INTRODUCTION

Language, a unique human quality, draws upon a complex interplay of language and cognition to achieve fluency of expression, clarity and organization of ideas conveyed, depth of understanding, and the ability to synthesize vast new meanings from the input. When we derive meanings, the whole is more than the sum of the input, which is why two people who read the same book or watch the same movie often come away with very different but accurate impressions and levels of understanding (Chapman, 1995). The following example illustrates two disparate capacities to synthesize meaning from the well-known movie *The King's Speech*.

Overview of the movie *The King's Speech* highlighting the main ideas and themes

Participant 1: The movie is about Prince Albert of England who suffered his whole life with a stuttering problem. The Prince’s father, King George V, demands that Albert train himself by reading his father’s speech. Prince Albert’s wife, Elizabeth, arranges for him to seek help from Lionel Logue, an Australian speech therapist. Mr. Logue’s training involved muscle relaxation, breath control, and unorthodox techniques of reading aloud while listening to music on headphones. Although the prince was not fond of his speech therapist initially, the two men become friends and confidants over time. After his father’s death, the prince was crowned King George VI. Lionel’s support to the king was most noted during the radio address to Britain in September 1939, upon declaration of war with Nazi Germany. Following the radio address, the King steps onto the palace balcony with his family to thank thousands of Londoners gathered outside to listen, cheer, and applaud the king’s speech. In recognition of personal service to the king, Mr. Logue was later appointed to the Commander of the Royal Victorian Order.

Participant 2: *The King's Speech* is a story of resilience and responsibility. The movie is about a self-effacing prince of England who overcame a personal struggle to fulfill his and his family’s responsibility to become the leader of his people during a very difficult time in the country’s history. Prince Albert suffered from a disability all his life and perceived himself too weak to rule the British Empire. However, after the death of his father, King George V, and the scandalous abdication of his brother, King Edward VIII, he was crowned King George VI of England. With his country on the brink of war with Germany and in desperate need of a leader, his wife, Elizabeth, encourages him to seek help from an unconventional Australian speech therapist, Lionel Logue. After a rough start, the two eventually form an unbreakable bond despite class difference during the course of treatment. With the support of Logue, his family, his government, and Winston Churchill, the King overrides his fear and delivers a radio address that not only uplifts his people and unites them in battle, but also inspires confidence in his leadership. Overall, the movie portrays the power of adversity to strengthen oneself. Prince Albert’s disability and his inevitable responsibility allowed him to not let fear, but courage, motivate his every act.

The two overviews of the movie share commonalities and yet at the same time reveal stark contrasts as to how
meaning is extracted from complex information. On the one hand, both show comparable levels of syntax, lexical complexity, and similar levels of information reduction. Participant 1’s overview is primarily a sequential recall of the key events in the movie. This rote-like restatement of the movie’s sequence of events illustrates a capacity to recall the key information, but an overview that fails to convey meaning beyond the literal/concrete facts. Contrast that with the overview of participant 2, which conveys generalized meanings/themes of power, responsibility, resilience, and courage to overcome not only a personal struggle, but also an entire country’s struggles. These similarly condensed versions of the original content, yet distinctly different depths of abstracting higher level meanings, reflect distinct competencies that serve to inform the cognitive-linguistic level at which the individual is performing to absorb, reprocess, and produce meaning.

The ability to abstract meanings from large amounts of information, as in the King's Speech Overview, participant 2, is referred to as “gist reasoning” (Chapman, 1995; Vas et al., 2011). The functionally relevant complex cognitive-linguistic function of gist reasoning is not routinely evaluated in traumatic brain injury (TBI) management. Aphasia batteries that are traditionally used to characterize specific language functions in TBI do not measure cognitive-linguistic functions involved in abstracting meanings from large amounts of content. Neurologists, neuropsychologists, and speech-language pathologists are increasingly cognizant of the relative insensitivity of basic language measures (i.e., processing at the word and sentence level) in TBI that have been developed to be informative in the context of more focal lesions common in stroke. Researchers identify the need to employ complex language metrics (e.g., discourse) that are sensitive to the diffuse neuropsychology of TBI (i.e., typically widespread axonal damage with superimposed focal damage to frontal and temporal lobes). To be clinically viable, these metrics must also have the attributes of being reliably and validly measured, widely adoptable, and time-efficient in characterizing performance patterns (Chen et al., 2006).

The current chapter proposes discourse as a meaningful context to assess and train higher-order complex language functions in TBI populations. The chapter begins with a brief review of existing discourse metrics in TBI that examine language processing beyond the word and sentence level. Following the review, the construct of discourse gist reasoning is described both from a neurobiological and from a theoretical perspective. Third, the emerging findings of gist reasoning performance in TBI populations, including adolescents and adults, are discussed. The concluding section presents recent advances in adopting a gist reasoning approach to advance complex cognitive-linguistic abilities. The overarching principle is an emphasis on identifying and employing sensitive measures of cognitive-linguistic functions at both acute and chronic stages postinjury, prioritizing long-term monitoring, and treatment to detect and mitigate later emerging language deficits.

### LANGUAGE IN TRAUMATIC BRAIN INJURY

Historically, language proficiency in adults with TBI has been evaluated using aphasia batteries. These standardized batteries reliably identify basic language deficits including fluency, recall, naming, repetition, complexity of syntax, and categorizing (Miceli et al., 1981; Armstrong, 1991, 2005; Caplan et al., 1996). However, the majority of individuals with TBI do not manifest classic aphasic disturbances, especially in chronic stages of recovery; instead, they typically show sparing or dramatic recovery of specific language functions. Therefore, the view that language is rarely persistently impaired in all but the most severe cases of TBI remains widely held (Coelho, 2007). Furthermore, the consistent finding of relatively good recovery of basic language abilities (e.g., lexicon and syntax) underestimates the nature of long-term broad-based cognitive-linguistic sequelae that has eluded clinicians from pursuing the full range of complex language (e.g., discourse) deficits (Coelho et al., 1991; McDonald, 1993, 2000; Brookshire et al., 2000).

Despite the relative sparing or recovery of lower-level language skills and the limited occurrence of persistent aphasia following a TBI, survivors often struggle (even years post-TBI) with absorbing and applying the complex information required for functional tasks including job performance, new learning, and social functioning that draw upon proficient language function (Ylvisaker, 1992; Galski et al., 1998; Cannizzaro and Coelho, 2002; Chapman et al., 2006). Therefore, the impetus to examine higher-order language abilities such as discourse has gained momentum over the last two decades. Discourse, defined broadly as connected language, refers to the “linguistic expression of ideas, wishes, and opinions in everyday life,” typically conveyed as a sequence of sentences that has coherent organization and meaning” (Chapman and Sparks, 2003). Language, at the discourse level, is sometimes referred to as “information structures,” “macrolinguistics,” or “higher-order language components” to distinguish it from more basic language domains (Chapman, 1995). Discourse is at the core of communicative functionality and can be manipulated to measure how newly encountered information is encoded, reprocessed, stored, and utilized. Facility with discourse drives much of what
we do and how we perform in our daily lives. We continuously engage in processing a variety of discourse genres depending on the function and relevance of the task or activity. For example, we engage in conversational discourse during speaker–listener interactions and social exchanges, we use descriptive discourse to explain attributes and features of an object, we use narrative discourse to describe an event, we use procedural discourse to explain a task procedure, and we use expository discourse to inform a listener of a topic through facts or interpretations (Biddle et al., 1996; Coelho, 2002; Chapman et al., 2006).

Currently available discourse metrics in the TBI populations are broadly classified into recall and organizational measures. The recall measures predominantly examine the number of details remembered from texts. The recalled details are analyzed for the number of independent clauses and any subordinate clauses associated with it, mapping recall to specific propositions (i.e., a unit of meaning), syntactic complexity, and the cohesion across sentences (Hartley and Jensen, 1991; Coelho, 2002). Research findings of discourse recall in TBI are mixed. Whereas some studies have reported comparable recall details between the TBI and healthy adults (Liles et al., 1989), others reported significantly lower performance in the TBI group (Mentis and Prutting, 1987; Hartley and Jensen 1991). The lower performance was characterized by decreased cohesion (i.e., idea-to-idea linkage between sentences) (Coelho et al., 2005) or recognition of details from a text in a yes/no question format (Nicholas and Brookshire, 1995; Ferstl et al., 2005).

Discourse organization measures examine ability to structure the essential information in a well-formed format (Hough and Barrow, 2003). Commonly identified discourse organization deficits in TBI have included impaired sequencing of essential details to narrate a story (Tucker and Hanlon, 1998; Zalla et al., 2002) or describing a procedure despite normal range of vocabulary and sentence complexity (Snow et al., 1997, 1999). Researchers have also reported commonly observed behaviors of tangentiality, verbosity, and repetition of details that may have contributed to poor sequencing of the details such that juxtaposed ideas do not link to each other (Hough and Barrow, 2003; Davis and Coelho, 2004). Similar findings of discourse recall and organization impairments have been reported in adolescents with TBI on narrative discourse measures (e.g., Test of Narrative Language) that examine story retell (with no picture cues), story generation tasks (using picture cues), and answering literal and inferential comprehension questions (Gillam and Pearson, 2004). The construct of gist reasoning expands on these existing discourse paradigms to propose a functionally relevant complex language function of abstracting meaning from large amounts of information, henceforth referred to as “gist reasoning.”

**CONSTRUCT OF GIST REASONING: A COMPLEX LANGUAGE FUNCTION**

Gist reasoning, the ability to abstract meanings from large amounts of information, is at the core of everyday life, including job efficiency, academic performance, and social functioning (Chapman, 1995; Anand et al., 2011a; Vas et al., 2011). Getting the big picture is much more central to complex information processing than remembering the precise details that one hears or reads (Ulatowska and Chapman, 1994; Chapman et al., 1995; Gabrieli, 2004). The capacity to extract the core message versus recalling the details is called upon frequently throughout one’s day, whether it involves understanding newspaper articles, movies, lectures, Internet stories, information from job interviews, or comprehending personalized medical information that one receives from healthcare professionals. This ability to abstract meanings versus remembering specific facts minimizes cognitive overload of incoming stimuli and assists in constructing a form of meaning that is more robustly stored and retrieved than the composite details (Gamino et al., 2009).

Humans encode, store, and retrieve information in a manner that is far from camera-like. The human brain encodes the large influx of input mostly in the form of abstract or gist-based meanings interpreted in the context of one’s knowledge and experience (van Dijk, 1995; Gabrieli, 2004). Chapman and colleagues posit three significant cognitive control processes, namely (1) strategic attention (inhibiting less important details), (2) integrative reasoning (combining world knowledge with important information to construct generalized ideas), and (3) innovation (deriving multiple interpretations) to play a significant role in gist reasoning (Anand et al., 2011b; Chapman and Cook, 2012; Vas, 2012).

The notion of superior memorability of gist over details is an age-old phenomenon. Early 20th century pioneer theorist Frederic Bartlett set forth the notion of superior memorability of gist meanings over isolated details (Bartlett, 1932; Schacter et al., 1998). Bartlett rejected the notion that memory for information is a passive replay or a literal copy of information; rather, he argued and showed that memory for meaning involves reconstruction of the information. This evidence was based on a recall paradigm involving an American Indian story in which recall for details of the story was weak and recall for the gist of the story was robust and constant during varying periods of delay. As Bartlett stated: “The first notion to get rid of is that memory is literally reduplicative or reproductive. In a constantly changing
world, literal recall may become increasing less important to elucidate how the human mind optimally processes and stores information. Evidence shows memory to be far more decisively an affair of construction rather than one of mere reproduction" (Bartlett, 1932). Since Bartlett’s introduction of the notion of gist, several discourse-processing theorists have elaborated on this concept (e.g., Kintsch, 1988; Kintsch and van Dijk, 1983; Nichelli et al., 1995; Chapman et al., 2004). Discourse processing is identified as a multidisciplinary field (e.g., linguistics, psychology, sociology, education, and artificial intelligence) concerned with exploring the “processes of comprehending, producing, reproducing, composing, recalling, summarizing and otherwise creating, accessing, and using discourse representations” (Graesser and Gernsbacher, 2003). To this effect, theorists proposed cognitive models such as the Situation Model (Zwaan and Radvansky, 1998), the Context Model (Kintsch and van Dijk, 1983), and Construction-Integration (Kintsch, 1988) to elaborate the structures, patterns, and mental representations that underlie discourse processing.

The distinctions between memory for gist and memory for details have proven to be clinically informative when elucidating cognitive impairments in older adults and in clinical populations. For example, cross-sectional and longitudinal studies of cognitively normal older adults have found gist reasoning to be relatively stable despite decline in memory for details (Chapman et al., 2002). One key explanation for preserved gist memory in the context of declining detail memory is that older adults may rely on relatively intact gist reasoning capabilities to compensate for declining episodic memory for details. Clinical populations present with interesting disparities between gist and detail-level memory. For example, whereas adults with aphasia (due to left hemisphere damage) present with relatively intact gist reasoning ability and decreased memory for details, individuals with right hemisphere brain damage demonstrate the opposite pattern, that is, decreased memory for gist and relatively intact memory for details (Ulatowska et al., 1989, 1998). Adults in earlier stages of Alzheimer’s disease manifest memory deficits at both gist and detail levels (Chapman et al., 2002). Adolescents with TBI also present with a distinctive pattern of relative recovery of fact-learning abilities compared to typically developing adolescents, yet manifest a persistent and marked gap in competence in constructing gist meanings, years post-injury (Chapman et al., 2004, 2006; Gamino et al., 2009). Additionally, adolescents with TBI also have difficulty distinguishing between important and unimportant details, treating all information at the same level of focus. In characterizing the discrepancy between gist reasoning and near normal performance on discrete fact learning, Chapman and colleagues postulated that higher-order cognitive skills involving top-down processing are more likely to be compromised than are bottom-up skills following a TBI in both adolescent and adult populations.

### NEUROBIOLOGICAL SUPPORT OF GIST REASONING

The neurobiological framework of “functional specialization and functional integration” set forth by Chen and colleagues (2006) could be adopted to elucidate distinctions between simple versus complex cognitive-linguistic functions. Functional specialization is conceptualized as the basic cognitive processes that are localized to specific cortical regions. In contrast, functional integration refers to the dynamic interaction of networks across brain regions (e.g., temporal and parietal cortices) during performance of complex tasks and is the most relevant to everyday functionality. Especially, functional integration indicates engaging frontal networks to modulate distributed neuronal activity in order to facilitate specific processes that are relevant to internal goals while suppressing nonrelevant processes (Fuster, 2000; Miller and Cohen, 2001; Curtis and D’Esposito, 2003). That is, the functional integration domain draws upon cognitive control functions to modulate information processing in a top-down fashion.

Top-down control processes are generalized, goal-oriented, internally driven, voluntary (not automatic) cognitive operations that facilitate both focused attention on task-relevant stimuli and ignoring of irrelevant distractions (Kane and Engle, 2002). Neurolinguistically, top-down modulation involves bidirectional operations of both the enhancement and suppression of neural activity in cortical regions depending on the relevance of the information to our goals (Fig. 31.1). Increasingly, imaging data support the role of prefrontal cortices in top-down modulatory tasks. This neurobiological framework is especially relevant to characterizing cognitive performance following a TBI, which is typically characterized by frontal lobe damage and multifocal neuropathology of distributed cortical and subcortical networks (Chen et al., 2006).

Chen’s framework of functional specialization versus functional integration provides an elucidative distinction to characterize simple versus complex language functions. In the context of the language domain, functional specialization relates to basic language functions that draw upon specialized brain regions (e.g., syntax linked to Broca’s area). On the other hand, the domain of functional integration within the realm of language function entails the capacity to combine meaning derived from the basic language input with
Compared to an individual with lower gist reasoning skills, an individual with higher gist reasoning may encode details more efficiently when (i.e., details). That is, an individual with higher gist reasoning can assist in memory for verbatim content that although gist and detail are dissociable, gist representations can assist in memory for verbatim content. More recently, these cognitive-linguistic skills (Reyna and Brainerd, 1995; Chapman et al., 2012; see Brainerd and Reyna, 2002), include rich personal knowledge to construct higher-order synthesized meaning. Thus, complex language competence, manifested by synthesizing meaning through gist reasoning, involves functional integration across brain neural networks, with a central role of frontal cortices and the prefrontal cortex in the integration of neuronal activity across multiple brain regions in abstracting meaning from complex information (Chiu Wong et al., 2006; Anand, 2008).

**THEORETICAL SUPPORT OF GIST REASONING**

Theoretical support for distinguishing between complex language functions and basic language skills comes from cognitive scientists Brainerd and Reyna (1995). These theorists propose two dissociable language representations of “verbatim” and “gist” during discourse processing. Whereas verbatim representation includes basic language encoding and expression of explicit facts, gist representation captures the consolidated core meanings from information by drawing upon complex cognitive-linguistic skills (Reyna and Brainerd, 1995; Chapman et al., 2012; see Brainerd and Reyna, 2002, for review). Reyna and colleagues propose that individuals prefer gist representations over verbatim details of information, as gist-level encoding is more robustly encoded and retrieved over time. More recently, these theorists adopted a constructivism view and proposed that although gist and detail are dissociable, gist representations can assist in memory for verbatim content (i.e., details). That is, an individual with higher gist reasoning skills may encode details more efficiently when compared to an individual with lower gist reasoning ability (Reyna, 2008). Empirically, distinctions between higher-order and lower-level language skills have proven to be clinically informative when elucidating impairments in TBI (Gamino et al., 2009; Vas et al., 2011).

**MEASUREMENT OF GIST REASONING**

Gist reasoning is examined on a criterion-referenced assessment called Test of Strategic Learning (TOSL) (Gamino et al., 2009), which evaluates four aspects of discourse processing including gist reasoning, interpretative statement, memory for details, and judgment of important versus unimportant content. The TOSL measure has a manualized objective scoring system for all the four aspects of assessment. Plans are underway to have access to an online test version. For research purposes, two trained examiners score each of the four assessment aspects. Interrater reliability of scores assessed on intraclass correlation coefficients for all four aspects of the measures in our TBI studies has been consistently over 90%.

1. **Gist reasoning:** The TOSL measure consists of three texts designed to examine how one constructs generalized/gist meanings from lengthy information. The three texts vary in length (from 291 to 575 words) and complexity. For each of the texts, the participant is asked to construct a gist-based overview/synopsis of ideas that are not explicitly stated in the text. An example of a gist-based overview/synopsis is first illustrated to clarify that the task entails combining and synthesizing the explicit details in the text to construct generalized ideas. The participant is provided with a copy of the text.
to follow along as the examiner reads each text aloud. After the examiner completes reading the text, the participant’s copy is taken away so that the participant does not have the option to refer to the original text while providing his or her abstracted ideas in the form of a written overview/synopsis. Each abstracted gist-idea receives one point. A total composite of 38 points is possible for the three overviews/synopses of the three texts.

2. **Interpretive statements(s):** In addition to the abstracted overview/synopsis, the participant derives an interpretative statement from each text. Interpretive statements include life lesson(s), take home message(s), or solutions to real life applications that one can glean from each text. Interpretive statements are scores for both quality (number of accurate interpretive statements) and quality (degrees of abstraction of each interpretive statement).

3. **Memory for text details:** Each text has eight probe questions that examine recall of key information in each text; that is, 24 probe questions for all three texts. Each probe receives a score of 2, 1, or 0 points depending upon accuracy and completeness of the response. A cumulative score for three texts ranges from 0 to 48, with 48 being the highest possible score.

4. **Important versus unimportant information:** Following examining memory for details for each text, a set of 10 sentences (five important and five unimportant) from the text are read to the participant. Participants are not aware of the important versus unimportant ratio. The participant judges if each sentence is relevant and critical to understanding the core meaning of the text. One point is awarded for an accurate response.

**GIST REASONING AND TRAUMATIC BRAIN INJURY**

Chapman and colleagues’ longitudinal and retrospective studies provide some of the first evidence of gist reasoning impairments in adolescents when tested 1–5 years post brain injury (Chapman et al., 1999a, b). The ability to recall concrete facts (from lengthy texts) in youth with TBI when followed years after an earlier brain injury were found comparable to their noninjured typically developing peers (Chapman et al., 2006). However, despite the relatively intact performance on memory for details, gist reasoning (i.e., ability to abstract meanings) performance was significantly impaired in adolescents with TBI as compared to normally developing adolescents. The adolescents adopted an immature cognitive strategy of “copy and delete” instead of the more age-appropriate strategy of combining ideas into transformed statements that was characteristic of the typically developing control group. That is, preadolescents and adolescents with TBI adopted a lower developmental cognitive approach reflected in rote recall learning versus a higher-order reasoning-based learning approach, even when tested years after injury. Moreover, it was found that children with earlier age at injury had poorer gist-reasoning outcomes when compared to children injured at an older age. Specifically, children injured before 8 years of age demonstrated lower performance than those injured after 8 years of age, despite similar injury severity and even longer recovery periods for the adolescents injured at a younger age (Chapman et al., 2004, 2006). That is, emerging evidence suggests detrimental effects of earlier age at injury to long-term recovery of higher-order cognitive functions.

Gist reasoning is considered a developmental phenomenon that continues to evolve from lower-level verbatim fact-based learning to a more advanced and sophisticated gist-based learning (Reyna and Kiernan, 1994). This transition begins in early school years (as early as 8 years of age) and is refined throughout adolescence into young adulthood (Brown and Day, 1983; Chapman et al., 2006). The disparity in subsequent development of higher cognitive-linguistic skills associated with an earlier-age TBI may be consequent to the disruption of the frontal brain network development. The frontal networks undergo elaborate myelination and growth during adolescence and continue to develop into young adulthood (Ewing-Cobbs et al., 1987, 2004; Sowell et al., 1999; Chapman and McKinnon 2000; Taylor et al., 2002; Levin, 2003) (Ch. 15). Disruption of frontal networks (e.g., secondary to a TBI) prior to full development could alter or impede subsequent acquisition of higher-order integrative cognitive-linguistic abilities (e.g., gist reasoning) despite recovery of isolated skills (e.g., rote memory skills) (Dennis, 2000; Gamino et al., 2009; Anderson et al., 2012) (Chs 40 and 41). As a child with TBI grows older, the discrepancy between his or her abilities and those of noninjured typically developing peers may increase over time (Brookshire et al., 2000). Therefore, a TBI in childhood could be more detrimental to later emerging cognitive skills, particularly frontal-mediated cognitive control processes, when compared to an injury sustained when the brain is more fully developed (Chapman, 2006).

In addition to the gist reasoning deficits in adolescents, preliminary evidence suggests that the impact of childhood TBI on gist reasoning persists even into adulthood. In a recent study, researchers found that adults (ages 20–55) in chronic stages of recovery (>10 years) who sustained a moderate-severe TBI in their preteen or teenage years had lower gist reasoning abilities as
comparing to their noninjured peers (Vas and Chapman, 2012). Similar to the gist reasoning impairments found in adolescents, adults with TBI (injured during adolescence), when compared to their noninjured peers, had significant difficulty in abstracting meanings from large amounts of information. When asked to abstract meanings from complex texts, a majority of the adults recalled a large number of details in a verbatim format. Emerging evidence from an adult TBI study reports that gist reasoning may be impaired even in individuals who were injured in adulthood (i.e., at or above the age of 18) despite near normal IQ and reading comprehension (Vas, 2012). The cumulative evidence of gist reasoning deficits in (1) adolescents with TBI, (2) adults who sustained a TBI in preteen and teenage years, and (3) adulthood TBI, even with near normal IQ, demonstrates that a TBI has a lasting detrimental impact on the ability to abstract meaning despite no significant difficulty in comprehending the literal content of the text meaning at word and sentence levels.

The clinical utility of gist reasoning as a window into complex cognitive activity across ages and clinical populations (e.g., attention deficit hyperactivity disorder, traumatic brain injury, mild cognitive impairment) seen at the Center for BrainHealth of the University of Texas at Dallas led to the development of training procedures to determine whether complex information processing could be improved to optimize brain repair and cognitive recovery. Chapman and colleagues at BrainHealth developed a training program labeled Strategic Memory Advanced Reasoning Training (SMART) that promotes deeper understanding of information encountered in everyday life (Gamino et al., 2010; Vas et al., 2011). The training focuses on teaching the three cognitive strategies of strategic attention, integrated reasoning, and innovation that are considered essential components for gist reasoning. The following section reviews existing discourse training programs and describes the SMART program and associated promising findings of improving complex language functions in individuals with TBI, even in chronic stages of recovery.

**HIGHER-ORDER/COMPLEX LANGUAGE REHABILITATION**

Language training in TBI has focused largely on basic language skills aimed to improve conversational discourse and social pragmatics (Helffenstein and Wechsler, 1982; Milton and Wertz, 1986; McDonald and Flanagan, 2004; Togher et al., 2004). The overarching goal of traditional language training is to enhance competence in contextually determined functional language use. Specifically, the programs target awareness of social rules, ability to verbalize ideas in a logical and coherent sequence, and monitoring the appropriateness of one’s own spoken communication (Cicerone et al., 2000; Turkstra et al., 2001, 2006; Togher et al., 2004; McDonald et al., 2008). Commonly used strategies to improve conversational skills and social pragmatics are modeling, role-playing, feedback, self-monitoring, behavioral rehearsal, and social reinforcement. Researchers have adopted and modified these strategies relevant to the setting and population. For example, Helffenstein and Wechsler’s (1982) 20 hour social skills training (also referred to as interpersonal process recall) includes individualized videotaped interactions followed by structured review of the taped interactions with feedback provided by the conversation partner, a therapist, and the individual with TBI. Another training labeled Communication Awareness Training (Coelho et al., 2005) utilizes a three-step technique for increasing awareness of disrupted discourse, developing strategies specific to the context, and practicing the strategies in novel situations. With the target behavior agreed upon by the participant and the clinician, a simple reinforcement schedule is implemented during treatment. Thomas-Stonell et al.’s (1994) computer-based program for students with TBI targets classroom communication skills. Training focuses on self-awareness and monitoring of verbal communication skills. The student’s teachers are actively involved in guiding the student through initiating conversations, taking turns, and focusing on assigned topics of conversation. Evidence demonstrates that group communication treatment can produce clinically meaningful improvements in language functioning, including improved functional communication, beyond the effects of social contact alone. Overall results from communication skills and social pragmatic training studies indicate moderate benefits in the short term, although long-term follow-ups have shown minimal sustenance of the gains (Yorkston et al., 1999; Body and Perkins, 2004; Ylvisaker et al., 2005).

Discourse training in TBI beyond the basic verbal communication and social pragmatics realm has been sparse (Coelho, 2007). For example, in a small sample study (one adult with TBI and three healthy adults), researchers examined the benefits of discourse organization training. The training included teaching essential elements of cohesive episodes, including (1) an initiating event that causes a character to formulate a goal-directed action sequence, (2) an action, and (3) a direct consequence resulting in attainment or nonattainment of the goal. Although short-term benefits were evident following training, long-term maintenance and generalization of the benefits beyond trained skills were limited (Cannizzaro and Coelho, 2002). In another small-sample study (one participant with TBI and one with stroke), researchers examined the benefits of discourse
comprehension training following the Strategies of Observed Learning Outcomes (SOLO) methodology (originally developed by Biggs and Collis, 1982). The SOLO program included a five-level hierarchical training of comprehension ranging from “prestructural” (e.g., no relation between question and answer) to “elaboration” to other situations. Results indicated improved text comprehension abilities after 15 treatment sessions. Comprehension was evaluated by the accuracy of cued responses to predetermined questions. In addition to improved accuracy for answering the predetermined questions, the TBI participant demonstrated improvements in organization and integration of information as well as self-monitoring and self-cueing abilities (Penn et al., 1997).

Chapman and colleagues have expanded upon existing discourse training methodologies to enhance higher-order language function and to facilitate the integrity of networks to promote frontal lobe recovery at later stages post-TBI in both pediatric and adult populations. The gist reasoning-based training program labeled Strategic Memory Advanced Reasoning Training (SMART) utilizes a top-down, strategy-based approach to train individuals to construct generalized meanings with no direct emphasis on remembering explicit facts. Specifically, several strategies are trained to facilitate top-down cognitive control processes of strategic attention, integration, and innovation that represent the core components of the SMART program (Chapman et al., 1999a; Gamino et al., 2010). Whereas strategic attention involves blocking less relevant details to focus on important information, integrated reasoning teaches strategies to abstract and create meanings or goals from information or tasks. Innovation focuses on generating and discovering novel concepts, ideas, and diverse goals and perspectives (Anand et al., 2011b; Vas et al., 2011; Chapman and Cook, 2012).

The strategy instruction is hierarchical, with each strategy dynamically building upon previous strategies to condense and transform the many explicitly encountered details into brief abstracted gist meanings through reasoning and inferencing. Each successive stage puts greater challenges on the individual to employ top-down information processing strategies of cognitive control to efficiently encode and construct abstracted meanings for efficient storage and retrieval. The SMART program incorporates a wide range of discourse materials to teach the gist reasoning strategies. Because the program is strategy-based rather than content-driven, the focus is neither content-specific nor situation-dependent. Throughout the training, responses that represent rote recall of the facts or “seeking the single, correct answer” are not accepted, both of which represent more of a bottom-up processing of information. The SMART program seeks to “un-teach” the strong bias and often taught process to remember as much detail as close to verbatim as possible, as a verbatim form of learning has been shown to be fragile in terms of long-term learning and memory (Brainerd and Reyna, 1998; Radavansky, 1999; Gabrieli, 2004). Trying to remember as much of the detail as possible places an inordinate workload on both immediate and working memory processes, even in a nondamaged brain, much less one that has sustained an injury.

The SMART program instructs individuals to practice using the strategies throughout their routine daily life tasks as they are faced with different forms of information which they need to attend to and absorb. For example, when discussing a recently viewed movie, such as The King’s Speech, as presented in the chapter’s introduction, the goal in the SMART program is not to give a straightforward listing of the events that took place, but rather to give a variety of interpretations or life messages that the movie conveyed along with justifications. This contrasts with training that emphasizes repetition of task content, which promotes a bias towards automatic processing and disengagement of prefrontal cortex-mediated control. Application of SMART to daily life activities is an integral part of the training. That is, participants are taught to incorporate general thinking strategies in contexts such as planning an event, going on a job interview, learning from a lecture, watching TV, movies, or explaining a concept. The SMART strategies along with sample activities to improve gist reasoning are delineated in a widely available book written for general audiences (Chapman, 2013). The program format is feasible for individual and group training, with the number of 1–1.5 hour sessions ranging from 8 to 12 sessions depending on the clinical trial. Encouragingly, significant cognitive gains have been achieved during this short-term intensive training. Moreover, the effects have continued to manifest months post-training (e.g., 3 months and 6 months post-training) (Vas et al., 2011).

Emerging evidence from adult TBI populations indicates that SMART improves abstraction abilities. Furthermore, the benefits extend to untrained executive functions. In a recent randomized control trial in adults with TBI (ages 20–65) in chronic stages of recovery (>1 year postinjury) participants in the strategy-based SMART program showed significant improvements on gist reasoning as compared to the control TBI group. The TBI control group had equally engaging sessions, with the control group focusing on learning about brain functions, brain injury, and brain health in general. Both groups were comparable in the number of training hours, group participation, injury severity, age, IQ, and education. In addition to the significant gains in synthesizing meaning, benefits of the SMART program extended to untrained measures of immediate memory,
executive functions of working memory, nonverbal reasoning, and cognitive switching, and improvements in daily functional activities (Vas et al., 2011). Findings from adult TBI studies (including veterans and civilians) report generalized benefits in daily life functional integration. Examples include improved social abilities (e.g., initiating and planning activities with family and friends), enhanced productivity (initiating job search, efficiency at existing workplace), effective home management (completion of household chores and home upkeep), and improved sense of well-being (Vas et al., 2011; Jantz et al., 2013; Tuthill et al., 2013). Moreover, the benefits of the SMART training were evident not only in the short-term (i.e., immediately post-training) but were also maintained at 6 months post-training (Fig. 31.2).

Emerging evidence from a pilot study employing the SMART training program with children with TBI indicates similar improvements in not only gist reasoning ability but also untrained measures of working memory and executive functions (Chapman and Cook, 2012). Similar to adult TBI findings, preliminary results from the SMART program in adolescents (ages 12–20) in chronic stages of recovery (at least 6 months post-TBI) revealed significant improvements in gist reasoning performance after training. Benefits were also found on untrained domains of working memory, inhibition, and recall of details from texts as compared to a rote-memory training control group. Furthermore, post-training gains were evident on parent-reported daily life executive functions behaviors.

Improved gist reasoning following SMART has also been reported in healthy populations, including typically developing middle school children and senior adults. After implementation of the SMART program in middle school classrooms, improvements were noted in both gist reasoning performance and fact-learning abilities as well as improved academic performance on state-mandated tests (e.g., Texas Assessment of Knowledge and Skills) (Gamino et al., 2010). In contrast, students who learned only rote memory strategies failed to show gains in gist reasoning despite gains in fact-learning ability. Similarly, Anand and colleagues (2011b) found significant improvement in gist reasoning performance after just 8 hours of gist reasoning training in cognitively normal older adults. Moreover, significant transfer effects were found on executive function measures, including cognitive switching, concept abstraction, and verbal fluency.

The consistent findings of improved higher-order language abilities along with frontal-mediated cognitive control functions across populations (TBI and healthy) elucidates the language-cognition relation and guides future research and clinical management in TBI across the lifespan. The implication is that a top-down complex reasoning approach (i.e., the SMART program) is effective in strengthening and/or remediating functionally relevant higher-order cognitive-linguistic proficiency in adolescents and adults in chronic-stage traumatic brain injury as well as healthy individuals. In healthy seniors, cognitive gains following SMART correlated with neural changes (Chapman et al., 2013). Especially, significant gains were found in global and regional cerebral blood flow (CBF), greater connectivity in the default mode network and the central executive network, and increased white matter integrity in the left uncinate demonstrated by an increase in fractional anisotropy. In short, complex cognitive training appears to repair and strengthen cognitive-linguistic performance and harness neural plasticity.

**GIST REASONING AND COGNITION**

Discourse processing draws upon extensive cognitive processing, including manipulation of lexical semantic operations, organization and monitoring of information, and inferring implied meanings (e.g., Wapner et al., 1981; Hinchliffe et al., 1998; Copland et al., 2002; Chapman et al., 2004). Evidence of supportive and positive relations between discourse and cognition has led to terms such as “discourse cognition” and “cognitive-linguistic performance” (Graesser, 2007; Graesser et al., 2007). Advances in cognitive neuroscience, including brain...
imaging methodologies, have led to increased attention and understanding of the role of frontal lobe-mediated cognitive control functions in discourse competence (Snow et al., 1997, 1999; Chapman et al., 1999b; Yorkston et al., 1999). Thus, discourse processing is postulated to be mediated by a wide range of cortical and subcortical networks with a prominent role linked to the frontal lobe and its intricate connectivity throughout the brain (Robertson et al., 2000; Mar, 2004; Plante et al., 2006; Anand et al., 2009).

Effects of a TBI on discourse processing abilities including recall of discourse details and drawing inferences from coherent sentence pairs were examined in adults (Beeman, 1993; Ferstl et al., 2002; Zalla et al., 2002). Examining discourse processing at the gist level further enriches the scope of discourse measures in characterizing high-level cognitive-linguistic faculties. Research has shown that adolescents and adults with gist reasoning deficits also demonstrate impaired executive functions as compared to healthy controls (Chapman et al., 2006; Vas and Chapman, 2012). Recent evidence from adult TBI studies demonstrates a significant positive relation between integrative gist reasoning function and specific processes of working memory, inhibition, switching, fluency, and memory (Vas and Chapman, 2012, Jantz et al., 2013). Yet, gist reasoning performance cannot be fully explained by performance on these measures either in isolation or in combination. For example, discussion in the earlier part of this chapter of the paradoxical findings of comparable memory for details between adolescents with TBI (with gist reasoning deficits) and their noninjured peers clearly demonstrates that gist reasoning is beyond recall of explicit details. In sum, both adolescent and adult TBI findings suggest that specific cognitive processes may enable appropriate selection and updating of discourse information, but the ability to synthesize meanings from complex information is a unique integrated cognitive function that is beyond the cumulative sum of the commonly tested cognitive processes in standard neurology and neuropsychology practice.

Another interesting paradox noted in the gist reasoning studies in TBI populations (both adolescents and adults) is the notion of intelligence. We have not consistently found a significant correspondence between standardized IQ scores and gist reasoning. Although standard IQ performance was positively correlated with gist reasoning, the ability to abstract meanings is impaired despite near normal IQ (Vas et al., 2011; Chapman and Cook, 2012). That is, IQ performance may not be indicative of one’s cognitive capacity, especially complex language abilities. The classic way to measure intelligence may have lower predictive value in everyday life functionality.

FUTURE DIRECTIONS

A paradigmatic shift away from focusing predominately on lower levels of language function in TBI towards a growing momentum to adopt discourse metrics is encouraging for the advancement of long-term cognitive-linguistic functional outcomes in TBI, whether sustained in childhood or adulthood. However, efforts to improve access to higher-order language metrics to practicing neurologists, physiatrists, neuropsychologists, and rehabilitation professionals is critical to guide accurate assessment and training of higher-order language sequelae following a TBI. Higher-order language training should be an integral part of traditional cognitive-linguistic rehabilitation, as these language functions have a far-reaching influence on most cognitive domains, including navigating through the challenges of learning and adaptation during rehabilitation and long-term recovery.

Moreover, examination of neural processes that mediate higher-order functions may provide a neuroscientific basis for development of brain biomarkers of frontal lobe integrity and/or brain change in response to training (Chen and D’Esposito, 2010). In a complex cognitive training study of healthy normals, we have identified significant increases in total brain blood flow, improved functional connectivity using fcMRI, and enhanced structural connectivity as measured by diffusion tensor imaging (Chapman et al., 2013). We suspect that TBI populations may show similar or even more significant change, which is currently being investigated. The potential to identify a brain pattern that could serve as a marker to implicate good prognosis for subsequent recovery of higher-order language function would advance our understanding of recovery of discourse processing. Lastly, a proactive approach of follow-up assessment at regular intervals and short-term intensive treatment of higher-order language would serve to stave off the cumulative effects of the TBI with advancing age to the greatest degree possible.

CONCLUSIONS

Advancing the field of brain repair in TBI by translating the breakthroughs of discourse metrics into clinical practice has never been more vital, particularly considering the increasing number of individuals who suffer “invisible” but life-altering injuries in the battlefield and as a result of high-impact sports. The discourse metric of gist reasoning may help fill the void and perhaps elucidate the paradox evident in a majority of adult TBI survivors. The paradox is reflected by the many individuals who regain near normal general intellectual functioning, including specific linguistic skills,
yet experience difficulties on functional tasks that necessitate synthesizing large amounts of information. Furthermore, top-down strategy-based approaches to cognitive-linguistic training (e.g., gist reasoning SMART) could advance methods for improving long-term recovery of complex language deficits in TBI and generalize to complex cognitive functions. In conclusion, we propose gist reasoning performance as a functionally relevant construct that characterizes high-level language proficiency and provides a window into complex cognitive abilities. Furthermore, training of gist reasoning abilities as a routine way to process complex information has the potential to benefit cognitive health and optimize brain repair across the lifespan.

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