Contextual bias and inferencing in adults with right hemisphere brain damage

It is widely accepted that damage to the right cerebral hemisphere (RHD) can cause difficulty with discourse comprehension. This deficit has been linked to a reduced ability to use context to aid comprehension. Although some results suggest that adults with RHD have difficulty using context to generate inferences (Beeman, 1993; Purdy, Belanger, & Liles, 1992; Rehak, Kaplan, Weylman, Kelly, Brownell & Gardner, 1992), other results indicate the opposite (Blake & Lesniewicz, 2005; Brownell, Potter, Bihrle & Gardner, 1986; Lehman-Blake & Tompkins, 2001; Tompkins, Bloise, Timko & Baumgaertner, 1994).

Using a thinking-out-loud protocol, Blake and Lesniewicz (2005) explored the use of contextual cues for predictive inference processing by adults with RHD. The results indicated that adults with RHD were able to use contextual cues to generate, maintain, and indicate the likelihood of inferences. However, the same individuals had difficulty using contextual cues to moderate the number of alternative inferences generated. Thus, even if they stated that one outcome was likely to occur, they continued to generate multiple alternative inferences. One caveat of this study was that the data obtained depended upon the participants' willingness or ability to talk aloud while reading the experimental stories.

The current study was designed to assess predictive inferencing and use of context using an implicit reading time measure. Based on previous results of predictive inferencing by adults with RHD (Blake & Lesniewicz, 2005; Lehman-Blake & Tompkins, 2001), participants with RHD were expected to generate target predictive inferences in both high- and low-predictability contexts.

Procedures

Participants

Potential participants were recruited through newspaper advertisements and stroke support groups. Twenty-eight individuals met all inclusion criteria, including: right handed, between the ages of 50 and 85 years, learned only English before school-age, and no history of drug or alcohol abuse. The 14 individuals with RHD had no evidence of lesions in the left hemisphere, and no visuospatial neglect (as measured by the *Behavioural Inattention Test*; Wilson, Cockburn & Halligan, 1987). The 14 individuals without brain damage had no evidence of cognitive decline (as measured by the *Mini-Mental State Exam*; Folstein, Folstein & McHugh, 1975). Select demographic and clinical variables are provided in Table 1.

Methods

Stimuli were short (10-15 sentence) stories. Stories in the high predictability (HIGH) condition strongly suggested one likely outcome (e.g., stealing a ring). In the low predictability (LOW) versions, the intended outcome (stealing) was one possible outcome, but others also were possible. The control versions did not suggest any specific predictive inference. For the HIGH and LOW versions, the second-to-last sentence (target sentence) of each story disconfirmed the expected outcome. A post-target sentence was neutral in regard to the predicted outcome, but was consistent with the theme of the story. Target and post-target sentences were identical across the three versions of each story to allow direct reading time comparisons. Inference generation was deduced from reading times for the target (disconfirming) sentence. If readers generated the target inference (e.g., he stole the ring), then reading times would be slowed on the target sentence that disconfirmed the inference (e.g., he bought the ring) as compared to reading time for the same sentence in the control version of the story. Continued slowing on the post-target sentence indicated that participants required extra time to process the contradiction suggested in the target sentence.

The study was conducted as a within-subjects design, with all participants reading all three versions (HIGH/LOW/Control) of each story. Testing took place across three sessions with one version of a story presented in each session.

Results

One participant from each group was excluded due to reading times greater than two standard deviations above the group means. Within groups, one-sample one-tailed t-tests were conducted to examine whether slowing was present on experimental versus control condition sentences. For the NBD group, slowing on the HIGH condition stories was detected for the target ($t(12) = 3.92$, $p=.002$, $d=1.0$) and post-target sentences ($t(12) = 2.80$, $p=.016$, $d=.74$). Slowing on the LOW condition stories was detected only for the target sentence ($t(12)=2.59$, $p=.024$, $d=.69$; post-target sentence $t(12)=1.64$, $p=.13$, $d=.44$).

For the RHD group, slowing on the HIGH condition stories was detected only for the target sentence ($t(12)=3.73$, $p=.003$, $d=.99$ (post-target sentence $t(12)=1.33$, $p=.21$, $d=.36$). No slowing was observed for either target ($t(12)=0.64$, $p=.13$, $d=.44$) or post-target sentences ($t(12)=.62$, $p=.55$, $d=.17$) in the LOW condition.

Between group effects were examined using a series of two-tailed, independent t-tests. No significant group differences were obtained for reading times on target or post-target sentences for HIGH or LOW conditions (all $t(26) <.85$, $p>.40$).

Discussion

Results from the previous thinking-out-loud study (Blake & Lesniewicz, 2005) provide insight into the interpretation of the current results. A summary of results from the two studies is provided in Table 2. In the current study, adults without brain damage generated target predictive inferences in both high- and low-predictability stories. The extra time needed to integrate the unexpected outcome for the high-predictability stories may reflect that the target inference was strongly activated and highly contradictory to the actual outcome. Extra integration time was not required for the low-predictability stories, perhaps because the actual outcome was plausible given the context, and may have been one of multiple inferences generated.

Given high predictability stories that contained multiple contextual cues biasing toward a specific outcome, adults with RHD generated inferences, but did not require extra time for integration. In Blake and Lesniewicz's (2005) study, adults with RHD generated multiple possible outcomes even after stating that a target predictive inference was highly likely. It is possible that the outcome described in the "disconfirming" sentence was one of the alternative predictions generated. Thus, although comprehenders with RHD in the current study exhibited slowing on the target sentence that contradicted with one predicted outcome, they quickly accepted the stated outcome. This might occur if the actual outcome was one of the predictive inferences generated, although it may have been considered less likely, and possibly was activated to a lesser extent.

Given low predictability stories in which several outcomes were possible, adults with RHD, as a group, did not exhibit generation of target predictive inferences low-predictability contexts. Taken in isolation, these results could be interpreted to suggest that adults with RHD required strong contextual bias to generate predictive inferences. However, the interpretation changes when current results are combined with results from the previous study (Blake & Lesniewicz, 2005), in which adults with RHD generated target inferences as well as multiple alternative outcomes in low-predictability stories. The absence of evidence for inferencing in the current study could be due to the generation of multiple alternatives, none of which was activated substantially more than another. Thus, the outcome stated in the disconfirming sentence did not strongly contradict any inferred outcome, and indeed, may have matched one of the inferred outcomes.

Conclusions

Integration of results from two studies leads to the conclusion that adults with RHD can use contextual bias to generate predictive inferences, but stimulates questions about interpretations based on results from a single type of task. Future studies are necessary to examine the possibility that strength of activation may influence findings on implicit measures of inferencing.

Table 1. Select demographic and clinical data for two participant groups.

	NBD (N=14)	**RHD (N=14)**	**t**	**p**	**d**
Sex	9 female 5 male	6 female 8 male			
Age	65.2 (7.2) 53-79	67.6 (98.8) 54-81	-0.79	.43	.30
Education	14.6 (2.7) 10-19	14.07 (2.4) 11-18	0.59	.56	.20
Discourse Comprehension Test[1] Total Errors	 4.1 (2.3) 0-7	 5.2 (2.9) 2-12	 -1.06	 .30	.42
DCT: detail stated	1.6 (1.1) 0-3	1.6 (1.3) 0-4	0	1.0	0
DCT: detail inferred	1.9 (1.0) 0-4	3.1 (1.3) 2-7	-2.6	.02	1.0
DCT: main idea stated	.36 (.63) 0-2	.21 (.43) 0-1	.70	.49	.28
DCT: main idea inferred	.29 (.47) 0-1	.36 (.75) 0-2	-.30	.76	.16
Receptive Vocabulary[2] (standard score)	106.8 (13.9) 80-124	98.8 (11.1) 77-114	1.69	.10	.64
Inferencing and Non-literal language[3] (20 possible)	19.0 (1.9) 14-20	18.4 (1.6) 16-20	0.87	.40	.34
Working memory[4] (recall errors)	8.1 (5.7) 1-18	13.8 (5.2) 4-23	-2.73	.01	1.0
Social Inferencing[5] total score (64 possible)	51.5 (5.7) 37-58	43.4 (7.1) 29-55	3.33	.003	1.3
sarcasm (32 possible)	24.4 (4.2) 17-31	18.9 (4.3) 12-27	3.37	.002	1.3
lies (32 possible)	27.1 (3.6) 17-31	24.5 (4.9) 13-32	1.63	.12	.60

[1]Brookshire & Nicholas (1993). *Discourse Comprehension Test*.
[2]Dunn & Dunn (2000). *Peabody Picture Vocabulary Test III*.
[3]Burns (1997). *Burns Brief Inventory of Communication and Cognition* – Inferencing and non-literal language subtests
[4]Tompkins et al., (1994).
[5]McDonald et al., (2002) *The Awareness of Social Inference Test* – Enriched subtest

Table 2. Summary of results from two studies of predictive inferencing.

	NBD	RHD
High-predictability stories		
likelihood of target inference*	highly likely	highly likely
number of alternate inferences generated *	few	many
target inference generated?	yes	yes
extra integration time needed?	yes	no
Low-predictability stories		
likelihood of target inference*	somewhat likely	somewhat likely
number of alternate inferences generated *	many	many
target inference generated?	yes	no
extra integration time needed?	no	no

* data from Blake & Lesniewicz, 2005.

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