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Hippocampal amnesia disrupts the flexible use of procedural discourse in social interaction

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Abstract

Background—We have worked to develop rich communicative environments as a way to study the real-world demands that communication places on language-and-memory-in-use by focusing on the impact of declarative memory impairments on social interaction. Here, we analyse *procedural discourse*—the practice of telling another person how to do something (e.g., giving directions).

Aims—To facilitate comparison to previous research on procedural discourse, this study includes an analysis of the procedural steps produced by target participants. This study also offers a novel approach by focusing on the collaborative and interactional nature of how procedural discourse is produced to meet the demands of real-world communication.

Methods and Procedures—Procedural discourse samples were obtained on nine individuals with hippocampal amnesia and nine comparison participants each interacting with a clinician. Using traditional procedural and linguistic-based measures and interactional discourse measures, we

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[1]During data collection of these samples the camera was positioned to best capture the amnesic and comparison participants. Consequently, this angle excluded the clinician and all of her nonverbal resources.

[2]There were no statistically significant group differences for procedural task time across prompts, $t(16) = -1.269$, $p = .222$; shopping, $t(16) = -1.392$, $p = .183$; and tyre, $t(15) = -1.674$, $p = .115$: total number of participant words, sandwich $t(16) = -.578$, $p = .571$; shopping, $t(16) = -.747$, $p = .466$, and tyre, $t(15) = -1.218$, $p = .242$: or total number of T-units, sandwich, $t(16) = -.715$, $p = .485$; shopping, $t(16) = -.715$, $p = .485$; and tyre, $t(15) = -.485$, $p = .634$.

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analysed target participants' individual contribution to procedural descriptions and contributions of both the clinician and participant across the samples.

Outcomes & Results—No significant group differences were observed for procedural and linguistic-based measures. Rather, participants with amnesia were more reliably distinguished on interactional discourse measures (e.g., lack of engagement and support for clinician, less detail and personalisation of procedural steps, difficulty in shifting social stance).

Conclusions—These findings accord with our previous research suggesting that hippocampal amnesia disrupts the flexible deployment of declarative knowledge and the ability to shift social stances/perspectives to meet the demands of social interaction. These findings contribute to the evolving portrait of language-and-memory-in-use and further support the value of examining interactional aspects of communication in the empirical study of brain–behaviour relationships.

Keywords

Memory; Hippocampus; Procedural discourse; Social interaction; Amnesia; Language

Exploring the interdependent relationship between language and memory is a core theme in cognitive neuroscience and speech-language pathology. Traditionally this research has employed structured tasks in controlled laboratory environments that work to differentiate and isolate memory and language abilities. We have been developing rich communicative environments that support social interaction as a way to study the real-world demands that communication places on language-and-memory-in-use and to systematically examine interactional aspects of communication. We believe that this theoretical perspective, which examines memory and language together, offers greater ecological validity to our research findings and is a promising approach in the empirical study of brain–behaviour relationships.

In order to foster rich communicative environments for the systematic study of the interrelationships of language and memory across a range of discourse types (e.g., conversation) and in the deployment of a variety of discourse resources (e.g., reported speech), we developed the mediated discourse elicitation protocol (MDEP) (Hengst & Duff, 2007). Designed as a conversationally based protocol, the MDEP is sensitive to the complexities of social interaction including the shifting roles of the clinician and client across the session. It includes specific prompts that allow for targeted elicitation of different forms of talk, as well as unscripted conversational interludes that allow for the emergence of spontaneous or unelicited discourse. Using the MDEP protocol, and other interactional paradigms designed to target collaborative referencing (see Duff, Hengst, Tranel, & Cohen, 2006), we have found evidence for high-level disruptions of language-and-memory-in-use in individuals with declarative memory impairment in hippocampal anterograde amnesia when interacting with routine partners and clinicians (Duff, Hengst, Nolan, Tranel, & Cohen, 2005; Duff, Hengst, Tranel, & Cohen, in press).

One example comes from our analysis of the interactional use of reported speech, a discourse practice in which speakers represent, or re-enact, words or thoughts from other times and/or places (e.g., *John said, ''I'll be there at six''*), across discourse samples obtained using the MDEP (Duff, Hengst, Tranel, & Cohen, 2007). We found that while the linguistic abilities of amnesia participants were sufficiently preserved to allow them to accurately produce the same variety of reported speech forms as comparison participants, they nonetheless displayed a restricted use of reported speech as an interactional discourse resource. Specifically, they produced only half as many reported speech episodes (RSE) as comparison participants. As might be expected from having anterograde amnesia, the RSEs referring to recent events (i.e., post-amnesia-onset events) were more schematic and less detailed than those produced by healthy participants. However, their restricted use of reported speech was not limited to reports

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about the recent time period. Rather, we saw a paucity of reported speech use in communicative interactions even when representing intact remote memories. Also noteworthy was that the sessions with amnesia participants contained fewer RSEs produced in marked collaboration with the clinician (e.g., jointly produced episodes, play-conversations) than was the case for comparison participants. Taken together, we found that hippocampal damage and declarative memory deficits impair the flexible and interpretive use of reported speech as an interactional discourse resource in communication.

The interactional paradigm being explored here seems well suited to specifying the memory requirements and the role of hippocampus for the successful use of reported speech and, more generally, for language-and-memory-in-use. This is extended further in the current study, which analyses another interactional discourse resource—*procedural discourse*—from our larger data set using the MDEP from individuals with amnesia and healthy participants (Duff et al., 2005). To facilitate comparison to previous research on the production of procedural discourse in acquired neurogenic communication disorders, this study includes an analysis of the procedural discourse steps produced. However, to further our exploration of language-and-memory-in-use, this study also offers a novel approach by focusing on how procedural discourse is produced to meet the dynamic and emergent interactional demands of collaborative communication.

PROCEDURAL DISCOURSE

Defined broadly as telling someone how to do something, procedural discourse is a recognisable pattern of interaction that is pervasive in a wide variety of everyday settings. In interactions marked by highly asymmetrical power relations (e.g., school, home, work), procedural discourse is routinely employed to allow experts (e.g., teachers, parents, supervisors) to provide novices (e.g., students, children, subordinates) with guidance in accomplishing new or unfamiliar tasks (e.g., handing in homework, how to make a bed, using the copier). However, procedural discourse is also routinely employed in interactions between relative peers, allowing one person to take up the stance of local expert to, for example, respond to a stranger's request for directions, take a classmate's advice on completing an assignment, or exchange views on the best way to cook a favourite recipe. From an interactional perspective, procedural discourse is marked by participants acknowledging or establishing a novice–expert relationship and by the expert telling the novice how to do something, often presented as a series of steps. Critically, the interactional success of procedural discourse depends on the expert presenting the essential steps for a particular task in sufficient detail to establish and display their expertise with the procedure as well as to support the novice in completing the procedure on his/her own. Although such detail may be multimodal (e.g., including the use of actions, gestures, and pictures), our perspective defines procedural discourse primarily as a verbal description of how to do something, and not solely a nonverbal demonstration of the target procedure.

Given the prevalence of procedural discourse in everyday communication, it is not surprising that it has been a frequently examined discourse genre in both clinical assessment and research of discourse-level performance across a variety of populations including healthy older adults (North & Ulatowska, 1981), individuals with traumatic brain injury (TBI) (Hartley & Jensen, 1991; Snow, Douglas, & Ponsford, 1997), aphasia (Ulatowska, Doyel, Stern, Haynes, & North, 1983); Alzheimer's disease (AD) (Ripich, Carpenter, & Ziol, 1997), and temporal lobe epilepsy (TLE) (Bell et al., 2003). The underlying assumption supporting such widespread use of clinical and research tasks designed to tap into procedural and other discourse forms (e.g., narrative, picture description) is that each discourse task places unique linguistic and other cognitive (e.g., memory) demands on the communicator (Shadden, Burnette, Eikenberry, & DiBrezzo, 1991; Ulatowska & Chapman, 1989). The memory demands of producing a narrative in a story

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re-telling context should differ from those in a picture description task, and research findings on the variability of talk produced in response to different discourse prompts support the uniqueness of each of these discourse forms. Shadden et al. (1991) found that in healthy participants procedural discourse samples were longer and syntactically more complex than narrative or picture description samples. However, attempts to correlate discourse performance post hoc with indices of cognitive ability have yielded modest and variable effects (e.g., Bell et al., 2003; Hartley & Jensen, 1991; Ulatowska et al., 1983) and few attempts have been made to offer a theoretical perspective or description of how various cognitive domains would support distinct aspects of discourse performance across tasks.

It is interesting to note that striking differences in task performance (e.g., number of procedural steps produced) are rarely evident between healthy individuals and individuals whose cognitive impairments include declarative memory deficits (e.g., TBI, AD, TLE). Researchers (e.g., Snow et al., 1997; Ulatowska et al., 1983) have suggested that disruptions in procedural discourse may not be evident in populations whose *procedural memory* is intact, as is the case in most amnesias (Cohen & Squire, 1980). We disagree with this assertion for two reasons. First, the intact status of previously acquired procedural memory cannot account for successful procedural *discourse* in describing actions for which the individual has had little or no previous experience (e.g., for some people, changing a tyre). Second, procedural memory refers to a type of memory processing dependent on on-line tuning and modification of cortical and subcortical processors thought to support knowledge that is not only inflexible (i.e., can only be revealed in the original learning context), but that is also largely inaccessible to conscious introspection or verbal report (Cohen, 1984). Accordingly, procedural memory is not a good candidate mechanism for supporting communicative interactions requiring a person to *tell* another how to do something or to deploy that knowledge in a novel, flexible manner to meet unique communicative demands and goals in interaction.

Instead we propose that procedural discourse depends critically on declarative memory, requiring the use of general semantic knowledge about the world and/or our highly detailed and autobiographical episodic accounts of past experiences, which can be mobilised flexibly to support communicative interaction. Interactionally, procedural discourse also requires high-level discourse skills and the ability to take on or shift to the social stance of expert. Consistent with this view, when disruptions in procedural discourse performance are documented they have been attributed to interactional impairments, such as difficulty taking the listener's perspective, monitoring performance, or use of irrelevant information (Hartley & Jensen, 1991; Snow et al., 1997; Ulatowska et al., 1983). Yet, in both clinical and research settings, procedural discourse is conventionally examined from participant monologues rather than from interactions with others, and these methodologies effectively isolate the speaker's productions, and the role of the listener, from the larger communicative context (Snow et al., 1997). Such an approach may, we believe, have underestimated the incidence of procedural discourse impairments.

THE CURRENT STUDY

The current study is, to our knowledge, the first study of procedural discourse in individuals with isolated declarative memory impairments, from hippocampal amnesia, and certainly the first to explore it within the rich interactional, collaborative communication paradigm advocated here. Based on the current understanding of amnesia and our previous work on use of interactional discourse resources (e.g., reported speech) in amnesia discourse, a number of different patterns of spared and impaired performance might be predicted. First, on a classical view of amnesia as a deficit exclusively of memory (i.e., sparing language and other cognitive abilities), and given our previous findings that amnesia participants have sufficiently preserved linguistic abilities, we might predict that no group differences will emerge on traditional

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linguistic variables. Second, even acknowledging the possible implications of memory (and its impairment) for successful performance on various cognitively mediated tasks in general, and more specifically our view of the central role of declarative memory in supporting procedural discourse, we might predict that procedural discourse will be intact in individuals with amnesia if the procedures to be described are carefully chosen to be familiar to participants from the time period long before the onset of (and thus not subject to) their amnesia. Third, our view, however, is that real-world settings place significant demands on language-and-memory-in-use, emphasising the critical interdependencies of language and memory. Accordingly, we would predict that hippocampal amnesia disrupts the flexible and interpretative deployment of declarative knowledge to meet unique and novel interactional communication goals (e.g., use of high-level discourse to produce detailed, personalised information; shifting social stance to display expertise), resulting in impairments in at least some measures of procedural discourse.

To examine these possible predictions about the contributions of declarative memory in the production of procedural discourse, and the impairments likely to result from amnesia, analyses of participants' procedural discourse will be conducted with regard to: (i) descriptions of target procedures based on number, accuracy, length, and syntactic complexity of procedural steps produced, (ii) the interactional nature of procedural discourse (i.e., how procedural discourse is collaboratively negotiated, produced, and confirmed by participants and the clinician, and (iii) procedural descriptions by the participant and/or the clinician outside of elicited tasks.

METHOD

Participants and data set analysed

The current analysis was completed on interactional data obtained during discourse sampling sessions conducted by the lead author with each of 18 participants; 9 with amnesia and 9 healthy comparison participants. Of the nine participants with amnesia, seven sustained bilateral hippocampal damage from an anoxic/hypoxic event and two sustained more extensive bilateral brain damage from herpes simplex encephalitis. Structural magnetic resonance imaging (MRI) examinations were completed on eight of the nine patients confirming bilateral hippocampal damage. For participant 2563 (who wears a pacemaker and was unable to undergo the MRI examination) anatomical analysis was based on computerised tomography, and only damage in the hippocampal region was visible. In six patients, high-resolution volumetric MRI analyses were conducted, revealing significantly reduced hippocampal volumes (studentised residual differences in hippocampal volume relative to a matched comparison group down by 1 to 8 *z*-scores) (Allen, Tranel, Bruss, & Damasio, 2006; Buchanan, Tranel, & Adolphs, 2005).

At the time of data collection patients were on average 50 years old (range 42–58) and were in the chronic epoch with time post-onset ranging from 1 to 25 years ($M = 9.33$). The Wechsler Memory Scale-III General Memory Index scores for each participant were at least 25 points lower than their scores on the Wechsler Adult Intelligence Scale-III, and the mean difference between Full Scale IQ and General Memory Index was 31.2 points. The average Delayed Memory Index was 65.3, more than 3 standard deviations below population means. The nine comparison participants were matched pairwise on sex, handedness, age, and education to the participants with amnesia. Table 1 presents the participants' demographic, neuropsychological, and neuroanatomical characteristics.

Data were collected using the MDEP (Hengst & Duff, 2007), designed to elicit conversationally produced discourse samples in a clinical setting across four discourse types beginning with a 10-minute conversation and followed by three prompts each for story telling, picture description, and procedural discourse. Sessions were videotaped and fully transcribed (i.e., on-task and between-task interactions). To broadly characterise the amount of verbal and

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collaborative effort across discourse activities, interactional turns were identified and counted, and each turn was coded for number of words and activity (e.g., prompts, procedural, between-task talk). *Interactional turns* were defined as utterances[1] produced by one individual with turn boundaries denoted by a change in speaker. *Words* were broadly counted and standard words (e.g., dog), fillers (e.g., *uh*), contractions (e.g., *don't*), and all words in false starts (e.g., *and put the park put the car in park*) were included in total counts.

The analysis presented here was limited to the procedural discourse, or approximately the last 10 minutes of data collected for each participant. The procedural discourse unfolded sequentially in three phases: (1) task request/ negotiation, (2) production of procedural steps, and (3) confirmation of procedures. The request for procedures was introduced broadly (*I want you to tell me how to do things*) and elicited with three specific prompts (*Tell me how to make your favourite sandwich; Pretend I'm from Timbuktu and I don't know how to shop in a supermarket; Tell me everything I need to know to go shopping in an American supermarket; Tell me how to change a tyre on a car or truck*). Prompts, chosen for their frequency of use in the literature (e.g., Cherney, Shadden, & Coelho, 1998) and presumed familiarity to participants, were personalised for each participant (e.g., your favourite sandwich) and presented in a conversational manner. To further promote ecological validity and shape the discourse as a display of participant expertise, during the target participants' production of the procedural steps for each prompt the clinician's collaborative role included writing down the participants' procedural discourse. To confirm the written procedures, when the participants finished producing the procedural steps the clinician read the procedures back to the participant and offered an opportunity for participants to make any necessary additions or corrections.

Of the 18 sessions, 17 were fully videotaped without difficulties; however, for 1 amnesia session the tape ended early and the final procedural prompt (changing a tyre) was not recorded, resulting in a total of 26 procedural descriptions obtained from amnesic participants and 27 from comparison participants. Sampling yielded a total of 161 minutes of videotaped interaction across amnesia (M = 8 minutes; SD = 2 minutes) and comparison (M = 10 minutes; SD = 2 minutes) sessions, with no group differences, $t(16) = -1.179$, $p = .256$. Samples were similar with respect to the total number of words produced across amnesia (M = 1295.44; SD = 432.48) and comparison (M = 1390.22; SD = 307.70) sessions, with no group differences, $t(16) = -.536$, $p = .600$.

Data analysis

Using both the videotapes and transcripts, the procedural discourse samples were analysed in two ways. First the target participants' (amnesia and comparison) production of procedural steps was analysed with traditional procedural and linguistic-based measures, and group differences were examined using two-tailed independent samples t-tests. Second, clinician and participant contributions across all three phases of the procedural discourse were analysed and group differences were examined using a two-tailed Mann-Whitney U test. Detailed descriptions of the measures used in each analysis follow.

Analysis of amnesic and comparison participants' production of procedural steps—

This portion of the analysis focused on the target participants' contributions to the procedural discourse task during the middle phase—i.e., the production of procedural steps. Specifically, we analysed the time participants spent producing procedural steps, total number of procedural steps (essential and optional), and the total number of T-units and words produced. Defined broadly, procedural step length captured the time in seconds that target participants spent describing each of the prompted procedures. Timing began after the clinician prompt and any task negotiation and ended when the clinician initiated reading the participant's procedures back for confirmation. Timing was continuous, and thus was not limited to

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participant talk time, but included all silences and clinician response during presentation of procedural steps for each of the procedural tasks. Participant speaking turns were segmented into T-units to provide a general measure of syntactic complexity. T-units are defined as a main clause and all subordinate or non-clausal structures attached or embedded within it (Cherney et al., 1998).

Procedural steps were analysed using an essential steps coding procedure developed by Ulatowska and colleagues (Ulatowska et al., 1983; Ulatowska, North, & Macaluso-Haynes, 1981). Accordingly, essential steps were defined as those that must be understood by the listener in order to know what basic actions are required to do the task. For making a sandwich, the five essential steps were: get bread, get filling ingredients, process ingredients, put ingredients on bread, put bread on top/put it together. The three essential steps for shopping in an American supermarket were: get cart, go through store, check out/pay. For changing a tyre, the five essential steps were: jack the car up, remove the nuts, take the wheel off, fit a new tyre on, put nuts back. Multiple steps (e.g., *put the lettuce on the sandwich, then you put your meat, put light mustard across it*) could be coded as the same essential step (e.g., put ingredients on bread). Non-essential steps that further clarified a step or gave additional information were coded as optional (e.g., *make a list, set the parking brake*). Given the observation that amnesic participants' conversational discourse can be highly repetitious (Ogden & Corkin, 1991) steps were also coded as novel or repeated.

Analysis of the clinician/participant contributions to procedural discourse samples—To identify the interactional and collaborative nature of procedural discourse across participant–clinician interactions, we examine interactional discourse in all three phases. During the initial phase, *task request/negotiation*, we analysed requests for clarification (e.g., *You can't say call a tow truck can you?*), statements about selecting the specific procedure (e.g., *I like ham and cheese*), and comments or evaluations around ending the procedure (e.g., *Is that what you want?*). During the second phase, *the production of procedural steps*, we coded participant turns for personalised content (e.g., *In ours the deli is in back*) and perceptual detail through verbal descriptions/adjectives (e.g., describing sandwich bread as: *medium dark, nice and crunchy*). We also coded for clinician's interactional support by counting back-channel turns (e.g., *M hm*). During the third phase of the task, *confirmation of procedures*, we coded participants' engagement by counting backchannel turns and their corrections to clinician reading (e.g., *I forgot the tomato*).

Finally, across the data, we identified all spontaneously produced procedural discourse (i.e., not elicited by the clinician). To differentiate such occurrences from the prompted procedural discourse samples, episodes of spontaneously produced procedural discourse are referred to as procedural descriptions. Procedural descriptions were defined as extended talk (three or more contiguous turns) about a given procedure. Procedural descriptions could occur as side-talk during a targeted procedural discourse task or during conversation between tasks. Use of spontaneous procedural descriptions would be further evidence of the ecological validity of the MDEP and might yield additional interactional discourse data for future analysis.

Reliability

Point-by-point inter-rater and intra-rater reliability of coding for traditional procedural and linguistic-based measures (i.e., number of words, T-units, procedural steps, essential steps) and interactional discourse measures (i.e., number of task request/negotiation turns, number of clinician backchannel turns and number of steps with marked use of perceptual detail, adjectives, and personalised content during production of procedural steps, number of participant backchannel turns produced during clinician confirmation) was obtained on 15% of the data by an original and a second rater. Intra-rater and inter-rater reliability was 99% and

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99% for number of words, 97% and 97% for T-units, 98% and 94% for procedural steps, and 87% and 97% for essential steps. Intra-rater and inter-rater reliability was 86% and 89% for number of task request/negotiation turns, 90% and 93% for number of clinician backchannel turns, 93% and 95% for number of steps with perceptual detail, adjectives, and personalised content, and 93% and 93% for number of participant backchannel turns during clinician confirmation.

RESULTS

Target participants' contribution to the production of procedural discourse

Comparison of the individual contributions of the amnesia and comparison participants, the middle phase of sampling, revealed that the two groups could not be distinguished on any of the traditional linguistic and procedural discourse measures.[2] Table 2 displays the descriptive statistics of these variables. Amnesia and comparison participants produced 832 procedural steps with 191 steps for the sandwich prompt, 316 steps in the shopping prompt, and 325 produced in the tyre prompt. We examined if the number of procedural steps produced by participants differed between groups for each of the three tasks. No significant group differences were observed across prompts: sandwich, $t(16) = -.361$, $p = .723$; shopping, $t(16) = .577$, $p = .572$; and tyre, $t(15) = .556$, $p = .587$. A total of 288, or 35%, of the total steps were coded as essential steps. We also examined if there were group differences in the production of the predetermined number of essential steps for each prompt and no significant differences were observed: sandwich, $t(16) = 1.213$, $p = .243$; shopping, $t(16) = -.658$, $p = .520$; and tyre, $t(15) = -.785$, $p = .445$. The majority of procedural steps (544 or 65%) were coded as optional steps, with a similar number of optional steps by amnesia (275) and comparison (269) participants. The percentage of total steps coded as repeated was also similar between amnesia (12%) and comparison (11%) participants.

Interactional and collaborative nature of procedural discourse

The mediated discourse elicitation protocol, which works to recast procedural discourse as an interactional accomplishment between the participants and clinician, yielded rich interactional data. By examining the production of procedural discourse across the three phases, task request/ negotiation, production of procedural steps, and confirmation of procedures, we begin to outline some intriguing differences between the amnesic and comparison participants' patterns of engagement in the procedural discourse task.

Task request/negotiation—During the initial, or negotiation, phase the clinician took a much more active role with the participants with amnesia than with comparison participants to identify and settle on the specific procedure to describe. A total of 222 interactional turns were dedicated to task request/ negotiation with twice as many turns in amnesia sessions (154/1096, or 14%) than in comparison sessions (68/869, or 7%), a difference that was statistically significant ($Z = -2.351$; $p = .019$). The increased number of task negotiation turns in amnesia sessions was directed towards the amnesia participants' difficulty in displaying and shifting to the stance of expert, often taking the form of amnesia participants (AP) refusing the task, perhaps to save face, and the clinician (Cl) making offers and suggestions to help shape the specific context and form the procedures would take:

AP:	Oh:: I don't like sandwiches very well so.
Cl:	You can make your Don's favorite sandwich or … your kid's favorite.
AP:	[laughs] It probably be Ryan my son loves peanut butter sandwiches and jelly.
Cl:	Okay. We'll make one of those.

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It should be noted that comparison participants (CP) also refused the task, but in ways that displayed a more authoritative stance and that were presented and taken up in a more playful manner as evidenced by the participant and clinician joint laughter in the example below:

CP:	Okay…you get a man. And you say change that tire [laughing].
Cl:	[laughing] And then what do you do?
CP:	I don't have a clue. Okay. Jack it up.

Producing the procedural steps—During the production of procedural steps, the clinician and participants displayed more interactional engagement during the comparison sessions than the amnesia sessions. This was documented both in the clinician's use of verbal backchannel turns and in the participants' display of involvement in the task through use of perceptual detail, adjectives, personalised content, and nonverbal displays. Across the middle phase of all 18 sessions, the clinician made 404 verbal backchannel responses (e.g., *Okay*, *M hm*), with 219 (53% of turns) and 185 (34% of turns) turns in comparison and amnesia sessions, respectively. Although this difference was not significant ($Z = -1.239$; $p = .215$), we were concerned that the increased backchannel turns in comparison sessions could suggest differences in the way the clinician interacted with the two groups. From a communication accommodation perspective, we would expect any interactional patterns in one partner to also be reflected in some way in the other partner's behaviours. In reviewing the videotapes we found that many comparison participants were attentive to the clinician's note taking (e.g., *Sort of a test of your ability to write more than my ability*), leaning across the table to watch her write and pausing until she finished writing the preceding step. In these cases, the clinician's backchannel responses served to indicate she was done writing and that they could continue. In contrast, five of the nine amnesic participants closed their eyes or were looking at the ceiling or floor during production of their procedural steps, perhaps reducing any interactional need of clinician's backchannel turns.

Across the 832 participant-produced steps, 90 were coded as having marked use of perceptual detail, adjectives, and personalised content. The most striking interactional difference was the increased used of these resources to contextualise procedures by comparison participants in 75 steps (or 17%). These procedural steps were richly detailed (e.g., *dark green leaf lettuce; the fun expensive kind with lots of grains and nuts in it*), highly specific (e.g., *4 strips of bacon, 3/8 inch thick*), and personalised (e.g., *I prefer Hellmann's; Super Wal-Mart is my favorite store*). The combination of detail and personalisation, particularly in the shopping prompt, seemed to be supported by specific autobiographical or visual representations that created a shared visual image (e.g., *go right inside the door there will be these little hand baskets; walk up to the doors they will open automatically and there will probably be a greeter; at the end of each aisle if you look up they have signs hanging that lists six different categories*). In contrast, amnesia participants' procedural discourse largely lacked these elements and was found in only 15 steps (or 4%). This was a significant difference from comparison participants ($Z = -3.517$; $p < .001$).

Confirmation of procedures—Across all discourse samples, the comparison participants consistently displayed more engagement with the clinician during the confirmation phase. During the clinician's read-back of the procedures, 142 backchannel responses (verbal or nonverbal) were produced, with 77 (19%) by comparison participants and 65 (14%) by amnesic participants. Similar to the finding of the clinician's use of backchannel turns, although the difference between to the comparison and amnesia participants' use of backchannel turns did

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not differ statistically ($Z = -.844$; $p = .399$), review of the tapes again revealed that many of the amnesia participants were less engaged (poor eye contact or eyes closed while the clinician read back the procedures for confirmation). The total number of corrections made by participants across the three prompts was similar for amnesia (25) and comparison (24) sessions, but interactionally the offers functioned quite differently. Comparison participants frequently corrected the step sequence (e.g., *reverse the first two sentences*) or details (e.g., *just one slice of bread*), often in playful ways (e.g., *No, I said get a man*) whereas amnesia participants were more likely to add the next step (e.g., *and just eat it*).

Spontaneous procedural descriptions—Across the data 12 spontaneously produced procedural descriptions were identified, 5 in amnesia sessions and 7 in comparison sessions. One of the most interesting characteristics of these spontaneous productions was the way they blended with the ongoing conversations. The conversational blending resulted in procedural descriptions that were distributed across multiple turns, often with frequent interruptions or side conversation (e.g., *What kind of dog do you have?*) between procedural steps. In some instances, the procedural descriptions were so interrupted by conversational intrusions that they did not meet our minimum criteria of three contiguous turns. Procedural descriptions were also blended with, or supported, broader conversational goals. For example, in the following excerpt a participant with amnesia used procedural description as part of a therapy narrative:

AP:	For therapy I had to make a meal.
Cl:	Did you?
AP:	Yep I like cooking.
Cl:	Uh huh.
AP:	I had to make it for my actual therapy to get out of the therapy after the heart attack. They said we want you to go to the store and buy everything you need to fix this meal.
Cl:	M hm.
AP:	So I went and bought the stuff at the grocery store with the hospital's money.
Cl:	Hey!
AP:	Made a meatloaf. Had a 'tatas, corn, and a good meatloaf after I picked it up. And I had to set the oven to the right temperature and leave it in for the right amount of time.

DISCUSSION

Using the mediated discourse elicitation protocol (MDEP) we were able to collect conversationally produced procedural discourse from participants with and without amnesia, in interaction with a clinician. No significant differences were found between amnesic and comparison participants on any variables related to a given individual's production of procedural steps in their discourse (time, words, number of steps, T-units). However, striking differences were documented between amnesia and comparison participants on interactional discourse measures, across all three phases of the procedural discourse samples. During the first phase, task request/ negotiation, the clinician discussed possible procedures (e.g., what type of sandwich was to be prepared) at greater length and in more detail with amnesia than with comparison participants, working longer with them to identify and settle on a specific procedure they would be willing, and have had the expertise, to describe. However, during the last two phases (presentation of procedural steps and confirmation), the clinician and comparison participants consistently displayed much more engagement with each other and the task (e.g., responding to each other with backchannel turns; participants' use of detail, personalised comments, corrections) than was documented between the clinician and amnesia participants. These findings indicate that participants with amnesia had sufficiently preserved

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linguistic abilities and sufficient access to remote declarative knowledge to produce procedural discourse and to structure meaningful procedural steps, but their procedural discourse was compromised in attempting to meet the interactional demands of real-world communication.

Contemporary cognitive neuroscience investigations of memory and amnesia have focused on the nature, integrity, and accessibility of mental representations or stored knowledge, and the processes that operate on them. Relatively less attention has been directed at the role or function such representations serve in everyday remembering and in social interaction, thus neglecting to answer Bartlett's question ''what do they make it possible to do?'' (1932, p. 215). Bartlett argued for a functional view of memory that was in service of constructing images, scenes, and representations that guide our performance allowing for the creation, interpretation, and sharing of meaning in everyday social interactions. In the work reported here, it is precisely in social interaction that we clearly see the effects of amnesia on language-in-use.

In her writing on involvement strategies, Tannen (1989) argued that the use of detail and imagery in discourse serves to create shared images between interlocutors, and that the power of conveying shared meaning and emotion resides in our ability to evoke scenes in discourse. We see here that while participants with amnesia produced a series of procedural steps in their discourse that did not differ quantitatively from healthy participants, they differed from healthy comparison participants in rarely producing steps that contained personal content, adjectives, or detail. To be effective, procedural discourse must be produced with sufficient detail to establish and display one's expertise with the procedure and to support the novice in completing the procedure independently. Our findings suggest that the consequences of hippocampal amnesia, seen here as a lack of detail and imagery in the production of procedural discourse, go well beyond impaired recollective experience, compromising the ability to establish a social stance as expert in procedural discourse and, more broadly, impairing the ability to fully experience and create meaning in moment-to-moment social interactions with others.

Procedural discourse is at the interface of language use and memory, making its study a robust approach for examining the impact of memory impairments on interactional aspects of communication. Yet the observed disruption in producing procedural discourse in interaction by individuals with hippocampal amnesia cannot be explained simply by invoking traditional taxonomies of spared and impaired memory systems. Findings from the current study suggest that in addition to disrupting the ability to form new long-term declarative memories of places, people, and the temporal–interactional relations among them, hippocampal damage also impairs the flexible deployment of declarative knowledge—including even intact remote declarative knowledge—to meet novel interactional demands. Of particular interest are the demands that social interaction places on the flexible integration of declarative knowledge and the ability to shift among social frames or take another's perspective. It has been suggested that the medial temporal and frontal lobes may share a common functional anatomy that supports not only remembering of the past but also envisioning the future and, most germane here, considering the viewpoint of others (Buckner & Carroll, 2007). Evidence from our work on the interactional discourse abilities of individuals with hippocampal amnesia supports the suggestion that these patients may have impairments in perspective taking and shifting social stances, whether it be in their production of significantly fewer reported speech episodes to represent the voice of, or speak for, another person (Duff et al., 2007) or, in the current work, where individuals with amnesia exhibited difficulty shifting to or displaying the stance of expert.

While the scope and specific neural correlates of the deficits in language-and-memory-in-use seen here await further study, examination of interactional discourse abilities and resources appears to be a robust tool for documenting these disruptions in everyday communication. Likewise, this approach has immediate clinical application for working with clients with high-

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level disruptions in communication. Particularly promising was that the MDEP supported the spontaneous production of blended procedural discourse with conversational narratives by both participant and clinician, permitting us to analyse the subtleties of interactional communication. In creating rich interactional and communicative environments with which to observe language-and-memory-in-use, we are beginning to develop the means to reveal and capture the kind of subtle yet devastating disruptions that are a frequent aspect of neuropsychological deficit but that have been challenging to document in formal settings and on formal measures.

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TABLE 1

Participant demographic, neuropsychological, and anatomical characteristics

Participant	Sex	Handedness	Education in years	WAIS-III FSIQ	WMS-III GMI	Aetiology	Hippocampal volume
0001	F	R	9	90	54	Anoxia	N/A
1606	M	R	12	91	66	Anoxia	−3.99
1846	F	R	14	84	57	Anoxia	−4.23
1951	M	R	16	121	75	HSE	−8.10
2144	F	R	12	99	56	Anoxia	−3.92
2308	M	L	16	87	45	HSE	N/A
2363	M	R	16	98	73	Anoxia	−2.64
2563	M	L	16	94	63	Anoxia	N/A
2571	F	R	16	112	87	Anoxia	−1.01

WAIS-III, Wechsler Adult Intelligence Scale-III; FSIQ, full scale IQ; WMS-III; Wechsler Memory Scale-III, HSE, Herpes simplex encephalitis. Hippocampal z-scores represent the combined (left and right hemisphere) studentised residuals of hippocampal volume relative to a group of comparison subjects (Allen et al., 2006; Buchanan et al., 2005).

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TABLE 2

Comparison of participants' contribution to procedural discourse

	Participants with amnesia		Comparison participants	
	Mean	***SD***	**Mean**	***SD***
Sandwich				
Total time (seconds)	59.0	33.9	80.7	38.4
Total words	108.6	68.7	125.4	54.5
T-units	8.3	3.4	9.6	3.8
Total steps	11.0	5.3	10.2	3.7
Essential steps	3.4	1.0	2.9	0.9
Shopping				
Total time (seconds)	103.7	38.9	128.9	37.9
Total words	206.2	125.6	247.7	109.2
Total T-units	15.1	7.6	17.3	5.7
Total steps	16.6	7.4	18.6	7.3
Essential steps	2.7	0.5	2.4	0.9
Tyre				
Total time (seconds)	98.9	42.4	138.7	58.1
Total words	201.8	135.4	275.0	112.7
T-units	18.8	9.6	21.0	9.5
Total steps	18.1	7.3	20.0	6.6
Essential steps	3.9	1.1	4.2	0.7