# THE EFFECT OF COMPRESSED SPEECH ON THE ABILITY OF RIGHT-HEMISPHERE-DAMAGED PATIENTS TO USE CONTEXT

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## Abstract

The ability of RHD patients to use context under conditions of increased processing demands was examined. Subjects monitored for words in auditorily presented sentences of three context types-normal, semantically anomalous, and random, at three rates of speech – normal, 70% compressed (Experiment 1) and 60% compressed (Experiment 2). Effects of semantics and syntax were found for the RHD and normal groups under the normal rate of speech condition. Using compressed rates of speech, the effect of syntax disappeared, but the effect of semantics remained. Importantly, and contrary to expectations, the RHD group was similar to normals in continuing to demonstrate an effect of semantic context under conditions of increased processing demands. Results are discussed relative to contemporary theories of laterality, based on studies with normals, that suggest that the involvement of the left versus right hemisphere in context use may depend upon the type of contextual information being processed.

Key words: right-hemisphere-damage, context, language, processing resources

## Introduction

Contemporary views of hemispheric specialization for language competence posit a specialized role for the right hemisphere (RH) that is unique from that of the left hemisphere (LH). While individuals who suffer a LH stroke frequently present with aphasia, manifested in difficulty at the levels of syntax, semantics, and phonology, those who suffer RH damage present with a starkly different profile. Right-hemisphere-damaged (RHD) individuals have no apparent difficulty at these more basic linguistic levels. They do, however, evidence deficits at a higher linguistic level – in particular, at the level of discourse (for review see Brownell, Gardner, Prather et al., 1995). Discourse-level deficits have been noted in a number of domains – in the comprehension of narratives (e.g., Hough, 1990; Joanette and Goulet, 1990; Schneiderman, Murasugi and Saddy, 1992), the appreciation of humour (e.g., Bihrle, Brownell, Powelson et al., 1986; Shammi and Stuss, 1999) and the comprehension of nonliteral forms of language such as verbal irony (e.g., Kaplan, Brownell, Jacobs et al., 1990) and indirect speech acts (e.g., Weylman, Brownell, Roman et al., 1989), to name a few.

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Some investigations (e.g. Schneiderman et al., 1992; Tompkins, 1991; Tompkins and Flowers, 1987; Tompkins, Spencer, and Boada, 1994; Weylman et al., 1989) have focused on the possibility that RHD individuals have difficulty using contextual information in language processing, a proposal that emerged to account for the seemingly diverse discourse-level deficits that are seen in RHD patients (Cook, 1989; Cook and Beech, 1990; Gardner, Brownell, Wapner et al., 1983). Results of these studies have been mixed. Tompkins and Flowers (1987), for example, found that RHD individuals benefited from information provided in a previous paragraph to facilitate the detection of mood in auditorily presented semantically neutral sentences, compared to when the sentences were presented in isolation. Similarly, Tompkins (1991) found that the use of highly redundant story contexts improved the detection of mood in auditorily presented semantically neutral comments as compared to the use of moderately redundant story contexts. In contrast, Schneiderman et al. (1992) found that RHD patients were impaired in their use of context to facilitate the arrangement of sentences into stories. Finally, the results of Weylman et al. (1989) suggested impaired use of biasing information by RHD patients compared to normals in determining a literal versus a non-literal reading of an indirect speech act.

The concept of “context” is difficult to precisely define. When relating to a higher level discourse structure, it can embody meaning beyond that contained within the simple words and combination of sentences that make up the discourse. For example, in any verbal interaction, many variables impact on the meaning of a discourse including, for instance, the physical surroundings, the relationship of participants, and speaker intentions. In an effort to specifically target the processing of a simple linguistic context, Leonard, Waters and Caplan (1997a, 1997b) conducted a series of experiments investigating the ability of RHD individuals to use written contextual information to resolve ambiguous pronouns. Leonard et al. were particularly interested in isolating context use at very simple levels of language – the level of the single sentence and two-sentence passages, with the goal of minimizing the presence of potential confounds found in longer and more detailed discourse-level stimuli. Contrary to expectations, the results indicated that the RHD group was as successful as the normal control group in using context to aid in the identification of a preferred referent.

These findings were interpreted relative to the cognitive resource perspective proposed by Tompkins and her colleagues (Tompkins, 1990, 1991; Tompkins, Boada and McGarry, 1992; Tompkins, Bloise, Timko et al., 1994). These investigators have argued that discourse-level deficits evidenced by RHD patients and, thus, potential deficits in context use, emerge only as the demands of the task exceed available processing resources. In other words, they suggest that deficits will be evidenced in effortful tasks such as having to provide the definition of an idiom; whereas if the task taps more automatic processing, such as in a word-monitoring task, evidence for intact knowledge will be found. In fact, Tompkins et al. (1992) were successful in demonstrating such a distinction regarding knowledge of idiomatic expressions in the RHD patients they tested. Gagnon, Goulet and Joanette (1994) also found evidence for differential response by RHD patients when engaged in on-line, automatic processing versus off-line, effortful processing of lexical semantics, with deficits emerging when engaged in the off-line task only.

Along a similar line of reasoning as Tompkins and her colleagues, Leonard et al. (1997a, 1997b) argued that the RHD group that they tested was successful in using contextual information to resolve ambiguous pronouns because the demands of the task were low and, thus, did not exceed available processing resources. They noted, for example, that the stimuli were presented visually and were only 1-2 sentences in length, thereby placing minimal demands on memory. As well, it was argued that the task of having to determine a coreferent was, in and of itself, a relatively "automatic" language process. While these arguments were plausible, they were, nonetheless, offered post-hoc and, indeed, the tasks used in Leonard et al. (1997a, 1997b) were not a true test of the cognitive resource perspective.

In an effort to more systematically evaluate the claim that RHD patients can use contextual information during on-line automatic processing, Leonard and Baum (1998) tested a group of RHD patients and normal controls using a word-monitoring task. Target words (underlined in the following examples) were presented in normal (1) and semantically anomalous (2) sentence pairs:

(1) *Tim was experiencing a considerable amount of trouble walking home. The terrible pain was getting increasingly worse in his <u>foot</u>.*

(2) *Tim was kissing a proper wall in treatment showing today. The remarkable hotel was doing increasingly wild to his <u>foot</u>.*

Stimuli were presented auditorily and subjects were required to respond as quickly as possible once a target word was heard. Consistent with previous studies with normals (e.g., Marslen-Wilson and Tyler, 1980), both the normal and RHD groups demonstrated an effect of semantic context, reflected in faster reaction times to normal versus anomalous sentences. It was argued that the facilitation found under the normal context condition must have been due to the build-up of semantic information as the sentence was processed, as both the normal and anomalous sentences were syntactically sound.

The results of this study, in addition to those of Leonard et al. (1997a, 1997b), support one aspect of the position advanced by Tompkins and her colleagues (Tompkins, 1990, 1991; Tompkins et al., 1992; Tompkins et al., 1994), that a proposed impairment in the use of context by RHD patients is a function of task demands. That is, there is accumulating evidence to suggest that when processing demands are reduced and on-line processing is measured (as in the word-monitoring task described above), RHD patients can effectively use contextual information to process language. A critical corollary to this position, however, is that as processing demands increase, impairments in the use of context by RHD patients will emerge.

The goal of Experiment 1 was to systematically test this proposal. Once again a word-monitoring task was used. Subjects were required to monitor for target words in normal and semantically anomalous sentences. A third context condition (random) was also added in which sentences were both semantically and syntactically anomalous. The stimuli were presented at two different rates of speech – normal and compressed to 70% of normal. The literature on the comprehension of compressed speech indicates that, while young adults can process speech compressed by as much as 50% with substantial effort (e.g., Wingfield, 1975), normal elderly adults may exhibit slower language processing in general and thus their systems may be taxed by smaller increases in speed (e.g., Tun, Wingfield, Stine et al., 1992; Wingfield, Poon, Lombardi et al., 1985; Wingfield and Ducharme, 1999). The increased rate of presentation leaves less time for normal linguistic analysis to occur, yielding decrements in language comprehension and recall tasks (e.g., Chodorow, 1979; Foulke, 1971; Wingfield et al., 1985; Wingfield and Ducharme, 1999). It was hypothesized that if RHD patients have more difficulty using contextual information as processing demands increase, then an effect of semantic context (i.e., faster reaction times to normal versus anomalous sentences), expected to hold under the normal rate of speech condition, would be absent under the compressed rate of speech condition. Further, it was predicted that, if right brain damage selectively impairs the processing of semantic contextual information (leaving syntactic processing intact), then an effect of syntax (i.e., faster reaction times to anomalous versus random sentences) would be found for both normal and RHD groups at both the normal and compressed rates of speech.

## Experiment 1

### *Materials and Methods*

#### *Subjects*

Two groups of subjects were tested: a right-hemisphere-damaged (RHD) group and a group of non-brain-damaged normal controls (NC). Subjects were all right-handed, native English speakers. Hearing for all subjects was found to be within normal limits as determined by a hearing screening at less than 35 dB HL at the speech frequencies 0.5, 1, and 2 kHz.

The RHD group consisted of 10 individuals (mean age: 68 years; mean level of education: 12 years). Patients were recruited from a number of institutions in Montreal and surrounding areas. Exclusionary criteria included the presence of multiple infarcts, a history of drug or alcohol abuse, and a history of psychiatric or neurological illness. All patients were at least six months post-onset at the time of testing. None of the individuals in the RHD group was aphasic, as determined from available reports. All RHD patients were administered a test battery adapted from the *Test of Language Competence – Expanded Edition* (Wiig and Secord, 1987) to evaluate their competence in the areas of comprehension of figurative language and the generation of inferences (areas frequently identified as impaired in RHD individuals). Seven patients were found to have deficits in comprehending figurative language and seven in generating inferences. Only two subjects (3 and 5) evidenced no apparent deficits in either area. Visual neglect was also screened using the Bells Test (Gauthier, Dehaut and Joanette, 1989). Two subjects (2 and 6) were identified as presenting with visual neglect and one (8) with possible attentional deficits.

The NC group consisted of 10 individuals (mean age: 66 years; mean level of education: 14 years) chosen from a pool of volunteers in the Montreal area. The control subjects were matched as closely as possible to the RHD subjects on the variables of age and education. None of the subjects had a known history of psychiatric or neurological illness. All subjects passed a battery of neuropsychological tests to rule out the possibility of cognitive disorders such as dementia. (See Table I for subject information).

#### *Stimuli*

The stimuli consisted of individual sentences, ten words in length, many of which were used in Leonard and Baum (1998). Two factors were manipulated in the construction of the stimuli – Position and Context. The factor Position had three levels – beginning, middle, and end – and referred to the position of the target word in the sentence (beginning word

TABLE I
*Subjects Information*

| Subject | Age (years) | Education (years) | Sex | Site of lesion (acc. to CT scan) |
|---|---|---|---|---|
| RHD | | | | |
| 1 | 56 | 12 | F | Right posterior communicating artery |
| 2 | 62 | 12 | M | Right temporo-parieto-occipital |
| 3 | 31 | 13 | F | Right middle cerebral artery (MCA) |
| 4 | 76 | 11 | M | Right parietal |
| 5 | 70 | 21 | F | Internal capsule and corona radiata |
| 6 | 85 | 5 | F | Right MCA |
| 7 | 69 | 12 | M | Right parietal |
| 8 | 76 | 11 | M | Right fronto-temporo-parietal |
| 9 | 85 | 11 | M | Right hemorrhage |
| 10 | 67 | 14 | M | Right thalamus |
| Mean | 68 | 12 | | |
| NC | | | | |
| 1 | 57 | 11 | F | |
| 2 | 85 | 12 | F | |
| 3 | 30 | 15 | M | |
| 4 | 72 | 22 | F | |
| 5 | 71 | 12 | F | |
| 6 | 72 | 13 | F | |
| 7 | 61 | 11 | M | |
| 8 | 62 | 20 | M | |
| 9 | 64 | 18 | F | |
| 10 | 89 | 7 | F | |
| Mean | 66 | 14 | | |

position 3-4; middle word position 5-7; end word position 8-10). The factor Context referred to the syntactic and semantic integrity of the sentence and it had three levels – normal, anomalous, and random. Normal sentences were both semantically and syntactically sound (e.g., *In the early morning John prepared and loaded the boat*). Anomalous sentences were semantically anomalous; that is, they respected the syntactic rules of English but did not make sense (e.g., *On the late music John assured and paved the boat*). Anomalous sentences were constructed by changing the content words (except for the target word) of the normal sentences, respecting word class and word frequency as much as possible. Random sentences were both semantically and syntactically anomalous (e.g., *Morning the loaded the prepared John in and early boat*). Random sentences were constructed by scrambling the words in the normal sentences.

Target words were all monosyllabic. Word frequency of the target words ranged from 68-641 (Francis and Kucera, 1982) and was approximately equally balanced across positions (mean frequencies: beginning – 269; middle – 236; end – 224). There were 10 different target words at each position, resulting in a total of 90 stimuli.

The stimuli were recorded by an adult male speaker of English and digitized at a rate of 10k samples per second with a 4.5 kHz low-pass filter and 12-bit quantization using the BLISS speech analysis system (Mertus, 1989). During the recording, every effort was made to maintain normal prosody across context types. The target word was heard first, followed 500 ms later by the stimulus sentence. The inter-trial interval was 5 seconds. Timing of responses (in ms) by the computer began as soon as the target word was heard in the stimulus sentence and ended once a response was made.

*Procedure*

The stimuli were divided into three blocks of 30 sentences each, ensuring that there was only one instance of each target within each block. Further, within each block, the stimuli were randomized, with the condition that no more than 2 consecutive sentences be of the same context type. This fixed random order was presented to subjects using an inter-block interval of 10 seconds. Nine practice trials preceded the presentation of the experimental stimuli.

There were two conditions of stimulus presentation – a normal rate of speech and a compressed rate of speech. Under the compressed rate of speech condition, the stimulus sentences were compressed to 70% of normal using the Kay Computerized Speech Lab (Analysis Synthesis Laboratory, Model 4304). This programme uses the residual signal of a LPC analysis of each stimulus sentence to modify frame length values by a factor of 0.7, without altering the corresponding pitch. Sentences were then resynthesized. It has been shown with young normals that speech intelligibility is largely maintained with rates of speech as fast as 60% of normal, following a brief period of accommodation (Wingfield, 1975). Presentation of the target word prior to the stimulus sentence remained at a normal rate of speech. Subjects were tested under both conditions on separate days with at least 6 days separating testing sessions, and with the order of conditions counterbalanced across subjects.

Under both rate of speech conditions, the stimuli were presented to subjects over closed headphones in a laboratory setting. Subjects were seated in front of a response box and instructed that they would be hearing a target word followed by a sentence and they were to press the response button as soon as they heard the target word in the sentence. Subjects were encouraged to rest their finger from their unimpaired hand on the response button between trials. The target word was also presented to the subjects visually on a card so as to make it easier for them to remember it. Subjects were alerted to the fact that some of the sentences would not make sense. In addition, under the compressed rate of speech condition, subjects were further alerted to the fact that the sentences would be presented at a very fast rate of speech.

## *Results*

A 2 × 3 × 3 (Group × Position × Context) analysis of variance with both subjects (F1) and items (F2) as random factors was performed on the mean reaction times, separately for each speech rate condition. Reaction times greater than 5 seconds were automatically timed out and not included in the analysis. As well, extreme reaction times, defined as those greater than 2 standard deviations from the mean, calculated per subject, per condition were also not included in the analysis. Under the normal rate of speech condition, this resulted in the exclusion of 4.2% and 7.5% of responses by the NC and RHD groups, respectively. Under the compressed rate of speech condition, 7.1% of responses by the NC group and 9.2% of responses by the RHD group were excluded. All pairwise comparisons were done using the Newman-Keuls procedure ($p < 0.05$).

Figure 1 shows the mean reaction times to target words by Position and Context for each group under the normal rate of speech condition. The analysis revealed significant main effects of both Position [F1 (2, 36) = 5.88, $p < 0.01$; F2 (2, 81) = 33.29, $p < 0.001$] and Context [F1 (2, 36) = 24.91, $p < 0.001$; F2 (2, 81) = 9.5, $p < 0.001$]. Pairwise comparisons of the means revealed that reaction times were slower to target words in the beginning position (mean = 560 ms) than to those in both the middle and end positions (means = 393 and 387 ms, respectively) which did not differ from each other. Reaction times to target words were also faster under the normal (mean = 383 ms) than under the anomalous (mean = 460 ms) and random (mean = 497 ms) context conditions which, in turn, were significantly different from each other. No interactions were significant.

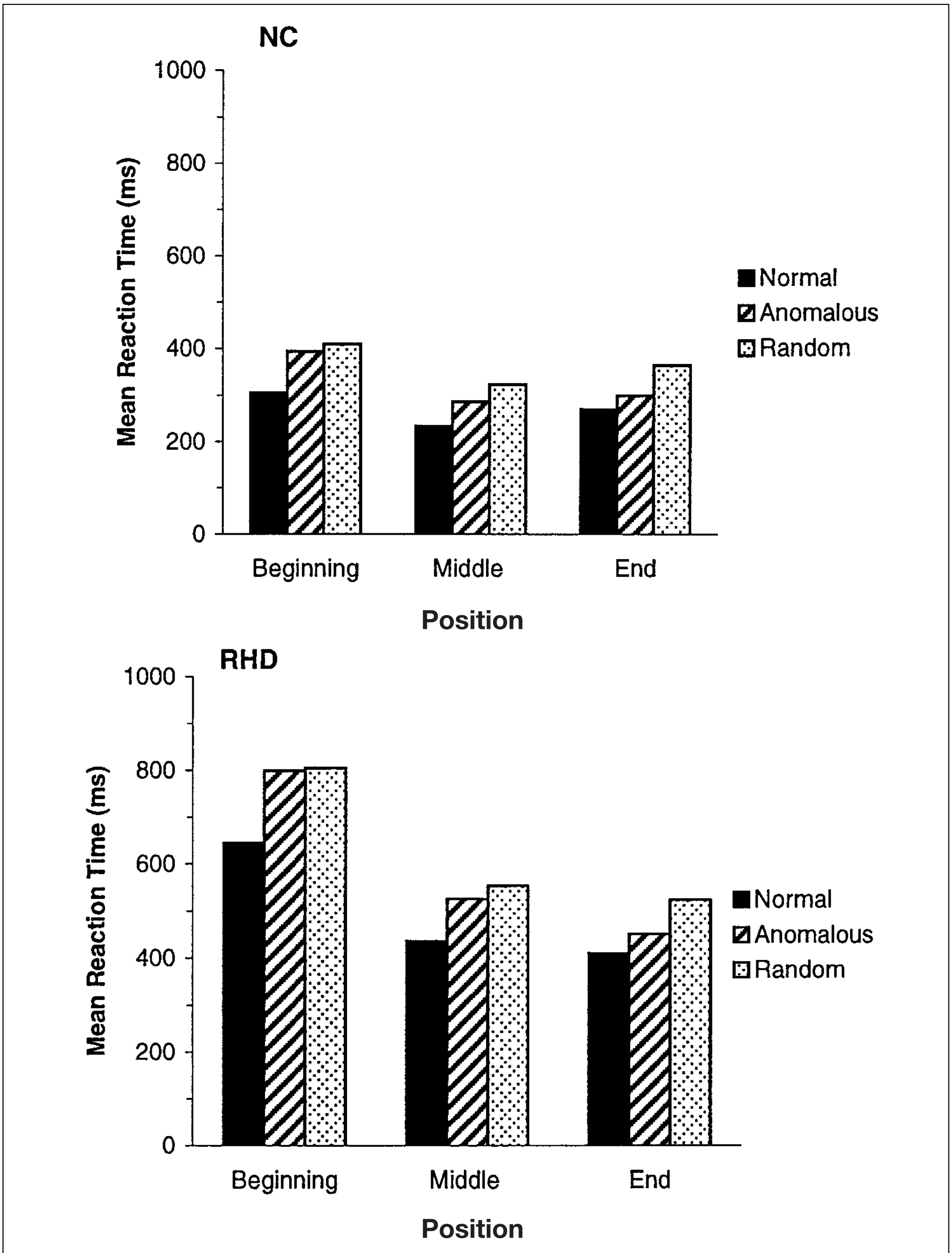


Fig. 1 – *Mean reaction times (ms) to target words by Position and Context under the normal rate of speech condition.*

Inspection of the individual data revealed that the effect of Position was quite robust. The finding of slower reaction times to targets at the beginning of sentences compared to both the middle and end positions was found for 100% of the subjects in each group. The effect of Context was also extremely robust. All of the members of both the NC and RHD groups showed an effect of semantic context, reflected in faster reaction times to normal versus anomalous sentences. As well, 100% of the NC group and 80% of the RHD group demonstrated an effect of syntax, reflected in faster reaction times to anomalous versus random sentences.

Figure 2 shows the mean reaction times to target words by Position and Context for each group under the compressed rate of speech condition. Main effects of Group [$F1\ (1, 18) = 6.15$, $p < 0.05$; $F2\ (1, 81) = 297.9$, $p < 0.001$], Position [$F1\ (2, 36) = 18.95$, $p < 0.001$; $F2\ (2, 81) = 25.59$, $p < 0.001$], and Context [$F1\ (2, 36) = 7.68$, $p < 0.01$; $F2\ (2, 81) = 5.55$, $p < 0.01$] were found. Overall, the NC group responded faster than the RHD group (means = 295 and 538 ms, respectively). Again, reaction times to targets at the beginning position were slower (mean = 504 ms) than to those at both the middle (mean = 382 ms) and end (mean = 364 ms) positions, which did not significantly differ from each other. As well, reaction times to targets in normal sentences (mean = 380 ms) were faster than to those in anomalous (mean = 431 ms) and random (mean = 439 ms) sentences, which, in turn, were not significantly different from each other.

The interaction of Group × Position was found to be significant by both subjects and items [$F1\ (2, 36) = 5.46$, $p < 0.01$; $F2\ (2, 81) = 12.70$, $p < 0.001$]. Analysis of simple main effects revealed that the effect of Position (i.e., slower reaction times to targets in the beginning compared to middle and end positions) held only for the RHD group. The interaction of Position × Context was also found to be significant, but by subjects only [$F1\ (4, 72) = 3.00$, $p < 0.05$]. Analysis of simple main effects revealed that the effect of Context held only at the middle (means: N = 345 ms; A = 382 ms; R = 419 ms) and end (means: N = 304 ms; A = 384 ms; R = 403 ms) positions; however, pairwise comparisons between reaction times to normal, anomalous, and random sentences at these two positions revealed no significant differences between sentence types.

## *Discussion*

Overall, the findings are consistent with our previous work (Leonard and Baum, 1998; Leonard et al., 1997a, 1997b) in demonstrating that RHD individuals can use context under conditions of reduced processing demands. Under the normal rate of speech condition, normal effects of both semantics and syntax emerged for both the NC and RHD groups. The finding of faster reaction times to normal versus anomalous sentences is attributed to the facilitation of the semantic information that is present in normal sentences, since both normal and anomalous sentences were syntactically intact. Similarly, the advantage in response times to anomalous versus random sentences is likely due to a facilitative effect of syntax, since both sentence types were semantically anomalous and the only difference between the two related to the support of the syntactic structure present in the anomalous sentences. These findings were extremely robust, as indicated by the inspection of the individual data which revealed that close to all subjects in both groups evidenced these patterns of performance. Indeed, the findings were not surprising and have been

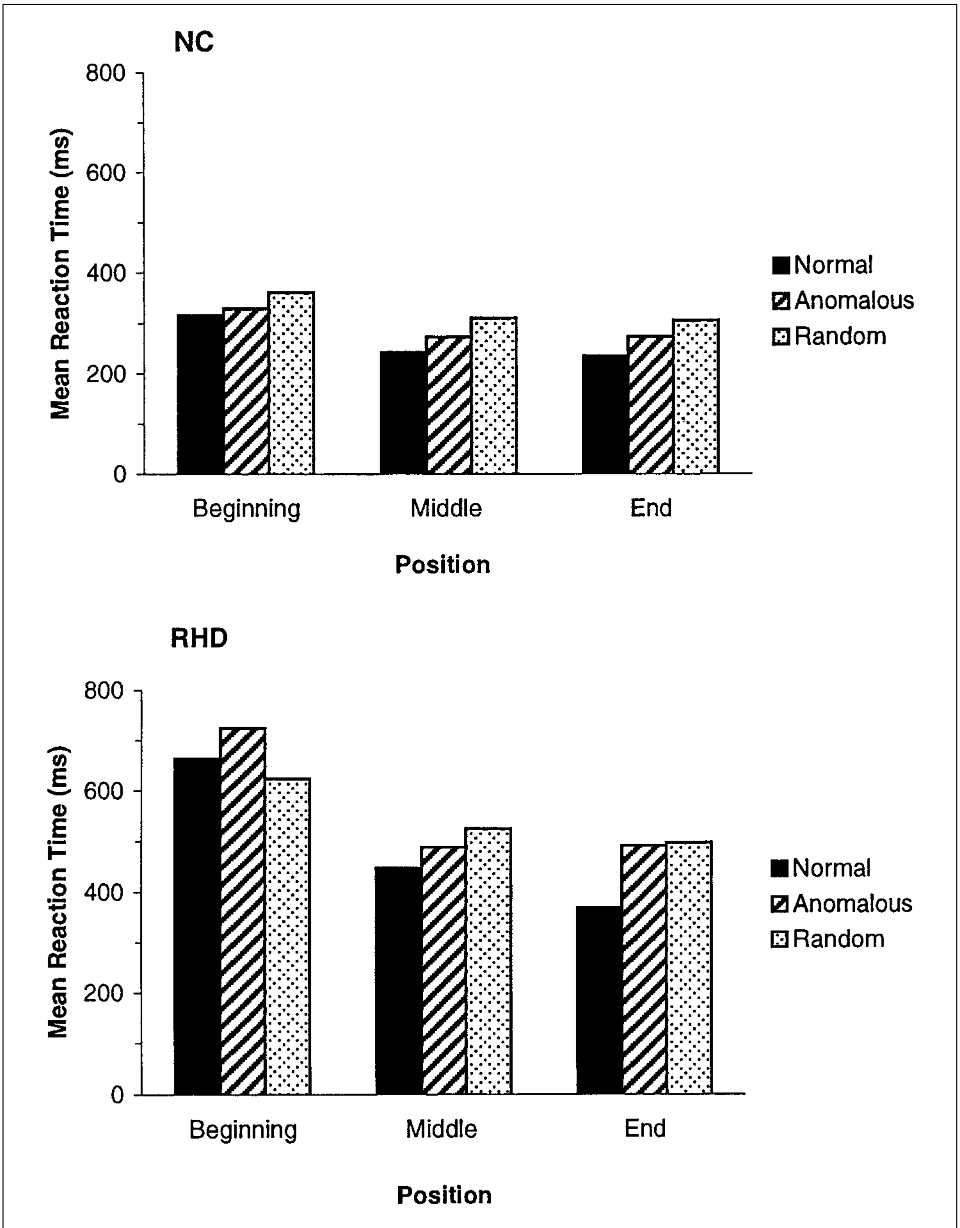


Fig. 2 – *Mean reaction times (ms) to target words by Position and Context under the compressed rate of speech condition.*

demonstrated with both young (Marslen-Wilson and Tyler, 1980) and elderly (Waldstein and Baum, 1992) normal subjects.

The result that was surprising, and certainly contrary to expectations, was that the RHD group continued to show a facilitative effect of semantic contextual information under the compressed rate of speech condition. It was originally hypothesized that a compressed rate of speech condition would serve to increase task processing demands, yielding deficits in context use by RHD patients. This pattern of performance was proposed as being a critical corollary to the cognitive resource perspective of Tompkins and her colleagues (Tompkins, 1990, 1991; Tompkins et al., 1992; Tompkins et al., 1994). However, the findings failed to support this hypothesis. The results indicated that, while the independent facilitory effect of syntax disappeared in the compressed speech condition, the facilitory effect of semantic context remained for both the NC and RHD groups. Once again, an inspection of the individual data suggests that the effect of semantic context was quite robust with 90% of the individuals in the NC group and 70% of those in the RHD group demonstrating such a pattern. It should be noted that there was nothing remarkable about the three RHD individuals (3, 4, and 10) who did not show an effect of semantic context under this condition of compressed speech in terms of lesion site or presence of visual neglect. However, it is interesting to note that RHD 4 and 10 performed particularly poorly on the test of figurative language (2/10 and 6/10 correct, respectively [excluding these two patients, the average accuracy rate was 8/10]).

The important question that arises from this investigation is why does the RHD group continue to evidence an ability to use linguistic contextual information under the compressed rate of speech condition? If, as suggested by some (e.g., Cook, 1989; Cook and Beech, 1990; Gardner et al., 1983), the RH is specialized for context use and RHD patients are particularly vulnerable to deficits in its use when the task is effortful and thus exceeds processing resources (Tompkins, 1990, 1991; Tompkins et al., 1992; Tompkins et al., 1994), then the facilitory effect of semantic context found under the normal rate of speech condition should have been absent or, at least reduced relative to normals, under the compressed rate of speech condition. As already discussed, this differential pattern of performance did not emerge.

The most obvious account of this pattern of results is that the compressed rate of speech condition was not sufficiently demanding so as to exceed the processing resources available to the RHD subjects. While it was arguably a more effortful condition for both groups of subjects, it was only assumed that it would exceed the processing capacity of the brain-damaged patients. There is no objective way to truly measure this assumption a priori. Experiment 2 was conducted to address the possibility that an even faster rate of speech is required to sufficiently burden the processing system of RHD patients such that deficits in context use will emerge.

## Experiment 2

### *Materials and Methods*

#### *Subjects*

All 10 of the NC subjects and 6 of the RHD subjects from Experiment 1 participated in Experiment 2. RHD 3 and 4 were no longer interested in participating and RHD 7 and 9 were deceased. These four subjects were replaced and the resulting group had a mean age

TABLE II

*Subject Information for the New RHD Patients*

| Subject | Age (years) | Education (years) | Sex | Site of lesion (acc. to CT scan and/or neurological report) |
|---|---|---|---|---|
| RHD | | | | |
| 12 | 41 | 9 | F | Right middle cerebral artery |
| 13 | 65 | 12 | F | Information not available |
| 14 | 65 | 13 | F | Right internal capsule, right basal ganglia |
| 15 | 65 | 9 | F | Right middle cerebral artery |

of 68 and a mean level of education of 11. As in Experiment 1, all subjects were right-handed, native English speakers, with normal hearing. The new RHD subjects[2] were also screened on the battery of tests described in Experiment 1 with the following results: All subjects presented with deficits in both the comprehension of figurative language and the generation of inferences. Two subjects (13 and 15) presented with left neglect.

See Table II for subject information on the four new RHD subjects.

*Stimuli and Procedure*

The stimuli were the same as those used in Experiment 1. Stimuli were presented to subjects at a rate of speech compressed to 60% of normal. All other procedures were identical to those used in Experiment 1. The two experiments were separated by approximately one year.

## *Results*

A 2 × 3 × 3 (Group × Position × Context) analysis of variance with both subjects (F1) and items (F2) as random factors was performed on the mean reaction times. Reaction times greater than 5 seconds were automatically timed out and not included in the analysis. As well, extreme reaction times, defined as those greater than 2 standard deviations from the mean, calculated per subject, per condition, were also not included in the analysis.[3] This resulted in the exclusion of 1.8% and 3.2% of responses by the NC and RHD groups, respectively. All pairwise comparisons were done using the Newman-Keuls procedure ($p < 0.05$).

Figure 3 shows the mean reaction times to target words by Position and Context for each group under the 60% compressed rate of speech condition. The analysis revealed significant main effects of both Position [$F1\ (2, 34) = 8.07$, $p < 0.01$; $F2\ (2, 81) = 38.11$, $p < 0.01$; min $F'\ (2, 49) = 6.66$, $p < 0.01$] and Context [$F1\ (2, 34) = 6.10$, $p < 0.01$; $F2\ (2, 81) = 2.45$, $p = 0.09$]. Pairwise comparisons of the means revealed that reaction times were slower to target words in the beginning position (mean = 673 ms) than to those in both the middle and end positions (means = 479 and 465 ms, respectively) which did not differ from each other. Reaction times to target words were also faster under the normal (mean = 493 ms) than under the anomalous (mean = 553 ms) and

[2] Due to an oversight, screening tests for RHD 14 were not administered.

[3] It was noted that RHD 8 had an inordinate amount of timed out values under the A and R conditions across all positions. As this resulted in as few as 2-5 responses for these conditions, this subject's data were not included in the analysis.

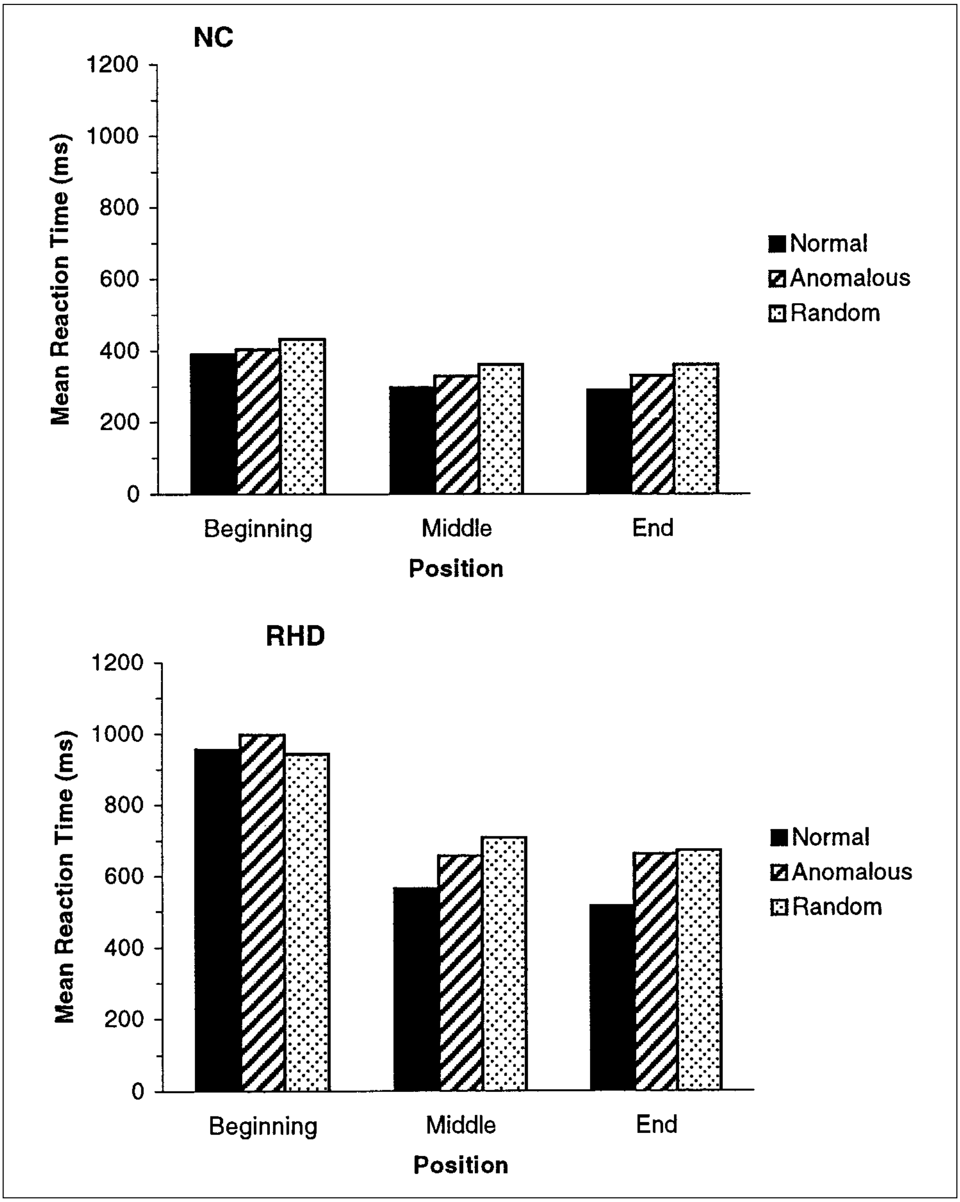


Fig. 3 – *Mean reaction times (ms) to target words by Position and Context under the 60% compressed rate of speech condition.*

random (mean = 570 ms) context conditions, which did not differ from each other. No interactions were significant.

Inspection of the individual data revealed that the effect of Position was quite robust. The finding of slower reaction times to targets at the beginning of sentences compared to both the middle and end positions was found for 90% of the subjects in the NC group and 100% of subjects in the RHD group. The effect of semantic context (N < A) was also extremely robust, demonstrated by 90% of the NC group and 89% of the RHD group.

### *Discussion*

Experiment 2 was conducted in an effort to determine whether the normal performance of the RHD patients in Experiment 1 was due to the limited task demands of the 70% compressed speech condition. The results of Experiment 2 indicate that both NC and RHD individuals continue to demonstrate an effect of semantic context at a rate of speech compressed to 60% of normal. This result suggests that the failure to find an absent or reduced facilitory effect of semantic context by RHD individuals in Experiment 1 is not likely attributable to the task not being sufficiently demanding so as to exceed available processing resources. In fact, decrements in language comprehension and recall performance have been shown, even with young normal adults, at compression rates of 68%; compression much beyond 60% renders processing quite difficult, even for such young health individuals (e.g., Wingfield and Ducharme, 1999). On the other hand, one can never be certain to what extent the demands of a particular task interfere with normal processing, and this is, indeed, the challenge of conducting such studies. On-going investigations are attempting to address these issues using a dual task paradigm. Dual tasks involve simultaneously engaging the subject in a second unrelated task that presumably invokes the same processing resources, while performing the experimental task. They are believed to increase processing demands in that both tasks are competing for a limited set of shared processing resources (Bower and Clapper, 1989).

## General Discussion

Two experiments were conducted with the purpose of investigating the effect of compressed speech on the ability of RHD individuals to use contextual information to monitor for words in sentences. Contrary to the hypothesis that RHD individuals would have difficulty in context use under conditions of increased processing demands, the effect of compressing the rate of speech to 70% (Experiment 1) and then 60% (Experiment 2) of normal did not in any way influence the facilitory effect of semantic context. Both groups continued to have faster reaction times to target words presented in normal versus anomalous sentence contexts. To the extent that we can assume that the task of using compressed speech was sufficiently burdening to the system of RHD individuals[4], it seems reasonable to presume based on these results that RHD patients are *not* selectively vulnerable to context use in tasks that promote effortful processing.

However, before entirely abandoning the suggestion that the RH is

[4] One additional piece of evidence in support of the increased task demands is the finding in both experiments that, with compressed speech, the effect of syntax (i.e., A < R) no longer emerged for either group of participants. The absence of this normally robust effect suggests that the increased speed of processing may have surpassed even the normal individuals' capacities.

specialized for context use (Cook, 1989; Cook and Beech, 1990; Gardner et al., 1983), an important distinction needs to be made in terms of the type of contextual information provided by the stimuli used in this experiment. Fraunfelder and Tyler (1987) have proposed that there are at least two types of linguistic contexts – "structural" contexts and "nonstructural" contexts. Structural contexts are thought to contribute to the construction of a higher linguistic unit such as a sentence. They are, therefore, important in message level (semantic/syntactic) contextual integration. Nonstructural contexts, on the other hand, refer more to the development of meaning associations between words as they are processed. They are not thought to necessarily contribute to the development of a higher linguistic unit (Fraunfelder and Tyler, 1987). However, when embedded within a discourse, nonstructural contexts can, conceivably, contribute to the construction of overall discourse structure, or macrostructure, through the establishment of semantic relationships. With regard to the present experiment, it can be argued that the stimuli in the normal context condition represented structural contexts, with the target words completing integrated syntactic/semantic units.

The relevance of this distinction to the discussion of laterality issues regarding context use is found in visual field studies of normal brain functioning. Faust and her colleagues have found evidence to suggest that it is the LH, not the RH, that is critical for message level contextual integration (Faust, 1998; Faust, Babkoff and Kravetz, 1995; Faust and Kravetz, 1998). For example, using a lexical decision task, Faust et al. (1995) found greater facilitation for sentence primes than for single word primes when the stimuli were presented to the right visual field (RVF) (i.e., the LH), but not when presented to the LVF (i.e., the RH). Similarly, in a second experiment, they found that normal sentences primed lexical decisions more than did scrambled sentences when presented to the RVF, but not the LVF. If, therefore, the integrity of the LH is, indeed, important for using syntactic/message level contextual constraints, it is not surprising that RHD patients in the present investigation, who presumably have an intact LH, benefited from the integrated syntactic/semantic context found under the normal context condition.

The question remains as to whether the RH plays a unique role in context use. Once again, evidence from visual field studies with normals suggests that indeed it does. It appears that the RH is important in the use of nonstructural contextual information (Beeman, 1993, 1998; Beeman, Friedman, Grafman et al., 1994; Chiarello, 1998; Faust, 1998; Titone, 1998). Specifically, it has been proposed that the RH is involved in activating and maintaining peripherally related meaning associations between words. Beeman (1993, 1998; Beeman et al., 1994) refers to this process as "coarse semantic coding" – the weak activation of large, peripherally related semantic fields – which can be contrasted with the LH advantage for "fine semantic coding" – the strong activation of more restricted semantic fields – which allows the LH to quickly zero in on context-appropriate meanings during processing. Evidence to support this view is found in a number of studies. Burgess and Simpson (1988), for example, investigated cerebral asymmetries in the processing of ambiguous words. They used a lexical decision task with left and right visual field presentation of target words related to ambiguous primes at two different stimulus onset asynchronies (SOA). Results indicated that under RVF (LH) presentation, both the dominant and subordinate meanings were activated at the shorter SOA with a sharp decline in activation of the subordinate meaning at the longer SOA. In contrast, under LVF (RH) presentation, activation of both the subordinate and dominant meanings remained at the longer SOA, with, in fact, greater facilitation of the subordinate meaning at the longer compared to the shorter SOA. These results were interpreted to suggest that while the RH maintains activation of meaning associations (in this case, both the subordinate and dominant meanings of ambiguous words), the LH quickly chooses a preferred meaning (i.e., the dominant meaning).

Beeman et al. (1994) have also found support for maintenance of peripheral meaning associations in the RH using a summation priming paradigm. Using divided visual field presentation, subjects were presented with three consecutive primes that were either peripherally related (e.g., *foot, cry, glass*) or unrelated (e.g., *dog, church, phone*) to a target word (e.g., *cut*) that was to be named. A summation priming effect (i.e., better accuracy in naming target words when preceded by summation primes versus unrelated primes) was found to be greater when stimuli were presented to the LVF (RH) as compared to the RVF (LH). Similar results have been reported by Titone (1998) using sentence primes. In one experiment, sentence contexts biased *central* semantic features of subordinate meanings of ambiguous words (e.g., "*Because it featured a great orchestra, they really liked the ball*"). In a second experiment, the sentence contexts biased *peripheral* semantic features of subordinate meanings of ambiguous words ("*Because it lasted the entire night, they really liked the ball*"). The results indicated that when the sentence context biased central semantic features of subordinate meanings, both the left and right hemispheres showed subordinate meaning activation; however, only the RH evidenced contextually appropriate activation of subordinate meanings when the biasing sentence context highlighted peripheral semantic features.

To summarize, a number of investigations have found evidence to suggest that the RH is important in the activation and maintenance of peripheral meaning associations between words (e.g., Beeman et al., 1994; Chiarello, 1998; Titone, 1998), whereas the LH appears to be more specialized for quickly inhibiting contextually inappropriate meanings and zeroing in on preferred, contextually appropriate interpretations (e.g., Burgess and Simpson, 1988; Faust et al., 1995; Faust and Kravetz, 1998; cf. Tompkins, Baumgaertner, Lehman et al., 2000). Such a model of hemispheric specialization for language processing suggests that while the LH is certainly most efficient for linguistic processing, the RH contributes to the detection and integration of more subtle meaning relationships that may, in turn, be used in such discourse-level tasks as the generation of inferences and the interpretation of metaphors (Beeman, 1998; Beeman et al., 1994; Chiarello, 1998).

Returning to the results of the present investigation, a number of conclusions may be drawn. First and foremost, consistent with our previous work (Leonard and Baum, 1998; Leonard et al., 1997a, 1997b), the results of this study represent yet another demonstration of the ability of RHD individuals to use a given type of contextual information, even under conditions of increased processing demands. An important consideration that has emerged from these results, however, is that not all contexts are created equal. It may, in fact, be the case that demonstrations of context use by RHD patients thus far and, in particular, with respect to the present investigation, may be related to the fact the stimuli used supported a structural context. Importantly, therefore, future studies must control for structural versus nonstructural contexts in attempting to delineate the specific role of the RH in context use. Additionally, manipulation of this factor in studies with brain-damaged individuals will represent an attempt to integrate the findings of normal hemispheric function that have been collected in visual field studies with the performance of brain-damaged individuals. While, admittedly, studies of normal versus pathological functioning do not necessarily tap the same processes, any model of hemispheric specialization for language processing must accommodate evidence from both domains.

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