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Suppression and discourse comprehension in right brain-damaged adults: a preliminary report

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Abstract

Eighteen right-hemisphere-damaged (RHD) and 15 control subjects listened to sentences that ended in lexical ambiguities. The sentence verbs biased ambiguity interpretation. Probe words, representing unbiased meanings of the ambiguities, were presented for rapid judgements of their fit with the sentences. In rejecting probe words, both groups showed interference from unbiased meanings of the ambiguities at a short (175 ms) probe interval. Only RHD adults demonstrated interference 1000 ms after sentence offset, indicating that they suppressed contextually inappropriate meanings less effectively than control subjects. Discourse comprehension performance in RHD adults was also correlated with suppression. Theoretical and clinical implications are considered.

Introduction

It is well established that right hemisphere brain damage (RHD) can result in communication impairments, including specific discourse comprehension deficits. Existing research indicates that these discourse comprehension difficulties tend to emerge under certain conditions. In general, RHD adults do not have obvious discourse comprehension problems when cognitive demands are minimized, when inferential processing is straightforward, or when integration can proceed without revision (for review see Joanette *et al.* 1990, Tompkins *et al.* (1994a, Tompkins 1995). Rather, their discourse comprehension problems tend to arise when understanding requires integrating multiple or disparate aspects of the discourse context, such as cues to speaker mood or motives, and plausibility (Brownell *et al.* 1992, Weylman *et al.* 1989); when initial assumptions must be revised to make sense of discourse units (Brownell *et al.* 1986, Tompkins and Mateer 1985); and with literally false material such as jokes, metaphors, and indirect requests, in which alternative meanings must be reconciled with other contextual cues (cf., Molloy *et al.* 1990).

This study investigated discourse comprehension inadequacies in adults with RHD. Our enquiries were guided by the recently articulated Structure Building Framework of comprehension (e.g. Gernsbacher 1990). According to the Structure

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Building Framework, 'the goal of comprehension is to build a cohesive mental representation or "structure"' (Gernsbacher *et al.* 1990, p. 431). First a comprehender lays a foundation from incoming information: perceptual processes that encode acoustic signals and generate initial propositions create activation patterns that initiate the foundation for this mental structure. Then, the comprehender elaborates the developing structure by mapping onto it related information encoded from the text or activated from world knowledge. When information is encountered that is not easily related to the initial structure, the comprehender shifts to begin a new substructure. Once portions of memory are activated, two modulatory mechanisms are essential to the processes that culminate in comprehension. An enhancement mechanism heightens the activation of information associated with the contextually appropriate interpretation, and a suppression mechanism dampens activation that is less appropriate or relevant. In a series of experiments with non-brain-damaged adults, Gernsbacher and colleagues determined that comprehension skill is associated with suppression function. Poorer comprehenders do not inhibit inappropriate information as quickly as their more skilled counterparts, across tasks, modalities, and domains (e.g. visual and auditory, linguistic and non-linguistic) (Gernsbacher 1990, Gernsbacher and Faust 1991, Gernsbacher *et al.* 1990).

As noted above, RHD adults demonstrate discourse comprehension problems that surface primarily when alternative or competing meanings must be considered and resolved (e.g. Joanette *et al.* 1990, Tompkins 1995). According to the Structure Building Framework, comprehenders must initiate new substructures to deal with incongruent material. Thus, one possible source of comprehension problems in RHD adults is that they do not generate new substructures when appropriate. This seems unlikely, since they can revise initial interpretations and represent alternative meanings in conditions designed to minimize processing demands (Tompkins 1990, 1991, Tompkins *et al.* 1992). Also, in answering questions about material designed to stimulate an inference revision, RHD patients accept both initial and amended inferences as correct, suggesting a propensity to maintain an eventually inappropriate interpretation (Brownell *et al.* 1986), rather than a failure to generate or consider an alternative.

A more probable source of RHD adults' difficulty with comprehending incongruent material is that, once irrelevant or incompatible information is activated or represented, they do not inhibit it as effectively as normally ageing adults. Several previous studies are suggestive in this regard. For instance, Tompkins (1991) found that RHD adults were disproportionately slower than left-hemisphere-damaged or normal control subjects in their correct mood judgements about target stimuli preceded by incongruent affective contexts, although there were no qualitative differences between groups when target stimuli followed congruent or neutral emotional contexts. Hence, incongruity exerted a particularly negative influence on the speed of RHD subjects' accurate judgements. Results of Brownell and colleagues' (1986) inference revision study can also be interpreted in terms of ineffective suppression. Their RHD subjects appeared to hold on to an initial assumption in the face of information that called for a change. Simultaneously, however, they performed adequately on questions about the revised inferences, indicating that both inferences were available and active.

This study examined Gernsbacher's suppression mechanism as one likely source of discourse comprehension difficulty for adults with RHD. Our task involved lexical ambiguity processing in single sentences. We selected it because it has demonstrated sensitivity to differences between more and less skilled young normal comprehenders (Gernsbacher *et al.* 1990), and offers a straightforward test of suppression function in an area of relative strength for RHD adults. We predicted that RHD adults would not suppress incompatible or irrelevant interpretations as effectively as normally ageing adults, a problem that would be manifest in slowness rejecting probe words related to contextually inappropriate interpretations of the lexical ambiguities. We also expected suppression effectiveness to predict discourse comprehension performance for the RHD subjects.

Method

Subjects

To date we have tested 18 RHD adults and 15 non-brain-damaged control subjects without known neurological impairment (NBD). The groups do not differ in age or years of education (see Table 1 for subject data). RHD adults were identified with the cooperation of two acute-care hospitals and one rehabilitation facility. They averaged 37 months post-onset of unilateral, primarily thromboembolic (80 %) cerebrovascular accident (range 8–78 months), documented by CT or MRI scan report. Exclusions were based on medically documented evidence of bilateral, cerebellar, or brainstem lesions; deteriorating condition such as Alzheimer's or Parkinson's disease; or substance abuse. Control subjects were identified through senior citizen groups, media advertisements, and volunteer departments of local rehabilitation centres. They met the same biographical and behavioural inclusion criteria as the stroke patient subjects, and were questioned to rule out previous major neurological episodes or conditions and substance abuse. Control subjects' scores on the Mini-Mental State Examination (Folstein *et al.* 1975) equalled or exceeded 27 points of a total 30 possible ($M = 29{\cdot}2$; $SD = 0{\cdot}9$).

All subjects enrolled in the study were monolingual native American English speakers, and met stringent criteria for auditory acuity and premorbid right-handedness (see Tompkins *et al.* 1994a, for methods and criteria).

Stimuli and tasks

Subjects listened to short stimulus sentences (e.g. 'He dug with the spade') and judged whether an auditorily presented probe word fitted with the sentence meaning. Suppression effectiveness was assessed by comparing response times (RTs) for accurate probe word judgements in paired experimental (ambiguous) and comparison (unambiguous) stimuli, at two probe intervals (175 and 1000 ms after sentence offset). Stimuli and tasks were modified from Gernsbacher and Faust (1991), and extensively validated with NBD judges (see Appendix A for an overview of validation procedures and results).

Suppression trials

All *experimental stimulus sentences* are single sentences of 4–6 syllables ($M = 5$). Each ends in a lexical ambiguity that has two relatively equiprobable meanings (e.g. SPADE; see Appendix A for information about determining meaning dominance).

Table 1. Demographic and descriptive subject data

Characteristics	RHD ($n = 18$)	NBD ($n = 15$)
Age (years)		
M	62·6	65·7
SD	9·1	5·7
Range	(48–75)	(56–73)
Education (years)		
M	12·3	13·7
SD	2·3	1·9
Range	(8–16)	(12–17)
Gender	4 Female	9 Female
Estimated IQ[a]*		
M	104	110
SD	10·0	5·3
Range	(85–119)	(103–118)
Judgement of line orientation[b] (30 possible; corrected for age and gender)		
M	22·7	25·3
SD	4·9	4·6
Range	(15–29)	(17–31)
Vocabulary knowledge—Peabody Picture Vocabulary Test[c]* (175 possible)		
M	156	166
SD	9·9	7·2
Range	(135–170)	(150–174)
Working memory measure[d]* (word recall errors; 42 possible)		
M	13·5	8·0
SD	7·6	6·3
Range	(3–27)	(0–18)
Neglect—Behavioural Inattention Test[e]* (146 possible; 129 cutoff score)		
M	135·7	142·6
SD	18·6	4·4
Range	(67–146)	(132–146)

* Significant difference between groups by *t*-test at $p < 0{\cdot}05$.
RHD = Right brain-damaged group; NBD = non-brain-damaged group.
[a] Wilson *et al.* 1979.
[b] Benton *et al.* 1983.
[c] Dunn and Dunn 1981.
[d] Tompkins *et al.* 1994a.
[e] Wilson *et al.* 1987.

The verb in experimental sentence stimuli biases the interpretation of the sentence-final ambiguity toward one of its meanings (e.g. 'He *dug* with the SPADE'). Paired *comparison stimulus sentences* ($M = 5$ syllables, range 4–6) were developed to control for alternative explanations for the findings, such as overall slowness in processing, or possible working memory deficits. For comparison sentences, unambiguous words are substituted into the final-word position of the experimental sentences. These unambiguous words are semantically comparable to the contextually biased meaning of the final ambiguity in experimental items (e.g. 'He dug with the SHOVEL'). A single probe word is matched with a single experimental/comparison stimulus pair. Probe words represent the unbiased meaning of the ambiguity in experimental stimuli (e.g. CARDS), and are unrelated to comparison stimuli. A complete list of experimental and comparison stimulus pairs, and their associated probe words, is provided in Appendix B.

Slowness to reject a probe word after an experimental stimulus sentence, relative to its comparison sentence, suggests interference from activation of the contextually inappropriate meaning of the experimental lexical ambiguity. Based on evidence that both meanings of balanced lexical ambiguities are mentally activated briefly regardless of the surrounding context (for review see Simpson 1984, Simpson and Burgess 1988) we expected control subjects to exhibit interference from the unintended meaning of the final lexical ambiguity at the short (175 ms) probe interval. However, non-brain-damaged adults should quickly suppress the inappropriate interpretation (Onifer and Swinney 1981, Swinney 1979, Tanenhaus *et al.* 1979). As such, they would show little evidence of residual interference from the unrelated probe word at the delayed (1000 ms) probe interval, and little difference in RTs in experimental and comparison stimuli. Data from our laboratory, gathered for words that are ambiguous as to their literal or metaphorical interpretations, suggest that RHD patients would also show evidence of interference from the contextually inappropriate meaning of the final ambiguity at the short probe interval (Tompkins 1990). The hypothesized difference from control subjects would be manifest at the delayed probe interval. If RHD patients are ineffective at suppressing contextually inappropriate interpretations, they should continue, at the delayed probe interval, to exhibit a marked reaction time disadvantage for probe words in experimental, relative to comparison, stimuli.

Comprehension task

Discourse comprehension was assessed with four narratives from the Discourse Comprehension Test (DCT, Brookshire and Nicholas 1993). Each was followed by eight tape-recorded yes/no questions about stated and implied main ideas and details. Scoring consisted of counting the number of errors, for each of the four categories of questions, across the four stories.

Stimulus preparation

Sentences, comprehension narratives, and yes/no questions were recorded at a slow normal rate (average 3·3 syllables per second, or approximately 200 words per minute) with neutral intonation by an experienced female speaker (C.T.). Probe stimuli were recorded by a practised male speaker to aid perceptual segmentation. Recording was done in a sound-treated booth, directly onto a Gateway 2000 computer, using the WAVE for Windows program (v. 1·0, Turtle Beach Software) to capture stimuli in separate files.

Comprehension task stimuli were dubbed to high-quality metal audiocassette tapes (TDK MA-X90). Suppression task stimuli were digitized and computeredited to add trial numbers, and to insert probe words at the appropriate post-stimulus intervals (175 and 1000 ms). A single probe word production was added to each member of experimental/comparison stimulus and short/long interval pairs; RT initiation pulses were inserted 100 ms before the onset of each probe word. Each trial was saved in a separate computer file. Sentence duration was comparable for experimental ($M = 1{\cdot}52$ s, range 1·3–2·0) and comparison sentences ($M = 1{\cdot}49$ s, range 1·2–2·0).

Six blocks (three for short interval trials, three for long interval trials) of 24 trials each were created by mixing 12 suppression pairs with filler trials and 12 stimulus pairs assessing subjects' appreciation of other, similar biasing sentences (followed by probe words related to the biased meaning of the final lexical ambiguity). Experimental items were pseudo-randomly distributed into blocks, according to the following conditions: (1) matched experimental and comparison items never occurred in the same block; (2) matched experimental and comparison items were always at least 10 items apart, across blocks; (3) no more than three experimental or comparison items occurred in succession; (4) no more than three yes or no responses occurred in succession; and (5) two filler trials began each block, one filler ended each block, and repeated presentations of filler trials never occurred in the same block. Of the total 144 items, half were to be answered 'yes' and half 'no'.

Apparatus and procedures

Suppression task stimuli were presented via a portable computer (Compudyne 4DX2/66) using WAVE for Windows (v. 1·0). Comprehension tapes were played on a portable, professional-quality audiocassette recorder (Marantz PMD420). For each task the speech signal was routed through a stereo headphone amplifier (Edcor HA 400A), individually adjusted for each subject during practice trials, and then presented binaurally through high-quality headphones (Fostex T20). Timing pulses went to a custom-built millisecond timer, which stopped when subjects pressed one of two buttons labelled 'yes' or 'no' on a custom-built manual response box. Subjects responded with a single finger, typically the index finger, and all subjects responded with their right hands.

Test blocks and comprehension narratives were counterbalanced and interspersed with subject description tasks (Table 1) and tasks related to another investigation. This arrangement of tasks allowed for maximum separation of short and long probe interval trials. All testing was completed in three or four sessions, lasting 60–90 min each, over approximately 10–14 days. Subjects were tested in a quiet room in their homes, at a rehabilitation centre, or in the first author's laboratory. For the suppression task, subjects were instructed to indicate as quickly as possible whether each probe word fitted with the meaning of the preceding sentence. Response times were recorded in milliseconds, by the computer and by the examiner, together with accuracy data. For the comprehension task the examiner simply noted each subject's responses on a score sheet.

Subjects were provided at least three live voice and six computer-controlled practice items for the suppression task. Practice continued until subjects were responding with assurance and RTs had stabilized. Corrective feedback was given during live voice practice trials; during computer-presented trials the subjects were encouraged to continue responding as quickly as possible. Computer-presented practice items were repeated prior to initiating the second set of suppression task trials (short or long interval, depending on the counterbalancing). For the comprehension task, subjects practised with an additional narrative from the DCT, presented live voice and followed by five questions representing all four question type categories.

During experimental testing, only general encouragement was given after subjects completed a block of trials. Training and practice took about 10 min per task. Each block of the suppression task lasted 7–8 min (depending on probe interval), and each comprehension narrative, with associated questions, required about 3–4 min to administer.

Results

Independent *t*-tests computed separately for each group indicated no gender or order differences in performance. Accordingly, these variables were not considered in the major analyses reported below.

Probe judgement error analysis

Accuracy data for the suppression task are presented in Table 2. Independent *t*-tests indicated that mean accuracy did not differ between groups for either short ($t(31) = -0{\cdot}21$; $p > 0{\cdot}05$) or long interval trials ($t(31) = -0{\cdot}90$; $p > 0{\cdot}05$).

Probe judgement RT *analyses*

To avoid confounding potential item differences with probe interval differences, RT analyses were conducted only on matched pairs of correct responses across short and long probe interval trials (allowing us to compare 'apples to apples'). Proportionalized suppression ratios were generated for these data, separately for short and long interval trials. The ratios were computed by calculating RT difference scores (experimental–comparison), and dividing these by comparison RTs, to take into account absolute group differences in response speed.

Further, to ensure sufficient data for interpreting the RT analyses, we calculated and analysed suppression ratios for only those subjects who scored at least nine of 12 correct on the matched pairs of items in short and long probe interval trials. Thirteen subjects in each group met this criterion. The demographic and clinical profiles of these subjects did not differ from those reported in Table 1 for the larger groups. Group RT data for these subjects are presented in Table 2.

Within-group *t*-tests were performed on the suppression ratio data to assess our *a-priori* expectation that RHD subjects would show less evidence of suppression from short to long intervals than would NBD subjects. As predicted, subjects with RHD showed no decline in proportionalized suppression ratios from short ($M = 0{\cdot}08$, $SD = 0{\cdot}07$) to long probe intervals ($M = 0{\cdot}06$, $SD = 0{\cdot}09$; $t(12) = 0{\cdot}86$), while control subjects evidenced significant decline from short ($M = 0{\cdot}08$, $SD = 0{\cdot}10$) to long intervals ($M = 0{\cdot}03$, $SD = 0{\cdot}08$; $t(12) = 2{\cdot}24$). Thus, as expected, subjects in both groups experienced interference from the unbiased meanings of the lexical ambiguities at the short probe interval. Also as predicted, this interference largely disappeared for NBD adults at the delayed interval, but continued to influence RHD subjects' RTs.

Table 2. Performance data for two groups

Probe judgement accuracy (12 possible)

	RHD	NBD
Short interval		
M	10·3	10·5
SD	(1·1)	(2·3)
Range	8–12	5–12
Long interval		
M	9·9	10·5
SD	(2·4)	(0·8)
Range	3–12	9–12

Probe judgement RTs (seconds)†

	RHD		NBD	
	Experimental items	Comparison items	Experimental items	Comparison items
Short interval				
M	1·51	1·47	1·19	1·16
SD	(0·24)	(0·26)	(0·21)	(0·20)
Range	1·20–1·95	1·21–1·98	0·92–1·64	0·85–1·50
Long interval				
M	1·69	1·63	1·22	1·19
SD	(0·45)	(0·30)	(0·20)	(0·15)
Range	1·09–2·85	1·12–2·07	0·87–1·55	0·93–1·47

Comprehension task errors (DCT, 32 possible)

	RHD	NBD
M	4·9	3·1
SD	(1·9)	(1·4)
Range	2–9	1–5

† Group mean RT data cannot be used to derive proportionalized suppression ratios, which were calculated for individual subjects with widely varying denominators (comparison RTs).

RHD = Right brain-damaged group; NBD = non-brain-damaged group; DCT = Discourse Comprehension Test.

Comprehension analyses

Group performance data for the DCT are also presented in Table 2. We analysed total error scores, combined across question types, because subjects made too few errors on each category of question to provide stable dependent measures with a range of scores suitable for correlational analysis. As might be expected, our RHD subjects made significantly more errors on the DCT than did the NBD group ($t(31) = 3{\cdot}12$; $p < 0{\cdot}01$).

To examine the association between suppression effectiveness and discourse comprehension in RHD subjects, a difference score was computed between averaged short- and long-interval suppression ratios. There was a moderate correlation between suppression ratio difference scores and DCT total error scores (Pearson $r = -0{\cdot}51$). There were no other significant or meaningful correlations with suppression ratios, for either group.

Discussion

The results of this study provide preliminary support for the hypotheses proposed earlier: RHD adults do not suppress inappropriate or contextually irrelevant meanings as effectively as do NBD adults, and ineffective suppression may be a contributing factor to discourse comprehension difficulties in adults with RHD. We continue to gather data for this project. When the sample sizes are sufficient, we will perform multiple correlational analyses to evaluate the extent to which suppression deficits predict discourse comprehension after controlling for other potentially important influences such as education and severity of neglect.

Performance on the two probes in this study provides an initial window on what is activated or represented over time as subjects process incoming information. This is important; past conclusions about RHD adults' difficulties with materials that support alternative meanings have come primarily from studies in which measures are taken long after the relevant stimulus, and as such can only reflect the end-products of the comprehension process. Unfortunately, with only two probe intervals we cannot determine from this study the extent to which the suppression mechanism is delayed in RHD adults. We stipulate delay here rather than complete malfunction, because converging evidence suggests that delayed or inefficient suppression is more probable than a failed or absent mechanism. For example, in this study all subjects achieved a high level of accuracy on suppression task trials, suggesting that the continued activation of an unintended meaning did not interfere with the eventual selection of the most appropriate interpretation. Similarly, as indicated earlier, subjects in our study of emotional inference revision (Tompkins 1991), and in Brownell and colleagues' (1986) investigation of pragmatic inference revision, showed evidence of accepting the intended response even though a competing interpretation was available.

As noted by Gernsbacher and Faust (1991), it is possible that ineffective enhancement contributed to our suppression results. Enhancement heightens activation of information associated with contextually appropriate interpretations. Difficulty in resolving competing interpretations could result from a general problem with recognizing or mapping contextually relevant information onto emerging comprehension structures. In this regard some accumulated data suggest that RHD patients are slow and error-prone in appreciating context (e.g. Joanette *et al.* 1990, Myers 1991, Wapner *et al.* 1981). However, our preliminary tests of this factor, using similar stimuli with probe words that are related to the biased meaning of the sentence-final ambiguity, suggest that it cannot account for the results reported here.

At first glance our results showing patients to activate and retain both interpretations of sentence-final lexical ambiguities appear inconsistent with other proposals about hemispheric processing of ambiguous materials, drawn from investigations of non-brain-damaged adults (e.g. Burgess and Simpson 1988) and adults with RHD (e.g. Beeman 1993, Brownell *et al.* 1986). In an influential study examining the time-course of meaning activation for lexical ambiguities in non-impaired individuals, Burgess and Simpson (1988) reported that dominant interpretations are activated similarly in both hemispheres. Subordinate meaning activation, however, builds over time in the right hemisphere, while the left hemisphere quickly selects a context-appropriate meaning. Many citing this work extend its findings to conclude that adults with RHD should be unable to activate and maintain alternative meanings (e.g. Beeman 1993, Chiarello 1988, Molloy *et al.* 1990). Those who make this deduction bolster it with evidence from studies indicating that RHD subjects have difficulty with materials that support or induce multiple interpretations (see e.g., reviews in Joanette *et al.* 1990, Tompkins 1995).

This is an appealing and apparently logical account, but there are several reasons to question it. First, it may be more complicated to generalize results from normal brains to damaged brains than such conclusions suggest. It is unlikely that a lesion in one hemisphere totally eradicates its processing substrates. In addition, brain damage can result in an exaggeration of function through damage to inhibitory circuitry, rather than a loss of those functions. Damage to one hemisphere might also interfere with input from the other hemisphere that is crucial to an integrated interpretation or response. Thus, our results are not inconsistent with the position that left hemisphere functions could take precedence in suppressing unintended interpretations. Rather than alternative interpretations not being activated after RHD, however, they may take more time or greater mental effort to suppress.

Secondly, as noted earlier, most of the evidence documenting RHD adults' difficulties with multiple meanings comes from off-line studies (e.g. Brownell *et al.* 1986; others reviewed in Molloy *et al.* 1990), and as such cannot address the question of meaning activation. By contrast, a variety of priming and word-monitoring studies conducted in our laboratory indicates that RHD adults do show evidence of activating multiple meanings, under conditions designed to minimize demands for strategic processing and to tap relatively automatic mental operations. We have observed this with lexical ambiguities that may be interpreted either literally or metaphorically (Tompkins 1990), with emotional comments that are disambiguated by prosody (Tompkins 1991, Tompkins *et al.* 1994b), with familiar idiomatic expressions (Tompkins *et al.* 1992), and with the balanced lexical ambiguities in this study.

Beeman's (1993) investigation of coherence inferencing in RHD adults employed a cross-modal lexical decision task, an exception to the tendency to use off-line methodologies with RHD patients. Beeman reported that RHD adults did not show the normal advantage for processing inference-related words, and concluded from this and other evidence that the patients lacked activation of the semantic information needed to draw the intended inferences. We have raised elsewhere a number of concerns about Beeman's methods and conclusions (Tompkins *et al.* 1994a), related primarily to the multiple task demands and the timing of the inference probes. We are currently pursuing a suppression hypothesis for RHD patients' performance on materials like Beeman's, examining the possibility that patients may activate the competing inferences that are induced by his stimuli, but have difficulty selecting the appropriate ones in the context of his experimental methods.

Finally, it is possible that the current results should not be compared with predictions based on the processing of highly biased ambiguities, such as those used by Burgess and Simpson (1988). Our study examined lexical ambiguities with relatively equiprobable meanings, for which access or other processing operations may differ from those for words with dominant and subordinate meanings (Atchley *et al.* 1996, Williams 1992). In this regard Atchley *et al.* (1996) reported results in contrast to their original findings for biased ambiguities. Specifically, both meanings of equibiased ambiguities are activated in both hemispheres, at all prime-target intervals investigated.

A suppression focus is appealing as a framework for future research with RHD adults, because ineffective inhibition could underlie a variety of observations about their communicative performance. These include the following: (a) RHD patients tend to pursue incorrect associations in continuations of structured conversations (Rehak *et al.* 1992) as well as in comprehension tasks (Brownell *et al.* 1986); (b) they have difficulty rejecting plausible but false statements or inferences that are not part of presented narrative stimuli (Joanette and Goulet 1987, Schneiderman *et al.* 1992); (c) they evidence problems linking disparate mental models or representations at the discourse level (Frederiksen and Stemmer 1993, Stemmer *et al.* 1994); (d) their errors in explaining idiomatic phrases are related to the non-literal meanings (Tompkins *et al.* 1992); (e) they make intrusion errors in descriptions based on common scripts (Roman *et al.* 1987) and require more prompting to complete script continuations, in some cases being diverted from the topic or task by their own intrusions; (f) their connected speech is often described as embellished, tangential, and excessively detailed (Joanette *et al.* 1990, Myers 1991, Wapner *et al.* 1981) suggesting that related but irrelevant information is not being dampened; and (g) even in the linguistic domain, an area of strength, they have problems with tasks that require reassigning the syntactic status of elements contained in a single stimulus (Schneiderman and Saddy 1988), highlighting what may be a more general difficulty with shifting from one interpretation to another. A focus on suppression is also intriguing given evidence that neurotransmitter systems important for filtering irrelevant stimuli are more concentrated in the right hemisphere, and more disrupted by RHD (Tucker and Williamson 1984).

There are also several clinical implications of this work. Findings such as these, when replicated and extended, should contribute to formulating plausible accounts of the nature of RHD patients' strengths and weaknesses. Thus, they should assist in determining what to assess, how to assess it, and what to treat. Also, results like these provide a principled foundation for the development and application of treatment techniques, whether newly derived or routinely used. For example, it is common to work with RHD adults on identifying relevant and irrelevant information, and discounting that which is less appropriate. If we can identify suppression deficits in individual patients, and these deficits limit comprehension skills, it should be possible in the future to predict and test who might be appropriate candidates for such a treatment approach.

In sum, the suppression framework appears to provide a promising new perspective for analysing discourse comprehension impairments after RHD in adults, and for organizing our clinical decision-making process related to such problems. We are currently examining the relationship of suppression function to language comprehension in a study of higher-level inference revision, a project that will help to determine the generality of the suppression contribution to discourse comprehension deficits in adults with RHD.

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References

Atchley, R. A., Burgess, C., Audet, C. and Arambel, S. (1996) Timecourse, context effects, and the processing of lexical ambiguity in the cerebral hemispheres. *Brain and Cognition*, **30**, 277–280.

Beeman, M. (1993) Semantic processing in the right hemisphere may contribute to drawing inferences from discourse. *Brain and Language*, **44**, 80–120.

Benton, A., Hamsher, K. de S., Varney, N. and Spreen, O. (1983) Judgment of line orientation. *Contributions to Neuropsychological Assessment* (Oxford University Press, New York), pp. 44–54.

Brookshire, R. H. and Nicholas, L. E. (1993) *Discourse Comprehension Test* (Communication Skill Builders, Tucson, AZ).

Brownell, H. H., Carroll, J. J., Rehak, A. and Wingfield, A. (1992) The use of pronoun anaphora and speaker mood in the interpretation of conversational utterances by right hemisphere brain-damaged patients. *Brain and Language*, **43**, 121–147.

Brownell, H. H., Potter, H. H., Birhle, A. M. and Gardner, H. (1986) Inference deficits in right brain-damaged patients. *Brain and Language*, **27**, 310–321.

Burgess, C. and Simpson, G. B. (1988) Hemispheric processing of ambiguous words. *Brian and Language*, **38**, 86–104.

Chiarello, C. (1988) Semantic priming in the intact brain: Separate roles for the right and left hemispheres? In C. Chiarello (Ed.) *Right Hemisphere Contributions to Lexical Semantics* (Springer Verlag, New York), pp. 59–69.

Folstein, M. F., Folstein, S. E. and McHugh, P. R. (1975) Mini-Mental State: a practical guide for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, **12**, 189–198.

Frederiksen, C. H. and Stemmer, B. (1993) Conceptual processing of discourse by a right hemisphere brain-damaged patient. In H. H. Brownell and Y. Joanette (Eds) *Narrative Discourse in Neurologically Impaired and Normal Aging Adults* (Singular, San Diego, CA), pp. 239–278.

Gernsbacher, M. A. (1990) *Comprehension as Structure Building* (Erlbaum, Hillsdale, NJ).

Gernsbacher, M. A and Faust, M. E. (1991) The mechanism of suppression: A component of general comprehension skill. *Journal of Experimental Pyschology: Learning, Memory and Cognition*, **17**, 245–262.

Gernsbacher, M. A., Varner, K. R. and Faust, M. E. (1990) Investigating differences in general comprehension skill. *Journal of Experimental Psychology: Learning, Memory and Cognition*, **16**, 430–445.

Joanette, Y. and Goulet, P. (1987) Inferencing deficit in right brain-damaged: absence of evidence. Paper presented at the 10th European Conference of the International Neuropsychological Society, Barcelona.

Joanette, Y., Goulet, P. and Hannequin, D. (1990) *Right Hemisphere and Verbal Communication* (Springer Verlag, New York).

Molloy, R., Brownell, H. H. and Gardner, H. (1990) Discourse comprehension by right-hemisphere stroke patients: deficits of prediction and revision. In Y. Joanette and H. H. Brownell (Eds) *Discourse Ability and Brain Damage* (Springer Verlag, New York), pp. 113–130.

Myers, P. S. (1991) Inference failure: the underlying impairment in right-hemisphere communication disorders. *Clinical Aphasiology*, **20**, 167–180.

Onifer, W. and Swinney, D. A. (1981) Accessing lexical ambiguities during sentence comprehension: effects of frequency of meaning and contextual bias. *Memory and Cognition*, **9**, 225–236.

Rehak, A., Kaplan, J. A. and Gardner, H. (1992) Sensitivity to conversational deviance in right-hemisphere-damaged patients. *Brain and Language*, **42**, 203–217.

Roman, M., Brownell, H. H., Potter, H. H., Seibold, M. S. and Gardner, H. (1987) Script knowledge in right hemisphere-damaged and in normal elderly adults. *Brain and Language*, **31**, 151–170.

Schneiderman, E. I. and Saddy, J. D. (1988) A linguistic deficit resulting from right-hemisphere damage. *Brain and Language*, **34**, 38–53.

Schneiderman, E. I., Murasugi, K. G. and Saddy, J. D. (1992) Story arrangement ability in right brain-damaged patients. *Brain and Language*, **43**, 107–120.

Simpson, G. B. (1984) Lexical ambiguity and its role in models of word recognition. *Psychological Bulletin*, **96**, 316–340.

Simpson, G. B. and Burgess, C. (1988) Implications of lexical ambiguity resolution for word recognition and comprehension. In S. Small, G. Cottrell and M. Tanenhaus (Eds) *Lexical Ambiguity Resolution: Perspectives from psycholinguistics, neuropsychology, and artificial intelligence* (Morgan Kaufmann, San Mateo, CA), pp. 271–288.

Stemmer, B., Giroux, F. and Joanette, Y. (1994) Production and evaluation of requests by right-hemisphere brain-damaged individuals. *Brain and Language*, **47**, 1–31.

Swinney, D. A. (1979) Lexical access during sentence comprehension: (Re)consideration of context effects. *Journal of Verbal Learning and Verbal Behavior*, **18**, 645–659.

Tanenhaus, M. K., Leiman, J. M. and Seidenberg, M. S. (1979) Evidence for multiple stages in the processing of ambiguous words in syntactic contexts. *Journal of Verbal Learning and Verbal Behavior*, **18**, 427–440.

Tompkins, C. A. (1990) Knowledge and strategies for processing lexical metaphor after right or left hemisphere brain damage. *Journal of Speech and Hearing Research*, **33**, 307–316.

Tompkins, C. A. (1991) Automatic and effortful processing of emotional intonation after right or left hemisphere brain damage. *Journal of Speech and Hearing Research*, **34**, 820–830.

Tompkins, C. A. (1995) *Right Hemisphere Communication Disorders: Theory and management* (Singular, San Diego, CA).

Tompkins, C. A. and Mateer, C. A. (1985) Right hemisphere appreciation of prosodic and linguistic indications of implicit attitude. *Brain and Language*, **24**, 185–203.

Tompkins, C. A., Bloise, C. G. R., Timko, M. L. and Baumgaertner, A. (1994a). Working memory and inference revision in brain-damaged and normally aging adults. *Journal of Speech and Hearing Research*, **37**, 896–912.

Tompkins, C. A., Boada, R. and McGarry, K. (1992) The access and processing of familiar idioms by brain-damaged and normally aging adults. *Journal of Speech and Hearing Research*, **35**, 626–637.

Tompkins, C. A., Spencer, K. A. and Boada, R. (1994b) Contextual influences on judgments of emotionally ambiguous stimuli by brain-damaged and normally aging adults. *Clinical Aphasiology*, **22**, 325–333.

Tucker, D. M. and Williamson, P. A. (1984) Asymmetric neural control systems in human self-regulation. *Phychological Review*, **91**, 185–215.

Wapner, W., Hamby, S. and Gardner, H. (1981) The role of right hemisphere in the apprehension of complex linguistic materials. *Brain and Language*, **14**, 15–32.

Weylman, S., Brownell, H. H., Roman, M. and Gardner, H. (1989) Appreciation of indirect requests by left- and right-brain-damaged patients: the effects of verbal context and conventionality of wording. *Brain and Language*, **36**, 580–591.

Williams, J. N. (1992) Processing polysemous words in context: evidence for interrelated meanings. *Journal of Psycholinguistic Research*, **21**, 193–218.

Wilson, B., Cockburn, J. and Halligan, P. (1987) *Behavioural Inattention Test* (Thames Valley Text Co., Bury St Edmonds).

Wilson, R. S., Rosenbaum, G. and Brown, G. (1979) The problem of premorbid intelligence in neuropsychological assessment. *Journal of Clinical Neuropsychology*, **1**, 49–53.

Appendix A: Summary of stimulus validation procedures for suppression task

Piloting was done to identify ambiguous lexical items that were most balanced in terms of meaning dominance, and to obtain relatedness ratings for sentences and probe words built around these ambiguous words. Piloting proceeded in two phases.

Meaning dominance

1. Thirteen normally ageing subjects, similar in age and education to the stroke patient subjects from our former studies, were asked to generate the first meaning that came to mind for 33 ambiguous single words (from Gernsbacher and Faust 1991). The number of occurrences of particular meanings of each ambiguous word was tabulated to determine meaning dominance. For example, the word SEAL yielded two meanings ('to close' and 'animal'). Seven of the 13 subjects generated 'to close' and six generated 'animal' as the first meaning; therefore, the dominance ratio was 7:6. When the meaning dominance ratio differed by just one point the ambiguous word was designated as 'mixed meaning dominant'.
2. As a result of step 1, potential stimulus items that had a clearly dominant first meaning (i.e. ⩾ 90% of all subjects generated one response) were excluded, as were words with more than two different meanings. From the remaining words the 15 most evenly balanced stimuli were chosen for further validation, described below.

Relatedness ratings

1. Stimulus sentences were created around the ambiguous words, one of each biased towards each of the two meanings of the ambiguities, to construct a large pool of sentences to be tested with different probe words. All sentences were of the structure exemplified in the Method section. An example is the sentence pair 'He trained the SEAL'/'He tightened the SEAL'.

   Probe words reflecting the different meanings of the ambiguous words were obtained from the meaning generation task, described above. (For this example, probe words were ZOO and TIGHTEN.) Probes that could form a compound word with the sentence-final ambiguous word (e.g. row–boat) were rejected.
2. Nine different normally ageing adults, similar in age and education to the former stroke patient subjects, rated the relatedness of the single probe words to the experimental sentences. They used a four-point scale (0 = unrelated, 3 = highly related). Three probe words were paired with each sentence. One (e.g. TIGHTEN) reflected the unbiased meaning of the ambiguous word (e.g. the 'container' meaning of the word SEAL in a sentence such as 'He trained the SEAL'). Two additional probes served a foils. Foil probes were synonymous or highly related to the meanings originally generated for the ambiguous word (for this example, LID and DOLPHIN). Validation criteria were: at least 80% of raters had to agree with the intended bias of the probe (unrelated, or 0), and there should not be any score > 1 for an unrelated probe. Thirty-eight sentences and probes met these criteria.

Final stimulus selection

1. We selected as experimental stimuli those 12 ambiguities in validated items that received relatedness ratings closest to 0 ($M = 0{\cdot}04$, range 0–0·13), and that exhibited the highest interrater agreement ($M = 0{\cdot}96$; range 0·88–1·00). Six of these contained ambiguities of mixed meaning dominance, and six included ambiguities with differences of up to three points between their meanings (e.g. a ratio of 5:8; see Meaning Dominance, above).
2. Comparison sentences were created by changing the final ambiguous word of the experimental stimulus sentences, as described in the Method section. We did not validate the comparison sentences because their bias was expected to be more obvious than that in the experimental sentences. It was thus assumed that a comparison item matching an already-validated experimental item would be valid also.

Appendix B: Experimental (E) and comparison (C) stimuli for suppression task

Stimulus sentences	Probe word
(E) He trained the seal (C) He trained the dolphin	tighten
(E) She stepped on the ant (C) She stepped on the worm	family
(E) He scheduled his patients (C) He scheduled his clients	calm
(E) He built a shed (C) He built a hut	skin
(E) He landed a punch (C) He landed a jab	soda
(E) She dug with the spade (C) She dug with the shovel	cards
(E) He waited a second (C) He waited a minute	award
(E) He swatted the fly (C) He swatted the gnat	airplane
(E) He ate the perch (C) He ate the trout	ledge
(E) He was in the front row (C) He was in the front seat	oars
(E) He roped a steer (C) He roped a cow	guide
(E) They installed more fans (C) They installed more windows	concert