Maintenance of inferences by adults with right brain damage

"Inferencing" is a complex process that involves not only generating an inference, but also selecting the appropriate inference if more than one is suggested, and maintaining an inference over time as needed. Deficits may occur at any stage within the inferencing process. While problems with inferencing have been suggested as underlying deficits that may account for the disorganized verbal output and discourse comprehension deficits in adults with right hemisphere brain damage (RHD) (e.g., Beeman, 1993; Brownell, Potter, Bihrle, & Gardner, 1986; Myers, 1999; Tompkins, Lehman-Blake, Baumgaertner, & Fassbinder, 2001), it is not yet clear what stage(s) of inferencing might be affected and whether there are conditions that exacerbate inferencing deficits.

The Resonance model of comprehension (Myers & O'Brien, 1998) provides one explanation of how inferences are generated and maintained (or re-activated). In this model, items within working memory (from the text currently being comprehended) provide signals to information in long-term memory (LTM), including both world knowledge and elements previously mentioned within the text. Specific information in LTM 'resonates' with information in working memory if there is a close pattern match. Items in LTM that sufficiently match concepts in working memory (WM) are activated, and those that are most strongly activated are brought into WM where they can be integrated into a mental representation of the text. For example, in a story in which a man is going on a vacation, the mention of a lake and a rod might resonate with the concept of "fishing" (from LTM). If these concepts were sufficiently similar, "fishing" would be activated, brought into WM, and then integrated into the mental representation so that the reader would infer that the man was going fishing. If the text does not immediately reinforce the idea of "fishing", the inference may be purged from WM before being integrated into the mental representation, because it no longer resonates with the other active concepts. Alternately, the inference may be put into LTM, but still be available for re-activation. The Resonance model predicts that previously activated information can be re-accessed, although this process may require some time to be completed.

Results from a previous study (Lehman-Blake & Tompkins, 2001) indicated that both adults with RHD (with mild communication deficits) and NBD adults exhibited generation of predictive inferences that were strongly suggested by a context. Maintenance of those same inferences was exhibited by the majority of the NBD group but by only about half of the participants with RHD. Due to the nature of the stimuli, it was not possible to determine whether the inferences were: (a) not integrated into the mental representation, and thus "lost", or (b) if the re-activation process was simply slow. The purpose of the current study is to test these two explanations for the lack of maintenance of inferences by some individuals with RHD.

METHODS

Participants.

Forty-two right-handed individuals between the ages of 50 and 80 years are being recruited for the current study. To date, 22 NBD and five RHD participants have completed testing. Testing will continue until 20 participants with RHD have been enrolled. Group characteristics are provided in Table 1. All potential participants had to pass a vision screening to ensure that they could read the written stimuli. This screening excluded individuals with RHD who had visual neglect that could impede their comprehension of the stimuli. Adults with RHD had lesions due to stroke restricted to the right hemisphere of the brain, based on reported results

from CT or MRI scans. Individuals in the NBD group had to meet age- and education-based criteria on the Mini Mental State Examination (Crum, Anthony, Bassett & Folstein, 1993; Folstein, Folstein & McHugh, 1975).

Stimuli. The stimuli (see Table 2) were the stories used by Lehman-Blake and Tompkins (2001) with the addition of a final sentence, as described below. The six-sentence stories contained one predictive sentence that strongly suggested a single outcome. This outcome was not suggested or explicitly stated at any other point in the story. The fifth sentence was the target sentence, and it disconfirmed the predicted outcome. The final sentence was neutral in regard to the target inference, but cohered with the theme of the story. The purpose of the final sentence was to test for "spill-over" effects that might appear if the re-activation process was slowed.

Three versions of each story were constructed, with variable placement of the predictive sentence, as seen in Table 2. Predictive, target, and final sentences were repeated verbatim across story sets (one Recent, one Distant, one Control story) to allow direct comparisons across conditions. The dependent variable of interest was reading time for target and final sentences in experimental versus control stories. Slowed reading time for the target disconfirming sentence in experimental conditions (compared to Control) was taken as evidence of inference activation, because the target sentence contradicted the inference in the Recent and Distant conditions, but not in the Control conditions. Slowed re-activation would present as slowed reading times on the post-target sentence.

Procedures.

Participants were tested individually in a quiet room. They read stories one line at a time from a laptop computer screen using E-Prime software, Version 1.1 (Schneider, Eschman, & Zoccolotto, 2002). Presentation rate was controlled by the participant, who pressed a button to replace each sentence with a successive sentence. Reading time was measured as the amount of time that elapsed between button presses.

RESULTS and DISCUSSION

Data from the NBD group were submitted to statistical analyses, and results are reported below. Due to the small number of RHD participants tested to date, data from this group are provided, but were not statistically analyzed (see Table 3).

Results from the NBD group indicated that this group did generate and maintain the target predictive inferences, evidenced by slowed reading time for target sentences in both the Recent and Distant conditions as compared to the Control condition (Recent $t(21)=3.88$, $p<.05$; Distant $t(20)=2.50$, $p<.05$). These results mirror that of the previous study (Lehman-Blake & Tompkins, 2001). Due to the fact that these individuals did maintain inferences over time, as expected, there was no difference in post-target reading times across the three story conditions.

For the RHD group, inspection of individual data indicated that three of the five participants generated predictive inferences as evidenced by slowed reading of the Recent condition target sentence. The two remaining participants evidenced slowing on the post-target sentence. Thus, all of the individuals generated the intended inference, but two of them displayed slow activation. Examination of the Distant condition stories indicated that all but one of the five participants maintained the target inferences over time.

SUMMARY

The results suggest that healthy older adults can generate predictive inferences and they are able to maintain those inferences over time until they become important for the context.

Preliminary results from the RHD group are similar to the NBD group, although they suggest that some individuals with RHD may be slow or inefficient at generating predictive inferences. More definite conclusions about the operation of inference processes by adults with RHD cannot be made until a larger number of participants have completed the testing. Results from the full complement of participants with RHD will add to our current understanding of inferencing deficits in this population, and how inferencing processes affect discourse comprehension and production.

Table 1. Demographic and select clinical data for two participant groups.

Participant characteristics	NBD	RHD
sex	13 female / 9 male	3 female / 2 male
age (years)		
Mean (S.D.)	65.1 (6.8)	67.6 (8.6)
Range	53-79	59-78
education (years)		
Mean (S.D.)	15.6 (3.1)	13.0 (2.4)
Range	10-22	11-16
discourse comprehension errors[1]		
Mean (S.D.)	4.2 (2.4)	5.2 (4.0)
Range	0-8	2-12
(max = 32)		
Mini Mental State Exam score[2]		
Mean (S.D.)	29.6 (0.5)	---
Range	29-30	
(max=30)		
Behavioural Inattention Test[3]		
Mean (S.D.)	---	142.8 (2.6)
Range		139-146
(max=146)		
Receptive Vocabulary[4]		
Mean (S.D.)	189.1 (10.9)	178.2 (15.9)
Range	162-199	155-195
(raw score max=204)		
Social Inference Score[5]		
Mean (S.D.)	51.0 (5.9)	39.8 (7.6)
Range	37-61	29-47
(max=64)		
working memory recall errors[6]	(N=21)*	
Mean (S.D.)	8.2 (5.1)	16.4 (4.9)
Range	1-19	10-23
(max = 42)		

[1] *Discourse Comprehension Test* (Brookshire & Nicholas, 1993)
[2] *Mini Mental State* (Folstein, Folstein, & McHugh, 1975)
[3] *Behavioural Inattention Test* (Wilson, Cockburn & Halligan,1987)
[4] *Peabody Picture Vocabulary Test, Third Edition* (Dunn & Dunn, 1997)
[5] *The Awareness of Social Inference Test* (McDonald, Flanagan, & Rollins, 2002)
[6] Auditory working memory task (Tompkins et al., 1994; Lehman and Tompkins, 1998)
* One NBD participant was excluded due to equipment failure.

Table 2. Sample stimulus item.

CONDITION and INFERENCE	SAMPLE STORY
Recent inference = fish	Tim set out his jacket and his cap. He had been looking forward to this trip for months. Tim had been busy at work and wanted some time alone. **He put his rod in the car and drove to the lake.** *He couldn't wait to go skiing by himself.* *This was his first vacation in six months.*
Distant inference = fish	Joe set out his gloves and his coat. **He put his rod in the car and drove to the lake.** He had been looking forward to this trip for a month. Joe had been busy at work and wanted a weekend alone. *He couldn't wait to go skiing by himself.* *This was his first vacation in six months.*
Control no inference	Don set out his coat and his hat. He had been looking forward to this trip for weeks. Don had been busy at work and wanted a few days alone. *He couldn't wait to go skiing by himself.* *This was his first vacation in six months.*

Note: bold denotes the predictive sentence; italics denote the target and post-target sentences.

Table 3. Reading time data for two participant groups.

Stimulus Sentence	Reading time (and S.D.) in seconds	
	NBD (N=22)	RHD (N=5)
Target sentence		
Recent condition	3.28 (.94)*	4.69 (1.14)
Distant condition	2.87(.74)*	4.56 (1.20)
Control condition	2.68 (.65)	4.21 (.99)
Post-target sentence		
Recent condition	2.42 (.60)	4.10 (1.00)
Distant condition	2.45 (.72)	3.89 (1.14)
Control condition	2.44 (.72)	3.84 (.71)

* Significantly different from Control condition ($p<.05$)

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