellar hemisphere arteriovenous malformation hemorrhage. The effectiveness of GMT was assessed using a battery of standardized and experimental tests of executive function and attention and two questionnaires. The results show that the participant's awareness increased and that his performance on tests improved, both immediately after rehabilitation and at follow-up after 48 days and 4 months. Although these studies are considered top-down, they do not address the complexity of a task in a multi-dimensional model. For example, meal preparation is a complex task that involves an array of cognitive skills that need to be fully operational for its success. Also, successful completion of the same task on multiple trials does not demonstrate improvement in problem solving. In the current study, the participants were unaware of their success on problem solving skills during probe completion. They did not receive any feedback from the researcher on the success of their performance. Steady improvements in problem solving probes may be attributed to concurrent improvement in working memory, attentional resources and inhibition control.

Maintenance and generalization of learned skills

All participants demonstrated performed at or near their highest treatment probe score during the maintenance session indicating that treatment effects were maintained for trained

tasks over a 1-month period following completing of the treatment program. This may be attributed to self-motivated continuity in using computer training and treatment strategies, as reported by all participants during the 1-month wait time. During the maintenance session, each participant reported that they used the strategies that were most effective for them in improving their working memory, attention, and inhibition skills. In addition to treatment and maintenance probes, generalization probes were used to assess novel problem solving tasks. These were similar to the stimuli used in maintenance probes. Results indicate that all three participants demonstrated an upward trend in the treatment and maintenance phases for the generalization probes as compared to their baseline generalization scores. Generalization is expected to occur in a restorative, bottom-up approach in order to consider treatment valid outside therapeutic setting (Boelen et al., 2011).

Maintenance and generalization effects of top-down approach are scattered and anecdotal (Cicerone, 2000; GMT, Levine et al., 2000; PST, VonCramon & Matthes-VonCramon, 1991, 1994). The strongest evidence for maintenance and generalization of learned skills in a top down approach comes from a pilot study that was conducted with a multiple baseline across participants design to evaluate an instructional package (TEACH-M) (Ehlhardt, Sohlberg, Glang, & Albin, 2005). The aim of the study was to facilitate the learning and retention of a multi-step task by participants with impaired memory and executive functions using the instructional package. TEACH-M is an instructional sequence consisting of task analysis, step-by-step errorless learning, assessment of performance, review of learned skills, high rates of practice and spaced retrieval, predicting and checking performance. The results showed that four participants were able to learn a 7-step e-mail task following a series of instructions given by a therapist. As a group the participants demonstrated maintenance of effects after 30 days. All participants

demonstrated generalization of treatment effects to an altered e-mail interface. Two important drawbacks of this study were the lack of a control condition enabling the comparison of this instructional package with other instructional approaches, and also the fact that the instructions were not applied to other tasks than e-mail. These drawbacks encompass generalization barriers in other top-down approaches where problem solving is considered a unitary cognitive function, independent of lower-order cognitive foundations. Most top-down approaches employ a unidirectional, multi-layered, vertical strategy towards remediating a horizontal deficit. For example, in a unidirectional, vertical, instructional approach such as TEACH-M, participants are only taught steps for a singular complex task even though strategy learning and its associated steps employ a horizontal and intricate network of working memory, inhibition, and attentional control. However, there is no generalization to other novel tasks because the awareness associated with the underlying complexity of the strategy is not fully understood by the participant. In short, the individual does not comprehend "why" a strategy should and does work. A bottom-up approach not only provides an individual with the "how-to-guide" to a strategy but also helps them understand "why" a strategy works for a particular cognitive skill.

Results from the current study, add to and extend previous findings. In the current study, P1 reported using visualization, self-talk, and mnemonics to improve working memory skills during computer training tasks as well as at work. P1 was promoted to the receptionist position and had an increased cognitive load added to her work environment. P1 reported using verbalization, self-talk, and rehearsal to recall names of customers and associates. P1 supplemented auditory inputs with visual information by writing the names of people who called the desk. P1 reported increased self-confidence in free recall of short and long-term information with continued use of strategies. P2 eliminated external distractions and allowed additional

processing time to facilitate attention and improving inhibition skills. She reported decrease in anger and frustration in stressful, cognitively loaded situations with continued use of compensatory strategies and environmental modifications. P3 used verbalization, mental imagery and rehearsal as strategies to improve working memory and attention. P3 reported that these strategies were useful when learning Spanish as a new language; an initiative she took after starting the treatment program.

A couple of possible accounts for maintenance and transference of learned skills outside therapeutic setting are evidenced from the literature. First is the multi-modal treatment delivery model, which may have decreased internal fatigue and contributed to longer participation during training with shorter recovery time between tasks. These findings are consistent with those of Soong, Tam, Man, and Hui-Chan (2005) who investigated three delivery modes of problem-solving training in a pilot study with 15 brain-injured participants where participants were randomly allocated to a computer-assisted skills-training program, an online interactive skills training program, or a therapist-administered program and their efficacy was assessed in problem solving training. The contents of the training were identical in each delivery mode and participants were given source problems that they would encounter in everyday life and were instructed to draw analogies to solve similar, new problems. Results showed increased self-efficacy and improved basic problem-solving skills in all three delivery modes.

Multi-modal treatment delivery model lowered the risk for boredom or disinterest in participating in therapeutic tasks. Multi-modal treatment delivery was utilized in this study with participants completing paper-pencil, verbal and computer-based training, and tasks during the course of treatment. This treatment delivery model allowed the researcher to tailor the treatment sessions based on participant's severity of deficit rather than use a generalized treatment

protocol. Flexibility of treatment design allowed the researcher to determine baseline, gradually progress task difficulty and adjust or introduce new strategies based on participant performance. The participant receiving the treatment developed awareness to the cognitive deficits, identified the occurrence and cause of its breakdown, and could consciously repair the cognitive function with full understanding of the restorative/compensatory strategies.

Second, the treatment time may have empowered the participants to experience positive results with their memory, attention, and inhibition control and provided them with the confidence in utilizing these strategies outside of therapeutic setting. Provision of feedback by a trained speech-language pathologist during structured bottom-up tasks is essential to develop this positive experience. Individually tailored feedback provided each participant increased self-awareness of strengths and weaknesses, and improved ability to self-monitor and correct behavior. Feedback may have also allowed training tasks to serve as an experiential demonstration of how factors such as neurofatigue, emotional dysregulation, and motivation can interact with basic cognitive skills. For example, by week 3 of treatment, P2 could independently identify neurofatigue and environmental distractors that were detrimental to her attentional skills. The capacity to develop self-awareness and gradually empower the individual to address cognitive deficits independently is a significant benefit for using the bottom-up approach. Higher-order cognitive functions such as critical thinking, decision making, and reasoning are secondary only to presence of self-awareness of lower-order functioning. These findings, although anecdotal, are indicators of potentially positive maintenance and generalization of learned skills outside therapeutic settings using this bottom-up approach.

Conclusions

Three participants with TBI received treatment to improve their problem solving skills. A bottom-up treatment paradigm was used and all participants improved problem solving skills on the treated items and improved problem solving skills on the generalization probes. The participants maintained performance for one month following the end of the treatment. Further, participants self-reported that they incorporated the strategies in everyday opportunities. Though results were positive, they should be interpreted cautiously at this point as there are limitations with the study that need to be considered in future investigations. One limitation for the study was the time-constrained design that generated fewer data points to gather substantial evidence for maintenance and generalization of the learned skill. Results would have greatly benefited for CDC-based visual analysis if 2, 4 and 6-month follow-ups were conducted in addition to the one-month follow-up. Next, the cognitive functions remediated in the bottom-up approach are partly interdependent making treatment effects challenging to interpret. Even though participants improved following treatment, replication of results in a comparison treatment study of bottom-up and top-down approach would be beneficial. Replication of findings is also necessary to strengthen external validity of the treatment design to provide additional evidence for determining generalization of the treatment effects. The study participants presented with moderate-severe TBI. Individuals with mild TBI also experience problem-solving difficulties and future investigations should include study participants across the TBI severity spectrum.

Probability of practice effects should be considered and controlled in future studies. The computer training program consists of games that are similar to Color-Word Interference subtest of *D-KEFS,* which may have been accessed by the participants independently. Currently, there are no data pertaining to the required duration between administrations of the cognitive tests in

TBI population to eliminate potential for possible practice effects. Lo, Humphreys, Byrne and Pachana (2012) reported that the Letter-Number Sequencing subtest of *WMS-III* to have one of the least likelihood of practice effects in a normal population of individuals between the ages of 40-59. Practice effect information is currently unavailable for *D-KEFS or UCSD-UPSA* tests for the TBI population. In the cognitive literature, there are substantial differences in practice effects between cognitive domains; however, the domains most susceptible to practice effects have not been consistently demonstrated across studies (Lo et al., 2012). Due to the interrelated nature of the cognitive domains assessed in this study, findings from the current investigation need to be interpreted with caution due to non-availability of data for practice effects in the TBI population along with the small sample size.

The presence of emotional dysregulation is discussed and was part of the treatment paradigm; however, no objective measures of motivation, anxiety or frustration were included in pre-post testing. This was a deliberate exclusion in order to gain insight into the significance of emotional dysregulation as a barrier to problem solving. Future studies should focus on adding objective psychobehavioral measures to the test protocol to strengthen their findings.

Rehabilitation is aimed at enhancing the person's independence, and thus strives to improve daily functioning and social integration. The study participants presented with different executive function difficulties that negatively affected their problem solving skills in daily living, however, each had devised independent compensatory and restorative strategies either through use of external aids or family dependence to support the problem solving deficits. Although the study demonstrated generalization to untrained problem solving tasks in therapeutic setting, future investigations should evaluate generalization to problem solving skills in daily life.

Clinical implications in real-life setting: which approach to choose?

The traditionally drawn distinction between restorative interventions and compensatory interventions has motivated clinicians and researchers to debate which is superior and which creates the impression that a clinician should choose one of these approaches to guide their work with cognitively compromised individuals. However, it is clear that 'real-world' tasks don't simply require *either* foundational attention/arousal skills *or* executive abilities but multiple cognitive systems that work together in an integrated fashion. Although bottom-up and top-down interventions may facilitate improvements in both trained and untrained domains of functioning, researchers have shown that neither alone is likely to promote lasting functional improvement. Real-world functioning requires the integration of foundational and higher-order cognitive skills. Moreover, cognition does not occur in isolation. Emotions and emotional reactions can support or undermine the effective use of cognitive skills. Although the current study did not assess nor incorporate emotional and psychological processes involved in higher-order thinking, their role in problem solving is undeniably important. A good clinician should not only determine the best approach for the person with TBI when addressing problem solving but also consider their emotional regulation control. It may be impossible to identify a real-life situation in which only one circumscribed cognitive skill is required (Sun & Zhang, 2004). A simple task such as writing a check requires sustained attention, sequencing, memory, and executive self-monitoring skills. It is well known that all learning (whether facilitated by bottom-up or top-down approaches) is a product of use-induced changes in the brain's structure and functional organization (Buonomano & Merzenich, 1998). Throughout the literature the distinction between compensatory and restorative approaches is actually quite nebulous, and attempts to design and deliver exclusively restorative or compensatory interventions do not reflect the multidimensionality of real-world

functional task demands (Beolen, et al., 2013). Top-down approaches provide generalizable strategies or guiding principles that are widely applicable and relevant for 'real-world' functioning, but without adequate attention and information processing skills, the individual will be unable to learn, remember, process and incorporate feedback from the environment. However, bottom-up approaches are essential ingredients to improving basic capacities for attention and arousal, which are necessary prerequisites for learning, processing and other higher functions. However, transfer of skills to complex tasks of daily living is a challenge that is difficult to meet with bottom-up interventions alone (Dams O'Connor & Gordon, 2013). Although this study was designed to study bottom-up approach to problem solving treatment, in reality it encapsulated cognitive skills of lower and higher order function (attention and working memory, respectively) as traditionally discussed in cognitive literature. Future of cognitive rehabilitation is in designing an integrative model that provides meaningful and functional improvements in productive real-world by incorporating successful elements of bottom-up and top-down approaches and emotional regulation training tailored to meet the individual's needs.

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Appendix A

Problem solving probes for baseline and treatment conditions

(*Everyday Problems Test-EPT*; Willis, 1990)

Charts: Nutritional Information for Cereal

NUTRITION INFORMATION PER SERVING:

SERVING SIZE: 1 oz (2/3 cup)
SERVINGS PER CONTAINER: 16

	1oz CEREAL	WITH 1/2 CUP VITAMINS A & D FORTIFIED SKIM MILK	WITH 1/2 CUP VITAMIN D FORTIFIED WHOLE MILK
Calories	90	130	170
Protein	2g	6g	6g
Carbohydrate	24g	30g	30g
Fat	0g	0g	4g
Cholesterol	0mg	0mg	15mg
Sodium	300mg	360mg	360mg
Potassium	170mg	380mg	360mg

PERCENTAGE OF US RECOMMENDED DAILY ALLOWANCES (U.S. RDA)

PROTEIN	4	10	10
VITAMIN A	*	4	2
VITAMIN C	25	25	25
THIAMINE	25	30	30
RIBOFLAVIN	4	15	15
NIACIN	25	25	25
CALCIUM	*	15	15
IRON	25	25	25
VITAMIN D	*	15	15
VITAMIN B6	25	25	25
FOLIC ACID	25	25	25
VITAMIN B12	25	30	30
PHOSPHORUS	15	30	30
MAGNESIUM	10	10	10
ZINC	25	25	25
COPPER	6	6	6
PANTOTHENIC ACID	*	4	4

*CONTAINS LESS THAN 2 PERCENT OF THE U.S. RDA OF THESE NUTRIENTS

1. What % of the USDA of Vitamin A do you get in 1 oz. cereal without milk?

   a. Less than 2%
   b. Approximately 25%
   c. Approximately 4%
   d. Approximately 2%

2. How many calories are added to a serving of cereal if whole milk is used instead of skim milk?

   a. 20
   b. 30
   c. 40
   d. 50

Directions: Use of Cough Medicine

Indications: Temporarily Relieves Cough Due to Minor Throat and Bronchial Irritation as May Occur with a Cold.

DIRECTIONS: Follow dosage below:
Do Not Exceed 4 Doses in a 24-Hour Period.

ADULT DOSE (and children 12 years and over): 2 teaspoonfuls every 6 to 8 hrs.

CHILD DOSE

6 yrs. to under 12 yrs.
1 teaspoonful every 6 to 8 hrs.

2 yrs. to under 6 yrs.
1/2 teaspoonful every 6 to 8 hrs.

Under 2—Consult Your Doctor.

Warnings—A persistent cough may be a sign of a serious condition. If cough persists for more than 1 week, tends to recur, or is accompanied by fever, rash, or persistent headache, consult a doctor. Do not take this product for persistent or chronic cough such as occurs with smoking, asthma, emphysema, or if cough is accompanied by excessive phlegm (mucus) unless directed by a doctor.

3. What is the maximum number of teaspoons you should take in 24 hours?

   a. 2
   b. 4
   c. 6
   d. 8

4. Mr. Jones smokes and has a smoker's cough. What is the maximum number of doses he should take per day?

   a. 0
   b. 2
   c. 4
   d. 8

Forms: Telephone Service Application

Service Application

INSTRUCTIONS — Print all required information below.

TN:(814)_____

1. Name:

1st Free Listing Last First Mid. Int.

2. Service Address: Street _____

City: _____ State: _____ Zip: _____

3. Location: Apt.#: _____ Or Room # _____

4. 2nd Free Listing:

Last First Mid. Int.

5. Billing Address _____
If different from listed address

6. Local Usage Package (Check One): ☐ Unlimited ☐ Standard ☐ Budget

7. Long Distance Company (Check One): ☐ MCI ☐ ATT ☐ ITT ☐ US Sprint

8. Touch Tone Line (Check One): ☐ Yes ☐ No

9. Requested Connection Date: _____

10. Can Be Reached Number: ( ) _____

Home Telephone No. ( )	Home Street Address	
City	State	Zip Code

5. How many Directory Listings can you request for each new phone line without additional charge?

   a. 1
   b. 2
   c. 3
   d. 4

6. If you make many local calls, which usage option might be best for you?

   a. Budget
   b. Standard
   c. Unlimited
   d. AT&T

Form: N R P Membership Application

I want to win with NRP !

I'd like to enroll as a member for:

☐ one year/$5 ☐ three years/$12.50
☐ ten years/$35

Name _____
(please print)

Address _____ Apt. _____

City _____ State _____

Zip _____ Date of birth / /

13AA

☐ Check or money order enclosed, payable to NRP. (Please don't send cash.)

☐ If you're an active or retired educator, 50 or over, check here to join

Membership also includes spouse. $2.40 of dues is Maturity, 85¢ for NRP Bulletin.

7. If you buy a membership for the period from 1990 to 2000, how much would you pay?

a. $ 5
b. $35
c. $12.50
d. $24

8. If you are married and decide to join NRP how much would your partner have to pay?

a. $ 0
b. $ 5
c. $10
d. $25

Chart: Medicare Benefits Payment Schedule

Part A Medicare Benefits

SERVICE	1988	1989	1990	1991
Inpatient Hospital Services:	All but $540 for first 60 days/ benefit period.	All but $560 deductible for an unlimited number of days/calendar year.	All but Part A deductible for an unlimited number of days/calendar year.	All but Part A deductible for an unlimited number of days/calendar year.
Skilled Nursing Facility Care	100% of costs for 1st 20 days (after a 3 day prior hospital confinement). All but $67.50 a day for 21st-100th day.	80% of Medicare reasonable costs for first 8 days per calendar year without prior hospitalization requirement.	80% for 1st 8 days/ calendar year.	80% for 1st 8 days/ calendar year.
	Nothing beyond 100 days.	100% of costs thereafter up to 150 days/calendar year.	100% for 9th-150th day/calendar year.	100% for 9th-150th day/calendar year.

9. In 1988, what was the amount of the deductible an individual paid for Inpatient Hospital Services?

   a. $540
   b. $560
   c. 80%
   d. 60%

10. Mr. Jones entered a nursing home on January 1 of 1990. How much did Part A Medicare pay for his care in July 1990?

    a. 80%
    b. 100%
    c. All but $67.50
    d. Nothing

Directions: Stain Removal

Stain	How to remove from washable fabrics
FRUIT, FRUIT JUICES 	**Method A:** Sponge with cold water. Soak in cold or warm water with enzyme pre-soak for at least 30 minutes. Launder with detergent and bleach safe for fabric. If stain remains, apply a paste of *oxygen* bleach and water. Add a few drops of ammonia and let stand for 15 minutes. Launder again.
GREASE, OIL, TAR, FATS 	**Method 1:** Use powder or chalk absorbents to remove as much grease as possible, pre-treat with detergent, non-flammable dry cleaning solvent, or liquid shampoo and launder in hottest water safe for fabric, using plenty of detergent. **Method 2:** Rub spot with lard and sponge with a non-flammable dry cleaning solvent. Launder in hottest water and detergent safe for fabric.

11. Which 2 cleaning procedures indicate very hot water should be used?

    a. Only for cleaning juice stains
    b. Removing juice stains and Method 1 for grease removal
    c. Only Method 1 for grease removal
    d. Methods 1 and 2 for grease removal

12. Pretreatment is required before laundering for which 2 methods?

    a. Fat removal and second method for grease removal
    b. First and second methods for grease removal
    c. Fruit stains and first method for grease removal
    d. Fruit stains and second method for grease removal.

Chart: Taxi Rates

SPEEDY TAXI

ZONE	FIRST 1/7 MILE	EACH ADDITIONAL 1/7 MILE
1	$ 1.00	$ 0.20
2	$ 2.00	$ 0.30
3	Flat Rate--$ 7.00	

Note: All passengers ride for the price of one.

EXPLANATION OF FARE ZONES:

1 - All routes within downtown core.

2 - All routes within suburban areas, and between downtown core and suburban areas.

3 - All one-way travel to or from the Airport.

13. If two people are sharing a cab to the airport, how much would each person pay if they split the bill?

a. $1.00 for the first mile, and $0.20 for each additional mile
b. $7.00 for each of the two passengers
c. $3.50 for each of the two passengers
d. $2.00 for the first mile, and $0.30 for each additional mile

14. If you travelled only within suburban areas, for a distance of 1 mile, how much would you pay?

a. $2.30
b. $3.80
c. $4.10
d. $7.00

Directions: Safe Turkey Thawing Instructions

TURKEY THAWING DIRECTIONS

To Cook Immediately: Remove wrap. Place frozen turkey on rack in shallow pan. Cook uncovered in 325 degree oven for 1 hour. Remove neck and giblets. Immediately return to oven.

To Cook Later the Same Day: Leave in wrap. Thaw in frequently changed cold water (about 30 minutes per pound). Cook or refrigerate immediately.

To Cook Later the Following Day: Leave in wrap. Wrap frozen turkey in 2 or 3 layers of newspaper. Place on tray. Thaw at room temperature (about 1 hour per pound). Cook or refrigerate immediately

To Cook Two Days Later: Thaw wrapped turkey in refrigerator. (A large turkey may take up to 3 days.)

Important: Don't allow thawed turkey to stand at room temperature. Don't thaw commercially stuffed turkeys. Don't prepare stuffing and stuff turkey until ready to cook.

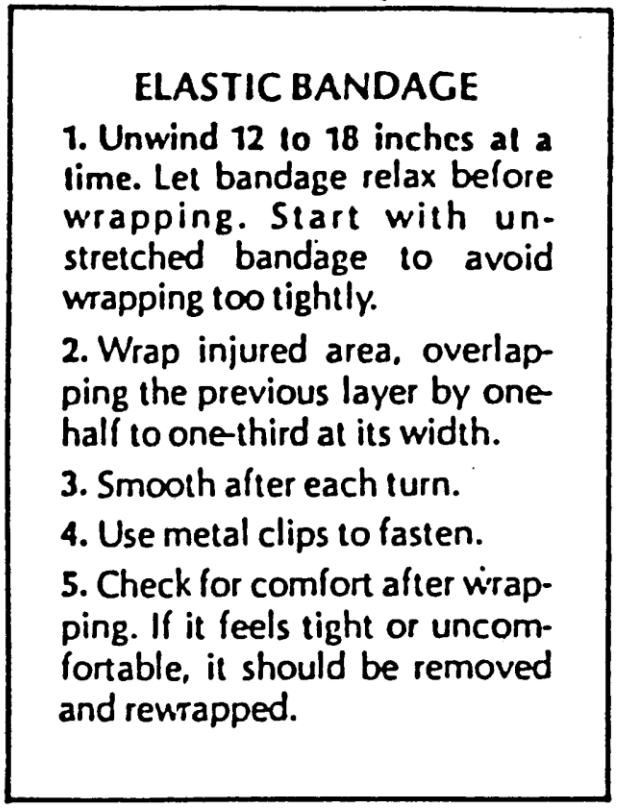
15. According to these directions, how long would it take to thaw a 12 lb. turkey using the cold water method?

    a. 6 hours
    b. 8 hours
    c. 12 hours
    d. 24 hours

16. If you have no refrigeration in which to thaw an 18-pound turkey for tomorrow's dinner, how should you prepare the turkey for thawing?

    a. Cold water method
    b. Cook immediately
    c. Cook unwrapped
    d. Cover with newspapers

Directions: How to Use an Elastic Bandage



17. What should you do if your bandage causes discomfort?

a. Remove it and talk to your doctor.
b. Remove it and wrap it again.
c. Assume that the bandage does not solve your problem.
d. Use 12 to 18 inches of bandage.

18. What helps to reduce the risk of making the bandage too snug?

a. Begin with a bandage that is not stretched.
b. Do not overlap the layers.
c. Stretch the bandage beforehand.
d. Using metal clips.

Chart: Comparison of Cereal Brands

Product	Cost per oz	Calories	Sodium	Sensory comments:
READY TO EAT CEREALS:				
Fiber One	15	57	140	Thin "noodles" with bran
Puffed Wheat	25	95	2	Tough, very soggy
Uncle Sam	12	77	65	Rolled grain with tiny seeds
Nutri-Grain Nuggets	13	96	110	Hard, crunchy wheat nuggets
Shredded Wheat & Bran	18	97	5	Small wheat biscuits, soggy
Shredded Wheat	16	97	6	Large wheat biscuits, soggy
Shredded Wheat Spoon Size	16	99	4	Small Wheat biscuits, soggy
Cheerios	22	106	290	Oat O's, A bit salty, soggy

21. If you were concerned about both low cost and low calories, which product would be the best choice?

    a. Nutri-Grain Nuggets
    b. Fiber One
    c. Cheerios
    d. Nabisco Shredded Wheat

22. If your doctor prescribes a diet low in salt and low in calories, which product should you definitely not purchase?

    a. Nutri-Grain Nuggets
    b. Quaker Puffed Wheat
    c. Cheerios
    d. Nabisco Shredded Wheat Spoon Size

Form: Property Tax or Rent Rebate

LOTTERY

PA-1000 (9-88)

PROPERTY TAX OR RENT REBATE PROGRAM

A. Please do not remove label. Make corrections on label if one is provided.

Your Social Security No. | Spouse's Social Security No.

Claimant's Last Name | First Name and Initial

Home Address

City or Post Office | State | Zip Code

Claimant's Birthdate (Month Day Year) | Claimant's Phone Number ( ) | County

Spouse's Birthdate (Month Day Year) | Spouse's First Name and Initial | Check here ☐ If Spouse is Deceased

B. This Claim Form Must be Filed by

1. I am filing for a rebate as a: (check one)
   - P. ☐ Property Owner (include a copy of your receipt for 1988 property tax bills.)
2. I certify that I am: (check one)
   - A. ☐ A Claimant, age 65 or older as of December 31, 1988.
   - B. ☐ A Claimant under 65 with spouse age 65 or older who resided in the same household as of December 31, 1988.
   - C. ☐ A Widow or Widower, age 50 to 64 as of December 31, 1988.
   - D. ☐ Permanently disabled and age 18 to 64 during 1988.
3. Have you received property tax or rent rebate checks in the past? ☐ Yes ☐ No

If "no," you must send proof of your age. If you are filing because you are disabled, you also must send proof of your permanent disability. Do not send original proof documents.

23. If you have not previously obtained a tax or rent rebate, what additional supporting information must you enclose with the form?

    a. Send a copy of your tax statement
    b. Send a copy of your rent bill
    c. Send proof of your age
    d. Send copy of your utility bill

24. If your spouse has died, what is the earliest age you would be eligible for a rent or tax rebate?

    a. 50 years
    b. 64 years
    c. 65 years
    d. over 65 years

Form: Order Blank for Sweeper Accessories

Offer good in the United States only.
Allow 4 - 6 weeks for delivery. Prices subject to change.

	PRODUCT DESCRIPTION	PART. NUMBER	QTY.	PRICE EACH	TOTAL AMOUNT
	Filter Bag	720330-00		2.25	
	Upholstery Brush	130632-00		2.75	
	Crevice Tool	134862-01		2.75	
	Dirt & Dust Collector				
	Kit A **SAVE 12%** 3-Filter Bags	3-720330-00		Special 5.95	
	Kit B **SAVE 19%** Cleaning Attachment Kit 1 - Crevice Tool 1 - Upholstery Brush 3 - Filter Bags	1-134862-01 1-130632-00 3-720330-00		Special 9.95	

For Your Convenience and future Dustbuster Accessory mail orders, we will forward an additional order form with delivery of any purchases made.

SUBTOTAL	$	
LOCAL SALES TAX (Except ID, ME, NV, ND, SD, VT, WY))	$	1.00
SHIPPING/HANDLING	$	1.50
TOTAL AMOUNT	$	

25. If you need several filter bags, what part number should you order to get a special price?

a. 720330-00
b. 130632-00
c. 134862-01
d. 3-720330-00

26. What would your total bill be if you lived in Idaho and ordered an upholstery brush?

a. $4.25
b. $5.25
c. $5.95
d. $7.00

Directions: Procedure if Involved in an Accident

1. Stop your car at or near the accident scene. If you can, move your car off the road so you do not block traffic.
2. Call the police if anyone is hurt or dies. Also call the police if any vehicle is so badly damaged that it must be towed. If the drivers of the cars are hurt and cannot notify the police, then others in the accident must call for help.
3. Get the following information from the other driver or drivers involved in the accident:
   a) Names and addresses.
   b) Telephone numbers.
   c) Driver license numbers.
   d) Registration numbers.
   e) Their insurance company names and policy numbers, or
   f) Information about financial responsibility.
4. Get the names and addresses of:
   a) People involved in the accident.
   b) Witnesses of the accident.
   c) Injured people.

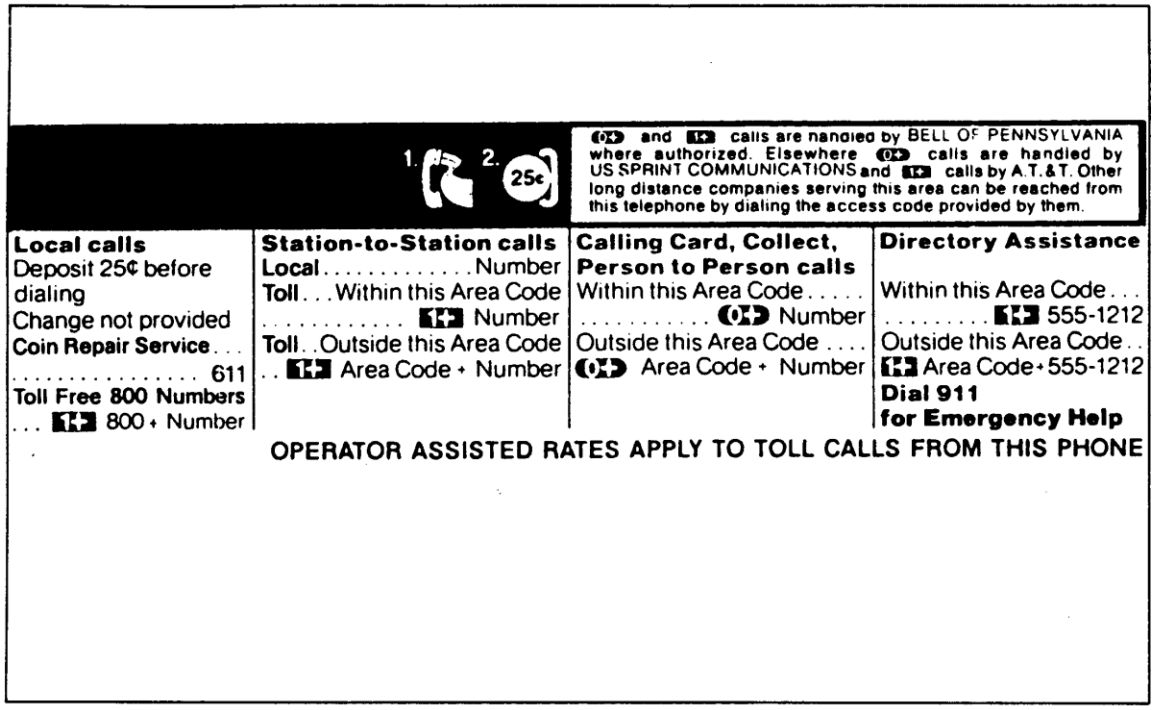
27. What monetary information should you get from a person involved in an accident if he/she doesn't have insurance?

    a. Sources of income
    b. The name of lawyer
    c. The insurance company name
    d. Their next of kin

28. If you have an accident in the middle of an intersection, but your car will run, what should you do with your car?

    a. Leave it where it is
    b. Move it out of traffic
    c. Have it towed
    d. Drive to the police station

Directions: Pay Phone Instructions



33. What number must you dial to charge a call to another area code to your credit card?

a. 0 + Number
b. 0 + Area code + Number
c. 1 + Area code + 555-1212
d. 1 + Area code + Number

34. On what types of calls will you be charged for operator assistance?

a. Local calls
b. Collect calls
c. Toll calls
d. 800 calls

Charts: Guide to Microwave-safe Cookware

ITEM	GOOD USE	GENERAL NOTES
TV dinner trays (aluminum)	Frozen dinners or homemade dinners	No deeper than 3/4 inch. Food will receive heat from top surface only. Foil covering must be removed
Microwave roasting racks	Cooking roasts and chickens, squash and potatoes.	Special racks available for cooking bacon.
Wooden spoons skewers, and straw baskets	Stirring puddings and sauces: for shish kabobs, appetizers, warming breads	Can withstand microwaves for short cooking periods. Be sure no metal fittings on wood or straw.
Paper plates, cups, napkins	Heating hot dogs, drinks, rolls appetizers, sandwiches	Absorbs moisture from baked goods and freshens them. Paper plates and cups with wax coatings should not be used.

29. What container is recommended for baking a potato?

a. Paper plate
b. TV dinner tray
c. Microwave roasting rack
d. Wooden skewer

30. You need to warm a crusty loaf of french bread. What type of container is recommended?

a. Straw basket
b. TV dinner tray
c. Paper plate
d. Roasting rack

Generalization probes

Chart: Energy Expenditure of a Healthy Adult

Approximate Energy Expenditure by a Healthy Adult Weighing About 150 Pounds

Activity	Calories per hour
Lying quietly	80-100
Sitting quietly	85-105
Standing quietly	100-120
Walking slowly, 2 1/2 mph	210-230
Walking quickly, 4 mph	315-345
Light work, such as ballroom dancing, cleaning house, office work, shopping	125-310
Moderate work, such as cycling, 9 mph, tennis, scrubbing floors, weeding garden	315-480
Hard work, such as chopping wood, shoveling snow, spading garden, swimming, "crawl"	480-625

45. If your job were one in which you had to stand quietly for a 4 hour shift, about how many calories would you use in 4 hours?

a. 100-120
b. 200-240
c. 300-360
d. 400-480

46. It takes you 30 minutes to clear your driveway of snow. About how many calories did you use?

a. 125-310
b. 240-312
c. 315-480
d. 480-625

Forms: Telephone Calling Card Application (Financial Information)

Financial Information (Please Print)

Bank references:

☐ Checking ☐ Savings	Bank name	City	State
☐ Checking ☐ Savings	Bank name	City	State

Credit references (include charge accounts, installment contracts, finance co., credit cards, etc.).
Give complete list of all amounts owing.

Credit or charge cards	Issuing company or bank	Monthly payments	Balance due
		$	$
		$	$

I agree to pay for charges to the account in accordance with the terms of the applicable tariffs as explained in the Account Agreement they will send me when my application is approved

FOR OFFICE USE ONLY

APPLICANT'S SIGNATURE X _____ Date _____

Please allow 4 to 6 weeks for delivery

SCM 889

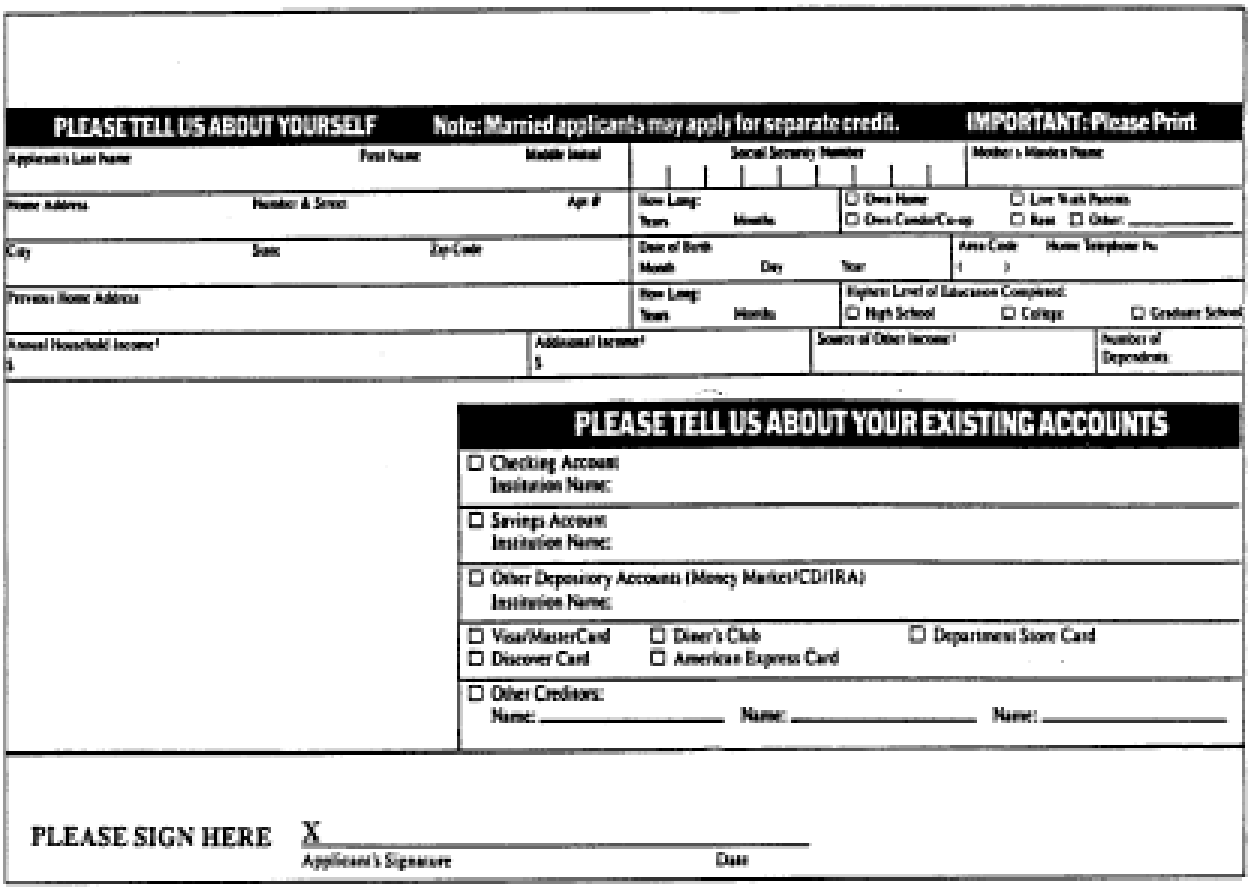
47. How long will it take for your Phone Card to arrive?

a. 1 to 2 weeks
b. 2 to 4 weeks
c. 4 to 6 weeks
d. 6 to 8 weeks

48. What expenses are you liable for when you sign this application?

a. all account charges
b. application processing fee
c. credit card check fee
d. delivery charge

Form: Credit Card Application



PLEASE TELL US ABOUT YOURSELF Note: Married applicants may apply for separate credit. **IMPORTANT: Please Print**

Applicant's Last Name | First Name | Middle Initial | Social Security Number | Mother's Maiden Name

Home Address | Number & Street | Apt #

How Long: Years Months

☐ Own Home ☐ Live With Parents
☐ Own Condo/Co-op ☐ Rent ☐ Other: _____

City | State | Zip Code

Date of Birth: Month Day Year

Area Code Home Telephone No.
( )

Previous Home Address

How Long: Years Months

Highest Level of Education Completed:
☐ High School ☐ College ☐ Graduate School

Annual Household Income?
$

Additional Income?
$

Source of Other Income?

Number of Dependents

PLEASE TELL US ABOUT YOUR EXISTING ACCOUNTS

☐ Checking Account
Institution Name:

☐ Savings Account
Institution Name:

☐ Other Depository Accounts (Money Market/CD/IRA)
Institution Name:

☐ Visa/MasterCard ☐ Diner's Club ☐ Department Store Card
☐ Discover Card ☐ American Express Card

☐ Other Creditors:
Name: _____ Name: _____ Name: _____

PLEASE SIGN HERE X_____
Applicant's Signature Date

49. What type of information would the bank want to know about where you used to live?

a. Number of dependents at old address, and how long you lived there
b. Your old address and how much household expenses were
c. Your old address and how long you lived there
d. Your old address and who lived there with you

50. What specific information should you provide regarding your Individual Retirement Account?

a. Account number
b. How long you have held account
c. Where the account is held
d. Balance in account

Directions: How to Apply for Food Stamps

1 FILE AN APPLICATION FORM	* The food stamp office will give you an application form on the same day you ask for one. You can ask for it in person, over the phone or by mail, or someone else may get one for you.
2 HAVE AN INTERVIEW WITH A FOOD STAMP WORKER	* After you have turned in your application, a worker will hold a confidential interview with you or another member of your household. * If you are 65 or older or disabled and you cannot go to the food stamp office and no one can go for you, let the office know. A worker will arrange to interview you at home or by telephone. Other people who cannot get to the office and who have no one to go for them may qualify for a home or telephone interview, too.
3 MEET ELIGIBILITY RULES AND PROVIDE PROOF THAT YOU ARE ELIGIBLE	* Resources: All households may have up to $1,750 worth of resources. Households of two of more persons may have up to $3,000 if at least one member is age 60 or older.

51. You are 59 years old and your spouse is 60. What is the maximum financial worth you can have and qualify for food stamps?

a. $1,750
b. $3,000
c. $3,500
d. $4,000

52. What must happen next, after you return your food stamp application to the office?

a. Interview with office personnel
b. You provide proof of income
c. Your application must be approved
d. You receive food stamp I.D. card

Chart: Choosing Furniture Polishing Products

FURNITURE POLISHING PRODUCTS

Product	Application	Results
Liquid polish	Apply with a soft cloth; buff lightly with a clean, soft cloth while wet	High luster; little protection
Paste wax	Apply sparingly with a soft cloth; buff vigorously with a clean, soft cloth when dry	High luster; moderate protection; slight yellowing
Spray wax	Spray on; buff with a clean, soft cloth while wet	Moderate luster; little protection
Dusting spray	Spray on; wipe off with a clean, soft cloth	Prevents dust from scattering; no protection
Scratch-cover liquid polish	Apply with a soft cloth; wipe off with a clean, soft cloth	Conceals blemishes; no protection
Oil finish	Apply with a soft cloth; dry with a clean, soft cloth	High luster; no protection

53. What product should you use to hide imperfections in the finish?

a. Paste wax
b. Spray wax
c. Oil finish
d. Scratch cover liquid polish

54. What product should you use if you want the most protection available for your furniture?

a. Liquid polish
b. Paste wax
c. Spray wax
d. Oil finish

Directions: Drivers' Right of Way Laws

Right-of-Way

When no signs, symbols, or police tell you what to do, you must follow special laws. Here are 3 of these laws:

1. Drivers must yield to pedestrians in these conditions:
   - —When pedestrians are crossing the roadway at an intersection without a traffic light (the crosswalk does not have to be marked).
   - —When pedestrians are crossing the roadway in specially marked crosswalks.
   - —When the driver is turning a corner and the pedestrians are crossing with the light.
   - —When a blind pedestrian carrying a white cane or being led by a guide dog is crossing the street.
   - —When pedestrians are crossing the sidewalk at a driveway or alley.
2. Drivers turning left must yield to oncoming cars going straight ahead.
3. When two vehicles approach or enter an intersection from different roadways at about the same time, drivers coming from the left must yield to vehicles coming from the right.

55. If you are continuing on the same road through an intersection, who should yield to you?

a. The car turning right
b. The last car reaching the intersection
c. The car going straight
d. The car turning left

56. Who has the right of way if you are making a right turn on red and a jogger is crossing with the light?

a. You have right of way
b. Jogger has right of way
c. First one to reach intersection
d. Driver making left hand turn

Forms: Fruit Basket Gift Order Form

1.
Ship to _____

Street _____ Apt. _____

City _____ State _____ Zip _____

Qty.	Name of Item	Item No.	Price	Sales Tax

CHECK ONE ☐ for Christmas ☐ for Thanksgiving ☐ for Hanukkah ☐ week of __/__/__

Ship to arrive: ☐ Ship when available ☐ Federal Express arrival date __/__/__

Greetings from:

57. What information about the product should you include in the order to assure that the right item is delivered?

a. Your telephone and credit card number
b. Your greetings to the recipient
c. The quantity, item name, and item number
d. The recipient's home and office phone number

58. What makes up the total cost for each item?

a. The item price plus a service charge
b. The item price plus sales tax
c. The sales tax plus a service charge
d. The service charge, item price and sales tax

Chart: Desirable Body Weight Ranges for Men and Women

Desirable Body Weight Ranges

Height without shoes	Weight without clothes	
	Men (pounds)	Women (pounds)
4'10"		92-121
4'11"		95-124
5'0"		98-127
5'1"	105-134	101-130
5'2"	108-137	104-134
5'3"	111-141	107-138
5'4"	114-145	110-142
5'5"	117-149	114-146
5'6"	121-154	118-150
5'7"	125-159	122-154
5'8"	129-163	126-159
5'9"	133-167	130-164
5'10"	137-172	134-169
5'11"	141-177	
6'0"	145-182	
6'1"	149-187	
6'2"	153-192	
6'3"	157-197	

Note. For women 18-25 years, subtract one pound for each year under 25.

Source. Adapted from the 1959 Metropolitan Desirable Weight Table.

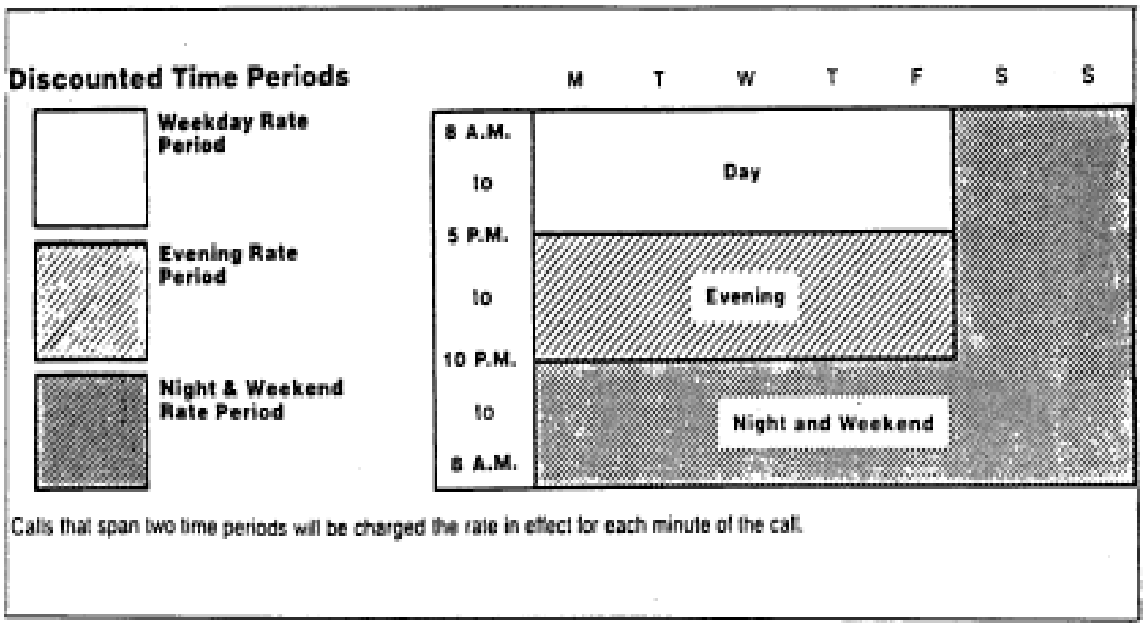
59. According to this chart, the desirable weight of a man who is 5'4" tall is almost identical to that of a woman who is how tall?

a. 5'4"
b. 5'5"
c. 5'6"
d. 5'7"

60. How many more pounds are men permitted to weigh than women of the same height?

a. 1-2 pounds
b. 2-3 pounds
c. 3-4 pounds
d. 4-5 pounds

Charts: Telephone Discounted Time Periods



61. Your son and daughter live in the same city out-of-state. You call your daughter at 11:37 a.m. on Saturday. You call your son at 9:30 p.m. on Wednesday. Both calls last 5 minutes. Which call is cheaper?

a. Phone call to daughter
b. Phone call to son
c. Calls cost the same
d. Daytime calls are cheaper

62. If your call begins at 4:57 p.m. on Monday, and lasts for 7 minutes, what is/are the applicable rate(s) for your call?

a. Weekday Rate
b. Evening Rate
c. Weekday and Evening Rate
d. Evening and Night Rate

Directions: Mail a Rebate with Proof of Purchase

TWO SPECTACULAR REBATE OFFERS!

OFFER #1 $1.00 Rebate when you purchase two GET-120 or T-120SHG Video Tapes in a single purchase.

OFFER #2 $1.00 Rebate when you purchase a GET-120SK Survival Kit (GE VCR Maintenance Kit).

1. To get your $1.00 rebate when you purchase 2 GET-120, or 2 T-120SHG video tapes, remove the proof-of-purchase seals from the video tape instruction manuals inside the tape packages. And affix them to the two shaded proof of purchase areas shown on this coupon.

2. To get your $1.00 rebate when you purchase the Survival Kit, cut the proof-of-purchase seal from the back box panel. And affix it where indicated on this coupon. Also, remove the proof-of-purchase seal from the instruction manual inside the box of tape and affix it to the smaller of the two non-shaded proof-of-purchase areas on this coupon.

Then mail this coupon along with the original dated store receipt (or receipts should you decide to take advantage of both rebate offers) to:

PROOF OF PURCHASE

PROOF OF PURCHASE

63. What must you mail along with the coupon and proof of purchase to receive your rebate?

a. Back box panel of kit(s)
b. Instruction manual(s)
c. Store receipt(s)
d. $1.00

64. Where inside the box of tape will you find the proof of purchase that is common to both offers 1 and 2?

a. Instruction manual
b. Non-shaded area on coupon
c. Back box panel
d. Inside the tape package

Appendix B

Paper-pencil tasks

Understanding, Predicting, and Recalling Time 2

Suggested target areas: temporal orientation, problem solving, deductive reasoning, memory

Have the client provide logical and appropriate times for the following activities.

Monday

Eat lunch _____

Wake up _____

Have a before-bedtime snack _____

Make lunch _____

Eat breakfast _____

Go to bed _____

Take a nap after lunch _____

Eat dinner _____

Tuesday

Go to bed _____

Go to work _____

Eat lunch _____

Get ready for work _____

Drive home from work _____

Wake up _____

Eat dinner _____

Attend morning meeting at work _____

Understanding, Predicting, and Recalling Time 3

Suggested target areas: temporal orientation, problem solving, memory

Have the client answer the following time questions using prediction and problem-solving skills.

1. Your doctor's appointment is at 9:00 AM and it takes a half hour to get there. What time do you have to leave to get there on time?
2. You are making lunch for friends and it takes 45 minutes for the food to cook. What time do you have to put the food in the oven to serve lunch at 1:00 PM?
3. Your favorite television show starts at 8:00 PM. It's now 7:10 PM. How many minutes until your show begins?
4. Your child gets out of school at 3:30 PM and it takes 15 minutes to get home. What time will he get home?
5. You went to bed at 10:00 PM and woke up at 2:00 AM. How many hours of sleep did you get?
6. Your class starts at 8:00 AM and meets for an hour and a half. What time will you finish the class?
7. The casserole you made takes 50 minutes to cook. You put it in the oven at 2:10 PM. When will it be done?
8. You were on schedule to arrive at your friend's house at 7:15 PM. The traffic is causing a 30-minute delay. Due to the delay, what time will you now get there?
9. You have to leave for work by 8:00 AM and it takes you an hour to get ready. What time do you have to get up?
10. The ball game begins in 35 minutes. It's now 10:55 AM. What time will the game start?
11. It will take you 45 minutes to mow the yard. It's 7:40 PM now. What time will you be finished?
12. The concert starts at 9:30 PM and it will last two and a half hours. What time will the concert end?
13. You finish work at 5:30 PM and it takes you 25 minutes to drive home. What time will you get home?
14. It is now 12:30 PM. It will take you one hour to ride your bike home from the park. What time will you get home?
15. The bread takes 70 minutes to bake. If you want it done by noon, what time do you have to put it in the oven?
16. It takes 3 hours to get to your friend's house. If you leave at 11:00 AM, what time will you arrive at your friend's house?

Calendar Work

Suggested target areas: temporal orientation, visual neglect and awareness, problem solving

Use an appropriate calendar to obtain specific temporal orientation information. Verbal, visual, and physical cues should be noted and used, based on the client's functioning skill level.

Current Month Questions

1. What day of the week is it?
2. How many days are there until the weekend?
3. How many weeks are there in this month?
4. What holidays fall in this month?
5. What day of the week does this month start with?
6. What is today's date?
7. What month is it?
8. What year is it?
9. What was yesterday?
10. What day is tomorrow?

Year Questions

1. What are the months of the year?
2. How many months are in the year?
3. What is the first month of the year?
4. What is the last month of the year?
5. What year is it?
6. How many days are in the month of January?
7. Find the day and date of Valentine's Day in the month of February.
8. What day of the week is the first day of June?

Daily Schedule

Suggested target areas: temporal orientation, memory, problem solving

Have the client use temporal orientation strategies/aids in order to obtain information regarding his daily or hourly schedule. Alter the type and complexity of daily schedule tasks, aids, and cues, depending on the client's functioning skill level (e.g., fill in the calendar with the client, change the amount of information to be recalled, use a calendar or clock).

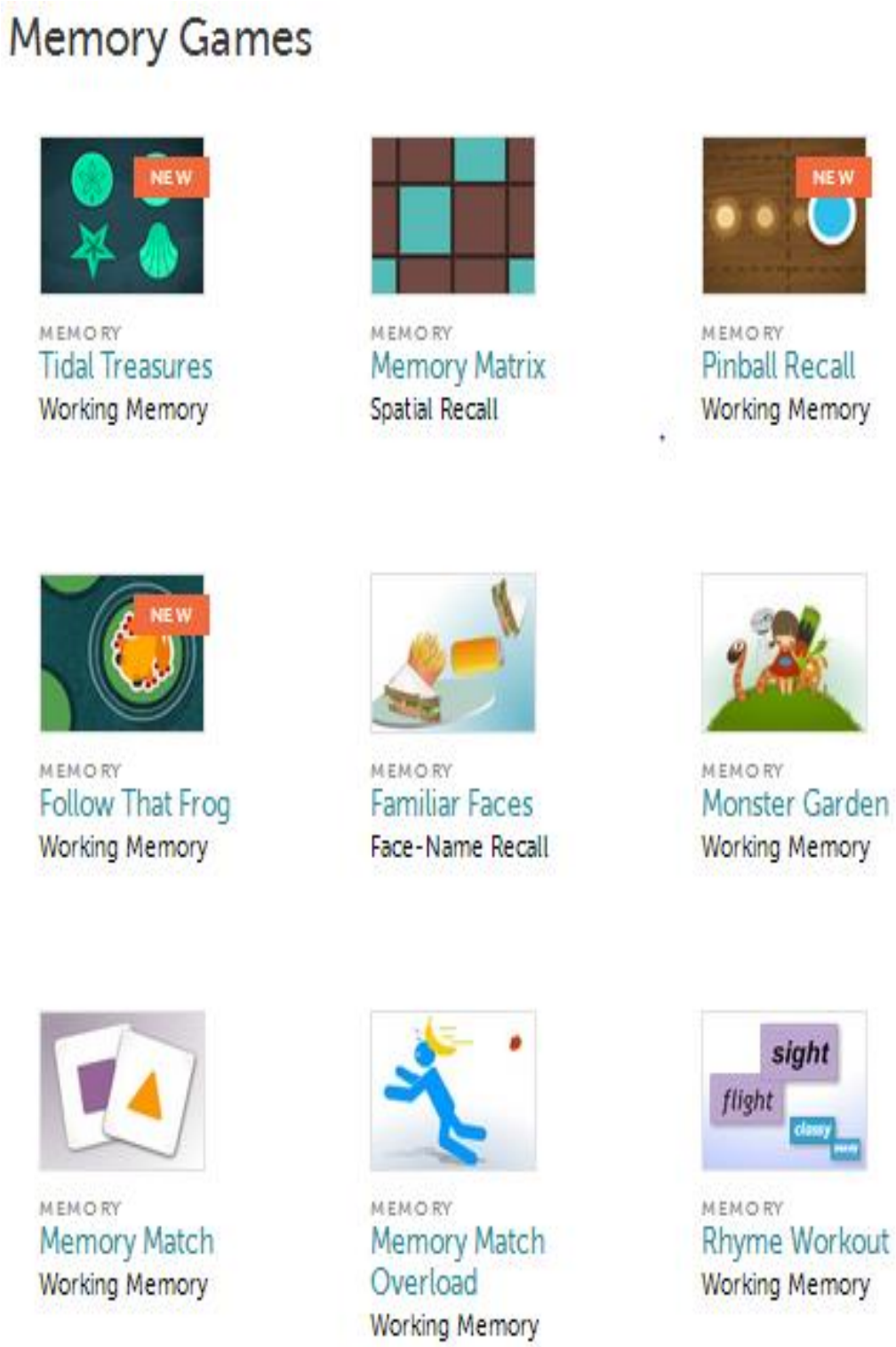
Possible Questions

1. What is the first thing you did today?
2. What time do you eat breakfast?
3. What therapy do you receive first?
4. What times do you have nothing scheduled?
5. When does your first therapy begin?
6. What therapy do you go to before lunch?
7. When is your last therapy of the day?
8. When do you eat lunch?
9. What do you do after breakfast?
10. What do you do after lunch?
11. How long is _____ therapy?
12. What time do you go to bed?
13. What is the last thing you do before bed?
14. Where do you go following breakfast?
15. Where do you go following _____ therapy?

Functional Carryover Activity

- Complete a chart that represents the client's daily schedule. You can write in the activities or use clock symbols to show the times of each activity. This can be completed before, during, or after the activities occur.

Computer training tasks



Attention Games

ATTENTION
Trouble Brewing
Divided Attention

ATTENTION
Star Search
Selective Attention

ATTENTION
Rhythm Revolution
Timing

ATTENTION
Train of Thought
Divided Attention

ATTENTION
Eagle Eye
Field of View

ATTENTION
Lost in Migration
Selective Attention

ATTENTION
Birdwatching
Field of View

ATTENTION
Observation Tower
Field of View

ATTENTION
Space Junk
Field of View

ATTENTION
Playing Koi
Divided Attention

ATTENTION
Top Chimp
Field of View

Flexibility Games

FLEXIBILITY
Word Bubbles Rising
Verbal Fluency

FLEXIBILITY
Ebb and Flow
Task Switching

FLEXIBILITY
Robot Factory
Response Inhibition

FLEXIBILITY
Disillusion
Task Switching

FLEXIBILITY
Brain Shift
Task Switching

FLEXIBILITY
Color Match
Response Inhibition

FLEXIBILITY
Word Bubbles
Verbal Fluency

FLEXIBILITY
Disconnection
Task Switching

FLEXIBILITY
Brain Shift Overdrive
Task Switching

Appendix C

Intervention training tasks and strategies

Memory

Tasks	Strategies
- Word list recall: organized and unorganized - Number recall: Forward/backward digits Phone numbers - Name-face recognition task - Paper-pencil/functional tasks: • Written passages • medication routines • appointments and calendars • scheduling tasks • making grocery list - Computer training: www.lumosity.com • N-back • Dual N-Back • Positional recall • Forward /backward digit recall	- Chunking - Categorization - Semantic organization - Association: name-number/face-name - Rehearsal - Timed and untimed interval recall - Acronyms - Visual imagery

Attention and inhibition

Tasks	Strategies
Computer training tasks: www.lumosity.com • Divided auditory attention task • Visual attention task • Continuous performance task • Rapid visual information processing task • Same-different task • Attention switching task • Stroop task • Interference task • Go/Nogo tasks Paper-pencil/functional tasks: • Diagram reduplication task • Letter/number identification task • Categorical switching task • Completing job-search • Correcting cable channel lineup • Medication correction	- Verbal cuing and redirection - Error awareness: intellectual, emergent and anticipation awareness - Error identification - Eliminating external distractions - Teaching self-talk and self-monitoring - Identify attentional overload - Gradual increment in number of activities - Simplification of complex task - Chunking - Fatigue management - Establish routine

APPENDIX D

East Carolina

University

Informed Consent to Participate in Research

Information to consider before taking part in research that has no more than minimal risk.

Title of Research Study: Improving problem solving difficulties in traumatic brain injury

Principal Investigator: Amit Kelkar, M.S.CCC-SLP

Institution/Department or Division: East Carolina University. Department of Communication Sciences and Disorders

Address: Allied Health Building, East 5th Street, Greenville, NC

Telephone #: 252-744-6100

Study Sponsor/Funding Source: Non-funded

Researchers at East Carolina University (ECU) study problems in society, health problems, environmental problems, behavior problems and the human condition. Our goal is to try to find ways to improve the lives of you and others. To do this, we need the help of volunteers who are willing to take part in research.

Why is this research being done?

The purpose of this research is to develop a new treatment for improving problem solving deficits in people with traumatic brain injury.

Why am I being invited to take part in this research?

You are being invited to take part in this research because you expressed interest in participating in the study, have a history of traumatic brain injury and report that you have problem solving difficulties at home and/or at work.

Are there reasons I should not take part in this research?
You are not eligible to participate if you are younger than 18 or older than 60 years, have a history of alcohol or substance abuse and/or mental illness, have a history of aphasia (language disorder) or read below fifth grade reading level.

What other choices do I have if I do not take part in this research?

You can choose not to participate.

Where is the research going to take place and how long will it last?

The treatment sessions will be conducted at your residence. One-hour treatment sessions will be conducted 4 times a week for 5 weeks for a total of 20 sessions. A single session assessing retained learned skills will be completed 1 month after completion of treatment.

What will I be asked to do?

You will be asked to do the following:

- Respond to several questions about your medical, social and educational background.
- Complete initial testing on measures of attention, memory, organization, planning and problem solving.

- Participate in treatment sessions 4 time a week for 5 weeks (total of 20 sessions) and one session to assess retained learned skills 1 month after completion of treatment.
- During treatments you will complete several online and paper-pencil exercises to improve attention, memory, organization, planning and problem solving.

Initial testing:

During initial testing you will complete four tests that take approximately 1 hour to complete. You may take rest breaks as needed during testing. The subtests of *Delis Kaplan Executive Functioning System (D-KEFS)* measure attention skills. The subtests of *Wechsler Memory Scale-III (WMS-III)* measure memory skills *and The UCSD Performance-Based Skills Assessment (UPSA-1)* measures problem solving skills.

A brief explanation for the tests is as follows:

1. The *Delis Kaplan Executive Functioning System (D-KEFS)-Trail Making Test:* assess attentional skills and takes approximately 15 minutes to complete. You as a participant are required to visually scan through letters and numbers based on the directions provided by the researcher.

2. *D-KEFS Color-Word Interference Test:* measures inhibition of verbal responses and takes approximately 15 minutes to complete. You are required to name the color or the word depending on the directions provided by the researcher.

3. *Wechsler Memory Scale- III (WMS-III)-Letter Number Sequencing (LNS) and Digit Span Test*: assesses attention and short-term memory. You will be asked to repeat a sequence of letters and numbers presented by the researcher in both these tests.

4. *The UCSD Performance-Based Skills Assessment (UPSA-1)* measures a person's capacity to problem solve in five selected areas of basic living skills. You will be asked to complete everyday activities involving planning a trip, managing money, communication, transportation and home management.

Treatment program

Following initial baseline testing, you will participate 20 sessions of attention, memory, organization, planning and problem solving training. This training will be conducted through paper-pencil tasks and computer-based games. We will use the website- www.lumosity.com- to complete the computer training. The researcher will provide you with methods and ideas to improve your memory, attention span, organization, planning and problem solving skills. The treatment sessions will be audio and video recorded. Only individuals on the research team will have access to the recordings. They will be deleted within 14 days of uploading to East Carolina University's secure departmental drive.

What possible harms or discomforts might I experience if I take part in the research?

The risks associated with this research are no more than what you would experience in everyday life.

What are the possible benefits I may experience from taking part in this research?
We do not know if you will get any benefits by taking part in this study. This research might help us learn more about how memory, attention span, organization, planning and problem solving skills help to improve problem solving deficits in people with traumatic brain injury. There may be no personal benefit from your participation but the information gained by doing this research may help others in the future. We expect that participating in this study may improve your problem solving skills at home and work environment allowing you to be more independent in your everyday life.

Will I be paid for taking part in this research?

We will not be able to pay you for the time you volunteer while being in this study.

What will it cost me to take part in this research?

It will not cost you any money to be part of the research.

Who will know that I took part in this research and learn personal information about me?
To do this research, ECU and the people and organizations listed below may know that you took part in this research and may see information about you that is normally kept private. With your permission, these people may use your private information to do this research:

- Amit Kelkar, M.S.CCC-SLP (Principal Investigator)
- Heather Wright, Ph.D.CCC-SLP (Faculty supervisor)
- Erik Everhart, Ph.D (Committee member on study)
- The University & Medical Center Institutional Review Board (UMCIRB) and its staff, who have responsibility for overseeing your welfare during this research, and other ECU staff who oversee this research.

How will you keep the information you collect about me secure? How long will you keep it?

No medical records or doctors notes will be reviewed during the course of the study. All information pertaining to your medical and social history will be collected from you and/or your legally authorized representative. All surveys and interview-related data will be coded with no reference to your personal information and the code will be known only to the researchers. Initial test scores will be in possession of the researcher at all times in paper format. Audio/video recordings will be gathered using a digital camcorder and data will be uploaded to ECU's secured and encrypted departmental drive. The audio/video recording will be immediately deleted from the camcorder within 14 days of uploading to ECU's secure drive to protect your privacy. No one else will have access to the audio/video recordings. All participant data sets (participant digital files and all collected data) will be coded (e.g. Subject ASK 1a) and will be known only to the researchers. All electronic data will be deleted on completion of the study. Computer training data will be collected through online profile developed for each participant individually. You will only be able to view your performance during online training.

What if I decide I do not want to continue in this research?

If you decide you no longer want to be in this research after it has already started, you may stop at any time.

Who should I contact if I have questions?

The people conducting this study will be available to answer any questions concerning this research, now or in the future. You may contact the Principal Investigator at 570-581-6763 (7 days a week, between 8 AM to 8 PM). If you have questions about your rights as someone taking part in research, you may call the Office for Human Research Integrity (OHRI) at phone number 252-744-2914 (weekdays, 8:00 am-5:00 pm). If you would like to report a complaint or concern about this research study, you may call the Director of the OHRI, at 252-744-1971 (weekdays, 8:00 am-5:00 pm).

I have decided I want to take part in this research. What should I do now?

The person obtaining informed consent will ask you to read the following and if you agree, you should sign this form:

- I have read (or had read to me) all of the above information.
- I have had an opportunity to ask questions about things in this research I did not understand and have received satisfactory answers.
- I know that I can stop taking part in this study at any time.
- By signing this informed consent form, I am not giving up any of my rights.
- I have been given a copy of this consent document, and it is mine to keep.

_____ _____

Participant's Name (PRINT) **Signature** **Date**

_____ _____

Signature of Legally Authorized Representative **Date**

Or caregiver/spouse/family member as witness

_____ _____

Printed name of Legally Authorized Representative **Date**

Or caregiver/spouse/family member as witness

Person Obtaining Informed Consent: I have conducted the initial informed consent process. I have orally reviewed the contents of the consent document with the person who has signed above, and answered all of the person's questions about the research.

_____

Principal Investigator (PRINT) **Signature** **Date**