A COMPARISON OF PAST AND FUTURE MEMORY FLUENCY TASKS: A PILOT STUDY OF ADULTS WITH AND WITHOUT TRAUMATIC BRAIN INJURY

by

SAMANTHA TAYLOR FOLK

(Under the Direction of Katy H. O'Brien)

ABSTRACT

Purpose: The purpose of the current study was to develop a narrative assessment of episodic memory and future thinking in adults with traumatic brain injury (TBI). We tested narrative types first with a group of healthy adults, then with a small pilot group of adults post-TBI. **Methods:** Participants included 16 healthy adults and a pilot group of 5 adults with TBI. Using structured autobiographical interviews, each participant produced six narratives, three about future and three about past events. Narratives were transcribed, analyzed for productivity measures, and coded for provision of memory details. **Results:** Both healthy adults and adults with TBI provided the greatest density of episode specific details in narratives discussing temporally remote and personally significant events. **Discussion**: Preliminary comparisons suggest adults with TBI are less efficient in producing narratives describing past and future events than healthy adults, and rely more on general semantic knowledge, rather than episode specific details.

INDEX WORDS: Traumatic Brain Injury, Discourse assessment, Assessment of Traumatic Brain Injury, Memory Fluency, Episodic Future Thinking, Remembering Imagining Window

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CHAPTER 1

INTRODUCTION

Traumatic brain injury (TBI) is a major cause of death and disability, affecting approximately 2.2 million Americans each year and accounting for nearly one third of all injury related deaths. A TBI results in heterogeneous disorders with different forms of presentation – the unifying factor being that it is caused by a bump, blow, or jolt to the head that interrupts the normal functioning of the brain (Taylor, Bell, Breiding, & Xu, 2017) The nature, intensity, direction, and duration of these forces determine the pattern and extent of damage (Maas, Stocchetti, & Bullock, 2008). TBI can be categorized as mild, moderate, or severe based on the extent and nature of injury, duration of loss of consciousness, post-traumatic amnesia, and the severity of confusion at initial assessment during the acute phase of the injury (Diagnostic and Statistical Manual of Mental Disorders-5; American Psychiatric Association, 2013).

Typically, TBI is considered the physical injury but cognitive disorders are a frequent result. Memory, attention, and executive function deficits are common, although problems with memory are the most frequent subjective complaints reported by TBI patients and their relatives. (Azouvi, Arnould, Dromer, & Vallat-Azouvi, 2017; Lê, Mozeiko, & Coelho, 2011). Memory deficits resulting from a TBI are diffuse, and impact both long-term and short-term memory abilities. Both anterograde and retrograde episodic memory deficits are highly prevalent after TBI and often these memory deficits seen are mediated by executive functioning processes (Azouvi et al., 2017; Dobryakova, Boukrina, & Wylie, 2015). People who experience TBI typically have difficulty accessing or retrieving stored information strategically, as well as integrating information in their working memories for narrative construction (Coelho, Mozeiko, & Lê, 2007; Rasmussen & Berntsen, 2014; Ylvisaker, Szekeres, & Feeney, 2008). It has also been proposed that those who experience TBI have difficulty establishing self-concept and even further, have difficulty temporally extending themselves into the past or future (Coste, Navarro, Vallat-Azouvi, Brami, Azouvi, & Piolino, 2015). Specifically, Autobiographical Memory and mental time travel have received substantial attention in recent research with populations with memory deficits such as TBI.

The injury profile of TBI is not homogenous due to its diffuse nature, but fronto-limbic structural damage is highly common in the TBI population (Rasmussen & Berntsen, 2014;). Many studies have demonstrated Autobiographical Memory (AM) to involve a wide network in the cerebral cortex, with specific reliance on the frontal lobe. Considering the common impact on the frontal areas, and diffuse nature of impact, those who have experienced TBI are likely to demonstrate AM dysfunction after TBI (Coste et al., 2015; Rasmussen & Berntsen, 2014, 2016). The deficit of episodic AM in TBI has been linked to the disruption of search and construction processes mediated by executive functions (Piolino, Desgranges, Manning, North, Jukic, & Eustache, 2007). The extensive connections of the prefrontal cortex to other areas of brain make it a likely candidate for control and regulation of goal-oriented functions, such as discourse ability (Lê et al., 2011). People with TBI may also demonstrate communicative deficits attributable not to aphasia, but rather because of disruption to non-linguistic, cognitive processes that sub-serve language functions (Coelho & Lê, 2007). Because Autobiographical Memory is assessed through the generation of narratives, the cognitive-communication deficits of people with TBI should be considered.

Cognitive Communication Deficits and Narrative Production

Adults with TBI frequently experience cognitive communication deficits that are a result of impaired memory and executive dysfunction. In contrast to populations with global amnesia (i.e., aging, MCI, dementia etc.), TBI is a general and diffuse cognitive deficit rather than a specific memory impairment. The communication profile of "non-aphasic" TBI population has been deemed "the language of confusion"—characterized by relatively fluent and grammatically sound expressive language, with functional auditory comprehension to succeed in general everyday interaction; however, as cognitive and social demands increase, breakdowns in communication frequently occur (Ylvisaker et al., 2008). Specifically, communication deficits may manifest in difficulty with confrontation naming, word fluency, and comprehension of complex commands which result in problems with organizational schema required for narrative discourse formulation and topic management in conversation (Coelho & Lê, 2007; Ylvisaker et al., 2008). These breakdowns are understood to reflect increasing cognitive demands, such as poor search strategies for target words, or problems with working memory and flexibility to hold on to and adapt to incoming complex commands.

Discourse is an intersection point of cognition and language. Thoughts must be organized and sequenced within and across sentences, requiring coordination of linguistic and cognitive systems. Many studies have made use of discourse analysis to demonstrate the cognitive communication dysfunction as a result of executive function, memory, and attention deficits after TBI (Lê et al., 2011; Ylvisaker et al., 2008). This type of analysis is an important piece of the assessment of individuals with TBI, as discourse analysis is sensitive to subtle deficits otherwise not as apparent in other methods of cognitive-communication testing (Coelho & Lê, 2007).

Episodic Future Thinking

Although memory is often thought of as a concept that connects humans to the past, evidence suggests that memory also plays a critical role in connecting humans to the future. Just as episodic memory is defined as personally experienced memories of events that are specifically situated in time, location, and contains semantic knowledge of one's past, episodic future thinking (EFT) is similarly defined, but refers to our ability to project ourselves into the future. A broader view now postulates that the memory system is responsible for both the ability of individuals to re-experience episodes from the past and also imagine or pre-experience episodes that may occur in the future (Atance & O'Neill, 2001; Corballis, 2009; Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002; Schacter & Addis, 2007). These types of memory are referred to as "episodic" meaning that these (either past or future) memories contain personally experienced events or episodes. When we imagine the future, we draw upon previous experiences in a way that uses similar neural resources and architecture as remembering (Szpunar, Watson, & McDermott, 2007). Remembering to imagine allows for more specific plans to be developed.

Schacter and Addis (2007) proposed the constructive episodic simulation hypothesis which states that the constructive nature of episodic memory, at least in part, is attributable to the role of the episodic system in allowing us to mentally simulate our personal futures. Coste et al. (2015) examined the ability of participants with TBI to temporally extend themselves into the past and future. Those with TBI showed deficits in both semantic and episodic self-representations, regardless of the time period, and even after controlling for basic cognitive functions, highlighting the disruption of self-representation across time following a TBI.

Conway and Loveday (2015) suggest that this back and forward remembering should be referred to as the *remembering imagining system (*the RIS*)*, which is an extended form of consciousness that consists of memories of the recent past and images and expectations of the near future visualized as a bell curve. This curve posits that we have the greatest awareness and recall of the recent past and the most-near future, and that awareness decreases as time progresses in either direction. A functional RIS connects memories of recent past to simulations of the near future which supports and informs goal-related progress and projections of the future (Conway, Loveday, & Cole, 2016). Corballis (2009) also suggests that the pre-experiencing of goals leads to positive health behaviors and goal attainment. Without the ability to remember and imagine, our behaviors may become more rigid, and script based, and less able to reflect changes in demands – behaviors which are also associated with cognitive deficits after TBI (Conway et al., 2016; Corballis, 2009; Rasmussen & Berntsen, 2014).

Several neuroimaging and behavioral studies of impaired populations have identified the default mode network, or "core network" as being central to EFT and the RIS. This core network is comprised of regions in the medial temporal lobe, posterior cingulate gyrus– including the retrosplenial cortex, medial prefrontal cortex, and lateral temporal and parietal regions (Esopenko & Levine, 2017; Gamboz et al., 2010; Rasmussen & Berntsen, 2014, 2016; Schacter & Addis, 2007; Schacter, Benoit, & Szpunar, 2017). Esopenko and Levine (2017) suggested that TBI-related volume loss in the brain contributes to a deficit in recollection of episodic memories, but that study only examined past recall and did not extend measures to future events as well.

There have been few investigations of EFT in adults with TBI, but what literature does exist suggests that people with TBI do struggle to project themselves both forward and backward in time. Rasmussen and Berntsen (2016) found that while adults with acquired brain injuries and damage specific to the PFC were particularly impaired in generating episodic information, the semantic production of past and future events was relatively preserved. The authors concluded that episodic and autobiographical memory rely on the PFC, and that in the absence of this network, semantic information is accessed instead. This study also made use of an autobiographical interview and examination of the core network of brain regions to examine this idea of EFT.

Measurement of EFT

Much of the key behavioral evidence supporting the role of episodic memory in future simulation comes from research studies using Levine's Autobiographical Interview (AI; Levine, etc. – all authors, 2002). The AI was first developed for a study of cognitive aging and episodic memory to reliably quantify the presence of episodic and semantic contributions to personal remote memory. It provides a scoring system which is derived from the important distinction that semantic memory contains de-contextualized generic knowledge of one's past (Levine et al., 2002; Rasmussen & Berntsen, 2014; Tulving, 2002;), whereas episodic memory contains the re-experiencing of details and awareness of one's self across time. This episodic-semantic distinction—described as "functionally different memory systems" by Tulving, 2002 – is important to consider in that semantic projection and memory do not require a re-experiencing component as EFT. The two are reliant on each other but can be dissociated, as in amnesic patients where semantic memory remains but episodic memory is absent (Levine et al., 2002). The scoring system which segments narratives into internal (episodic) and external (semantic) details. Internal details include pieces of information or details that are directly related to the main event described and reflected some level of re-experiencing. These internal details are divided into five mutually exclusive categories: time, place, thought/emotion, perceptual, and event. External details include factual information or details not related to the recollection of the main event. These external details are grouped into 4 categories: event, semantic, repetitions, and metacognitive statements. The AI has been used to examine patients with a breakdown in the RIS (or episodic memory deficits) characterized by a general reduction in internal/episodic details, with preserved or increased external/semantic details as compared to healthy controls. See Table 1 for a summary of the AI coding rubric.

Table 1
Summary of Coding Details.

Category	Description
Internal	pertains directly to the main event described, is specific to time and place, and reflects episodic re-experiencing
Event	Happenings related to main event, individuals present or not present, physical/emotional actions or reactions of others
Time	Year, month, season, day of week, time of day, duration in time
Place	Localization of event (city, street, location in room)
Perceptual	Five senses (auditory, olfactory, tactile, visual, body position, and duration
Thought/Emotion	Thoughts, emotional states, implications
External	pertains to additional details that don't contribute directly to the advancement of the narrative
Event	details pertaining to specific autobiographical events other than the main defined internal event
Semantic	factual information, or extended events that did not require recollection of a specific time and place
Repetition	Unsolicited repetition information that does not provide new information
Metacognitive/Other	metacognitive statements, editorializing, reflections on the story or storytelling

Note: Table adapted from Levine et al. (2002) for purposes of clarity

In Levine et al. 2002, participants were categorized into a young (aged nineteen to thirty-four) and old group (aged sixty to eighty-nine) and asked to choose one life event from five life stages, given a list of approximately 100 possible events. The participants were then provided with three probes to further support retrieval. The interviews were transcribed and coded using the scoring system outlined above. The results showed that younger participants were able to produce a greater number of internal episodic details than the older adults; in contrast, older adults produced more external semantic details compared to internal details. The researchers concluded that access to episodic details begins to decline with age, but access to semantic and non-episodic memories is preserved.

Gamboz et al. (2010) conducted a study involving fourteen older adults with amnesic Mild Cognitive Impairment (aMCI) and fourteen healthy controls. Amnesic Mild Cognitive Impairment is considered a transitional stage between healthy aging and Alzheimer’s Disease (AD), although all three populations – healthy agers, those with aMCI, and those with AD – may experience breakdowns in the RIS to some extent. aMCI is characterized by specific impairment of episodic memory with preserved cognitive function for daily living—an important population to track the course of memory decline in order to assess the relationship between past and future thinking. Each participant was directed to re-experience and pre-experience four autobiographical episodes in response to a computer screen displaying a cue word, a temporal direction cue (remember/imagine) and a temporal distance (last year or next year). Half of the participants received the future direction first and half received the past first. The participants were given one minute to formulate details and then began describing their narrative. After three minutes each participant was probed and then were able to continue with no time limit.

The participants then completed a subjective rating scale rating their sense of re-experiencing as well as plausibility of events for future events. Using Levine's scoring system, results concluded that patients with aMCI produced less episodic event-specific details and an increased reliance on semantic external details as projected. The results of this study provide evidence of a link between remembering the past and imagining the future, and that deficits that manifest in one direction may be expected to occur in the other as well. This is one of the first studies that examined the relationship between aMCI, episodic future thinking, and episodic memory. This is important because deficits in aMCI are similar to those associated with TBI, including difficulty remembering information. While the Levine et al. (2002) study solely focused on episodic memory, we can infer, based on the idea that remembering and imagining rely on similar networks (Szpunar et al., 2007), that a similar breakdown of detail production will occur in tasks of EFT. This study confirmed that in a population of adults experiencing memory failures, failures to generate future events also occurred.

Related populations with memory impairments similar to those of TBI have been studied using the AI in both past and future thinking conditions. For participants with neurologic disorders, the existing literature reveals: 1) a general trend of fewer internal versus external details, especially with more temporal distance (Schacter & Addis, 2007; Conway & Loveday, 2015; Gamboz et al., 2010; Levine et al., 2002; Rasmussen & Berntsen, 2014, 2016); 2) a general symmetry of the number of internal and external details provided in the past versus future conditions, indicating similar underlying mechanisms for past and future narrative construction; and 3) an overall reduced production of details for both healthy controls and non-healthy participants in the future condition (Rasmussen & Berntsen, 2014, 2016).

We can see these trends in studies of older and younger adults (Schacter & Addis, 2007), various brain lesions such as the medial temporal lobe (Race, Keane, & Verfaellie, 2011) and prefrontal cortex (Rasmussen & Berntsen, 2016), mild cognitive impairments (Gamboz et al., 2010), and moderate-severe TBI (Rasmussen & Berntsen, 2014).

RIS and TBI

To date, few studies have examined the RIS in people with moderate to severe TBI. Rasmussen and Berntsen (2016) were the first to examine both episodic memory and future thinking in patients with acute moderate to severe TBI. Participants described past and future events that were one year, five years, and ten years into the past/future, given written cue cards of instructions and emotionally neutral examples to model their narratives after. There was no theme required other than the events being personally relevant and memorable for the participant. Following their narratives, the participants filled out subjective rating scale of how much they felt a sense of re-/pre-experiencing of their narrative events. A fluency measurement was used to tally the number of prompts a participant required to generate a narrative, 4 being no prompts, and a score of zero meaning more than three were given and the participant did not produce any representation of events. Using the AI scoring procedure, the results of this study align with the pattern that participants with TBI produced fewer episodic details than healthy controls in both the past and future conditions, reflecting a deficit in both EFT and episodic memory.

Methodological Considerations

Despite this consistency in the overall pattern of EFT impairments observed in adults with neurological deficits, studies tend to employ a wide range of methods to collect past and future narratives. Only a very few have considered the effect of narrative elicitation tasks on study outcomes. Table 2 identifies several components considered for the present study, as it is important to how information is elicited. Each of the studies followed the general procedure of an Autobiographical Interview and used some version of Levine et al. (2002) coding procedures to conduct their studies; however, the methods in eliciting narratives from various populations differ across studies. The information in Table 2 informed our decision-making in selecting which narrative task would elicit the most information useful for assessment and treatment of TBI.

Race et al. (2011) investigated the nature and importance of the medial temporal lobe (MTL) involvement in future thinking by examining the narrative production of eight patients with amnesia with Medial Temporal Lobe lesions and twelve healthy controls. Patients with amnesia provided considerably fewer episodic details for both future and past thinking conditions than healthy controls, and their narratives remained unimpaired during picture descriptions. These results provide evidence that the MTL plays a role in both remembering and imagining. This study also indicates narrative construction abilities are preserved with this population of adults with isolated amnesia in the absence of other cognitive deficits, thus deficits observed in past and future narratives were related to memory, and not the task of producing a coherent narrative in general. In regard to the present study, it is unclear whether or not we can assume that decreased production of episodic memory detail in the TBI population is related to memory system errors, rather than discourse production abilities.

Table 2
Summary of EFT Stimuli and Measures.

Author, year	Population	Prompt given/Task	Time Periods	Temporal Distance	Number of stimuli	Timing component	Subjectivity rating?	Supports given
Levine et al., 2002	15 Young(*19-34*) vs. 15 older (66-89) adults	Face to face instruction to recall personally experienced events from each time period as if they are re-experiencing.	Past Only	Early childhood, teenage years, early adulthood, middle age, the previous year.	5 prompts, 3 probes	N/A	No	List of ~100 potential life events 3 probes for retrieval support
Gamboz et al., 2010	14 adults with aMCI and 14 healthy controls	Presented with one of 4 words on a computer screen with temporal direction and distance cue *no face to face communication of narrative	Past and Future 2 narratives for past and 2 narratives for future	1 year	4 prompts 1 rating scale after each	1 minute to formulate narrative, then unlimited time to produce narrative	Yes	No additional cues after instructions
Race, Keane & Verfaellie, 2011	8 Amnesic patients with MTL damage and 12 healthy controls	Face to face instruction to recall/imagine personally experienced events from each time period as if they are re-experiencing.	Past and Future	10 recent past/future 10 distant past/future (up to 20 years)	25 narratives 3 sessions	3 minutes + single standard probe then an additional 3 minutes	No	Single standard probe

		*inclusion of 5 picture narrative tasks						
Rasmussen & Berntsen, 2014	9 currently hospitalized mod-severe ABI and 9 healthy controls	Face to face instruction to recall/imagine personally experienced events from each time period as if they are re-experiencing.	Past and Future	1 month, 5 years, 10 years	6 prompts	N/A	Yes- 1 subjectivity rating for sense of re-experiencing	Written direction supports Given emotionally neutral experience example for both past and future
Rasmussen & Berntsen 2016	9 PFC lesions with mixed etiology ABI and 9 healthy controls	Face to face instruction to recall/imagine personally experienced events from each time period as if they are re-experiencing.	Past and future	1 month, 5 years, 10 years	6 prompts	N/A	Yes- 1 subjectivity rating for sense of re-experiencing	Written direction supports Given emotionally neutral experience example for both past and future

Note: All studies used the Levine et al. (2002) AI coding method.

Conway and Loveday's study (2015) examined the extent to which specificity of event description decreases as temporal distance increases by instructing participants to list all the personal events they could remember for each of the past five days and all the personal events that they the imagined could plausibly occur on each of the next five days. Results indicated a decrease in number of memories, as well as specificity of recall of memories over the five-day interval. Similarly, in the future condition, the further away in time, the less imagined episodic detail. Temporal distance should be considered for the present study, as the further out the temporal distance, the more rehearsed a narrative might become, thus moving into semantic territory, rather than true re-experiencing of various events.

Given that adults with TBI often present with an array of cognitive deficits, rather than memory alone, and that adults with TBI often have difficulty communicating effectively at the level of discourse, it is unclear if current narrative elicitation measures employed in the EFT literature are appropriate for this population. There are gaps in the literature with respect to understanding which stimuli may be most appropriate for identifying EFT changes in adults with TBI, as well as how this can be applied clinically and specifically to patients with TBI.

Therefore, the research questions for the current study are:

1. How does narrative productivity differ across three past and future elicitation prompts in a sample of uninjured controls?
2. How does provision of internal and external detail density vary across these prompts for healthy controls?
3. Does similar alignment or variation occur in a pilot sample of adults with TBI in regards to productivity as well as internal and external detail across elicitation prompt types?

CHAPTER 2

METHODS

In the present study, a group of healthy adults told past and future narratives using three different EFT stimuli varying in temporal distance and personal salience. Comparisons were made across the three stimuli and the two temporal directions (past and future). Data on a small group of adults with brain injury was also collected for exploratory purposes.

Participants

All research activities were conducted with the approval of the University of Georgia Institutional Review Board (see Appendix A for consent forms). Participants were recruited from across the state of Georgia through various efforts such as a participant registry through the Cognitive Communication Rehabilitation Lab at the University of Georgia, flyer and social media postings, and through advertising at events with the Brain Injury Association of Georgia. Initially participants filled out an eligibility survey which screened for participant reported exclusionary factors (e.g., hearing, vision, neurological factors, native language etc.). Following the eligibility survey, if the participant reported history of a TBI or any factors listed above, the lead researcher arranged a phone call or meeting to further screen the participant for eligibility. Once eligible, participants were scheduled to participate in the study at the University of Georgia Speech and Hearing Clinic.

Participants of this study included 16 healthy adults and 5 adults with brain injury, ages 18-65. All participants spoke English as a first language and had speech at least 80% intelligible at a conversation level (measured via eligibility screener). Participants were required to have vision adequate for reading and hearing adequate for a quiet office setting based on participant report of hearing and vision status. Participants were excluded if they reported having a history of neurological disease (other than TBI), mental health conditions not managed on an outpatient basis, a history of substance abuse requiring inpatient rehabilitation, and/or an history of aphasia. Participants in the TBI group required a documented history of moderate to severe TBI. See table 3 for participant characteristics (age, gender, etc), and Table 4 for injury information within TBI group.

Table 3
Participant Characteristics

	TBI Mean (*SD*)	Control Mean (*SD*)
Demographics	2 M, 3 F	2 M, 13 F
Age	39.4 (*19.60*)	21.47 (*1.46*)
Education (years)	15.54 (.*55*)	15.26 (.*70*)

Table 4
TBI Participant Injury Information

Participant	Age	Time Post Injury (years)	LOC	Severity of Injury	Description of Injury
1	32	3	>24 hours	severe	MVA
2	23	6	>24 hours	severe	MVA
3	22	9	30 min-24 hours	moderate	Sledding Accident
4	62	45	7 weeks	severe	MVA
5	59	19	>30 min	moderate	Bike
M (SD)	*39.4 (19.6)*	*16.49 (17.02)*			

Note: LOC = Loss of Consciousness/Length of Coma; MVA = Motor vehicle accident.

Materials

Episodic future thinking prompts.

Three narrative prompts were presented to each participant in the future condition and then three prompts again in the past condition, using an Autobiographical Interview format. To clarify, the prompt was presented in the future condition and the participant then formulated and responded with a narrative. Once a natural ending point was reached in the narrative response, a single standard probe was given, and the participant could then respond to this probe. After completing response to the probe, the same prompt in the past condition was presented, a response was given, the probe was administered, another response was given and then the next prompt in the future condition was presented. Therefore, three separate prompts were administered first in the future and then in the past condition which elicited six total narratives from the participant. The specific prompts were chosen in order to identify which type of narrative prompt would elicit the most quality information in order to better assess language following TBI using discourse analysis. Prompts were given only once, but the participant received a visual cue card as a reminder for each prompt in each temporal direction. The prompts were delivered in the same order to each participant, with the future condition delivered first for each participant as recommended by Race et al. (2011) to prevent production of past details from contaminating production of future details. Table 5 provides a summary of each type of prompt stimuli presented, Figure 1 provides a visual representation of the prompts, and Appendix B provides the prompt materials. The prompts were delivered in the same order presented in Table 5. Across all conditions, only neutral continuers were provided during narrative construction.

Table 5
Summary of EFT Prompt Stimuli

Assessment	Temporal Direction	Temporal Distance	Considerations and Expectations
Day of Week (DOW)	Past and future	One week	Most recent and relevant information
Birthday	Past and future	Variable within one year	Highly salient and personal experience
One Year	Past and Future	One year	Least defined protocol in terms of personal event and furthest time point away

The day of the week prompt queried participants to list past and future events with the last week and upcoming week, assessing the most recent time frame and the immediate RIS. The birthday prompt asked the participant to describe first what their next birthday may be like, and then what their last birthday was like. The temporal distance may be more or less remote depending on the date of their birthday in relation to the date of assessment. This temporal distance is more remote than the DoW task, and it asks about a personally salient event. This prompt may then also reveal social impacts of EFT and EM deficits when comparing adults with TBI to healthy controls. Lastly, the Year prompt asked the participant to describe a time point one year into the future from that moment, as well as an event from one year ago. This taps into a less defined event that may or may not be relevant to that person's life, and is the most temporally distant of the three prompts.

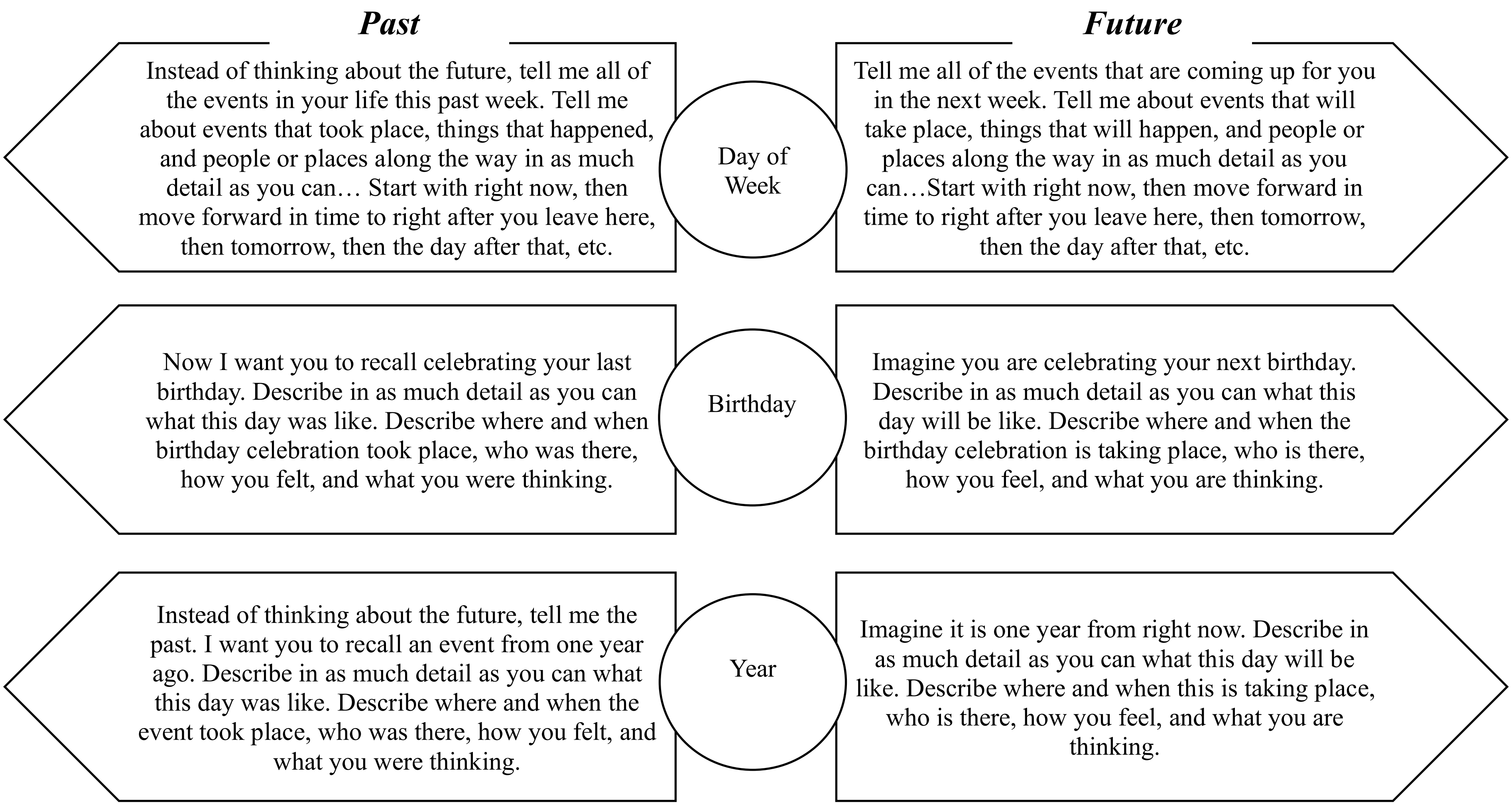

Figure 1
Specification of Prompts Delivered

Neuropsychological testing.

Neuropsychological testing was performed following the narrative tasks in order to describe participant function and supplement the current past and future measures. Participants were asked to complete a series of standardized tests of memory, language, executive functioning, verbal IQ, and cognitive status.

These tests include the Bedside Western Aphasia Battery-Revised (WAB-R; Kertesz, 2007), the Delis-Kaplan Executive Function System – Verbal Fluency Subset (DKEFS; Delis, Kaplan, Wecker, Hallam, & Kramer, 2001), the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS – form A; Randolph, 2012), the Peabody Picture Vocabulary Test (PPVT- form A; Dunn, Dunn, Klein-Tasman, & Mervis, 2018) and the Wechsler Test of Adult Reading (WTAR; Wechsler et al., 2001). The WAB-R Bedside was administered to all participants to ensure the absence of aphasia prior to any further testing or generation of narrative language samples.

The D-KEFS—Verbal Fluency Subset (Delis et al., 2001) is a subtest in which the participant is asked to rapidly name words that belong to a designated letter and a designated semantic category as quickly as possible. Then they are asked to generate words belonging to alternating semantic categories as quickly as possible. This assessment provides a measure of verbal knowledge, rapid systemic retrieval of lexical items, cognitive flexibility, and simultaneous processing and monitoring.

The RBANS (Randolph, 2012) consists of twelve subtests which give five scores representing five cognitive domains (immediate memory, visuospatial/constructional, language, attention, delayed memory) in additional to a total scale score. This assessment characterizes and tracks abnormal cognitive decline.

The WTAR (Wechsler et al., 2001) is a test designed to measure premorbid intelligence and level of verbal intellectual function. The participant is presented with irregularly spelled words and prompted to pronounce each. This assesses the participant's premorbid IQ by extension through assessing vocabulary and ability to pronounce irregularly spelled words.

Lastly, the PPVT (Dunn et al., 2018) is a receptive vocabulary assessment designed to assess one's receptive vocabulary skills. The examiner speaks a word describing one of the pictures and the participant is asked to identify pictures from a group of four. See Table 6 for participant scores on these measures in each group.

Table 6
Participant Scores

	TBI Mean (SD)	Control Mean (SD)
WTAR *Standard Scores, M = 100*	112.20 (15.21)	116.53 (6.40)
DKEFS *Standard Score, M = 10*		
Verbal Fluency: Letter	11.80 (3.70)	12.2 (4.18)
Verbal Fluency: Category	9.40 (4.16)	13.07 (2.76)
Verbal Fluency: Switching Fluency**	6.80 (3.70)	13.2 (4.31)
Verbal Fluency: Total Switching Accuracy**	7 (2.92)	14 (3.27)
Peabody Picture Vocabulary Test *Standard Score*	103.5(.71)	104.5 (6.68)
RBANS *Index Scores, M = 100*		
Immediate Memory	92.8 (12.48)	101.20 (11.61)
Visuospatial*	83 (19.3)	108.13 (12.61)
Language	98 (20.43)	100.8 (12.52)
Attention	88.40 (31.31)	106.40 (28.72)
Delayed Memory	87.2 (26.65)	103.87 (12.64)
Total Scale	82.2 (19.94)	103.60 (12.64)

*Note: *p < .05, ** p < .01*

A two-sample t-test was conducted to compare test results between groups. The TBI group scored significantly lower on the following subtests: DKEFS Verbal Fluency Switching Fluency; t (7.9) = -3.21, p = 0.01, and Total Switching Accuracy; t (7.6) = -4.5, *p* = 0.002, indicative of deficits with complex verbal executive function, and RBANS Visuospatial Index;

$t(5.1) = -2.72$, $p = 0.03$. No significant differences were found between groups for any other subtests listed above, even though the group with TBI had mean scores suggestive of delayed memory impairments. All language scores were within normal limits, suggesting differences in narrative production were not due to core language deficits, but to the cognitive deficits noted here.

Procedures

Following informed consent, participants first completed the Bedside Western Aphasia Battery to rule out any possible aphasia before continuation of testing. Next, participants entered the narrative portion of the study in which they were delivered the six EFT stimuli explained above. After the EFT section was completed, each participant was offered a break by the research assistant. Neuropsychological testing was then completed in this order: WTAR, DKEFS-VF, RBANS, PPVT. Following neuropsychological testing, the participants completed a payment form and had an opportunity to ask any questions about the study. The researcher then thanked them for their time.

All sessions were audio-recorded in order to allow for transcription and analysis. Research assistants then transcribed the narratives into communication Units(C-units), which segments utterances in a rule-governed way. C-Units can be defined as “independent clauses with its modifiers” and are commonly used in discourse analysis.

Data Analysis

Narratives were analyzed at the micro- and macrostructural levels of language. When analyzing microstructure, examined features which may describe or explain macrostructural differences in adults with TBI. The macrostructure level, which can be defined as language elements beyond the level of the sentence include the speaker's organization, cohesion, and structure of discourse (Lê et al., 2011). Macrostructural language requires employment of higher-level cognitive processes and is often the level at which we see the most impairment in the TBI population (Lê et al., 2011; Ylvisaker et al., 2008).

Microstructure.

Transcripts were analyzed using the Systematic Analysis of Language Transcripts (SALT; Miller, Chapman, & Scherer, 1999) in order to examine differences between groups and across the three protocols. Analyses focused on measures of productivity and semantic diversity. Productivity was measured by total number of utterances (TNU) and semantic diversity was measured by type token ratio (TTR).

Narrative transcription was completed by research assistants trained on samples external to this study. Each transcriber was required to meet 80% accuracy before beginning transcription on samples for the present study.

Macrostructure.

Transcribed interviews were imported into MAXQDA, a qualitative data analysis software system. The lead researcher and a trained research assistant coded provision of memory details following guidelines outlined in Levine et al. (2002). Memory details were divided into two categories of code: internal events such as episodic details specific to the event, or external events such as details outside the focus of the narrative as explained previously. Minor adaptations were made by the research team to the Levine rubric to add specificity and further examples. A summary of the coding is provided in Table 1; for the complete coding rubric, see Appendix C.

Narratives were coded by the lead researcher, and 20% of the coded narratives were independently coded by a trained research assistant. Both coders were trained to criterion of .8 reliability. Inter-coder (IOA) reliability measures were obtained via MAXQDA. Allocated documents were coded by both the lead researcher and assistant, and then frequency of codes and segment code agreement were compared, and percent agreement was calculated. Discrepancies found in coding were discussed in detail until resolved.

Coding Days of the Week.

For narratives from the DoW protocol only, further coding was done to categorize events into each day of the week so that it becomes a discrete unit. Each day the participant mentions throughout the week was assigned a code titled Day 1-6, or Day X. For example, if the participant was examined on a Monday, for the past DoW condition anything mentioned on Sunday was coded as Day One, anything mentioned on Saturday was coded as Day Two and so on.

Anything discussed outside of the week beyond the previous Monday was coded as Day X. The number of codes per day were taken into account to analyze number of details per day, as temporal distance increases.

Statistical Analysis

1. How does narrative productivity differ across three past and future elicitation prompts in a sample of uninjured controls?

We anticipated differences in productivity based on task alone – specifically, that the day of week would result in longer narratives than either of the other two tasks, each of which focused on events that occurred on a single day). We examined TNU and TTR in separate three by two-way ANOVAs that examine the effect of task (DoW, Birthday, One Year) and time (past, future) on productivity. Post-hoc comparisons used a Bonferroni-Holm correction for multiple comparisons as indicated by omnibus results.

2. How does provision of internal and external detail density vary across these prompts for healthy controls?

First, we examined total number of internal and external details across tasks, expecting to find that participants produced the greatest number of details in the DoW task. However, because we anticipated differing TNU across tasks, the total number of details in each category was divided by TNU to create density measures of internal and external details per utterance. These were then similarly entered into separate three by two-way ANOVAs with post-hoc comparisons as necessary. We expected that Birthday and One Year prompts would result in richer narratives with greater density of internal details than DoW.

3. Does similar alignment or variation occur in a pilot sample of adults with TBI in regard to productivity as well as internal and external detail across elicitation prompt types?

Data for adults with TBI was considered descriptively in comparison to the group of uninjured adults. These were plotted on graphs for visual analysis within and across groups. Content of narratives were considered qualitatively, using thematic analysis to identify if participants with TBI are considering the narrative prompts similarly to uninjured adults. Examining the quality of detail provided by the TBI population versus healthy controls for memory capabilities may reveal that those with TBI have less to say about their lives and their futures. Examining episodic detail provision may reveal whether this is attributable to less social interaction in general, to an episodic memory deficit, or if the memory deficit drives reduction of social interaction. Results can then inform future follow-up work.

CHAPTER 3

RESULTS

A MANOVA one-way analysis was conducted to determine microstructural and macrostructural differences across the three prompts (BDAY, Year, and DOW), in both past and future conditions for healthy controls. Significant differences were found across all prompts within control group ($F = 3.5$, $p = < .001$). Follow-up one-way ANOVAs examined differences across prompts below. All measures were different across conditions within control group (TNU, TTR, number of internal details, density of internal details, and density of external details), with the exception of number of external details. Results of these individual analyses are presented below. When considering differences within the control group across time conditions (past vs. future), a MANOVA analysis found no differences between past and future ($F = 0.83$, $p = 0.55$), indicating the controls performed similarly across all variables within prompts regardless of the time direction.

Microstructural Features Across Prompts Within Healthy Control Group

Differences across conditions within the control group was revealed by one-way ANOVA analysis for TNU ($F = 10.77$, $p < .001$) and TTR ($F = 16.51$, $p = < 0.001$). A Tukey post hoc analysis revealed that DOW prompts had a higher TNU ($p = < 0.001$) and a lower TTR ($p = < 0.001$) than birthday prompts (see Figure 2). Analysis also revealed DOW prompts had lower TTR ($p = < 0.001$) than the year prompts (see Figure 3). Overall, participants spoke the most during the DoW prompt, but had less varied language.

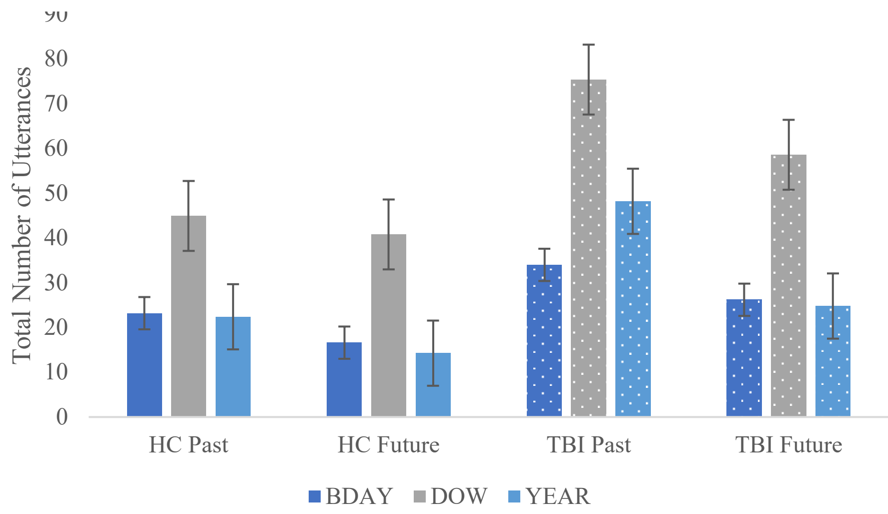

Figure 2

Total Number of Utterances Across Conditions and Prompts

Note: BDAY is Birthday prompt, DOW refers to Day of Week prompt and Year refers to Year prompt. TBI plots include patterned dots.

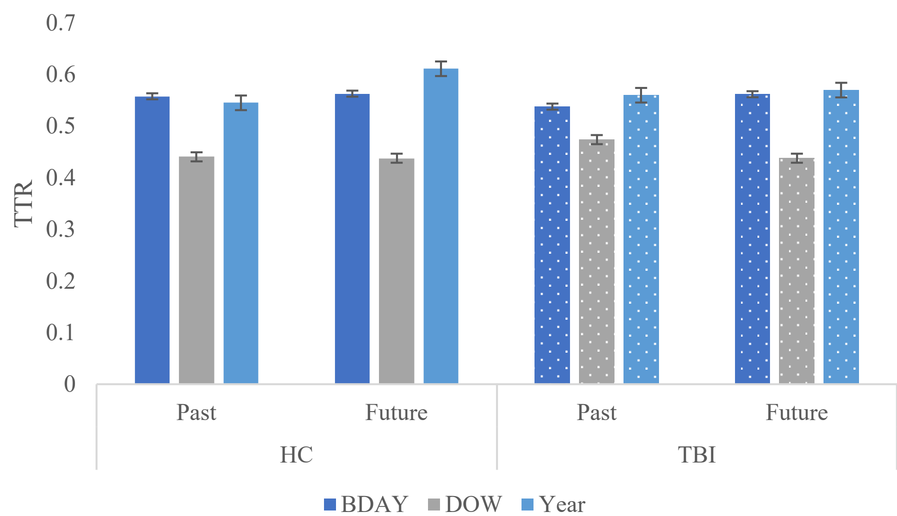

Figure 3

TTR Across Conditions and Prompts

Macrostructural Details Across Prompts Within Healthy Control Group

Number of Details.

One-way ANOVA analysis found significant differences for number of internal details across prompts ($F = 11.72$, $p = < 0.001$), but no significance was found for external number of details across prompts ($F = 0.41$, p = .66). Number of internal across prompts within the control group were then analyzed through a Tukey post hoc analysis. As with linguistic measures, results revealed that DOW prompts had a higher number of internal details ($p = < 0.001$) than birthday prompts. Analysis also revealed DOW prompts had a higher number of internal details ($p = <$ 0.001) than year prompts (see Figure 4). External details were not examined as MANOVA testing indicated no difference across prompts ($F = 0.41$, p = .66).

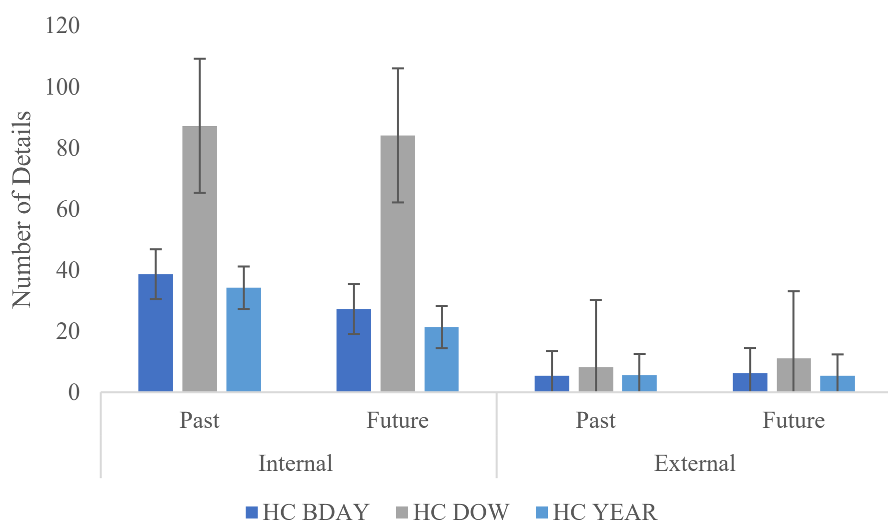

Figure 4
Number of Details Across Conditions and Prompts for HC

Density of Details.

One way MANOVA analysis revealed differences in density of internal details (*F* = 4.95, $p = 0.009$) and density of external details ($F = 3.74$, $p = .03$). Tukey post hoc analysis revealed DOW prompts had a higher internal density ($p = 0.006$) and a lower external density ($p = 0.05$) than the year prompts. Analysis also revealed that DOW prompts had a lower density of external details ($p = 0.05$) than birthday prompts (see Figure 5 for density for HC). There was no difference across these measures between birthday and year prompts.

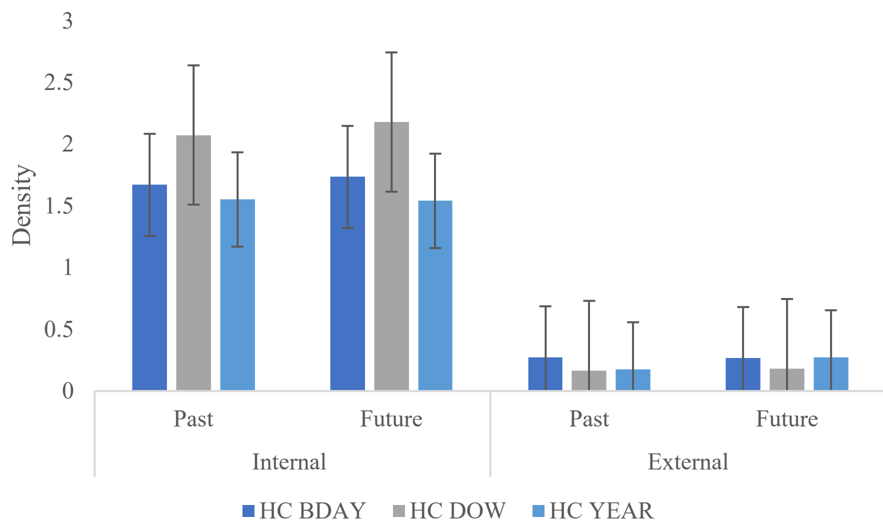

Figure 5
Density Across Conditions and Prompts for Healthy Controls

Productivity and Episodic Detail Provision Across Prompts Within TBI Pilot Group

A Friedman test within the TBI group across the three prompts revealed differences in TNU ($\chi2(2) = 7.60$, $p = 0.02$), TTR ($\chi2(2) = 7.60$, $p = 0.02$), and number of internal details ($\chi2(2) = 8.4$, $p = 0.01$). No differences were found for number of external details, density of external details, or density of internal details (see Figures 6 and 7).

Microstructural.

A criterium Fisher's least significant difference (LSD) test examining the difference between prompts revealed that TNU and TTR were different between birthday and DOW prompts, as well as DOW and year prompts, which was consistent with the control group (see Figures 2 and 3). Analysis revealed TNU ($p = 0.001$) were lower for the birthday prompt than for the day of the week prompt, while TTR ($p = 0.002$) was higher for the birthday prompt than for the DOW prompt. Similarly, TNU ($p =0.004$) were higher for the DOW prompt than for the year prompt, while TTR ($p = 0.004$) was lower for the DOW prompt than the year prompt. There were no differences across time conditions (past, future) within the TBI group. Overall, the TBI participants spoke the most in the DOW prompt, but used more diverse language in the birthday prompt regardless of time direction (See Figures 2 and 3) .

Macrostructural.

The Fisher's LSD test revealed that the number of internal details provided ($p = 0.003$) were lower for the birthday prompt than for the day of the week prompt. Similarly, more internal details ($p = 0.004$) were provided within the DOW prompt than in the year prompt (see figure 6). When considering density within the TBI group (see figure 7), no significant differences were found between the internal and external densities or number of details within the TBI group across all prompts. This was in marked contrast to the group of healthy adults, who exhibited large differences between internal and external detail density.

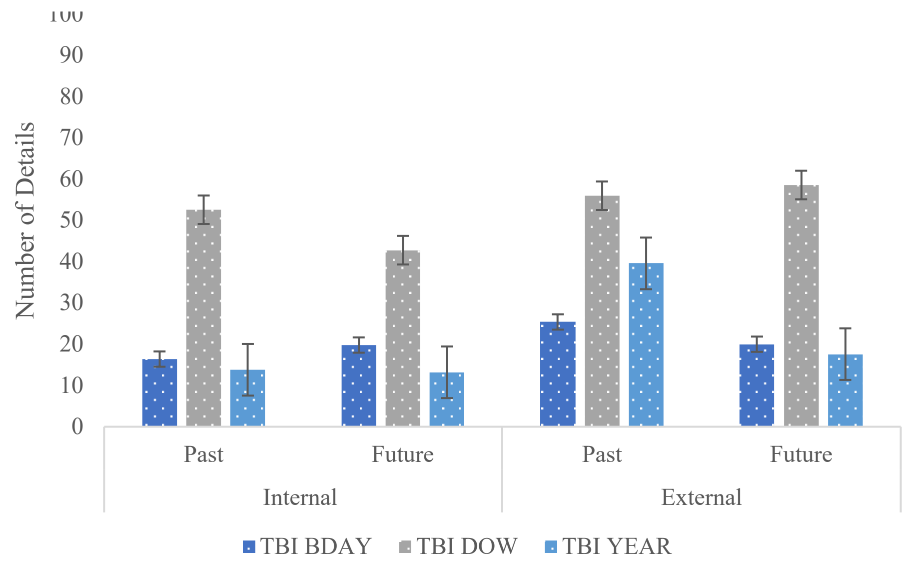

Figure 6
Number of Details Across Conditions and Prompts for TBI

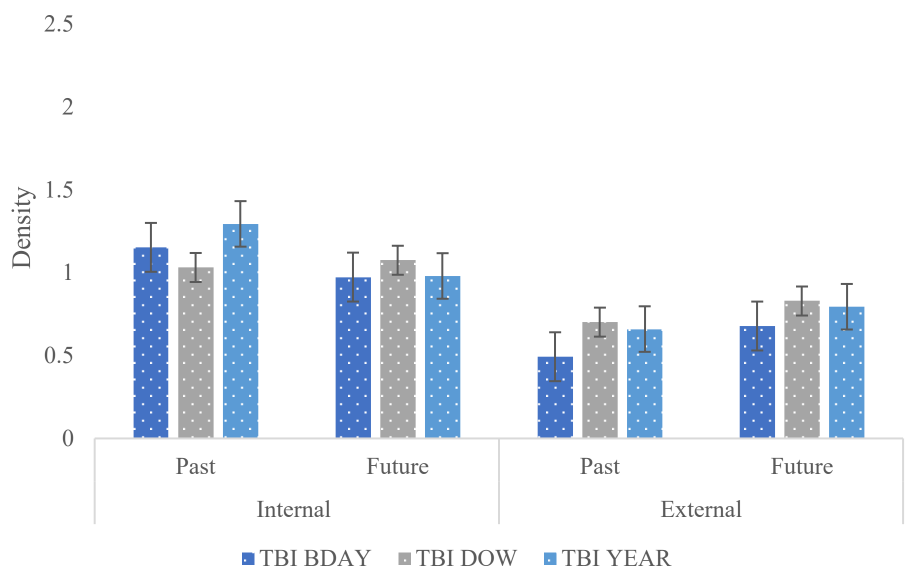

Figure 7
Density Across Conditions and Prompts for TBI

Comments on patterns of detail density across groups.

When considering detail density across groups, meaning the amount of internal detail provided *per utterance*, there are large and visible differences when comparing healthy control and TBI groups. Across all prompts, HC demonstrated higher internal detail density than the TBI group. The TBI group demonstrated a higher external density than the control group across all prompts. Lastly, when comparing internal versus external density within the control group, there is a much larger jump from external to internal. When examining the difference within the TBI group, the gap is much smaller between external and internal detail provision (see Figure 8 for density comparison across groups and prompts).

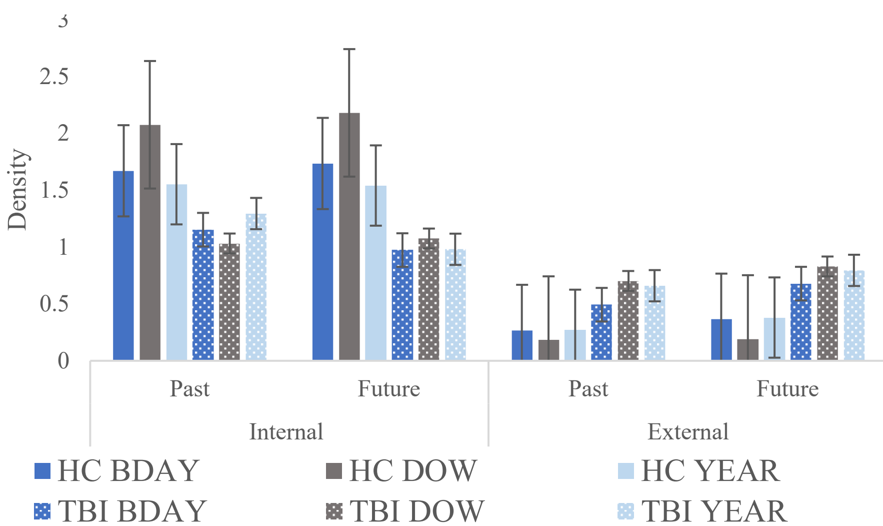

Figure 8
Density Across Conditions, Prompts, and Groups

Comments on day of week significance.

Visual analysis of internal and external detail provision between healthy controls and TBI participants reveals several differing patterns of verbal behaviors across groups. When considering internal detail provision, Figure 9 indicates that the HC group provided a more consistent amount of internal detail across the span of a past and future week when compared with TBI. As the temporal distance increases, the amount of internal information provided has a smaller slope than the TBI group. When examining the TBI group, most internal information is provided in the more recent days of the week, and the external information increases with each tail end of the week. Similar to internal details, the provision of external detail from the HC group has a lower and more even slope in comparison to the TBI group. The TBI group also appears to produce more external details.

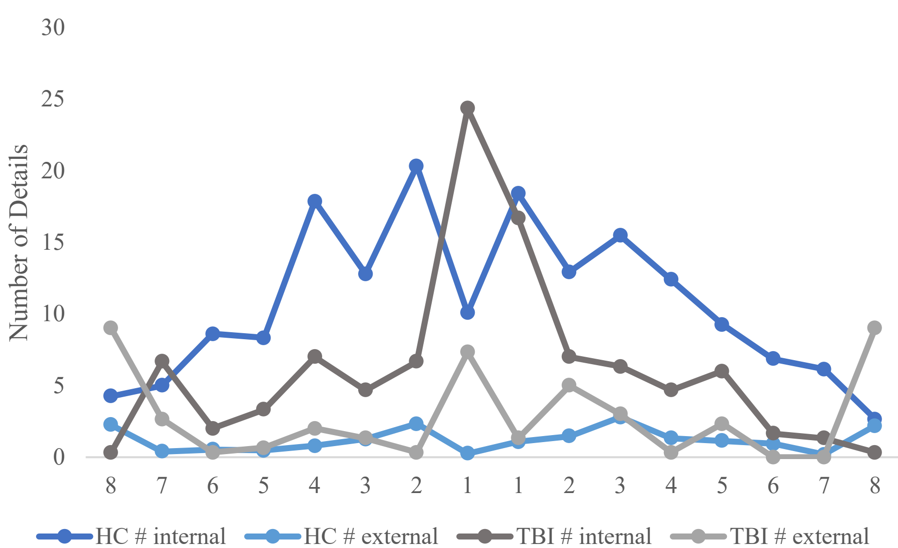

Figure 9

Number of Internal and External Details per Day Across Groups

CHAPTER 4

DISCUSSION

The present study examined three different narrative prompts given in the past and future conditions from a group of healthy controls and a pilot group of TBI participants. To determine which prompt elicits the most useful information in regard to assessment of discourse and EFT, analyses surveyed productivity and provision of internal and external details across groups and temporal direction. Statistical analysis revealed that although participants spoke more in the narratives with DOW prompts, the birthday prompt elicited more complex and linguistically rich narratives from participants. Participants spoke the least in the year prompts. Significance was not found for temporal direction within either group.

How does narrative productivity differ across three past and future elicitation prompts in a sample of uninjured controls?

Productivity measures across tasks reflected predicted outcomes for the healthy control group. The DOW prompt requests information for the least temporally distant memories and projections, and describes an appreciably longer timeframe, while birthday and year prompts request information for only a single day with increased temporal distance and personal significance. The year prompt requires the least specific, and most temporally distant information. The TNU was highest for DOW narratives in both the past and future conditions for healthy controls. Although the healthy control group produced longer narratives for the DOW prompt, TTR was higher in birthday and year prompts (see Figures 2 and 3). This indicates that although they are more linguistically productive, semantic diversity is decreased within the

DOW narratives for two possible reasons. First, participants are providing more routine information within their narratives and less likely to use diverse language. Many participants presented these details in list like, rather than narrative fashion. The birthday and year prompts reflected similar results for TTR, indicating participants were more likely to provide semantically complex information. When talking about a personally significant event, participants were more likely to use varied language than when talking about their daily routine. For example, when discussing weekly schedule, a participant might repeat the phrase (or something similar) “I have class” each day in a list-like format, whereas a participant discussing their birthday may use more rich language because they are describing an experience (e.g., names, places, and feelings etc.).

Secondly, TTR is impacted by the length of a narrative. TTR is the ratio of number of different words to number of total words provided in a given narrative. As the denominator increases (more total words), TTR decreases. Generally, TTR is used to identify naming or word-finding deficits in adults and children with language disordersy (Fergadiotis & Wright, 2011; Watkins, Kelly, Harbers & Hollis, 1995). Typically, TTR is calculated for an average of 100-200 utterances. As the number utterances or tokens in a narrative increase, the TTR will likely plateau or decrease due to limit of number of different words someone can use for a given topic. Therefore, TTR could have been lower in the DOW prompts due to the increased number of utterances in comparison to the birthday and year prompts (see Figure 3).

How does provision of internal and external detail density vary across these prompts for healthy controls?

As for number of details provided across prompts within the healthy control group, significance was only found for number of internal details. Number of external details did not differ across prompts within the healthy control group; however, there is an appreciably large jump between number of internal and external details provided when examining the healthy control group (see Figure 4), suggesting that healthy participants are less likely to provide excessive or elevated amounts of external information in response to any prompt. Levine et al. (2002) examined differences in age groups and found similar results in that the younger age group relied more on re-experiencing of episodic information than on semantic information when providing narratives in both time conditions. Other studies including Rasmussen and Berntsen (2014) and Gamboz et al. (2010) found that healthy controls consistently provided less external information than internal information in all narratives and time conditions.

Across the three prompts, DOW prompts were found to have the highest number of internal details when compared with birthday and year prompts. It should be noted that these narratives were much lengthier, thus allowing more opportunity for internal details to be provided.

When discussing number of details versus density of details, it is important to keep in mind that while some narratives elicited a higher *number* of details, episodic richness is measured by density of details in this case – that is, how many details are provided per utterance. Although the number of internal details provided within a given narrative may be higher than another, the measure of importance when considering episodic richness of narrative imagination and recall is density. Results revealed that the DOW prompt was found to have a higher internal density than the year prompt, but the DOW and Birthday prompts were not found to have significantly different internal densities. While the number of internal details may have been higher for DOW prompts than birthday prompts, the amount of internal episodic information provided per utterance was about the same for both. Meaning, that regardless of number of details and utterances provided, the episodic richness between DOW and birthday prompts did not differ statistically.

It is important to consider then the type of internal information provided within each prompt. The coding system provides a breakdown for type of internal information (see Table 1) in order to further identify content of narratives. Figure 10 displays that while internal event is highest for all prompts, DOW has a slightly lower percentage of thought/emotion, perceptual, and place details when compared to birthday and year prompts in both time conditions. DOW prompts may have more list-like internal details such as event and time, while a more personally significant experience such as a birthday will elicit more details for thoughts, perceptions and feelings in both the past and future conditions (see Figure 10). Although the participants are producing more language and providing more details in DOW prompts, the significance of the birthday prompt allows for generally the same level of recall and projection of detail as measured by density (see Figure 8).

External density appeared to be lower in DOW prompts as well, indicating that healthy participants may have had more external information to provide when talking about less routine information.

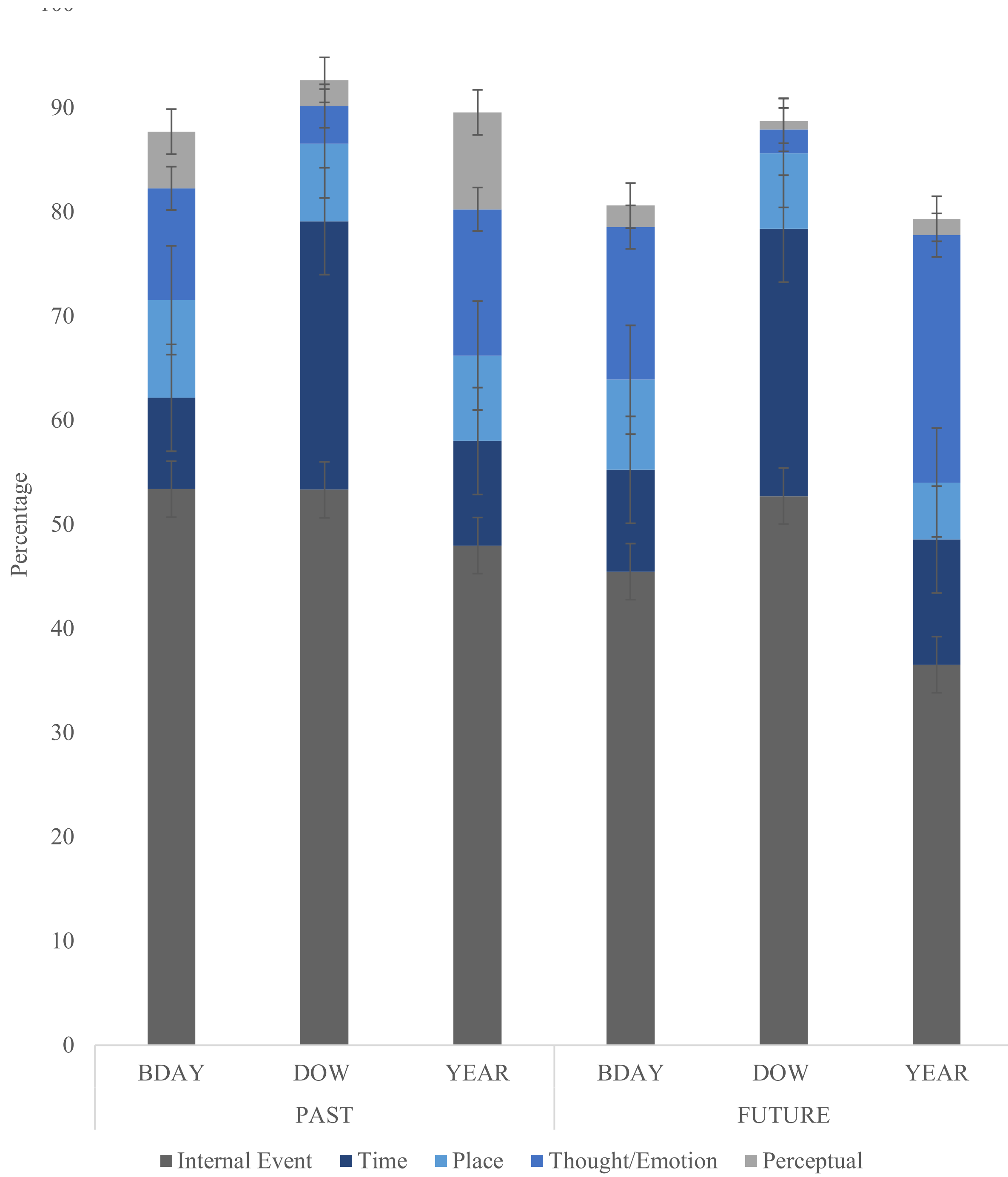

Figure 10

Percentage of Internal Detail Types for Healthy Controls Across Prompts

Does similar alignment or variation occur in a pilot sample of adults with TBI in regards to productivity as well as internal and external detail across elicitation prompt types?

Findings Within TBI Group.

Productivity measures within the TBI group reflected similar results to the HC group: an elevated TNU and decreased TTR for DOW prompts with increased TTR for birthday and year prompts. The DOW prompt elicits highest TNU, while the birthday and year prompts elicit a more lexically rich narrative across both healthy control and TBI groups. As found within the HC group, the TNU between past and future within the TBI group show less utterances in the future than in the past across all prompts. Although not statistically significant, a trend toward the TBI group providing fewer utterances in the past than in the future may be revealed with a larger sample size. Provision of internal and external details within the TBI group does appear to follow a markedly different pattern than that of the HC group. As seen in Figure 6, the number of internal details within the TBI group were lower than external details for all prompts, regardless of time condition. Meaning, the TBI group relied more on semantic information than episodic information when producing narratives--regardless of temporal distance, personal significance, and temporal direction. Rasmussen and Berntsen (2014) found strikingly similar results in that the TBI participants were much better at reporting external, or semantic, information versus internal, or episodic, information, especially when talking about the distant future.

Comparing HC and TBI.

When comparing TNU provided between TBI and HC groups, it can be seen in Figure 2 that the TNU provided by TBI participants was significantly higher than that of the HC group. When examining provision of internal versus external details across HC and TBI participants, Figures 2, 4 and 6 reveal that although the TBI group produced significantly higher number of *utterances* than the HC group, they also appear to have produced fewer internal details and more external details than the HC group. Also seen is a decrease in internal density and an increase in external density for the TBI group. These findings are consistent across all three prompts and in both past and future time conditions.

In line with predictions, the TBI participants demonstrated a higher level of language production but a low level of episodically relevant information when compared to healthy controls. Rasmussen and Berntsen (2014) found similar results in that their group of adults with acute TBI produced less internal information than the HC group regardless of temporal distance. Similar results were found in other populations with amnesia, including the aging population (Levine et al., 2002), aMCI patients (Gamboz et al., 2010), and patients with medial temporal lobe and prefrontal lesions (Race et al., 2011; Rasmussen & Berntsen, 2016). People with MTL lesions, or amnestic Mild Cognitive Impairments, are more likely to experience memory deficits in isolation, whereas people with TBI can experience a range of cognitive problems following injury.

A more pronounced effect might be seen in the TBI population due to the diffuse nature of injury and impact on the neural network supporting episodic memory as well as executive function (Rasmussen & Berntsen 2104, 2016). The current sample did exhibit executive function deficits, which may have impacted their ability to produce efficient, topically relevant narratives around past and future recall.

Another observation from these results indicates the sensitivity of discourse assessment to language and memory deficits within the TBI population. Adults with TBI typically present with more subtle language deficits that are challenging to observe in standardized cognitive or memory assessments that have clearly defined parameters. Discourse impairments interrupt the cognitive processes that allow the synthesis of linguistic and non-linguistic knowledge in order to produce organized, productive, and meaningful narratives (Coelho, 2007; Lê et al., 2011). Additionally, people with TBI often present with executive dysfunction, as well as diminished goal setting and motivation, each of which are thought to influence how episodic projections and memories are constructed (Conway et al., 2016; Corballis, 2009; Rasmussen & Berntsen, 2014). The comparative differences in narratives produced between healthy controls and TBI groups within this autobiographical interview highlight the cognitive and linguistic breakdown which are common following TBI, if difficult to capture using standardized measures.

Considering temporal direction and distance.

Rasmussen and Berntsen (2014) found that both healthy controls and TBI participants produced fewer internal details for future conditions than past regardless of temporal distance. However in the present study, performance on past versus future did not differ for either healthy controls or TBI group. Meaning the provision of internal and external details in the past was relatively similar to the future condition across all three prompts and regardless of temporal distance. This further confirms the reliance on similar cortical system for remembering and imagining information (Levine et al., 2002; Rasmussen & Berntsen, 2014, 2016). It also suggests that clinicians providing treatment to an individual with episodic memory problems may want to also address needs for envisioning and acting on the future. Without the ability to consider alternative situations by mentally simulating (or projecting) the future, one might then rely on rigid or stereotypical routine behaviors, as well as demonstrate problems with goal attainment. This lack of elaboration and maintenance of future representations of rewarding experiences, or experiences of failure, then leads to lack of motivation in meeting personal goals. It also impacts ability to problem solve and results in inflexible, stimulus-bound actions (Rasmussen & Berntsen, 2014). This might include training on proper goal setting, use of memory and projection techniques to maintain goals, and executive function training in order to provide strategies for more goal-directed behavior. Given the ability to track and maintain details relating to goal attainment, quality of life might be expected to increase through more adequate maintenance of goals.

Comments on DOW significance.

Conway and Loveday (2015) discuss that as temporal distance increases, the episodic richness of the memory decreases. Thus, the further time goes out, the more routine detail is provided, and fewer events specific to that day appear. For instance, on Day 1, a participant might say "I am going to eat around 6 at my favorite restaurant, Johnny's, with my friends Alison and Nicole," whereas on day 8, a participant might provide information with fewer details "I am going to eat with friends." Conway and Loveday (2015) also suggest that those with an impaired RIS have a more limited ability to project themselves into the past or future due to deficits in episodic memory and future thinking. This trend can be seen both in the past and future conditions, thus also further supporting the connection of remembering and imagining systems. In the present study, Figure 8 illustrate data in line with this prediction. The TBI participants provided more internal information on day one in both past and future, and then a sharp decrease of internal detail for day 2 and 3 which remains steady for the remainder of the narrative. For the HC group, we see less provision of details in the immediate future, but a higher and more steady provision of internal details overall. We also see less external information provided from the HC group, and as the distance increases, the TBI group provides more external detail.

CHAPTER 5

CONCLUSION

Limitations & Future Directions

The present study holds two main limitations which should be considered when interpreting results and applications. The first is that this was a small and homogenous sample of healthy controls with limited demographics (e.g., young and majority female). The second is the small size and diversity of injury and time post onset in the TBI participants. Interpretations should be taken with caution until a larger group of participants can be examined. Even in this small sample though, there appear to be large differences in how people with TBI recall personal experiences versus healthy adults. Results from the present study align with studies examining similar populations with larger and more diverse sample sizes (Rasmussen & Berntsen, 2014, 2016), indicating the sensitivity of these assessment protocols in detecting deficits even at this small scale.

Future directions might include the examination of a larger sample of TBI and age matched controls in order to determine more specific and fine-grained information as to which prompt provides the most clinically valuable information about language, memory, and social impact of a TBI. A quality of life measure could also be given as part of the study to determine whether detail provision, or lack-there-of is attributable to overall limited social interaction, or to an episodic memory deficit, or perhaps if the memory deficit drives reduction of social interaction.

Conclusion & Clinical Applications

In summary, the present study offers several conclusions: narrative discourse through the autobiographical interview is a valuable source for assessing episodic memory and future thinking in adults with and without TBI. Results across both the healthy control group and TBI group revealed valuable comparisons of macro- and micro-structural features of language as well as episodic versus semantic detail provision. Second, within this autobiographical interview, prompts requesting information with personal significance (such as the birthday prompt) elicited more episodically and lexically rich information from both groups; however, the DOW prompt elicited the most productive narratives of the three prompts. Lastly, participants with TBI provided highly productive narratives containing more external or semantic information and less episodic information overall across both time conditions. This finding did not differ across prompts. This suggests that the DOW and birthday prompts might demonstrate the "language of the confused" in that those with TBI may be highly productive within their narratives, but not providing episode specific details that drive effective and efficient communication.

After examination of the three prompts, several conclusions can be applied to clinical practice. Collection of narratives across these three different prompts provided targeted assessment information specifically about language, memory, and potentially the social impact of the patients' injuries. In terms of language between healthy controls and TBI participants, the day of week prompt was the most productive, but the birthday prompt was more descriptive and episodically rich among healthy controls. In terms of social network and support, it can be seen that while those participants with TBI have memory and language deficits, they may also be saying less because they have less to talk about. This can be seen in both the birthday and day of week prompt.

Overall, the findings from the present study indicate the need for a clinically applicable narrative assessment protocol, which may include prompts that require narratives containing personally significant information with various degrees of temporal distance (e.g., one week versus one year). What can be revealed from this type of assessment includes information about executive functioning, narrative organization, episodic memory and projection, as well as social circumstances resulting from their injury.

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Appendix A

UNIVERSITY OF GEORGIA
CONSENT FORM
Past and Future Memory Fluency in Adults with Traumatic Brain Injury

Researcher's Statement
We are asking you to take part in a research study. Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. This form is designed to give you the information about the study so you can decide whether to be in the study or not. Please take the time to read the following information carefully. Please ask the researcher if there is anything that is not clear or if you need more information. When all your questions have been answered, you can decide if you want to be in the study or not. This process is called "informed consent." A copy of this form will be given to you.

Principal Investigator: *Katy H. O'Brien, PhD, CCC-SLP*
Communication Sciences and Special Education
khobrien@uga.edu 706-542-9931

Purpose of the Study
The purpose of this study is to find out more about how we remember things that have already happened to us, and how we think about the future.

Study Procedures
If you agree to participate, you will be asked to …
- *Tell us about events that have recently happened to you, or that you could imagine happening in the future;*
- *Take a few short tests of memory, planning, and reading;*
- *Allow us to record audio so we can transcribe the information you tell us.*

The whole session will take about an hour to an hour and a half. The first part (when you tell us about past or possible events) will take about 10 to 15 minutes. The testing will take 45 to 60 minutes. You are welcome to take breaks throughout, and we will offer them to you between each task.

If you have a history of brain injury, we will request copies of any medical records related to your brain injury so we can find out more about your injury and recommendations for care or follow up that may have been made. If you agree, we will sign a form allowing us to access these records. If there is a charge for these records to be delivered to us, the Cognitive-Communication Rehab Lab will be responsible for all costs associated with this request for your medical records.

Risks and discomforts

- There are no risks to your healthy by being in this study; however, there are risks related to:
  - discomfort if you feel like you cannot remember things, or if you expect to do exceptionally well on the standardized tests. These tests are designed to describe a range of performance, so that no one does perfectly. That means that although you should try your best, missing some is normal and to be expected.
  - not wanting to share recent events with us because it makes you uncomfortable; you are not required to do so.
  - risk of breach of confidentiality regarding your history of brain injury
- To minimize your risks, you do not have to answer ANY question that you do not wish to, and are welcome to take breaks or end the interview if need be.
- Your data, including audio, will not be associated with your name and will be stored on UGA's Secure Institutional File System to minimize the risk of disclosing your survey information or audio.

Benefits

- There are no direct benefits to you in taking part in this study.
- Instead, we are using this data to find out more about how adults use language to remember and imagine, so that we can eventually expand this knowledge to support people with brain injury and memory impairments.

Incentives for participation

You will be paid $25 for participating this study. Your name and address will be requested and processed by our business department to issue you a check for participating in this study.

Audio/Video Recording

Audio will be recorded so that we can analyze language and memory features of the information you provide us. We also record testing sessions so that we can correct scoring if need be. These audio recordings will be kept indefinitely.

Some audio may be used in presentations describing results of this study. These clips will be actual recordings of your voice, but your name will not be used. Please initial below to indicate your preference of use of your audio in presentations. *You may still participate in this study even if you are not willing to have the audio of your interview shared.*

_______I do not want to have clips of the audio recording of my interview shared.

_______I am willing to have clips of the audio recording of my interview shared.

Privacy/Confidentiality

We used your identifying information to determine your eligibility for this study and to schedule your session. Once data collection is complete, this information will be deleted/destroyed. Instead, we will use a system of codes to anonymously maintain your data, including audio files.

Only researchers in the Cognitive-Communication Rehabilitation Lab will have access to your audio files. Your data will not be traceable if at a later time you wanted to access your individual results. Individual score reports will not be available and should not be considered diagnostic.

Researchers will not release identifiable results of the study to anyone other than individuals working on the project without your written consent unless required by law.

Taking part is voluntary
Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time without penalty or loss of benefits to which you are otherwise entitled. If you decide to withdraw from the study, the information that can be identified as yours will be kept as part of the study and may continue to be analyzed, unless you make a written request to remove, return, or destroy the information.

If you have questions
The main researcher conducting this study is Katy H. O'Brien, a professor at the University of Georgia. Please ask any questions you have now. If you have questions later, you may contact Katy O'Brien at khobrien@uga.edu or at 706-542-9931. You can also contact the Lab at Info@cogcomlab.org. If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at 706.542.3199 or irb@uga.edu.

Research Subject's Consent to Participate in Research:
To voluntarily agree to take part in this study, you must sign on the line below. Your signature below indicates that you have read or had read to you this entire consent form, and have had all of your questions answered.

Comprehension Questions
Please answer the following comprehension questions to ensure that you understand your rights and this research study:

1) I can stop participating in this study anytime.	True	False
2) If I have a history of brain injury, the research staff will request a copy of my medical records.	True	False
3) There are some risks that I could become bored, or that I could be identified because of the audio files or medical records if I participate in this research study.	True	False
4) This research study is voluntary. What does that mean?		

5) Name two activities you will complete as a part of this research study. (You can look at the first page if you need to review.)

____

__________________________ __________________________

Name of Researcher Signature Date

__________________________ __________________________

Name of Participant Signature Date

__________________________ __________________________

Legally Authorized Representative (as needed) Signature Date

__________________________ *relationship to participant*

Please sign both copies, keep one and return one to the researcher.

Appendix B

EFT Stimuli for the Present Study.

Protocol	Future Condition	Past Condition
Day of Week	For this first part, I'm going to ask you to do some thinking about what's coming up for you in the next week. Tell me all of the events that are coming up for you in the next week, starting with today, (day of the week). Tell me about events that will take place, things that will happen, and people or places along the way in as much detail as you can. You can skip things that are just part of your everyday routine like self-care (brushing your teeth, etc.) unless it will be notable for some reason. Tell me everything you can think of that will make that day different than another day. Start with right now, then move forward in time to right after you leave here, then tomorrow, then the day after that, etc. Any questions? Go ahead.	Now I want you to do something a little different. Instead of thinking about the future, tell me all of the events in your life this past week. Tell me about events that took place, things that happened, and people or places along the way in as much detail as you can. You can skip things that are just part of your everyday routine like self-care (brushing your teeth, etc.) unless it was notable for some reason. Tell me everything you remember about things that made that day different than another day. Start with right now, then move backwards through time to before you came here, then yesterday, then the day before that, etc. Any questions? Go ahead."
DoW Standard Probe	And can you tell me anything else you have coming up in the next week?	And can you tell me anything else that happened this past week?
Birthday	For this second part, I'm going to ask you to do some thinking about your next birthday. Imagine you are celebrating your next birthday. Describe in as much detail as you can what this day will be like. Describe where and when the birthday celebration is taking place, who is there, how you feel, and what you are thinking.	Now I want you to recall celebrating your last birthday. Describe in as much detail as you can what this day was like. Describe where and when birthday celebration took place, who was there, how you felt, and what you were thinking.

Birthday Standard Probe	Can you tell me any more about where and when the event is taking place, who is there, how you feel, and what you are thinking?	Can you tell me any more about where and when the event is taking place, who is there, how you feel, and what you are thinking?
One Year	Imagine it is one year from right now. Describe in as much detail as you can what this day will be like. Describe where and when this is taking place, who is there, how you feel, and what you are thinking. Any questions? Go ahead.	Instead of thinking about the future, tell me the past. I want you to recall an event from one year ago. Describe in as much detail as you can what this day was like. Describe where and when the event took place, who was there, how you felt, and what you were thinking.
Year Standard Probe	Can you tell me any more about one year from now, such as where and when this is taking place, who is there, how you feel, and what you are thinking?	Can you tell me any more about one year ago, such as where and when this is taking place, who is there, how you feel, and what you are thinking?

Appendix C

Internal Memory Coding for Episodic Details.

Event	Time	Place	Perceptual	Thought/Emotion
• Related to main event • Happenings • Individuals present • Physical/emotional actions • Reactions in others • When speaking of the future, participants may use the tag, "I would" to introduce events/actions • "let me be here to help you" – quotes from events are often (but not always) in this category – recounting what was said during the event • When speaking of the conditional, "I could" to introduce events	• Year • Season • Month • Day of week • Time of Day • Duration in time (can be vague), ex. "It was a pretty long drive" • Age/Time period "I was 13"	• Verb + place (when verb is indicating place) • Localization of an event including: • City • Street • Building • Room • Part of room • Do not include vague references "Everyone was *there*."	• 5 senses: • Auditory • Olfactory • Tactile • Visual or visual details • Body position • Duration • Weather conditions • Prescise quantity (of people there)	• Emotional state • Thoughts • Desires • Implications • Internal beliefs • "Decided" or "Thought" statements are usually coded here • Opinions or judgments: "nice," "beautiful" • "He's a really nice guy" – as a matter of opinion; not widely accepted fact • "they had a lot of things going on" – vague, unclear if true or just an opinion (not clearly a fact which would make it semantic) • "Hopefully"

External Memory Coding for Semantic Details.

Event	Semantic	Repetition	Other
• Specific details from other incidents (from any of the above of the above categories) **external** to the main event recalled • ex: "We went out to eat on Friday night." (but story is about an animal, a daytime ceremony, etc.) • Or setting up the story by telling a previous story – "the week before, we had also gone to Target and …"	• General knowledge or facts, ongoing events, extended states of being that don't advance the narrative (i.e., the internal events) • ex: "It was Spring, so it must have been warm." • ex: "Since we always celebrate the holiday and it was summer, it must have been the 4th of July." • ex: "In Minnesota, you can't buy alcohol on Sundays." • Information added to the story that doesn't contribute any info about a specific event, place, or time • ex. "My friends know that about me." • Qualities that will remain the same over time (i.e., tomorrow, in a month, two years, etc.) • ex: "I'm always going to be a drama queen!"	• Unsolicited repetition of details—providing identical information, a maximum 1-2 words different, and conveying the same meaning • Not a repetition if it provides new information, ex: previously mentioned beach and then said "it was beautiful day for the beach" = not repetition • Be sure to check story before the prompt as well (if you are scoring the story after the prompt)	• Metacognitive statements • ex: "This is really hard" • ex: "I haven't thought about that in a long time." • Editorializing • ex: "That was really dumb." • ex: "I don't know why I just said that." • Reflections on the story • Indications that the story has ended • ex. "that's it" or "I think that's it"