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Discourse Changes Following Severe Traumatic Brain Injury: A Longitudinal Study

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**DISCOURSE CHANGES FOLLOWING SEVERE
TRAUMATIC BRAIN INJURY: A LONGITUDINAL STUDY**

BY

ELIZABETH YOUNG

B.A., SPANISH LANGUAGE AND LITERATURE

THESIS

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**Discourse Changes Following Severe Traumatic Brain Injury: A Longitudinal
Study**

by

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B.A., Spanish Language and Literature

M.S., Speech-language Pathology

ABSTRACT

Purpose: There are few longitudinal data charting recovery of discourse skills following severe traumatic brain injury (TBI). Limited knowledge about the trajectory of discourse recovery and the best tools for assessing communication abilities in persons with TBI (PWTBIs) restricts detection of communication impairment and the ability to make informed prognostic judgments following TBI. This study sought to contribute longitudinal data to the research base, using clinically efficient measures that are sensitive to communication deficits associated with TBI and that use nuanced scoring systems to provide detailed characterization of discourse.

Methods: Twenty-three PWTBIs completed picture description tasks at 3 (or 6) months, 12 months, and 24 months post-injury. Discourse samples were orthographically transcribed and segmented into utterances according to the Codes for Human Analysis of Transcripts (CHAT) software manual guidelines. Main Concept Analysis (MCA) and Coherence Analysis (CohA) were used to describe the informativeness, efficiency, and

organization of each sample. Group changes in performance on these measures over time were documented.

Results: Significant recovery of discourse abilities occurred within the first year following TBI, with output becoming more informative and more organized at 12 months post-injury compared to 3/6 months post-injury. Discourse remained more informative at 24 months post-injury compared to 3/6 months post-injury. A non-significant decline in organization from 12 to 24 months post-injury resulted in failure to maintain significant gains in this area. Discourse efficiency did not change significantly across any timepoints and there were no significant changes occurring from 12 to 24 months post-injury.

Conclusions: The measures used in this study detected and described recovery of discourse skills following TBI. The bulk of recovery occurred within 1 year of injury and various aspects of communication (informativeness, efficiency and organization) appeared to follow distinct recovery trajectories. More research is needed to investigate factors that impact recovery patterns and the relationship between communication deficits following TBI and life participation. Such studies will further inform prognostic judgments, allocation of rehabilitation resources, and research programming.

KEY WORDS: cognitive-communication, discourse, efficiency, informativeness, longitudinal, organization, recovery, traumatic brain injury

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Introduction

Traumatic Brain Injury

The Center for Disease Control and Prevention (CDC; 2016) defines traumatic brain injury (TBI) as “a disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head, or a penetrating head injury”. TBI presents with a spectrum of severity, ranging from concussion, which is characterized by transient physiological disturbances to the brain, to severe injury that results in structural damage to the brain and prolonged loss of consciousness or death (Finfer & Cohen, 2001; McCrory et al., 2009). The leading causes of TBI are falls, motor vehicle accidents, being struck by or against an object, and assault (CDC, 2016; Roozenbeek et al., 2013). The global incidence rate of TBI is estimated to be 200 per 100,000 people per year, and at least 10 million TBIs serious enough to result in death or hospitalization occur annually around the world. These statistics underestimate the true rate of TBI, given that they rely on reports by facilities that provide acute trauma care, which does not include treatment sought from outpatient facilities, physician’s offices, military facilities in any part of the world, or those who do not (or cannot) seek treatment for TBI (Bryan-Hancock & Harrison, 2010; Langlois, Rutland-Brown & Wald, 2006). Globally, males and females of all ages acquire TBI, though it is thought to be more common in males.

The incidence of TBI in the United States is estimated to be 1.7 million annually (Faul et. al., 2010). The highest known incidence occurs in young children under 5, at almost twice the rate of the next highest incidence group (young adults age 15-24), followed closely by the elderly 65 years and older population (CDC, 2016). TBI among

veterans is also common, with over 370,000 U.S. service members being diagnosed with TBI between 2000 and 2017 (Defense and Veterans Brain Injury Center, 2017); it is important to note that these data are not included in CDC statistics. Furthermore, victims of domestic violence, usually women and children, often do not report TBI and are therefore also underrepresented (Murray, Lundgren, Olson & Hunnicutt, 2016). Finally, TBI among prison populations in the U.S. (and Australia and Europe) is common, occurring at a higher rate than the general population reported upon by CDC (Durand et al., 2017); these surveys typically focus on adult males, therefore little is known about female and/or juvenile populations. In 2006, an estimated 5.3 million Americans were living with TBI-related disability. The lifetime cost of TBI in the U.S. is estimated to be \$60 billion annually, including medical costs, lost productivity and lost wages (Langlois, Rutland-Brown & Wald, 2006). (These numbers are likely underestimates, for the reasons outlined above.) Preliminary data from investigations regarding the rate of TBI worldwide have found higher incidence in the developing world, although data is scarce (Bryan-Hancock & Harrison, 2010).

The impact of TBI on physical and mental functioning varies widely between individuals. Persons with TBI (PWTBIs) frequently report reduced cognitive skills (e.g., memory, attention, problem solving, etc.), impaired sensory function, reduced communication ability, sleep complications, and emotional disturbances such as depression and anxiety (National Institute of Neurological Disorders and Stroke, 2015; Grima, Ponsford & Pase, 2017; Kreutzer, Steel & Gourley, 2001; Vaishnavi et al., 2009). Although specific factors that are predictive of employment following TBI have not been conclusively demonstrated (Saltychev, Eskola, Tenovuo & Laimi, 2013), employment

rates 4 years post-injury among PWTBIs who were employed before the injury were reported at 50% in a recent sample (Ruet et. al., 2017), slightly higher than but consistent with previous reports of reduced employment rates, reduced wages, and underemployment (e.g., not full-time status, not pre-morbid career or income) (e.g., Shames, Treger, & Ring, 2007; van Velzen, van Bennekom, Edelaar, Sluiter, & Frings-Dresen, 2009). The negative impact of TBI on individual and societal well-being is also indisputable - in addition to aforementioned lost wages and contributions to society, PWTBIs experience significantly reduced social networks and opportunities for relational and community engagement, greater dependence of family members or other caregivers, as well as high rates of mental health problems, including anxiety and depression (e.g., Glintborg, Thomsen, & Hansen, 2017; Hoofien, Gilboa, Vakil, & Donovan, 2001; Morton & Wehman, 1995; Vaishnavi, Rao, & Fann, 2009). Still, little is known about the best methods for improving outcomes for this population (Grima, Ponsford & Pase, 2017; National Institute of Neurological Disorders and Stroke, 2015; Saltychev, Eskola, Tenovuo & Laimi, 2013) and research into all areas of functioning following TBI is merited to determine which aspects are amenable to current treatment approaches and which are not. Further investigation is also needed to determine which areas of functioning (physical, cognitive, etc.) and environmental factors contribute most to activity and participation limitations following TBI, using the World Health Organization International Classification of Functioning (WHO-ICF) framework (Tate, 2008). The results of such investigations may inform treatment priorities as well as policy decisions that may affect this population.

Communication following TBI

Cognitive deficits are one of the most commonly reported symptoms following TBI, with a prevalence rate of 25-70% (Roozenbeek et al., 2013; Vaishanvi et al., 2009). These deficits can affect executive function, learning, attention, processing, and problem-solving difficulties (Vaishnavi et al., 2009), negatively impacting behaviors critical for successful communication and social navigation. Communicating with others involves, at the most basic level, the sharing of knowledge and beliefs with others. Such sharing requires the following fundamental elements: an organized cognitive schema of knowledge and beliefs that facilitates recall of episodes, agents, and settings, and the ability to generate and link together propositions and utterances to express essential and relevant elements extracted from that cognitive schema (Van Dijk, 2014). It is understandable, then, that impairments in attention, memory, and other cognitive functions would negatively impact communication. As such, communication difficulties that arise from decrements in these cognitive functions are referred to as *cognitive-communication impairment* (Elbourn, Togher, Kenny, & Power, 2016).

Communication difficulties associated with TBI impact employment, participation in communication activities, and quality of life following the injury (Douglas, Bracy & Snow, 2015; Finch, French, Ou & Fleming, 2015; Kozlowsky Moreau et. al. 2015). Douglas, Bracy, and Snow (2015) examined the self-reported and family member-reported communication abilities of 46 PWTBIs, who were divided equally into groups that had or had not returned to work following their injury. The La Trobe Communication Questionnaire (LCQ) was used to elicit ratings of the frequency of communication difficulties in various domains, with higher scores indicating more

frequent difficulty with communication. PWTBIs who had not regained employment at the time of the study had significantly higher self-ratings on the LCQ. The relative frequency of communication difficulties reported by PWTBIs and their family members also varied by group, with unemployed PWTBIs reporting less frequent communication difficulties than their family members and employed PWTBIs reporting more frequent communication difficulties than their family members. In a study utilizing activity diaries over a 24-hour period to compare PWTBIs' participation in communication activities with that of uninjured peers, PWTBIs were found to communicate with others less frequently, engage with fewer people, and converse for less time overall (Finch, French, Ou & Fleming, 2015). Communicative activities were categorized into one of the following groups: meals, shopping/outings, household chores, entertainment, travel and work. The PWTBIs in this study reported significantly lower mean rates of satisfaction with mealtime conversations, which is likely the context that places the highest demand on the individual to keep the conversation flowing. Finally, Kozlowski Moreau et. al. (2015) found that degradations in social relationships, completion of activities of daily living, and difficulty returning to work were correlated with performance on standardized tests of language and cognition for those who reported such difficulties.

Aphasia batteries have traditionally been used to assess the surface form and content of language output. These assessment instruments detect errors in grammar, vocabulary use, the phonological formation of words, etc. For example, a person with aphasia (PWA) may omit bound morphemes, articles and prepositions (e.g. "you go store"), use words that do not match their intended message (e.g. "I put the dishes in the *bath tub*" instead of "I put the dishes in the *sink*"), or produce nonsensical speech sounds

rather than real words (e.g. “fibdop” instead of “tree top”). While PWTBIs can experience aphasia, especially if there is focal damage to the language-dominant hemisphere, the communication deficits more commonly seen in the diffuse damage often experienced by PWTBIs are related to the completeness, efficiency and organization of the ideas they choose to communicate rather than word retrieval or sentence structure. For example, PWTBIs may produce elaborate tangential speech and/or concepts out of sequence, placing a greater burden on the listener to follow or understand the intended message (Coelho, Liles & Duffy, 1991; Stout, Yorkston & Pimentel, 2000; Straus Hough & Barrow, 2003). Assessment tools designed for PWAs often fail to detect communication deficits in PWTBIs because they do not measure the linguistic skills that are most often affected by TBI (Coelho, Liles & Duffy, 1991; Elbourn, Togher, Kenny & Power, 2016; Van Leer & Turkstra, 1999).

The characteristics that are observed in speakers with cognitive-communication impairment include *confused*, *inefficient*, and *impoverished* language use (Coelho, Liles & Duffy, 1991; Elbourn, Togher, Kenny & Power, 2016). *Confused* language is unclear, incoherent and/or inaccurate, and can include unexplained topic shifts and ambiguous references to subjects and events in a discourse sample. For example, if someone followed the statement “I love Halloween” with “It’s really bad for you”, there would be no discernible relationship between those ideas without some kind of segue between them (i.e., “I love Halloween. It’s hard to stay away from the candy, though. It’s really bad for you”). *Inefficient* language is characterized by inclusion of irrelevant information and an abnormally high amount of revisions, repetitions and false starts. For example, if a speaker were describing how to make a peanut butter and jelly sandwich and included a

detailed description of their favorite brands of peanut butter and/or jelly, a personal story about a sandwich experience, and/or a tirade about gluten, a significant amount of their output would be unrelated to the point of the interaction, hence making their expression of the key concepts inefficient. Finally, *impoverished* language describes failure to provide enough information to convey a clear message. For example, if while giving route directions to a certain location an individual said “turn right and then turn there”, the listener would likely be unable to get to the desired location without referencing another source.

These cognitive-communication deficits associated with TBI can be very challenging for speech-language pathologists to assess (Turkstra, Coelho, & Ylvisaker, 2005). Errors in language form (i.e., grammar, vocabulary and phonology) such as are seen in aphasia, can easily be counted and compared to a widely recognized standard within a linguistic culture, whereas judgments about the appropriateness, completeness, and organization of information are influenced by the communicative context and tend to be more subjective. Disorders affecting language form can usually be detected in short, highly structured interactions (i.e., administration of aphasia batteries) whereas cognitive-communication deficits may not be detected outside of communicative contexts that require the speaker to independently organize information and make decisions about what should be explicitly stated (Coelho, Ylvisaker, & Turkstra, 2005; Turkstra, Coelho, & Ylvisaker, 2005). One of the goals of researchers investigating cognitive-communication impairment secondary to TBI is to identify the most valid and reliable methods for quantifying these characteristics and documenting how they change over time within and across study participants.

Discourse measures are becoming a preferred outcome indicator for PWTBIs as clinicians and researchers continue to reveal the inadequacies of traditional language measures when attempting to characterize communication deficits in PWTBIs (Carlomagno, Gianotti, Vorano & Marini, 2011; Coelho, 2007; Coelho, Liles, & Duffy, 1991; Richardson & Dalton, 2016; Stout, Yorkston, & Pimentel, 2000). Discourse refers to complex interpersonal communication in a variety of contexts, including conversation and monologue (Body & Perkins, 2003; Richardson & Dalton, 2016). A study by Straus, Hough, and Barrow (2010) compared the topic-maintenance, organization, and the appropriate use of words within sentences of 5 PWTBIs with 15 uninjured controls, finding that PWTBIs produced significantly less organized output and included more unrelated utterances than uninjured peers. Measures of language form (e.g., lexical errors and use of appropriate cohesive ties), however were not shown to distinguish the two groups. Similar findings were noted in a study by Marini, Zettin, and Galetto (2014) in which discourse skills (topic-maintenance, organization and informativeness) and language form (lexical errors, speech fluency, phonology) were compared between 10 PWTBIs and 20 uninjured controls during picture-description narrative tasks. No significant difference in the number of correctly formed words, speech rate, or grammatical complexity were found between groups. In contrast, the TBI group was significantly less thematically consistent, organized and informative than the control group; these group differences were not due to group differences in educational attainment.

Development of Discourse Measures for TBI

Although there is an emerging consensus that cognitive-communication skills should be assessed during discourse tasks to chart progress in this population, the best tools for measuring those skills have not been established (Body & Perkins, 2003). Even among those studies that attempt to measure the same aspects of discourse (e.g., efficiency, organization, informativeness), the same measures are rarely used across studies, as highlighted in a recent meta-analysis (Elbourn et al., 2016). Some measures have risen to popularity in the cognitive-communication research community, each with unique strengths and weaknesses that make them more or less valuable for specific purposes.

A word-level measure, Correct Information Units (CIUs), has been used to assess discourse informativeness in PWTBIs (Carlomagno, Gianotti, Vorano & Marini, 2011; Matsuoka, Kotani & Yamasato, 2012; Nicholas & Brookshire, 1993). A CIU is a single word that is relevant, accurate, and informative based on the stimulus topic. The number of CIUs may be expressed as a percentage of all words in the sample (%CIUs), allowing evaluation of relative informativeness and efficiency of output. Studies using CIUs to compare discourse performance of PWTBIs with that of uninjured peers have not found a significant difference in the total number of CIUs between groups, but the rate of CIU production and %CIUs has inconsistently distinguished these groups. Nicholas and Brookshire (1993) found a significantly lower number of CIUs produced per minute and %CIUs in PWTBIs. Matsuoka, Kotani and Yamasato (2012) also found that PWTBIs produced fewer CIUs over a given span of time than controls, but they found no significant difference in the ratio or total number of CIUs. Carlomagno, Gianotti, Vorano

and Marini (2011) found a significant group effect for CIUs per minute and %CIUs, with healthy controls earning higher scores on each measure, with no group difference noted for total CIUs. Together this information indicates that PWTBIs may approximate typical performance for overall informativeness (i.e., production of correct and relevant words during discourse tasks) but that they differ in how efficiently they communicate a message, whether due to slower rate or greater proportion of words that are not CIUs.

A frequently used measure that looks beyond the word-level is story grammar analysis, which assesses the organization of content and clear delineation of relationships between people and events within a narrative by evaluating the inclusion and completeness of episodes (i.e., initiating event → goal attempt → direct consequence). The amount of the discourse (e.g., number of utterances) contributing to episode structure may also be measured to indicate how much of a participant's output contributes to advancement of the story. PWTBIs' performance on story grammar analysis has been shown to distinguish them from healthy controls and correlate with performance on executive functioning tasks (Mozeiko, Le, Coelho, Kreuger & Grafman, 2011). Other ways to evaluate informativeness include analysis of "story completeness" and "story goodness". Story completeness refers to the inclusion of all essential elements in a story, regardless of how they are organized. Story goodness, measured using the Story Goodness Index (SGI), is judged based on the inclusion of all essential elements and the organization of those elements into episodes. Performance on the SGI has been found to correlate with performance on tests of executive function and memory (Le, Coelho, Mozeiko, Kreuger & Grafman, 2012). These measures use comprehensive systems to describe cognitive-communication ability. However, they are time-consuming to

administer and score, and provide less detailed descriptions of discourse performance compared to other candidate measures. For example, story completeness and story goodness count only complete concepts and complete episodes in a discourse sample, and does not account for partial expression or knowledge of a concept, or errors that are still understandable in context. Measures that are more clinician-friendly, less time-intensive, and offer a more nuanced scoring system capable of revealing subtle changes in discourse may yield a more efficient process to assess this population's abilities.

Two complementary discourse measures that can directly inform on the language use in PWTBIs - confused, inefficient, or impoverished - and can be conducted in a relatively efficient (non-transcription-based) manner have received relatively little attention to date. The first is the Main Concept Analysis (MCA) - a measure similar to story completeness that is commonly used in aphasia research. The presence and completeness of Main Concepts (MCs) have been shown to distinguish speakers with aphasia, even the very mildest forms, from typical peers (Dalton & Richardson, 2016; Nicholas & Brookshire, 1995). MCA utilizes a multi-level scoring procedure that takes partially correct, and partially complete, expression of essential ideas into account, making it well-suited for tracking change over time in populations with often subtle cognitive-communication impairments. MCA provides valuable insight regarding a speaker's ability to convey the "gist" of a story or topic with the added benefit of having a simple scoring procedure and normative data for several widely available stimuli. This measure is a strong candidate for capturing cognitive-communication abilities in PWTBIs, especially if used in conjunction with other measures more focused on communicative efficiency or organization.

Such complementary measures include cohesion and coherence, which are more frequently investigated in PWTBIs (e.g., Coelho, Liles & Duffy, 1991; Ellis, Henderson, Harris Wright & Rogalski, 2016; Straus Hough & Barrow, 2003; Van Leer & Turkstra, 1999). Coherence scoring examines the relevance and organization of verbal output and has been shown to be sensitive to the communication deficits found in PWTBIs (Carlomagno, Gianotti, Vorano & Marini, 2011; Ellis, Henderson, Harris Wright, & Rogalski, 2016; Straus Hough & Barrow, 2003). Cohesion, by contrast, addresses the use of appropriate lexical ties between utterances and has less consistently distinguished PWTBIs from uninjured peers. Some studies measuring coherence and cohesion in the same samples have found significantly lower scores on coherence measures among PWTBIs compared to uninjured controls and no significant difference on cohesion measures (Coelho, Liles & Duffy, 1991; Straus Hough & Barrow, 2003; but see Ghayoumi et al., 2015). While both cohesion and coherence may provide valuable information about the communication abilities of PWTBIs, it seems that coherence more reliably detects communication impairment in this population.

Selecting the most appropriate discourse measures for this population is a priority, and attention must also be paid to the elicitation method. Discourse characteristics in PWTBIs and uninjured peers have been shown to vary according to the specific communication task (conversation, story retell, etc.) (Stout, Yorkston & Pimentel, 2000; Van Leer & Turkstra, 1999). Retell of well-known narratives (e.g., Cinderella) has been used to elicit discourse samples, but there are some problems with this stimulus type. If a subject's experience with the topic is different from that of the norming sample, their output may not be accurately evaluated. Story retell also relies heavily on memory and

sustained attention, which may mask linguistic competence, preventing a speaker with TBI from communicating as informatively and effectively as they are capable (Mackenzie, Brady, Norrie, & Poedjianto, 2007). Certainly, difficulty recalling the events and actors within a narrative and sustaining attention to abstract material are components of cognitive-communication impairment. Still, measurement of other qualities, such as the ability to organize and connect a narrative in a way that the listener can follow, and that considers listener perspective, is complicated if recall and attention limit the ability to produce a complete narrative. Another reported complication with story retell is the tendency for participants to attempt to use the same language that was used in the initial presentation of the story (Coelho, Liles & Duffy, 1991).

Picture description tasks provide the benefit of not requiring fully functional memory or sustained attention, and not depending on the personal experience of the speaker (Van Leer & Turkstra, 1999). These features improve norming validity and more accurately reflect PWTBIs' true communication deficits. There is evidence supporting the efficacy of picture description tasks for reflecting communicative competence in daily life. Performance on language assessments using such tasks have been found to positively correlate with listener perceptions of communicative effectiveness in PWAs (Ross & Wertz, 1999). Furthermore, describing a scene to someone else is a relatively common communicative act. Picture description tasks are thus well-suited for reliably measuring communicative effectiveness in daily life across and within speakers.

Recovery of Cognitive-Communication Abilities

Cognitive-communication impairments are known to affect PWTBIs in the acute and subacute stages of recovery. It is often assumed that these skills recover over time,

but there is limited information available indicating whether long-term recovery does in fact occur, and if so, to what degree (Carlomagno, Gianotti, Vorano & Marini, 2011; Chapman, et. al., 2006; Coelho, Liles & Duffy, 1991; Elbourn, Togher, Kenny, & Power, 2016; Hough & Barrow, 2003; Marini, Zettin & Galetto, 2014; Stout, Yorkston & Pimentel, 2000). The only studies to our knowledge that has addressed this are reports by Snow, Douglas and Ponsford (1998, 1999) which found that conversational discourse skills did not improve between 3-6 months and 2-3 years following TBI, but performance on picture description tasks had reached normative levels over the same time period (Snow, Douglas & Ponsford, 1998; Snow, Douglas & Ponsford, 1999). No study to date has evaluated communicative performance beyond 3 years post-injury, and there is little consistency in outcome measures or time-post-onset among the investigations that report longitudinal outcomes (Elbourn, Togher, Kenny, & Power, 2016). As a result, the information available to researchers and clinicians working with this population may provide partial information about language performance at various points post-injury, but does not reveal the evolution of cognitive-communication skills and deficits over time. Given the impact of communication difficulties in daily life, as described above, it is important that recovery is well-characterized so that sound decisions may be made about allocation of treatment resources and research programming.

Purpose of the Present Study

Main Concept Analysis (MCA) and Coherence Analysis (CohA) are two complementary discourse measures that, when applied with reliable picture description tasks, should provide valuable information about the nature and magnitude of cognitive-communication impairment following TBI. We therefore intend to characterize these

discourse variables in a population of PWTBIs who are most likely to demonstrate cognitive-communication deficits and who also have more room for recovery - persons with severe TBI. The proposed study will describe changes in gist (MCA) and coherence (CohA) over the course of 2 years following severe TBI. MCA and CohA together will provide information regarding the completeness, efficiency and organization of language use. Analysis of language samples elicited during a picture description task will strengthen the validity and functional relevance of the results. This study will contribute longitudinal data to the research base and build upon previous work by utilizing methods that have been shown to accurately reflect this population's cognitive-communication deficits.

For this project, we are leveraging transcripts with accompanying video available via the TBIBank database (<http://tbi.talkbank.org/>). This database contains a collection of data, protocols, articles and multimedia interactions from studies addressing TBI, with the long-term goal of providing information that may be used to make evidence-based decisions in research and practice. This project is a collaborative effort with the University of Sydney TBI research team, and all of the media available to date, with multiple timepoints, have been contributed by Dr. Leanne Togher and her team of collaborators. There are currently no large-scale datasets tracking recovery of individuals with TBI in the U.S. that contain this type of data and are available for analysis. In order to begin improving rehabilitation for these individuals, it is appropriate to begin examining these questions with this existing dataset. While using data from a different country is not ideal, we would not expect the recovery patterns and deficits experienced

to differ greatly; as discussed previously, TBI is a problem across the developed world, with similar incidence and prevalence across countries.

Methods

Participants

Twenty-three adults with acquired severe TBI and no known neurological disorders or significant medical conditions before the injury was incurred were recruited through consecutive admission from three Brain Injury Units across metropolitan Sydney. Of 80 patients approached, 74 were referred and 65 consented to participate. Attrition over the span of the project saw 58 participants remaining at the end of the data collection phase. Twenty-four of those 58 participants produced discourse samples that included all three picture description tasks used in this study at 3 points post-injury - at 3 or 6, 12, and 24 months post-injury. One participant was excluded because his speech was not intelligible enough to be transcribed accurately in all of the discourse samples he provided.

All participants were speakers of English and 6 spoke at least one additional language (see *Table 1*). Three of the 6 were categorized as English Language Learners (ELLs), meaning their primary language was something other than English. Five of the participants identified as female. Ages ranged from 17 to 66 years ($M = 35.56$, $SD = 13.88$) and years of education ranged from 10 to 20 ($M = 14.2$, $SD = 3.09$). Participants were not automatically excluded due to a history of substance abuse or mental illness. All participants incurred a closed head injury. The leading etiology of injury was involvement in a motor vehicle accident ($n = 17$), followed by falls ($n = 5$) and assault ($n = 1$). Severe TBI was defined by an initial Glasgow Coma Scale (GCS) rating of eight or less and/or a period of Post Traumatic Amnesia (PTA) greater than 24 hours in length. Diagnosis of cognitive-communication disorder was not a parameter for inclusion in this

study, as the primary purpose was to examine and describe the communication abilities of a cohort. Similarly, there was no control for presence of dysarthria, aphasia, or frequency and duration of speech pathology intervention at any point.

Table 1. Demographic information for each participant.

Participant Number	Gender	Age	Years of Education (preinjury)	Primary Language	Cause of Injury	Injury Type
7	M	28	13	Indi	MVA	Closed
8	F	22	11	English	MVA	Closed
9	M	46	16	English	MVA	Closed
13	M	24	16	English	MVA	Closed
15	M	31	16	French	MVA	Closed
21	F	52	20	English	MVA	Closed
24	F	56	19	English	MVA	Closed
26	M	40	15	English	Fall	Closed
29	F	66	12	English	MVA	Closed
39	M	40	17	English	MVA	Closed
41	M	29	11	English	MVA	Closed
43	M	17	11	English	MVA	Closed
44	M	32	10	English	Fall	Closed
46	F	37	12	English	MVA	Closed
47	M	23	10	English	MVA	Closed
50	M	20	11	English	Fall	Closed
51	M	18	13	English	Fall	Closed
52	M	53	15	English	Fall	Closed
53	M	50	11	English	MVA	Closed
54	M	21	15	English	MVA	Closed
55	M	27	16	Mandarin	Assault	Closed
57	M	37	20	English	MVA	Closed
58	M	49	17	English	MVA	Closed

MVA = motor vehicle accident

Procedures and Stimuli

An examiner from the University of Sydney research team conducted an individual session with each participant. The session included an interview, procedural description (how to make a cheese and Vegemite™ sandwich), and story-retell (Cinderella) as well as the picture description tasks assessed in this study. The examiner followed the TBIBank protocol throughout administration of the task. The pictures used were the Broken Window (Menn et al., 1998), Refused Umbrella (MacWhinney, Fromm, Forbes, & Holland, 2011), and Cat Rescue (Nicholas & Brookshire, 1995), which were presented in that order every time the task was administered. These pictures were chosen because main concept checklists have been developed for them and allow a detailed description of how clearly and fully their content is described. (Checklists exist for other narrative tasks also, and those are being investigated by other members of this international collaboration.)

Transcription

The discourse samples were transcribed orthographically by the thesis author and then segmented into utterances according to the guidelines provided by the Codes for Human Analysis of Transcripts (CHAT) software manual (MacWhinney, 2000). The factors considered for establishing utterance boundaries include syntax, intonation, pauses, and semantics. Syntax and intonation were the primary determinants of utterance boundaries. Intonation was not considered for segmentation of utterances by ELLs due to differences in intonation patterns across languages and the potential influence of the native language intonation pattern on English speech. See Appendix A for a detailed description of utterance segmentation guidelines.

Discourse Analysis

Main Concept Analysis (MCA). MCs are statements that convey critical information for comprehending the ‘gist’ of a narrative. MCs for each of the picture description tasks included in this study have been developed in previous work (Nicholas & Brookshire, 1995; Richardson & Dalton, 2016; Richardson, Dalton & Tanaka, In Prep). To identify MCs for the picture description tasks, a list of relevant concepts (RCs) was generated for each picture set. An RC was defined as a statement about the discourse topic containing a subject, a main verb, and an object if appropriate. Subordinate clauses were sometimes included, provided only one main verb was present. Once a list of RCs was developed, transcripts from a large sample of typical speakers (N = 92) performing the picture description tasks were analyzed for the frequency of each RC. The RCs that were used most frequently among the sample of typical speakers (using a cut-off of 33% of the 92 speakers) were promoted to MCs and included in the analysis of discourse informativeness. The semantic content of an MC was considered more relevant than its syntactic organization, contributing in part to the variety of wording that was acceptable for an MC to be considered accurate and complete. For example “the father married again” would count toward the MC “the father remarried” (Richardson & Dalton, 2016).

Each MC for the picture description tasks included in this study was scored for presence, accuracy, and completeness according to the established criteria and given one of the following codes: Accurate and Complete (AC); Accurate and Incomplete (AI); Inaccurate and Complete (IC); Inaccurate and Incomplete (II); or Absent (AB). For a composite score, a numeric value (0-3) was assigned to each code: AC=3, AI=2, IC=2,

II=1 and AB=0. See Appendices B through D for detailed main concept checklists (Richardson & Dalton, 2016; Richardson, Dalton, & Tanaka, In Prep).

Coherence Analysis (CohA). CohA includes two related yet distinct analyses: Global Coherence and Local Coherence. Global Coherence is a measure of how relevant an utterance is to the overall topic of discussion. Local Coherence, by contrast, is a measure of how related an utterance is to the utterance that precedes it (Van Leer & Turkstra, 1999). Global Coherence measures discourse efficiency, whereas Local Coherences measures discourse organization.

Each utterance produced by the participants during the picture description task received a score of 1-5 for global coherence (where 1 does not relate at all to the topic, is unintelligible, or is a comment on the discourse, and 5 includes concrete information related to the topic) and a score of 1-5 for local coherence (where 1 indicates a radical topic shift, unintelligible utterance, or a comment on the discourse, and 5 indicates a relation through continuation, elaboration, repetition, subordination or coordination of ideas from the preceding utterance). Due to the low frequency of 2 and 4 ratings, “low” (scores of 1 and 2), “medium” (scores of 3), and “high” (scores of 4 and 5) bins were used. See Appendix E for a more detailed scoring protocol.

Data Analysis

See *Table 2* for MCA and CohA scoring of selected utterances. Performance on all measures was compared within speakers across 3 periods post-injury. Scores were collapsed across the 3 stories when the analyses were performed in order to increase the speech sample size and improve test-retest reliability (Brookshire & Nicholas, 1994). The first sample was taken at 3 months post-injury, unless the earliest available sample was

taken at 6 months post-injury (i.e., in coma or medically unstable at 3 months), in which case the 6-month sample served as baseline. This was necessary for 4 of the participants (17% of total). The second and third samples were taken at 12 and 24 months post-injury.

Screening of the data revealed a non-parametric distribution of change in performance over time. This prompted the investigators to utilize a Friedman test instead of a one way repeated measures ANOVA as originally intended. A Holm-Bonferroni correction for multiple comparisons was included to avoid a Type I error.

Table 2. Excerpts from transcripts with sample scoring for each discourse measure.

Participant 53 – 24 Months			
Utterance	MC	Global	Local
and inevitably it goes through the window and &uh knocks over the lamp upsets Dad from watching his telie [television] or whatever he was doing having a rest	AC	5	3
and &uh hopefully he has enough common sense to realize this is just one of those things that happen didn't happen on purpose and &uh might go out and kick the ball around with his young fella just to enjoy it	N/A	5	5
Participant 52 – 24 Months			
so she's trying to get the cat down	N/A	5	
anyway a good Samaritan's come along with a ladder	N/A	5	1
he's tried to get up the tree	AB	5	5
and the ladder's fallen down	AC	5	1
now, I don't know whether this is a vicious dog or not	AI	5	1
and that might be why the ladder fell down	N/A	5	1
Participant 44 – 3/6 Months			
that's how I went to hospital	N/A	1	
that's like me	N/A	1	5
I was stuck in a tree	IC	3	5

Results

Scoring Reliability

To determine intra-rater and inter-rater reliability, all original scores were first hidden from view. Then, a random number generator was used to select 5 participants (21.7% of the sample). The thesis author (responsible for generating the scores used in the analyses) then re-scored all measures, at all points post-injury, for each of the randomly selected participants. Point-to-point reliability was calculated by comparing the scores used in the analyses to those generated for the purpose of establishing intra-rater reliability. Intra-rater reliability for MCA analysis scores was 86.7% at 3/6 months, 90.4% at 12 months, and 90.4% at 24 months. Intra-rater reliability for Global Coherence scoring was 95.7% at 3/6 months, 99.4% at 12 months, and 99.2% at 24 months. Local Coherence was 93.6% at 3/6 months, 96% at 12 months, and 92.6% at 24 months.

Two experienced speech-language pathologists scored the same samples at all points post-injury to determine inter-rater reliability (one completed MCA reliability, the other CohA reliability). Reliability was calculated by comparing the SLP's scores to the graduate student's scores. Reliability for MCA scores was 85.2% at 3/6 months, 84.4% at 12 months and 83% at 24 months. Reliability for CohA was determined by comparing the bins (high, medium, or low) in which scores were placed rather than exact scores. This decision was made because the distinctions between scores within the same bin are minor and disagreement over these distinctions would not affect the results of this study. Global Coherence had an inter-rater reliability of 91.4% at 3/6 months, 95.1% at 12 months, and 98.1% at 24 months. Inter-rater reliability for local coherence was 91.1% at 3/6 months, 98.1% at 12 months, and 95.7% at 24 months.

Main Concept Analysis

See *Table 3* for a complete list of descriptive statistics for MCA including mean, standard deviation, median, range, skewness, and kurtosis. The median number of AC scores was 15 (out of a possible 27 total concepts, see Appendices B, C, and D) at 3/6 months post-injury, 18 at 12 months, and 17 at 24 months post-injury. The median number of AI scores was 2 at all timepoints post-injury. The median numbers of IC and II scores were 0 at all timepoints post-injury. The median number of AB scores was 8 at 3/6 months, 6 at 12 months, and 7 at 24 months post-injury. The median Main Concept Composite score was 51 (out of a possible 27 total concepts x 3 points if each were accurate and complete = 81) at 3/6 months, 60 at 12 months, and 57 at 24 months post-injury.

Table 3. Descriptive Statistics for Main Concept Analysis

Main Concepts	3/6 Months	12 Months	24 Months
AC			
Mean	14.65	17.09	16.39
Standard Deviation	4.15	4.23	4.28
Median	15	18	17
Range	6 - 21	9 - 23	7 - 24
Skewness	-0.45	-0.54	-0.74
Kurtosis	-0.57	-0.95	0.27
AI			
Mean	2.13	1.61	1.96
Standard Deviation	1.58	1.27	1.07
Median	2	2	2
Range	0 - 6	0 - 4	0 - 4
Skewness	0.84	0.24	-0.40
Kurtosis	0.18	-0.76	-0.16
IC			
Mean	0.22	0.78	0.61
Standard Deviation	0.52	1.89	1.64
Median	0	0	0
Range	0 - 7	0 - 7	0 - 7
Skewness	2.47	2.45	3.31
Kurtosis	5.89	5.43	11.28
II			
Mean	0.09	0	0
Standard Deviation	0.29	0	0
Median	0	0	0
Range	0 - 1	0 - 0	0 - 0
Skewness	3.14	0	0
Kurtosis	8.61	0	0
AB			
Mean	9.48	7.52	7.57
Standard Deviation	3.46	3.99	3.34
Median	8	6	7
Range	5 - 17	2 - 16	2 - 17
Skewness	0.69	0.75	0.81
Kurtosis	-0.58	-0.39	1.81
Composite			
Mean	48.74	55.91	54.04
Standard Deviation	11.18	11.76	11.68
Median	51	60	57
Range	24 - 65	31 - 73	27 - 74
Skewness	-0.56	-0.67	-0.61
Kurtosis	-0.62	-0.58	0.32

Global Coherence

See *Table 4* for a complete list of descriptive statistics for the Global CohA including mean, standard deviation, median, range, skewness, and kurtosis. The median ratios of High Global Coherence Scores were 0.83, 0.90 and 0.87 at 3/6, 12 and 24 months post-injury, respectively. Median Medium Global Coherence score ratios were 0.00 at 3/6, 12 and 24 months post-injury. Median Low Global Coherence ratios were 0.13, 0.05 and 0.10 at 3/6, 12 and 24 months post-injury, respectively.

Table 4. Descriptive statistics for Global Coherence.

Global Coherence	3/6 Months	12 Months	24 Months
High			
Mean	0.83	0.90	0.87
Standard Deviation	0.12	0.09	0.07
Median	0.85	0.90	0.88
Range	0.58 – 1.00	0.68 – 1.00	0.73 – 1.00
Skewness	-.38	-1.08	-.14
Kurtosis	-1.00	.99	-.22
Medium			
Mean	0.02	0.02	0.03
Standard Deviation	0.05	0.03	0.04
Median	0	0	0
Range	0 – 0.12	0 – 0.10	0 – 0.13
Skewness	2.61	0.95	1.38
Kurtosis	6.57	-0.06	1.23
Low			
Mean	0.15	0.07	0.10
Standard Deviation	0.10	0.08	0.07
Median	0.13	0.05	0.10
Range	0 – 0.33	0 – 0.32	0 – 0.25
Skewness	0.35	1.67	0.28
Kurtosis	-0.88	3.42	-0.45

Local Coherence

See *Table 5* for a complete list of descriptive statistics for the Local CohA including mean, standard deviation, median, range, skewness, and kurtosis. High Local Coherence score ratios were .541, .705 and .571 at 3/6, 12 and 24 months post-injury, respectively. Medium Local Coherence ratios were .160, .125 and .137 at 3/6, 12 and 24 months post-injury, respectively. Low Local Coherence ratios were .350, .153 and .250 at 3/6, 12 and 24 months post-injury, respectively.

Table 5. Descriptive statistics for Local Coherence.

Local Coherence	3/6 Months	12 Months	24 Months
High			
Mean	0.52	0.67	0.62
Standard Deviation	0.23	0.17	0.18
Median	0.54	0.71	0.57
Range	0.08 – 1	0.30 – 0.91	0.32 – 1
Skewness	0.11	-0.49	0.26
Kurtosis	-0.57	-0.58	-0.78
Medium			
Mean	0.16	0.14	0.14
Standard Deviation	0.11	0.10	0.09
Median	0.16	0.13	0.14
Range	0 – 0.44	0 – 0.31	0 – 0.28
Skewness	0.97	0.55	0.16
Kurtosis	1.60	-0.80	-1.17
Low			
Mean	0.32	0.19	0.24
Standard Deviation	0.17	0.15	0.12
Median	0.35	0.15	0.25
Range	0 – 0.71	0 – 0.53	0 – 0.52
Skewness	0.14	0.80	0.21
Kurtosis	0.02	-0.38	-0.06

Change over Time

The Friedman analysis revealed statistically significant changes in the proportion of AC MCs ($X^2 = 13.153, p = .001$), AB MCs ($X^2 = 9.098, p = .011$), MC composite scores ($X^2 = 9.356, p = .009$), and High Local Coherence scores ($X^2 = 6.822, p = .033$) over time. Post hoc analysis with Wilcoxon signed-ranks test and Holm-Bonferroni correction revealed significant differences in AC MC scores from 3/6 months to 12 months ($Z = -2.9, p = .003$) and 3/6 months to 24 months post-injury ($Z = -2.25, p = .024$); in AB scores from 3/6 to 12 months ($Z = -3.3, p = .001$) and 3/6 to 24 months ($Z = -2.4, p = .015$); in MC composite scores from 3/6 months to 12 months ($Z = -3.35, p = .001$); and in High Local Coherence Scores between 3/6 and 12 months ($Z = -2.8, p = .005$). There were no significant changes from 12 months to 24 months for any of the comparisons. *Figures 1A-F* show boxplots of each main concept code and composite score over time, while *Figure 2A-C* and *Figure 3A-C* show boxplots of the proportion of low medium and high scores for Global and Local Coherence, respectively.

Figure 1A-F. Boxplots for Main Concepts.

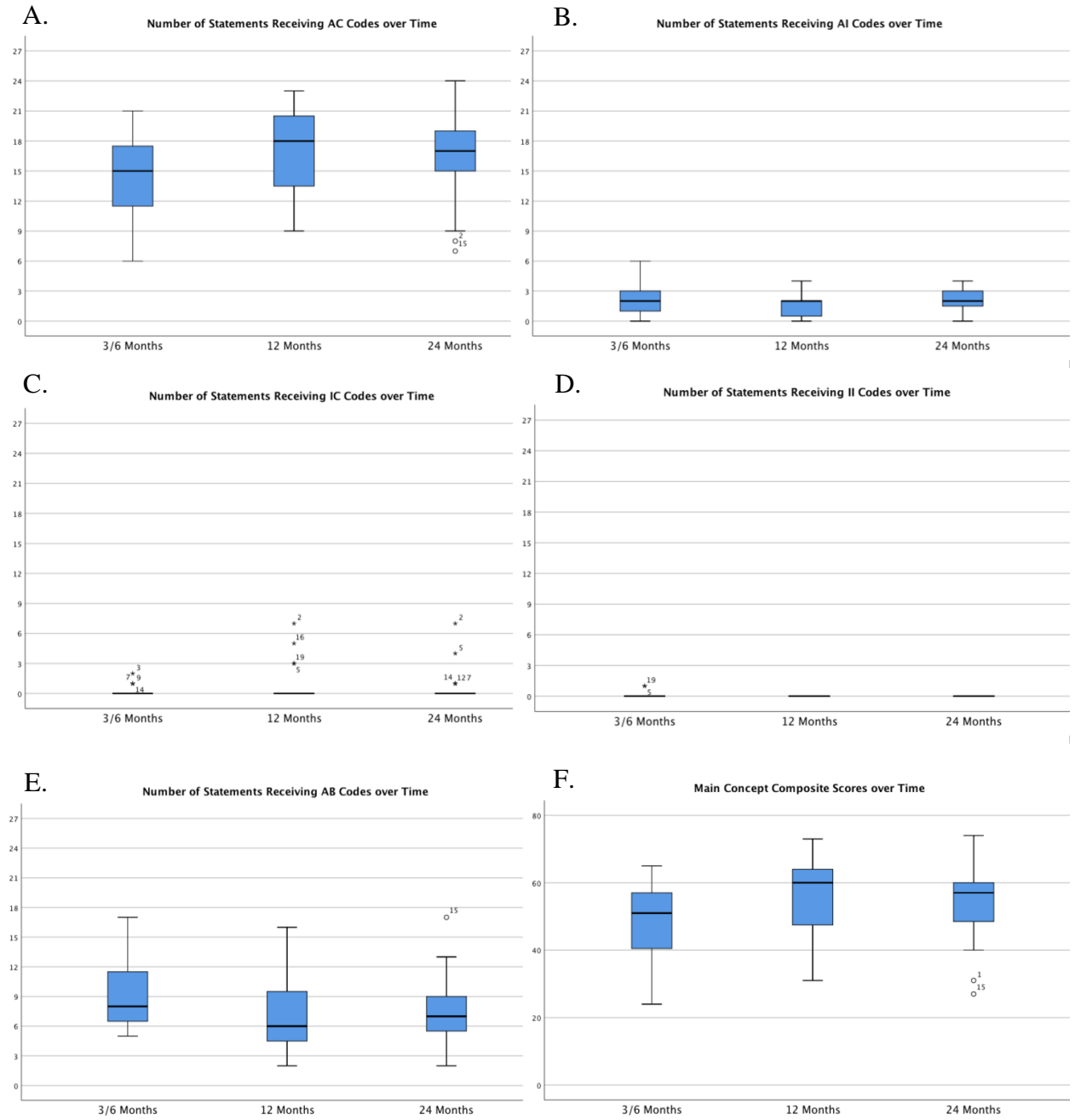


Figure 2A-C. Boxplots for Global Coherence.

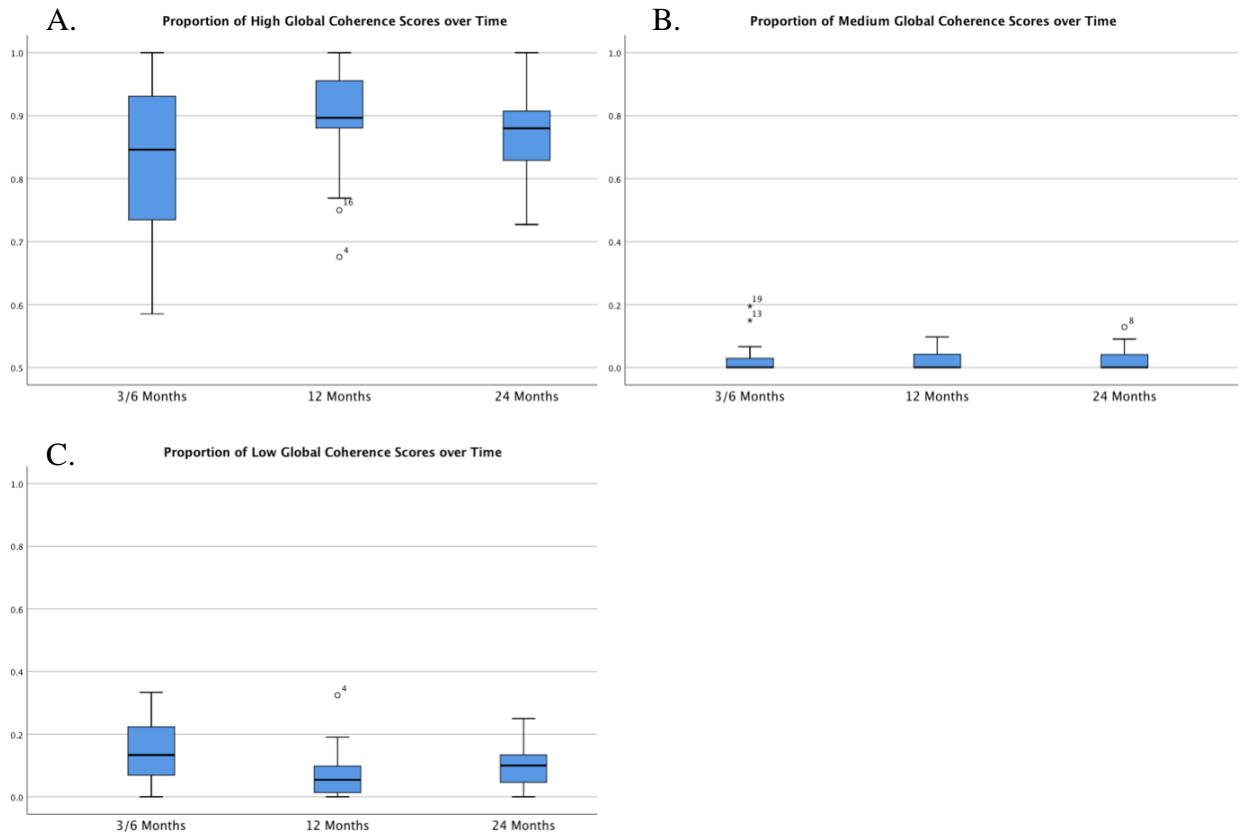
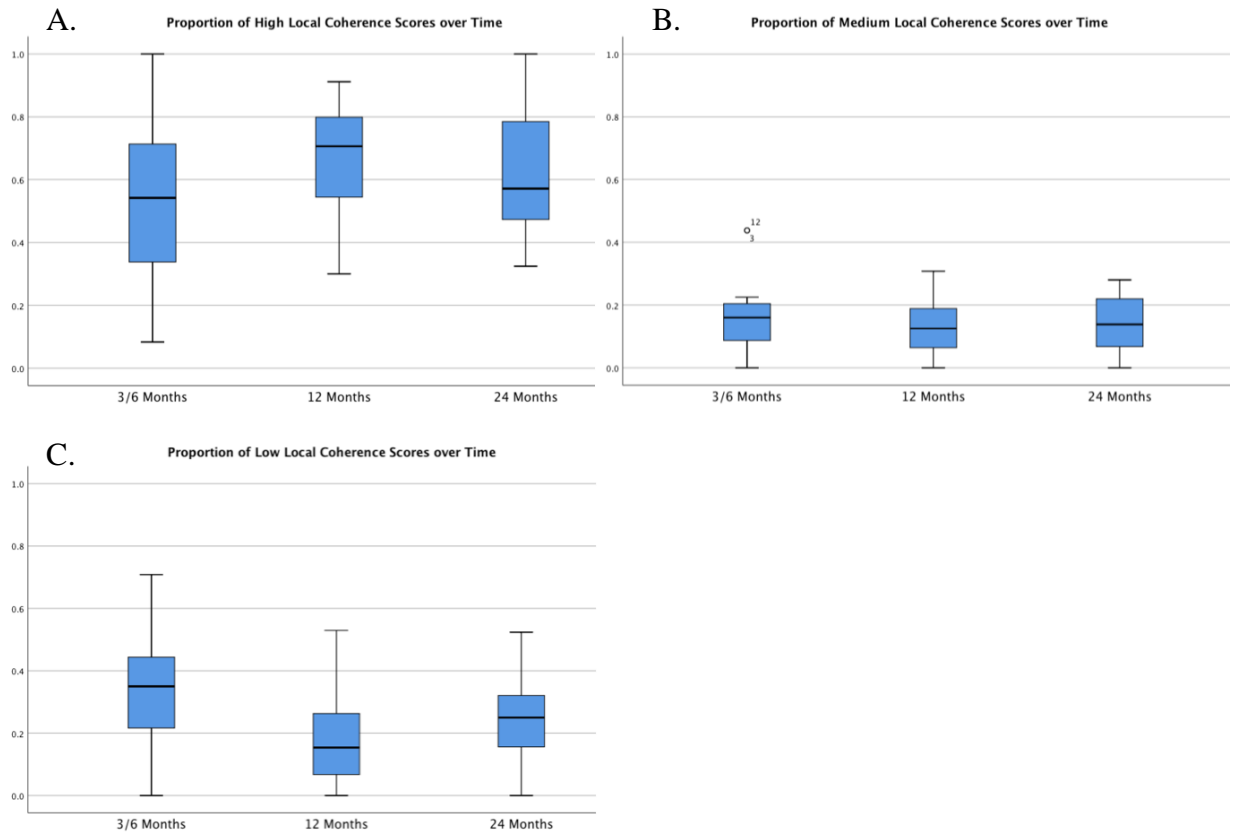


Figure 3A-C. Boxplots for Local Coherence.



Discussion

The aim of this study was to provide longitudinal data conveying changes in discourse skills over the span of 2 years following severe TBI. The measures selected for this study have been demonstrated to accurately and thoroughly describe the communication profiles of PWTBIs and other brain injury. This was the first study to utilize a measure of story 'gist' expression (MCA) and coherence (CohA) together. The participants produced more accurate and complete concepts, omitted fewer concepts, and were more informative overall at 12-24 months post-injury than at 3/6 months post-injury. Local Coherence analysis showed an increase within the first year of recovery in the ratio of utterances that flow logically from one to the next, though this improvement was not maintained. Global Coherence ratios did not change significantly across any timepoints, revealing no detectable change in the ratio of irrelevant statements produced. Overall, these results suggest that the discourse of our sample of persons with severe TBI became more informative during the first year following brain injury and that these gains were maintained at two years post injury. PWTBIs also became more organized within the first year of recovery, but gains were not maintained at two years, and no significant change in efficiency occurred. While significant changes were observed between 3/6 months and both 12 and 24 months, no significant improvements were observed between 12 and 24 months, indicating that the bulk of recovery happened primarily within the first year. Importantly, the results of this investigation revealed differential improvement across measures, demonstrating that discourse efficiency, organization, and informativeness may follow distinct recovery trajectories.

Performance by PWTBIs on MCA may be compared to that of healthy controls due to availability of normative data in previous work (Richardson & Dalton, 2016; Richardson, Dalton & Tanaka, In Prep). Among healthy controls, the median number of AC MCs was 20 and AB MCs was 7, with a median composite score of 60 across the 3 tasks used in this study. The median number of AI, IC, and II MCs was 0 for healthy controls. PWTBIs produced fewer AC MCs (median=15), more AI MCs (median=2), more AB MCs (median=8) and a lower composite score (median=51) at 3/6 months post-injury. The median number of IC and II MCs was 0 for PWTBIs at all timepoints. At 12 months post-injury, PWTBIs' performance approximated that of healthy controls, with a median of 18 AC MCs, 2 AI MCs, 6 AB MCs and composite score of 60. There was a negligible decline in performance from 12 to 24 months post-injury, with a median of 17 AC MCs, 2 AI MCs, 7 AB MCs, and composite score of 57. Although performance by PWTBIs improved to nearly that of typical peers by 24 months post-injury, the number of AC MCs never reached that of healthy controls and overall performance may have been declining. Normative data is not available for CohA analysis due to differences in data analysis and reporting in previous work.

Our study extends previous work (Power, Weir, Richardson, & Togher, In Prep) which demonstrated that, for a single picture description task in a large sample of persons with severe TBI (N=42), PWTBIs performance was significantly worse than controls at 3 and 6 months on measures of story grammar and completeness, and they did not improve over that short time span. Extending the lens to longer timepoints revealed some improvements in discourse informativeness and organization, which was also perhaps facilitated by more nuanced scoring systems compared to Power et al. (In Prep). Two

reports by Snow, Douglas & Ponsford (1998;1999) based on the same sample of PWTBIs found no significant improvement in conversational abilities from 3-6 months post-injury to 2-3 years post-injury, but significant recovery resulting in normative performance on a picture description task at 2-3 years post-injury (Snow, Douglas & Ponsford, 1998; Snow, Douglas & Ponsford, 1999). Further investigation is needed to examine the generalization of discourse skills during semi-structured clinical tasks to natural conversation. The authors above (1998) also noted that a subgroup of their sample (N=8) did show improved conversational ability, and that improvement was correlated with the severity of the injury at onset and the amount of time spent receiving speech-language pathology services. The majority of studies on cognitive-communication impairment in PWTBIs, including this one, utilize a varied sample that includes people with and without cognitive-communication impairment (precisely for those reasons above, in that identification of subtle deficits is a developing area). It is likely that these varied samples mask recovery.

Given the nature of our sample, it is worth noting that Australian healthcare system provides access to intensive rehabilitation during the first year following TBI, with a reduction in access to services beyond 12-months. It is possible that the observation of significant improvement on some of our measures within the first year, and lack of additional improvement in the second year of recovery, is related to the duration of services in addition to other spontaneous recovery processes. The relationship between the nature and intensity of the therapy and recovery magnitude and trajectory should be investigated further.

Detection of subtle cognitive-communication deficits in PWTBIs has long been a challenge, and only fairly recently has discourse moved to the forefront of that endeavor. Because of the known relationship between cognition and communication, and because we are still developing sensitive measures to detect cognitive-communication deficits, a promising area of research will be investigating relationships between cognition and communication abilities. Correlations between performance on measures of cognition and cognitive-communication skills appear in the current literature (Chapman, et. al., 2006; Kurczek & Duff, 2011; Marini, Zettin and Galetto, 2014). Performance on executive functioning tasks have been found to positively correlate with informativeness, topic-maintenance, and organization of narratives produced by adults with moderate TBI (Marini, Zettin & Galetto, 2014). Similarly, a group of adult women with hippocampal amnesia (affecting declarative memory) and normal working memory and executive function were found to have poorer discourse organization than typical controls in a study by Kurczek and Duff (2011). Chapman et. al. (2006) noted a positive correlation between the quality of narrative summaries (judged by topic-maintenance, organization, and lexical content) and performance on working memory tasks among children with TBI. Additionally, cognitive demands such as executive function and working memory can impact discourse performance and may result in more negative perceptions of PWTBIs (Byom & Turkstra, 2016).

Limitations and Future Directions

There are confounding factors that may have influenced the results of this investigation. There was no control for participation in therapy, history of drug or alcohol abuse, or subsequent brain injuries. Although intensive rehabilitation services were likely available to the participants included in this study, whether or not a significant portion of them accessed those services and the intensity of services received is unknown (Togher, 2014). The subtle improvements observed may have occurred naturally or with substantial intervention. A history of drug or alcohol abuse could affect recovery, as could recurrent drug or alcohol abuse after the injury. It is also unknown whether any of the participants incurred subsequent brain injuries over the course of this study. To highlight this, the participant who was excluded due to poor speech intelligibility presented with adequate intelligibility in the earliest discourse sample, but there was a drastic decrease in speech clarity in the subsequent samples. The occurrence of another brain injury or other life-changing event is a possible explanation for the decline in this participant's intelligibility. Although this sample represents a large degree of heterogeneity, this is consistent with the population in general, and makes it more likely that our results will be generalizable to the population at large.

Further study is needed to corroborate and/or expand upon our findings. More longitudinal data charting performance on measures of discourse informativeness, organization, and efficiency within participants will strengthen judgements of prognosis for PWTBIs with impaired discourse skills and provide direction for further inquiry regarding the factors that affect recovery of discourse skills. Comparison of discourse skills in PWTBIs to those of healthy controls at various points post-injury would provide

information regarding the degree of deficit over the span of recovery. Charting participants' life participation, including employment and satisfaction in social relationships alongside this data would also be revealing. This information would assist in demonstrating or ruling out a causal link between cognitive-communication impairment and functional outcomes following TBI. Additionally, studies of the relationship between cognition and communication, as mentioned above, will be valuable as we continue to work towards improved detection and prognosis.

The clinical impact of this type of research will be much more powerful if we consider clinical utility from the outset of research design. This study utilized reliable and straightforward measures that do not require time-consuming transcription. These measures are also relatively easy to implement clinically, making them viable options for clinicians to utilize to monitor progress in practice. Future studies could extend their utility by examining the proportion of statements that were scored for main concepts (e.g., %MCs) and calculations of MCs produced per minute in order to further examine efficiency.

Summary

This is the first study to report longitudinal data charting changes in repeated measurement of gist and coherence during discourse among survivors of severe TBI. While it has shed some much-needed light on the subject, more information is needed to equip clinicians who serve this population with the tools to make evidence-based prognostic and therapeutic judgments. Few studies examining the effectiveness of various treatment approaches directed at discourse skills exist, and the treatments explored do not have a sound theoretical model supporting them (Coelho, 2007). In addition to knowledge of the trends in recovery of discourse skills, clinicians need information regarding the effect of speech-language pathology intervention in general as well as specific approaches.

Appendix A

Utterance Segmentation (from CHAT short manual, p.24)

Utterance segmentation decisions can be challenging. In general, an utterance can be defined as a segment of running speech that appears to form a coherent unit (Saffran et al., 1989). When in doubt, err on the side of creating shorter rather than longer utterances. The following indicators are recommended, with primary weight given to syntax and intonation:

1. Syntax

Unless there are strong prosodic counter-indications, a well-formed sentence is considered to be an utterance. However, an utterance may not necessarily be grammatically correct to be considered an utterance.

2. Intonation

Falling intonation (or rising intonation in the case of a question) suggests the end of an utterance.

Do not use intonation as a judgement for utterance boundaries if speaker is ELL -- prosody is one of the most difficult pieces of a language to learn, and often speakers retain first language prosody (see participant 23)

3. Pauses

Pauses may not be a reliable guide to utterance boundaries. When pauses occur in what appear to be otherwise well-formed utterances, disregard them.

4. Semantics

Semantic criteria cannot be stringently applied in marking utterance boundaries in this population.

Words

@n	neologism (e.g., sakov@n)
exclamations	common ones: ah, aw, haha, ow, oy, sh, ugh, uhoh
interjections	common ones: mhm, uhhuh, hm, uhuh
fillers	common ones: &um, &uh
letters	@l
letter sequence	abcdefg@k
xxx	unintelligible speech, not treated as a word
&text	phonological fragment (&sh &w we came home)

Scoped Symbols

[: text]	target/intended word for errors (e.g., tried [: cried])
[*]	error (e.g., paraphasia -- w&k@u [: wet] [*])
[/]	retracing without correction (e.g., simple repetition)

[//] put repeated items between <> unless only one word was repeated
 retracing with correction (e.g., simple word or grammar change)
 put changed items between <> unless only one word was changed

Appendix B

Main Concepts: Broken Window

Essential information is italicised and bolded. Each essential segment is numbered (superscript) with alternative productions (if any were produced) listed by number below. These alternative productions are not intended to be an exhaustive list, but represent some of the more common productions of the normative sample and are included to aid in scoring. Additional, but non-essential, information often spoken to complete the main concept is in normal font.

1. ***¹A/²The boy ³was ³outside.***

1.1. “He” since referent is unambiguous; some give the boy a name

1.2. Is, decided to go

1.3. In his front yard, on the lawn, out of the house, etc.

Note: Sometimes, this concept was combined with number 2 in a statement like “The boy was playing soccer outside” or “The boy was kicking the ball in the yard”. These statements would receive full credit for both concepts 1 and 2.

2. ***¹A/²The boy ²was *playing* ³soccer.***

2.1. See 1.1

2.2. Played, is kicking, kicks, is practicing, etc.

2.3. With the soccer ball, with the ball, with the football* (*if not from U.S.)

Note: “He has a ball” or “He has a soccer ball” did not count towards this concept because it does not imply any kind of action with the soccer ball, and boy–action–ball was the concept that met criterion.

3. ***¹The ball ²breaks ³the man’s/neighbor’s window.***

3.1. Soccer ball, football*

3.2. Goes through, went through, crashes through/into, flew through, sails through/into, shattered, is kicked through

3.3. glass

4. ***¹The man ²is sitting in a chair* and/or inside the house.**

4.1. His dad, his father, the father, the neighbor, the guy; some give the man a name

4.2. Lounging, resting, relaxing, inside

Note: Most common were “The man is sitting,” “The man is inside,” “The man is sitting inside.”

Note: “The man is watching TV” or something similar did not count for this concept; that was a

separate relevant concept that did not meet criterion. However, if an individual said, “The man is sitting watching TV,” then they would receive credit for this concept since they

included “sitting.”

5. ¹The man ²was startled.

5.1. See 4.1

5.2. Surprised, amazed, afraid, astonished, freaked out, stunned, shocked, angry, upset, not happy, mad

Note: Occasionally, this concept was combined with number 3, in a statement such as “The ball crashed through the window and startled the man.”

6. ¹The ball ²broke ³a lamp.

6.1. See 3.1

6.2. Knocks down/over, smashes into, breaks, hit

6.3. No alternative for lamp was produced

7. ¹The man ²picked up ³the ball.

7.1. See 4.1

7.2. Grabs, gets, holds/is holding, catches, captures, has

7.3. See 3.1

Note: Occasionally, “The man stands up with the ball” and “The man jumps up with the ball” was used to express this concept, expressing that the man had performed some action to hold on to the ball.

8. ¹The man ²looked ³out of the window.

8.1. See 4.1

8.2. Looks, is looking

8.3. Outside, out, out of the glass

Note: “The man goes to the window,” “The man went to the window,” or “The man goes outside”, etc., did not count towards this concept. These were separate relevant concepts that did not meet criterion

Appendix C

Main Concepts: Refused Umbrella

1. The mother says ¹*it's going* ²*to rain* today.

1.1. It's supposed to, it might, it's predicted, it looks like, there's a chance

** Occasionally produces as "¹*Rain* ²*is in the forecast.*"

** Statements that implied bad weather was on the way e.g. "the weather was looking gray and cloudy outside" do not count towards this main concept

2. The mother says ¹*you* ²*need to take* ³*the umbrella.*

2.1. He (if appropriate reference), the boy, (male name)

2.2. Carry, here is, take, have, need, should have, might need, might want

** Sometimes produced as a command with the subject implied, e.g., "take this umbrella" these statements were considered AC since English allows the subject to be dropped in a command.

** Sometimes expressed as "¹*his mother* ²*offers* him ³*an umbrella.*" or something similar

** Occasionally produced as a question "don't you want to take this umbrella?"

** Sometimes produced "here is your umbrella"

3. ¹*The boy* ²*(does something to refuse)* ³*the umbrella.*

3.1. He (if appropriate reference), the boy, (male name), I (if reported speech)

3.2. Doesn't want, refuses, won't/not going to take, declines, says no

3.3. It (if appropriate reference)

** Occasionally this concept was stated as "He won't do it." in reference to the mother trying to make him take the umbrella, so the action he "won't do it" is "take the umbrella" and this should receive an AC (assuming the referent is produced).

4. ¹*The boy* ²*walks* ³*to school.*

4.1. See 3.1, a child

4.2. Goes, leaves, heads, takes off, starts, sets

4.3. Outside, out of the house, out, to/for/towards [location], down the road, off, out of the door, further, forth

** Sometimes the order of elements was switched, e.g. "out he goes"

5. ¹*It* ²*is raining.*

5.1. The rain, the deluge

5.2. Starts to pour, starts coming down, is falling, is sprinkling, gets harder, gets heavier, is raining, begins to rain, starts to rain, starts falling, comes, is coming down, starts raining, started sprinkling, started, rained

**Sometimes produced as a colloquialism, “The sky opens up” or “We have a downpour.”

** Occasionally produced as “Here ²*comes* ¹*the rain.*”

**Did not count the 2nd time talking about rain “increasing” as the last phrase

6. ¹*The boy* ²*gets* ³*soaking wet.*

6.1. See 3.1

6.2. Is, looks, stands there

6.3. Soaked, drenched, dripping

** Sometimes speakers would use first person (e.g. “I am all wet”)

**Occasionally this concept was combined with other main concepts such as “the boy runs back soaking wet”. Participants should get credit for both concepts for this type of utterance.

7. ¹*The boy* ²*runs* ³*back* and goes into the house**

7.1. See 3.1

7.2. Goes, heads, returns, turns, races, rushes, comes, gets, arrives, shows

7.3. Around, home

8. ¹*The mother* ²*is* ³*(negative emotional state).*

8.1. see 1.1

8.2. looks, feels

8.3. unhappy, mad, angry, upset, annoyed, frustrated, concerned, cross, disappointed

** Sometimes reported as “his mother doesn’t look happy”

** Statements about physical stance/nonverbal expression do not count, e.g., “She’s scowling.”

**Note: Occasionally, this concept was combined with number 6 and 7 in a statement such as “when I got home mom was not really happy with me when she saw how soaking wet I was.”

9. ¹*The boy* ²*gets* ³*an umbrella*

9.1. see 3.1, me

9.2. takes, receives, has, asks for, carries, retrieves, picks up, holds

9.3. it (if appropriate referent)

** Sometimes produced as “The mother ²*gives* ¹*the boy* ³*an umbrella.*” Or “she gave it to him”

**Must be produced after the boy returns home for the umbrella

10. ¹*The boy* ²*goes* back to school with the umbrella

10.1. see 3.1

10.2. walks, leaves, heads out, starts off, takes off, is off, is on his way, sets forth

**Note: Occasionally, this concept was combined with number 9, in a statement such as
“The next time he goes out he takes the umbrella with him.”

Appendix D

Main Concepts: Cat Rescue

1. ***¹The little girl ²was riding ³her/a bicycle.***
 - 1.1. She (if appropriate referent), the girl, the child, any feminine name
 - 1.2. Rode, rides, was on, is playing on, stopped riding, got off, was beside, has
 - 1.3. Bike, tricycle, trike, it (if appropriate referent)

2. ***¹The cat ²was in ³the tree*** because the dog chased/scared it.
 - 2.1. Kitty, kitten, it (if appropriate referent), any cat name
 - 2.2. Was up, was stuck in, got stuck in, climbed up, ran up, goes up, gets in, was caught in, ends up in, was on, was chased up, was scared up
 - 2.3. The tree limb, limb

****Sometimes expressed as “*The dog ²chased ¹the cat ³up the tree.*”**

3. ***¹The dog ²was barking at the tree.***
 - 3.1. It (if appropriate referent), puppy, pup, any dog name
 - 3.2. Barks, is barking, barked, is yelping

4. ***¹The man ²climbed up ³the tree*** to get the cat.
 - 4.1. The neighbor, the father, dad, daddy, someone older, big brother, he (if appropriate referent), any man’s name
 - 4.2. Was climbing, climbed, climbs, ran up, goes up into, got up on, crawls
 - 4.3. In the tree, the branch, the limb, the ladder, it (if appropriate referent), there

5. ***¹The ladder ²fell down.***
 - 5.1. It (if appropriate referent)
 - 5.2. Is down, falls, fell, has fallen, has fallen down, got away from him, is on the ground, has slipped away, has dropped away, fell off, has been knocked down

****Sometimes expressed with an agent that caused the ladder to fall, such as the wind or dog (e.g., “the dog knocked the ladder down”).**

6. ***¹The father ²is stuck ³in the tree ⁴with the cat.***
 - 6.1. See 4.1, the man and the cat, they (if appropriate referent)
 - 6.2. Is up, is, is stranded, is caught, ended up, is marooned, is sitting
 - 6.3. On the branch, on the limb

****Sometimes expressed as: “*The man ²couldn’t ³get down.*”**

7. ***¹Someone ²called ³the fire department.***
 - 7.1. The mother, the neighbor, the lady next door, the girl, the father, a passerby, an onlooker, he/she/they (if appropriate referent)

7.2. Notifies

7.3. the firemen, 911

**Sometimes expressed as a passive such as: “¹*The fire department* ²*has been called.*”

8. ¹*The fire department* ²*comes* with a ladder.

8.1. The firefighters, the firemen, they (if appropriate reference)

8.2. is on the way, is coming, came, have arrived, rushes out, bring*

8.3. “bring” is a verb that requires an object so “the ladder” or “the truck” or something similar is essential and must be present for the utterance to receive an AC.

9. ¹*The fire department* ²*rescues* ³*them.*

9.1. See 8.1

9.2. saves, is going to get, helps, gets, will take, gets [them] down

9.3. the man, the cat, the man and the cat

**Often combined with 8 as in “The fire department comes (with a ladder) to rescue the cat/man/them.” A person who says this should receive full credit for MC 8 and MC 9.

Appendix E

Coherence Analysis

Global Coherence:

The relationship of the meaning or content of an utterance to the general topic of conversation. The general topic of conversation is determined by the story being told.

Global coherence is rated on a scale from 1 to 5.

- Score of 5
 - The utterance provides substantive information related to the general topic. For example, on the topic of the subject's accident, "I was taken to the hospital by ambulance."
- Score of 4
 - The utterance contains multiple clauses, wherein one clause relates directly to the topic and the other relates indirectly. For example, "I was taken to the hospital, which was a first for me."
- Score of 3
 - The utterance provides information possibly related to the general topic or is an evaluative statement without providing substantive information, or the topic must be inferred from the statement. For example, "The hospital is a confusion place."
- Score of 2
 - The utterance contains multiple clauses, wherein one clause possibly relates to the general topic and one does not. For example, "The hospital is a confusing place, as usual."
- Score of 1
 - The utterance is unrelated to the general topic or is a comment on the discourse. For example, "that's all I have to say."

Local Coherence:

The relationship of the meaning or content of an utterance to that of the preceding utterance. The relationship may be achieved through continuation, elaboration, repetition, subordination or coordination of ideas from the preceding utterance.

- Score of 5
 - The topic of the preceding utterance is continued by elaboration OR temporal sequencing OR enumeration of related examples OR maintaining the same actor, subject, action or argument as the focus. For example, "O.J. was a football star. *He was very famous.*"
- Score of 4
 - The utterance contains multiple clauses, wherein one clause definitely relates to the content in the preceding utterance but another may not. For example, "O.J. was a football star. *I think that he was very famous.*"

- Score of 3
 - The utterance topic generally relates to that of the preceding utterance, but with a shift in focus from the subject or activity of the preceding utterance; or the utterance is referentially vague or ambiguous so that the relation to the preceding utterance must be inferred. For example, “O.J. was a football star. *He had a lot of things going on.*”
- Score of 2
 - The utterance contains multiple clauses, wherein one possibly relates to the content of the preceding utterance but the other(s) may not. For example, “O.J. was a football star. *I think he had a lot of things going on.*”
- Score of 1
 - The utterance has not relationship to the content of the immediately preceding utterance. It may be a radical topic shift, a comment on the discourse, or an unintelligible utterance. For example, “O.J. was a football star. *That’s all I know.*”

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