Beyond Utterances: Distributed Cognition as a Framework for Studying Discourse in Adults with Acquired Brain Injury

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ABSTRACT

Considerable effort has been directed at understanding the nature of the communicative deficits observed in individuals with acquired brain injuries. Yet several theoretical, methodological, and clinical challenges remain. In this article, we examine distributed cognition as a framework for understanding interaction among communication partners, interaction of communication and cognition, and interaction with the environments and contexts of everyday language use. We review the basic principles of distributed cognition and the implications for applying this approach to the study of discourse in individuals with cognitive-communication disorders. We also review a range of protocols and findings from our research that highlight how the distributed cognition approach might offer a deeper understanding of communicative mechanisms and deficits in individuals with cognitive communication impairments. The advantages and implications of distributed cognition as a framework for studying discourse in adults with acquired brain injury are discussed.

KEYWORDS: Distributed cognition, discourse, brain injury

Learning Outcomes: As a result of this activity, the reader will be able to (1) state the principles of distributed cognition and (2) develop protocols using this framework to study discourse in adults with acquired brain injury.

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Over the past several decades, considerable attention and effort have been directed at characterizing and understanding the nature of the communicative deficits observed in individuals with traumatic brain injury (TBI).[1–4] Early work in this area focused on distinguishing the pattern of deficits associated with TBI from those seen in the aphasias[5–7] and selecting the appropriate unit of analysis to capture the impairments individuals with TBI experienced in their everyday interactions. Researchers quickly recognized that aphasia batteries, focusing at the word, phrase, and sentence level, lacked the sensitivity and specificity to detect communication impairments in individuals with TBI and moved to eliciting and analyzing longer stretches of language (i.e., utterances, discourse).[8–11] In the years that followed, research identified measures that successfully differentiated the discourse of individuals with brain injury from that of healthy participants (e.g., productivity, t-units, cohesion, story grammar; see Cherney et al[12]) and attempted to correlate these measures with performance in aspects of cognition thought to underlie discourse performance (e.g., memory, attention, executive function[11,13–15]).

Today, there is widespread consensus that TBI, and acquired brain injury more broadly, can result in cognitive-communication deficits and that these deficits interfere with academic, vocational, and interpersonal pursuits.[16–19] However, despite our progress in the detection of these deficits, several critical challenges remain. First, performance on identified discourse measures do not reliability predict long-term communication success and there is little evidence that interventions for discourse-level impairments result in improved communication and social interaction in everyday settings.[2,16,20,21] Second, efforts to establish a link between aspects of discourse (e.g., cohesion) and cognition (e.g., executive functioning, working memory) have yielded only moderate and inconsistent correlations.[11,14,22] Although research findings to date support the notion that cognitive functions contribute to discourse in some way, correlative methods do not tell us how or when or why these cognitive processes support communication. Nor do they guide clinical decision making and treatment planning. Finally, there is a need for synthesis and integration of empirical findings into theoretical models and frameworks that account for the observed disruptions in patients and recognize the complex interplay and orchestration of communication and cognition.[2,16] Theoretically based discourse interventions also are needed.

We suggest that to meet these theoretical, methodological, and clinical challenges, it is time to reconsider the appropriate unit of analysis. We propose that distributed cognition[23,24] might serve as a framework for understanding interactions among communication partners, between communication and cognition, and between individuals with brain injury and the environments and contexts of their everyday language use. In this article, we review the basic principles of distributed cognition and the implications of applying this approach to the study of discourse in individuals with cognitive-communication disorders. We also review a range of protocols and findings from our research that highlight how the distributed cognition approach might offer a deeper understanding of communicative mechanisms and deficits in individuals with cognitive-communication impairments.

DISTRIBUTED COGNITION

Grounded in cognitive science, distributed cognition aims to understand the organization of cognitive systems by analyzing interactions among individuals, representational media (e.g., objects, materials, artifacts), and the rich environments within which complex human activity is situated.[23–25] Distributed cognition also has strong roots in the sociocultural school of psychology[26–28] and the notion that higher-order cognitive functions (e.g., language) develop through and are dynamically linked with our social interactions with people and the environment. A core theoretical principle of distributed cognition is that cognition, learning, and knowledge are not confined to an individual but rather are distributed across individuals and the environment. From this perspective, the unit of analysis is not an utterance, an individual, or a specific domain of cognition within the individual. Instead, the unit of analysis is the functional activities and social spaces in which complex behavior emerges, and the full range of resources (people, cognitive, semiotic, material) that are brought to bear for interactional success. Thus, we gain insight into the operation of cognitive systems (e.g., memory) by understanding how and when and why those systems are called upon in the service of executing complex behaviors such as problem solving or communication.

Employing ethnographic methods, the study of distributed cognition includes the analysis of verbal and nonverbal resources, the forms and functions of communication that takes place, and the dialogic trajectory of communication across functional, goal-directed activity.[29,30] Hutchins and colleagues[23–32] suggest that when observing human activity "in the wild," there are at least three ways in which cognitive processes may be distributed:

1. Cognitive processes may be distributed across the members of social groups.
2. Cognitive processes may involve coordination between internal and external (material or environmental) structure.
3. Cognitive processes may be distributed through time in such a way that the products of earlier events can transform the nature of later events.

We argue that these observations offer a new lens through which to study discourse in individuals with cognitive-communicative disorders. In particular, we believe redefining communication as a cognitive activity co-constructed among individuals and between individuals and their environment holds tremendous promise in advancing our understanding of the nature of cognitive-communication disorders and in the development of theoretically informed interventions with clinical efficacy. In the next three sections, we consider the implication of each type of distribution for the study of communicative disorders, using examples from our research on adults with acquired brain injury.

Communication as Socially Distributed Cognition

Communication as a socially distributed cognitive activity shifts the unit of analysis from the isolated competencies of a single individual to the emergent ways that meaning is distributed and co-constructed across people who are using a range of resources and materials as they engage in shared activity within dynamic environments.[24,30,33,34] Applying a distributed cognition approach to the study of cognitive-communication has several methodological implications for discourse data collection and analysis. In contrast to traditional linguistic approaches to the study of discourse[12] where the focus is on the verbal productions of a participant with acquired brain injury performing monologic discourse tasks in highly controlled settings, a distributed cognition approach argues for the examination of the multimodal, multi-interlocutor interactions centered around the accomplishment of a functional activity.

Hengst and Duff[35] developed the mediated discourse elicitation protocol (MDEP) to sample a range of familiar discourse types (i.e., conversation, narrative, picture description, procedural) in a clinical setting and to do so in a manner sensitive to the complexities of social interaction. Consistent with a distributed cognition view, the MDEP attends to and allows for data analysis of (1) all participants (not just speakers and not just participants with acquired brain injury), who are viewed as active collaborators in and co-constructors of the interaction; (2) all communicative resources (not just language) that contribute to the creation and understanding of meaning in interaction; and (3) goal-directed activities (not just correct linguistic production) that motivate and guide interaction.

In a line of work examining the contributions of declarative memory to meeting the demands of everyday language use, Duff and colleagues have used the MDEP to examine the interactional discourse data of nine participants with hippocampal amnesia and nine healthy comparison participants, each interacting with a clinician. One example from this work is an analysis of the interactional use of reported speech,[36] a discourse practice in which speakers represent, or reenact, words or thoughts from other times and/or places (e.g., John said, "I'll be there at six").[37] Importantly, the unit of analysis was the entire session rather than a discrete task, and analysis of reported speech examined all instances of reported speech produced by the participants and the clinician during both target discourse tasks (e.g., picture description) and nontask interactions (e.g., small talk between target tasks). In this analysis, Duff and colleagues found a significant group difference; there were only half as many reported speech episodes produced in the amnesia discourse sessions (273) as in the healthy comparison sessions (554).[37] Of particular interest here is that this difference could not solely be attributed to the performance of participants with amnesia. Although amnesia participants produced fewer reported speech episodes than healthy comparison participants (185 and 400, respectively), the clinician also produced fewer reported speech episodes in the amnesia sessions (88) than in comparison sessions (154). That is, the clinician's production of reported speech tracked with participants' productions. We also documented collaboratively produced reported speech episodes; that is, episodes that were discursively established by one partner (Clinician: "So I watch . . . this person being killed and then I go to bed and I'm you know lying there going, 'well'") and taken up and completed by the other partner (Participant with amnesia: "Did I hear something?"). Although the dynamics that contributed to this attunement are unclear, these findings are consistent with notions of communication as highly emergent and distributed. The joint productions also highlight the perspective that communication partners are active collaborators and co-constructors of meaning in interaction. We were only able to observe these phenomena by starting with a theoretical approach that views communication as distributed and using methods that attended to all participants.

In the same line of work on contributions of declarative memory to everyday language use, we have also used a collaborative referencing task[38–40] to examine interactional discourse of adults interacting with a familiar partner to complete a goal-directed activity.[41] In this study, each participant pair (individual with amnesia and their partner) sat at a table facing each other. Each participant had a board with 12 numbered spaces and identical sets of 12 playing cards displaying Chinese tangrams, and participants had a partial barrier between them (see Fig. 1). The director (the participant with amnesia) began with cards on the board and communicated to the matcher (the familiar partner) which cards to place in which numbered spaces so that at the end of the trial the two boards looked alike. The task was completed 24 times across 2 days. We reported that the amnesia participants exhibited normal collaborative learning, measured by the consistent and increasingly efficient use of referential forms for the previously unfamiliar tangram figures (e.g., windmill).[39] There was important difference between amnesia and comparison participants, however, in their marking of shared knowledge in discourse. That is, although healthy comparison participants discursively signaled to their partner, through the use of a definite reference (e.g., the windmill), that they believed this information was part of shared knowledge on the majority of trials (90%), the amnesia participants did so only half the time (56%).[42]

In a subsequent analysis, we were interested in the interactional consequence of participants' memory impairment on discourse of healthy familiar partners. That is, how did communicating with a partner with memory impairment affect healthy adults' use of definite references? This was assessed using the same collaborative referencing task, but this time with familiar partners as directors. In sharp contrast to the productions of comparison pairs, which were overwhelmingly definite (95%), partners of the participants with amnesia used definite references less than half the time (48%).[43] Interestingly, for the pairs managing amnesia, these data suggest that the role each played in the task did not matter much; the management of the memory impairment, discursively, is disrupted across participants. The finding that productions of one member of an interaction track with the productions of another provides additional evidence for the distributed nature of cognitive-communicative processes and also suggests that disruptions are

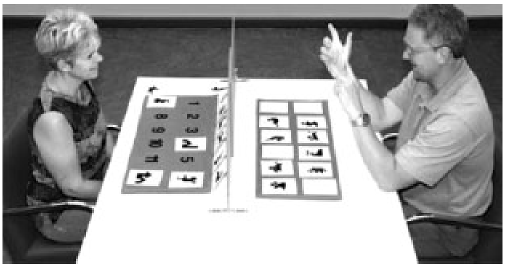

Figure 1 Set up of the collaborative referencing task.

distributed. That is, from the theoretical perspective that communication is always distributed across participants, the impact of the impairment is also distributed.[43] A view of communication as socially distributed cognition fundamentally shifts the unit of analysis from individual-with-deficit to the communicative practices of communication partners managing cognitive-communication disorders within functional activities.[44,45] Thus, distributed cognition offers a wider lens with which to view the impact of cognitive-communication disorders.

Communication as Coordination in Context

Communication as a distributed cognitive activity also involves a complex coordination between internal cognitive processes and external manifestations of these processes and/or physical representations of relevant information.[23] Using communicative mechanisms such as grounding[46] and shared attention,[47] individuals use their bodies and artifacts of interest to coordinate collaborative activities that are situated in the physical environment. These mechanisms help disambiguate references to information in the environment through verbal or linguistic cues such as clarification requests[48] and nonverbal or extralinguistic cues such as gestures.[49] The ability to disambiguate a speaker's reference has important implications for conversational and task outcomes.[50,51]

Gaining a better understanding of how brain injury might affect such referential communication has obvious implications for our understanding of its social and occupational effects and help to better identify therapeutic targets. However, research on these communicative mechanisms in TBI populations has been extremely limited. Only two studies to date have investigated whether verbal and nonverbal cues contribute to referential communication and whether individuals with TBI differ from neurologically intact counterparts in their ability to draw on these cues in interpreting communicative acts.[52,53]

The first study by Bara and colleagues[52] compared TBI and neurologically intact individuals in their ability to interpret video vignettes in which actors depicted simple and complex standard communicative acts (i.e., direct and indirect requests, deceit, irony) and failures of communication using only nonverbal cues such as pointing gestures (e.g., pointing toward the person to whom the speaker refers). The results showed that the two groups did not differ in their interpretations of simple and complex communicative acts, but that individuals with TBI performed significantly worse in interpreting deceit, irony, and failures than their neurologically intact counterparts did. These findings suggest that individuals with TBI show impaired ability to draw inferences from nonverbal cues in interpreting particular communicative acts.

In the second study, by Evans and Hux,[53] individuals with TBI and neurologically intact participants determined the implied meaning of indirect requests—references that require disambiguation—depicted in video vignettes. The actors in the vignettes disambiguated their references employing (1) verbal cues only, (2) gestures only, and (3) verbal cues and gestures. Results showed main effects of group membership and reference type but no interaction between these two factors. Both the TBI and healthy participant groups correctly interpreted intended meanings of requests significantly more accurately when the actors employed verbal cues and gestures in unison than when the speakers used either of these types of cues in isolation. Healthy participants, however, outperformed those in the TBI group across all reference conditions. These results suggest that combining verbal and embodied cues facilitates disambiguation in referential communication, and thus improves the listener's comprehension of the speaker's communicative acts. Nevertheless, individuals who sustained severe TBI still showed impaired ability to interpret disambiguation.

The findings just described advance our understanding of how individuals coordinate physically situated joint actions using verbal and nonverbal cues and of the consequences of impairments in communicative mechanisms that facilitate this coordination in individuals with brain injury. Results to date suggest that individuals with brain injury show an impaired ability to use verbal and nonverbal cues to interpret referential communication in the context of collaborative acts and specific social situations. Although promising, these studies have several methodological limitations. First, they require participants to retrospectively evaluate social situations from video vignettes, measuring offline processing of social cues from the perspective of a bystander. We do not know if these findings generalize to interactive situations that involve online processing from the perspective of an interlocutor. Second, cues that manifest cognitive processes and facilitate coordination in collaborative activities might appear in subtle forms (e.g., nonverbal leakage[54]) and interactively change over the course of the interaction (i.e., entrainment[55,56]). Video-based experimental stimuli and the use of human confederates in general do not allow for the precise control required to manipulate and change these cues.

New approaches to behavioral research promise significant progress toward overcoming the methodological challenges of previous studies. Two approaches that hold particular promise for behavioral research in brain injury are the use of simulated social cues in humanlike representations such as animated characters in a virtual environment[57] and the use of humanlike robots[58] and interactive experimental scenarios that allow participants to process communication cues online and respond in real time. These approaches offer the opportunity to create precisely controlled, reliable, and ecologically valid social stimuli, and they permit the study of online processing of these stimuli in dynamic, interactive situations. For instance, Mutlu and colleagues[59] conducted the first experimental study of nonverbal leakage using precisely timed simulated social cues in a humanlike robot, in a collaborative task in which participants played a version of the 20 Questions game with the robot (see Fig. 2). In each round of the game, the robot chose an item from a set of items arrayed on a table, and the participant attempted to guess the robot's choice by asking several questions that the robot could only answer with "yes" or "no." The task was manipulated so the robot produced a 250-millisecond-glance toward its pick before answering the participant's question, producing what is referred to as a nonverbal leakage cue, and the dependent variable was whether the presence of the leakage cue affected the number of questions that participants asked and the time it took them to identify the item. Results showed that presence of the leakage cue significantly improved participants' performance on both dependent measures, indicating that they perceived and processed the leakage cue, interpreted it in the context of the task, and used this information to better their performance in the task.

Our group is currently looking at whether individuals with TBI are able to process and interpret information like leakage cues in collaborative tasks. Such new approaches to creating experimental stimuli and interactive protocols enable the study of how embodied cues and information from the environment shape social perception in this population. A view of communication as coordinated in context fundamentally shifts the unit of analysis from isolated cognitive processes to the situated and embodied mediation of cognitive-communication and to the full range of phenomena that emerge in the social interactions between people, artifacts, and the environment. Thus, distributed cognition offers a comprehensive approach to understanding and studying the complex interplay and orchestration of communication, cognition, and environment in neurogenic populations.

Communication as Cognitive Processes Distributed through Time

Communication as a distributed cognitive activity recognizes that human activity develops over time and draws attention to the multiple time scales and trajectories that shape and influence interaction. The traditional approach

Figure 2 Set up of experimental protocol in nonverbal leakage task using humanlike robots.

to analyzing discourse in adults with TBI has been to sample at discrete times and to average discourse variables over time, generating percentages or total scores across a sample (e.g., percent of utterances that were on topic, percent of time the participant was looking at the other person). Implicit in the use of these aggregate data is the assumption that the process to be measured is static. Consider the time scale of a conversation between Bob and Doug. Bob starts off being on topic, then digresses halfway through in response to a comment from his partner and is off topic for the rest of the conversation. Doug says something off topic every second sentence. Both are on topic 50% of the time, but the dynamics differ substantially, as could the approach to intervention. Because conversations are not static processes, the average alone does not yield all the relevant information. Conversations are also nonlinear, as changes over time cannot be predicted from the initial state but rather are emergent and change as a function of the interactions between participants and among materials and the environment.

Consistent with the view that communication is distributed and unfolds over time, Turkstra et al[60] applied dynamic systems methods[61,62] to study the exchange of turns in TBI. Turn taking was chosen because of reports that it was a particular problem for adults with TBI, and also because turn boundaries could be reliably predicted by even naïve viewers[63] based on a combination of participants' eye gaze toward the partner, gestures, and back-channel responses that signal to the partner that the speaker is giving up the floor and relinquishing the turn. We predicted that atypical interactions among eye gaze, gesture, back-channel, and turn taking would be associated with an overall judgment that the person was a poor conversation partner. Participants were two men with TBI of similar severity and chronicity but different perceived conversation skills: AB, who was described by others as being a difficult conversation partner, and CD, who was described as a good conversation partner. Caregivers described both as having a generally egocentric communication style. It was predicted that although both would have fewer back-channel responses and spend less time looking at the listener (consistent with their egocentric style) than would typical peers, the timing of behaviors (e.g., eye gaze, gesture, turn taking) with turn-taking boundaries would be random in AB (i.e., not consistently signal to a partner that the conversation turn was over) and show organization in CD.

Participants engaged in semistructured conversations with a peer of their choice, and a sample of 180 seconds of data from the midpoint of the conversations was chosen for analysis. Data were analyzed using two approaches from dynamic systems theory. First, gaze, back-channeling, and turn-taking data were depicted graphically in relation to each other over time. Second, the timing of gaze relative to turn taking was analyzed using a variation of a previously published technique relating neuronal discharges to behavioral events.[64] This method allows for visualization of each behavioral event (looking at the listener), indexed to the time of another behavioral event (ending a speaking turn). From these data, it was possible to construct peri-event histograms showing the frequency with which the behaviors of interest co-occurred and allowing interpretations regarding the extent to which those co-occurrences were organized or random. As an example, consider examining the co-occurrence of gaze and turn boundaries. If the timing of gaze behaviors was unrelated to the turn exchange (i.e., they are random behaviors), there would be no structure to the histogram. If, however, there were a consistent temporal relationship (i.e., they are organized behaviors), there would be structure in the histogram. As a control, the time series' of gaze were randomized and summarized as a histogram. If gaze behaviors were related to turns, this would eliminate any pattern in the histograms.

The study had two main findings. First, both participants with TBI talked more and gave disproportionately fewer back-channel responses than did their partners. This was consistent with caregivers' reports of their egocentric conversation styles. Second, despite similarities in mean values for gaze (both participants looked at their partners ~50% of the time), the timing of gaze behaviors in relation to turns was markedly different. For AB, there was no apparent relation of gaze behaviors or back-channeling responses to turns. There was no relative increase in gaze probability surrounding the time when he would yield the floor and no difference between the randomized versus actual indexed data. If AB was not using gaze to signal that he was yielding the floor, it could interfere with his listener's ability to detect times to take turns, which in turn could have contributed to the partner's perception that conversations with AB were effortful. By contrast, the data from CD reveal typical timing of back-channel responses and a relationship between gaze and turns. These patterns could contribute to the perception that CD was easier to talk with than was AB.

Perhaps the most remarkable aspect of the study was the contrast between the descriptive data—which were highly similar between the two individuals with TBI—and the dynamic characterization of behavior over time. Differences between these individuals were not reflected in summary values for individual behaviors and would have been equally masked in aggregate data. Considered through the lens of distributed cognition, these data show the complex properties that emerge over the course of a conversation and that are not captured by either snapshots of the interaction or scores of individual variables. A view of communication as distributed through time fundamentally shifts the unit of analysis from isolated happenings or immediate sequences of interaction to the longer chains of activity including the interactional histories between particular people across specific situations engaged in a given activity.[35,65] Thus, distributed cognition offers a framework for conceptualizing cognitive-communication across time scales and trajectories that may prove illuminating when thinking about recovery over time and tracking therapeutic progress.

SUMMARY

All disciplines contemplate the boundaries of study for their fields and subfields. Decisions about the unit of analysis have significant theoretical and methodological implications. For fields with a clinical or applied component, these decisions also impact the type and quality of services provided. Indeed, the management and understanding of cognitive-communication deficits in individuals with acquired brain injuries evolved considerably when the decision was made to move beyond analyzing the production of individual words and phrases to examine the connected utterances of discourse. In this article, we propose it is again time to expand our unit of analysis for studying discourse in adults with acquired brain injury.

We suggest that distributed cognition offers a rich and deep understanding of communicative mechanisms and discourse deficits in individuals with cognitive-communication impairments. In presenting protocols and findings from our research, we have attempted to highlight the theoretical and methodological implications of distributed cognition for studying discourse in adults with acquired brain injury. For example, one implication of communication as distributed cognitive activity is that all discourse activity (not just conversation) be seen as co-constructed. This view extends even to those genres traditionally treated as monologue (e.g., narrative, picture description, procedural discourse) where the traditional focus has been on just the verbal productions of the speaker. A distributed cognition approach views the co-present clinician or researcher collecting a "monologue" sample as a co-constructor of the discourse and their silence and the absence of action is as meaningful in shaping what is said (or not) as their words and actions. Indeed, consistent with this view, researchers have pointed to the utility of examining jointly produced narratives (compared with narratives as monologue) and the perspective/role of the communication partner in the discourse of individuals with TBI and suggest that doing so favorably changes the characterization of their communicative ability.[65–68]

Of particular interest for the study of discourse in neurogenic populations is the focus distributed cognition places on interactions among communication partners, between communication and cognition, and between individuals and the environments and contexts of their everyday language use. From our perspective, these interactions are at the heart of characterizing and treating cognitive-communication impairments. Redefining communication as a cognitive activity co-constructed among individuals and between individuals and their environment offers a unique set of tools with which to approach the theoretical, methodological, and clinical challenges in the studying discourse in adults with acquired brain injury.

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