Accuracy and Response Times for Semantic Judgments and Lexical Decisions with Left- and Right-hemisphere Lesions

Joan C. Arvedson and Malcolm R. McNeil
University of Wisconsin, Madison, Wisconsin

Semantic-lexical processing appears vulnerable in both aphasic and nonaphasic brain-damaged persons. The extreme variability seen within and across linguistic domains in the aphasic person has led to the contention that an accessing or interference phenomenon may underly these deficits. McNeil (1983) suggested that an explanation for the variability may include disordered attentional processes. Kahneman (1973) had proposed the construct of attention as a capacity-limited system. The basic premise is that the human system has a pool or possibly several pools of available resources or attention, which are limited in quantity. These resources must be allocated on the basis of the needs of the entire system. A limited capacity theory suggests that there is a ceiling to the amount of effort which an individual can allocate to a particular task. This is important because most activities require the processing of multiple simultaneous stimuli, and these stimuli often compete for the available limited capacity. Task competition is at the core of limited capacity theories (Copher, Brickner, and Navon, 1982). If comparable performance can be shown in some optimal conditions, then differences in performance within the same task but with competition for resources may yield information pointing toward potential underlying mechanisms for performance in those tasks. In order to determine if resources could be shared for some components of the linguistic system, we chose specific semantic judgment and lexical decision tasks presented in binaural auditory processing conditions.

METHOD

The semantic judgment task consisted of 3 categories (fruit, fish, flower) taken from the norms for verbal items presented by Battig and Montague (1969) with 60 in-class and 60 out-of-class words spoken by a woman. The lexical decision task consisted of 60 nonwords and 60 real words, 30 abstract and 30 concrete, taken from the set of 925 nouns scaled for concreteness, imagery, and meaningfulness by Paivio, Yuille, and Madigan (1968) spoken by a man. Semantic judgment and lexical decision items were paired so that the two utterances in each pair were equal in duration. Examples of the types of lexical decisions paired with semantic judgment items are shown in Table 1. The words and nonwords were audiotape-recorded, then computer digitized (VOCAL Manipulation Program for Utterance Tape Production on a Harris 6024/5 computer, Waisman Center Research Computing Facility, June, 1981). The utterances were trimmed and onsets were aligned. The two items in a pair differed in total duration by no more than 25 msec. The paired items were recorded on audio cassette tape for binaural presentation. In the experimental conditions, the subjects heard two different items simultaneously. The different words for each task, spoken by the man and the woman were heard in both ears at the same time through earphones. For each separate condition reported here, subjects focused their attention on one speaker and responded to that speaker only.

Table 1. Examples of stimulus items.

SEMANTIC JUDGMENT (Female Voice)			LEXICAL DECISION (Male Voice)	
Category	Example		Example	Type
Fruit	apple	-	valley	concrete
	banana	-	interim	abstract
	lemon	-	mekrosp	nonword
Fish	perch	-	chair	concrete
	salmon	-	blandness	abstract
	tuna	-	sutdel	nonword
Flower	aster	-	cabin	concrete
	gladiola	-	pacifism	abstract
	marigold	-	fasitad	nonword

For the lexical decision task, subjects were instructed to say YES as quickly as possible when they heard the man say a real English word, and NO when they heard a nonword. For the semantic judgment task, they said RIGHT when the woman said an in-class category item and WRONG for an out-of-class item.

There were three groups (Table 2), 10 left-hemisphere lesion aphasic subjects (LH), 10 right-hemisphere lesion nonaphasic subjects (RH), and 10 non-brain-damaged control subjects (C).

Table 2. Biographical data.

Group		Age (years)	Education (years)	Months post onset
Left Hemisphere Lesion				
	$\bar{x}$	60	14	41
	Range	(25-72)	(9-17)	(8-156)
Right Hemisphere Lesion				
	$\bar{x}$	66	10	28
	Range	(42-85)	(8-17)	(2-156)
Control				
	$\bar{x}$	59	14	
	Range	(24-77)	(11-19)	

Descriptive testing was done with all subjects (Table 3). The aphasic subjects were mild to moderately impaired and best classified as 4 anomic, 4 Wernicke, and 2 mixed aphasia. The descriptive test data separated the groups on the basis of usual and customary clinical assessments which are differentially sensitive to aphasia and other pathological entities.

Table 3. Descriptive test data.

	RTT	PICA	RAVENS	BDAE Aud.	BDAE Repet.	Aphasia type
LH	12.9	13.8	30.4	110.7	18.6	Anomic-4 Wernicke-4 Mixed-2
RH	14.5	14.4	19.2	116.4	25.5	
C	14.8	14.8	31.7	118.7	26.0	

Note. RTT - Revised Token Test, PICA = Porch Index of Communicative Ability, BDAE - Boston Diagnostic Aphasia Evaluation.

I will report findings for three research questions which were preliminary questions for a larger study (Arvedson, 1986):

1. Are there significant differences among left-hemisphere lesion aphasic subjects, right-hemisphere lesion nonaphasic subjects, and non-brain-damaged control subjects for single response semantic judgment accuracy and response times in a focused attention condition?
2. The second question is essentially the same except for lexical decision accuracy and response items.
3. Are there significant group differences between the semantic judgment and lexical decision tasks? Is there a significant group by task interaction?

Subjects were required to get at least 60% correct on a pretest for eligibility into the study (Table 4). During this pretest, the semantic judgment task was presented in a dichotic format. Although the aphasic group had poorer accuracy than the other two groups (Figure 1), the 92% mean of the aphasic group reflects a nearly intact ability to make semantic judgments. The lexical decision task was presented with no competing signal. The groups did not differ significantly and all were well above the 60% minimum. All three groups had poorer accuracy for lexical decisions than for semantic judgments in the pretest conditions.

For the experimental tasks, the subjects were informed that they would hear two different words in both ears at the same time. The woman would say a word, either in-category or out-of-category, for the semantic judgment task. The man would say either a real word or a nonword for the lexical decision task. For example, apple in the woman's voice would be heard at the same time as valley in the man's voice. For each task, subjects were instructed to give all of their attention to one speaker and to ignore the other. That is, for the semantic judgment task, subjects were told to give

Table 4. Pre-test accuracy (percent correct).

	Semantic Judgment (two messages)		Lexical Decision (one message)	
Group	%	S.D.	%	S.D.
LH	92.3%	(5.0%)	85.5%	(3.1%)
RH	97.9%	(2.2%)	82.7%	(7.1%)
C	97.5%	(2.0%)	87.0%	(4.3%)

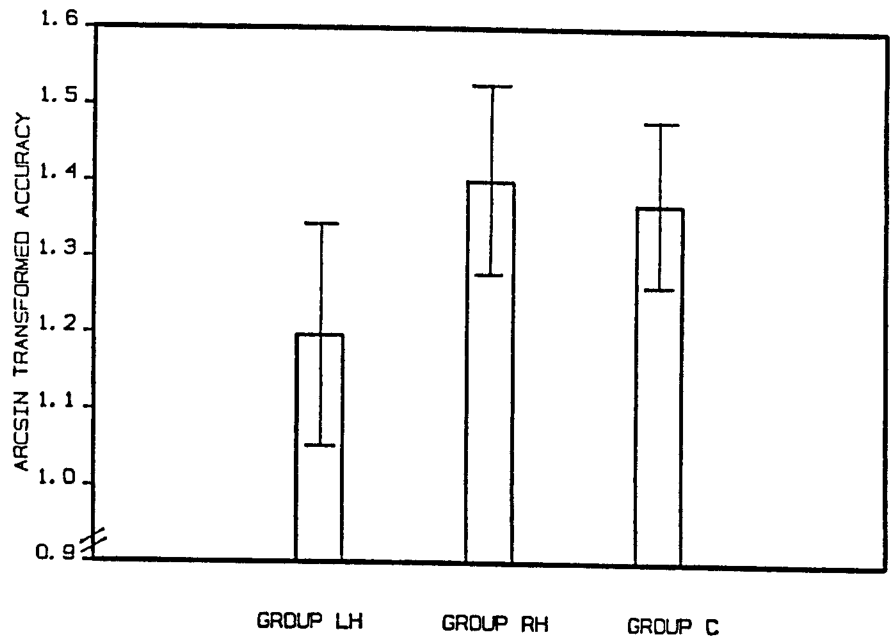

Figure 1. Semantic judgment accuracy: Two messages, one response.

all of their attention to the woman and ignore the man, and to answer right or wrong as fast as possible. The order of task presentation was counter-balanced across subjects in each group.

RESULTS AND DISCUSSION

The percent correct group accuracy means and standard deviations are shown in Table 5 for both tasks. The aphasic group (LH) had the lowest mean for semantic judgments. For lexical decisions, both brain-damaged groups had similar means, which were lower than the non-brain-damaged group. The subject means were arcsin transformed for data analysis.

Response times (RT) were measured in milliseconds from voice onset of stimulus word to voice onset of response (Table 6). The aphasic group (LH) had the longest response times for both tasks. The semantic judgment RTs of the aphasic group were longer than the RTs for lexical decisions. The

Table 5. Experimental accuracy (percent correct).

	Semantic Judgment		Lexical Decision	
Group	%	S.D.	%	S.D.
LH	81.9%	(8.0%)	73.0%	(5.0%)
RH	88.1%	(5.2%)	72.6%	(5.4%)
C	90.9%	(4.8%)	79.9%	(5.9%)

response times were log transformed. These transformed data were submitted to a series of Analyses of Variance with repeated measures. Alpha level of .05 was set for each analysis.

Table 6. Response times (milliseconds).

	Semantic Judgment		Lexical Decision	
Group	Msec	S.D.	Msec.	S.D.
LH	1805.9	(532.6)	1648.5	(310.2)
RH	1524.8	(327.5)	1580.2	(408.8)
C	1389.9	(227.0)	1377.9	(195.6)

Results and discussion for each separate question will be presented. A summary discussion will follow. Question 1 related to semantic judgments. There was a significant effect for accuracy, $F(2,27) = 3.96$, $p < .05$. Tukey post-hoc pairwise comparisons of mean group differences revealed that responses of the aphasic group were significantly less accurate than those of the non-brain damaged group (Figure 2). The right-hemisphere lesion group did not differ significantly from either of the other two groups. The finding that the aphasic group had significantly poorer overall accuracy for semantic judgments than the control group was expected since numerous reports have described semantic deficits in aphasic persons (e.g., Poeck, K., Kerschensteiner, M., and Hartje, W., 1972; Butterworth, B., Howard, D., and McLaughlin, P., 1984). The finding that the right-hemisphere lesion group did not differ significantly from the aphasic group led to consideration that as the irrelevant stimuli became more intrusive, the side of lesion or presence of aphasia seemed less critical than the fact that brain damage had occurred.

There was a significant effect for response times, $F(2,27) = 4.07$, $p < .05$. The aphasic group had significantly longer overall response times for semantic judgments than the non-brain-damaged group (Figure 3). The longer vocal RTs by the aphasic group could be attributed in part to a mild

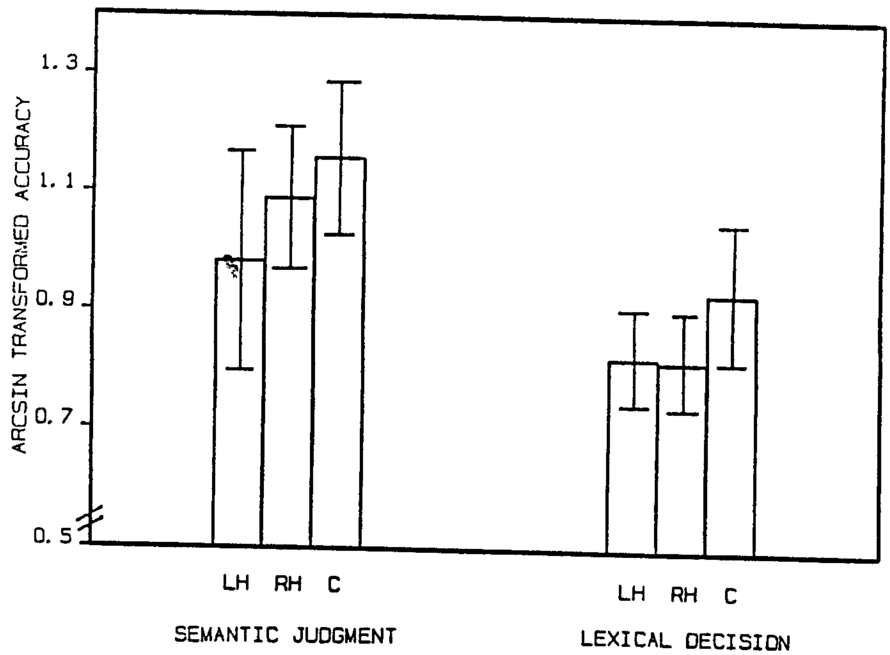

Figure 2. Accuracy for single response: Semantic judgment and lexical decision.

apraxic component for two subjects in that group. Another possibility could be that the vocal response is prcgrammed primarily by the left hemisphere (Kimura and Archibald, 1974) so that persons with left cerebral hemisphere lesions may require more time to make a vocal response than persons with right hemisphere lesions when auditory linguistic decisions are required. Riege, Klane, Metter, and Hanson (1982) found that vocal recognition responses were slower in both left- and right-hemisphere lesion stroke patients than in non-brain-damaged subjects. In addition, they found that their left-hemisphere lesion subjects responded "yes" and "no" reliably slower than their right-hemisphere lesion subjects. The fact that the right-hemisphere lesion group did not differ significantly from the aphasic group lends support for information processing or decision making factors resulting in delayed responses, rather than delays in actual response production.

In addition to overall response time analyses, the log transformed response times were tabulated on the basis of whether they were a hit, miss, correct rejection, or false alarm. Semantic judgment response times for the groups combined are shown in Figure 4. There was a significant Category by Accuracy interaction, $F(1,27) = 5.83$, $p < .05$. There was no significant three-way interaction involving groups. Tukey post-hoc testing of means revealed that for all three groups in-category correct responses (hits) were significantly shorter than out-of category correct responses (correct rejections), and shorter than both error response types (misses and false alarms). The out-of-category correct rejections were also significantly shorter than both types of error responses. The two types of error response times did not differ significantly from each other. Other investigators have reported that persons respond faster on correct responses than

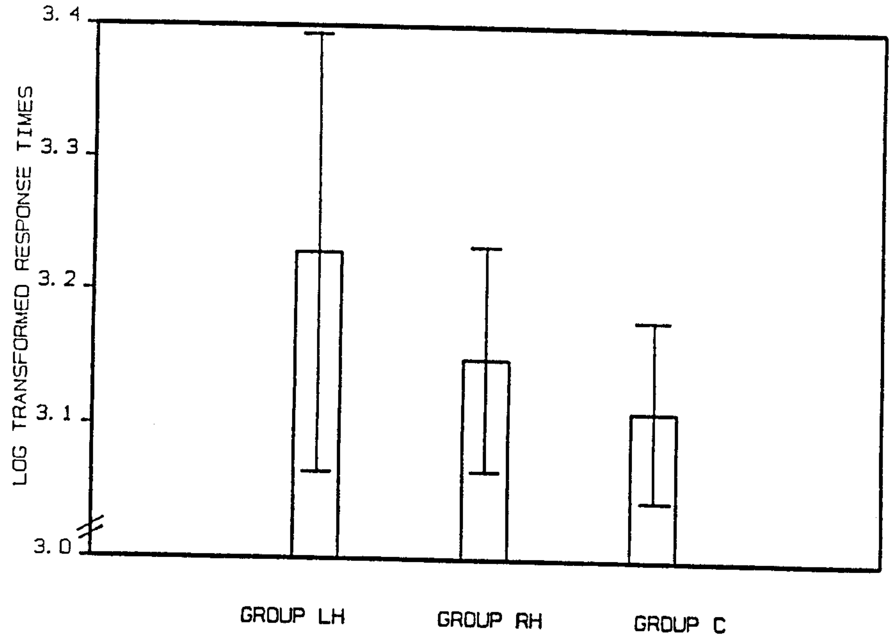

Figure 3. Semantic judgment response ti in single response condition.

on incorrect responses (e.g., Riege et al., 1982) and on target responses compared with non-target responses (e.g., Bradshaw and Nettleton, 1983). In the present study, all three subject groups made correct responses faster than error responses, and target responses faster than non-target responses. The correct target responses were significantly faster than all other response types for all three subject groups.

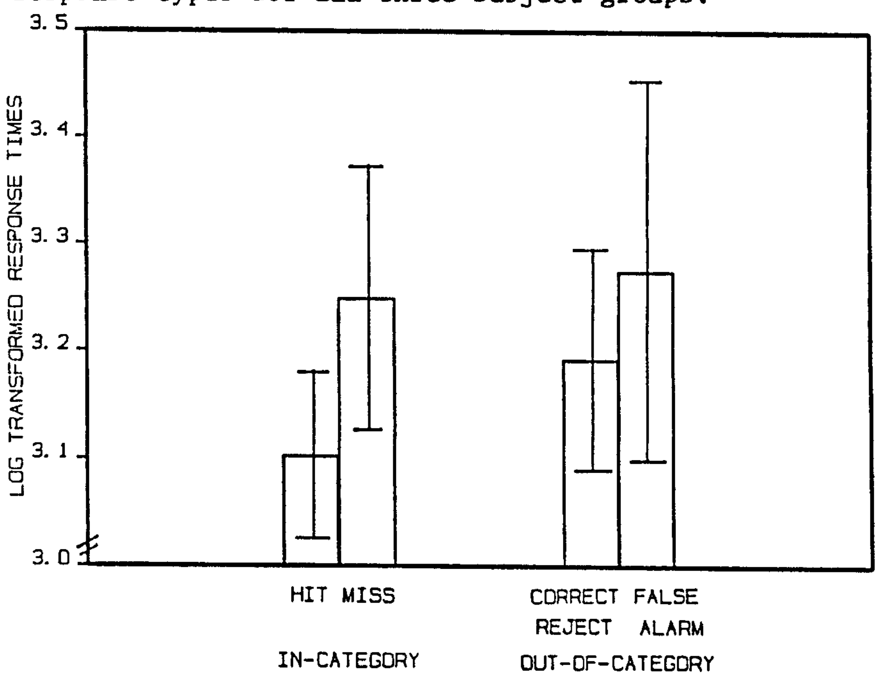

Figure 4. Semantic judgment single respons times for groups combined.

Results for Question 2 revealed a significant effect for accuracy in the lexical decision task, $F(2,27) = 4.02$, $p < .05$. Both brain damaged groups had significantly poorer overall accuracy than the non-brain-damaged group (Figure 2). The two brain damaged groups did not differ significantly from each other. The finding that both brain damaged groups had significantly poorer accuracy for lexical decisions compared with the non-brain-damaged control group, but did not differ significantly from each other, has some support (e.g., Zaidel, 1976; Gainotti, Caltagirone, Miceli, and Masullo, 1981). The comparable accuracy by all three groups when the lexical decision task was presented with no other distractors demonstrated that the pathological groups had not lost competence or knowledge for auditory processing of lexical decisions. In the binaural presentation, the actual task remained the same, although the difficulty was increased with the requirement for focused attention to one speaker in the presence of another speaker. This significant reduction in accuracy for the brain damaged groups compared to the non-brain-damaged control group points to possible disruption in information processing.

The accuracy of the three types of lexical decisions was examined separately from the overall accuracy (Figure 5). The Group by Type interaction was significant, $F(4,54) - 5.56$, $p < .05$. All three groups had poorer accuracy for abstract words than for concrete words. The higher accuracy for concrete words than for abstract words fits with past reports (for example, James, 1975; Bradley and Garrett, 1979) that concrete words are recognized better than abstract words when heard in competing conditions by non-brain-damaged persons. It was expected that concrete words should also be recognized better than abstract words for brain-damaged persons regardless of side or site of lesion. The aphasic group had its poorest accuracy for non-words, which was significantly poorer than the other two groups. The right-hemisphere lesion group and the non-brain-damaged group had their best accuracy for nonwords. Those two groups did not differ significantly from each other. The right-hemisphere lesion group had significantly poorer accuracy for abstract words than either of the other two groups. That finding was contrary to expectations for subjects with right hemisphere lesions, and not readily explainable. The comparable accuracy to the other two groups when there was no competition seems to be evidence that the right-hemisphere lesion group recognized the abstract words at least to the level of the other two groups. With binaural presentation of signals, perhaps the right-hemisphere lesion group had more difficulty than the other two groups in inhibiting the competing signal (e.g., the concrete noun in the semantic judgment task) which was paired with the abstract word. The semantic judgment task may have received some mandatory processing (e.g., Chiarello, 1985) by the right-hemisphere lesion group which interfered with the allocation of resources for the abstract words to a significant degree.

There were no significant group differences for overall response times. The lack of significant response time differences among the groups provides evidence that slowed decision or response times are not necessarily a consequence of brain damage in conditions when rapid vocal responding is stressed. The response times for the three types of lexical decisions are shown in Figure 6. There was not a significant group effect. There was a significant Type by Accuracy interaction, $F(2,54) = 18.71$, $p < .05$. The correct responses (hits) for concrete words were significantly shorter than both correct and error responses to abstract words and nonwords. In addition, the abstract word correct responses (hits) were significantly shorter than error responses (misses) for both abstract words and concrete words. These findings also supported the Riege et al. (1982) findings for faster correct responses, and the Bradshaw and Nettleton (1983) findings for faster target responses.

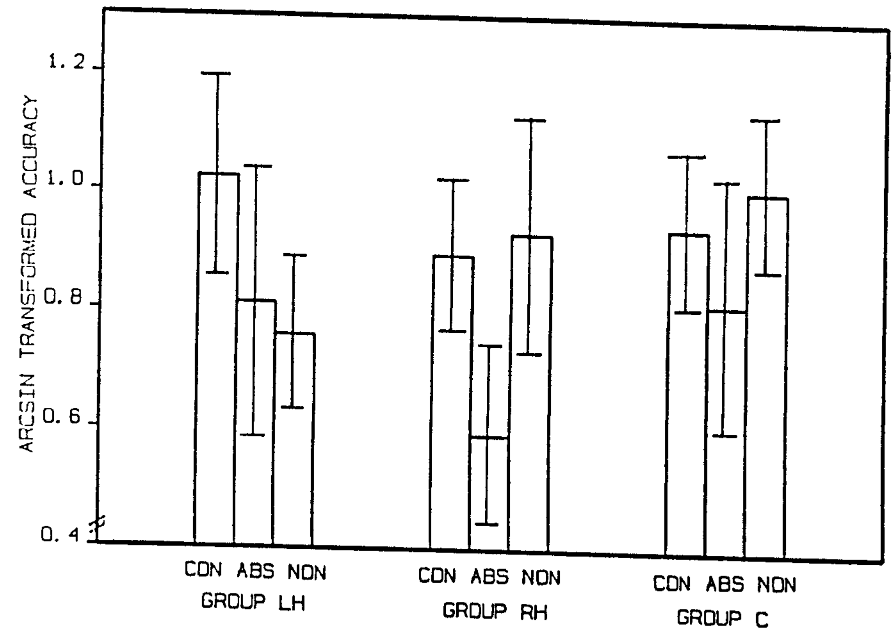

Figure 5. Lexical decision accuracy in single response condition.

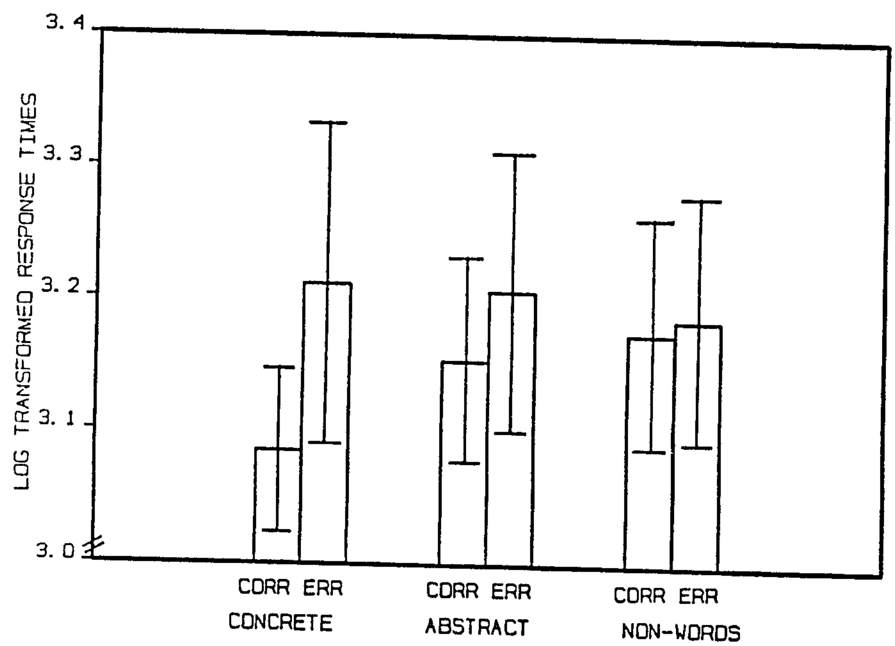

Figure 6. Lexical decision single respons times for groups combined.

Question 3 compared the two tasks. There were significant effects for Group, $F(2,27) = 5.34$, $p < .05$, and for Task, $F(1,27) = 95.41$, $p < .05$. All three groups showed significantly poorer overall accuracy for lexical decisions than for semantic judgments (Figure 2). There was no significant Group by Task interaction. Possible reasons for the poorer accuracy in the lexical decision task may include; (1) the non-words in the lexical decision task were all pronounceable, making them potential real words, (2) the number of potential real words encompasses one's entire lexicon, but the number of category nouns is limited.

Although there was a significant difference between the two tasks for accuracy, there was no significant difference between the two tasks for overall response times. The reduced accuracy by the two pathological groups for the lexical decision task was not accompanied by significantly longer response times as had been found for the aphasic group in the semantic judgment task. A speed-accuracy trade-off was not evident for the two tasks in focused attention conditions when overall response times were examined. The absence of a significant interaction involving groups indicates that the hierarchy of response times was the same for each group.

In summary, the lack of dissociations among the groups adds support for the concept of an aphasic-to-normal continuum, as suggested by McNeil (1982) or perhaps better stated as a brain-damage-to-normal continuum for at least some difficult auditory linguistic processing tasks. In general, the similarities between the two brain damaged groups when focused attention was required leads to speculation that extensive bilateral regions of the brain may be involved with auditory linguistic processing. Their significantly reduced accuracy compared to the non-brain-damaged control group in the presence of irrelevant stimuli supports an information processing model suggesting an interference or an accessing deficit rather than a loss phenomenon. A resource allocation model predicts that as competition increases for a task, more resources are needed and must be shared for that task. McNeil (1983) proposed that a deficit in attention and resource allocation is consistent with the performance deficits found in both right-hemisphere lesion nonaphasic and left-hemisphere lesion aphasic persons. The dynamic nature of auditory linguistic processing, along with the dynamic processes in neural reorganization which may be occurring following brain damage, lead to the expectation that the brain damaged groups would function at a reduced level of efficiency but in similar ways to the non-brain-damaged group. Thus, a model of resource allocation provides a framework to motivate further research which may eventually have an impact on clinical assessment and treatment methods.

ACKNOWLEDGMENT

This work was part of a dissertation submitted to the Graduate School of the University of Wisconsin-Madison by the first author in partial fulfillment of the requirements for a doctorate in the Department of Communicative Disorders. The authors would like to thank the following institutions in Madison, Wisconsin, for assistance in acquiring subjects for this study: St. Marys Hospital Medical Center, Visiting Nurse Service, Methodist Hospital, Jackson Clinic, and Madison General Hospital.

REFERENCES

Arvedson, J. Effect of lexical decisions on auditory semantic judgments using divided attention in adults with left and right hemisphere lesions. Doctoral dissertation, University of Wisconsin, 1986.

Battig, W.F. and Montague, W.E. Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. Journal of Experimental Psychology Monograph, 80, 1-48, 1969.

Bradley, D. and Garrett, M. Effects of vocabulary type in word recognition. Cognition, 7, 10, 1979.

Bradshaw, J.L. and Nettleton, N.C. Human Cerebral Assymetry. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1983.

Butterworth, B., Howard, D., and McLaughlin, P. The semantic deficit in aphasia: The relationship between semantic errors in auditory comprehension and picture naming. Neuropsychologia, 22, 409-426, 1984.

Chiarello, C. Hemisphere dynamics in lexical access: Automatic and controlled priming. Brain and Language, 26, 146-172, 1985.

Gainotti, G., Caltagirone, C., Miceli, G., and Masullo, C. Selective semantic-lexical impairment of language comprehension in right-brain-damaged patients. Brain and Language, 13, 201-211, 1981.

Gopher, D., Brickner, M., and Navon, D. Different difficulty manipulations interact differently with task emphasis: Evidence for multiple resources. Journal of Experimental Psychology: Human Perception and Performance, 8, 146-157, 1982.

James, C.T. The role of semantic information in lexical decisions. Journal of Experimental Psychology: Human Perception and Performance, 104, 130-136, 1975.

Kahneman, D. Attention and Effort. Englewood Cliffs, NJ: Prentice-Hall, 1973.

Kimura, D. and Archibald, Y. Motor functions of the left hemisphere. Brain, 97, 337-350, 1974.

McNeil, M.R. Aphasia: Neurological considerations. Topics in Language Disorders, 3(4), 1-19, 1983.

McNeil, M.R. The nature of aphasia in adults. In N.J. Lass, L.V. McReynolds, J.L. Northern and D.E. Yoder (Eds.), Speech, Language and Hearing, Vol. II. Philadelphia: W.B. Saunders Company, 1982.

Paivio, A., Yuille, J.C., and Madigan, S.A. Concreteness, imagery, and meaningfulness values for 925 nouns. Journal of Experimental Psychology Monograph Supplement, 76, 1-25, 1968.

Poeck, K., Kerschensteiner, M., and Hartje, W. A quantitative study on language understanding in fluent and nonfluent aphasia. Cortex, 8, 299-304, 1972.

Riege, W.H., Klane, L.T., Metter, E.J., and Hanson, W.R. Decision speed and bias after unilateral stroke. Cortex, 18, 345-355, 1982.

Zaidel, E. Auditory vocabulary of the right hemisphere following brain bisection or hemidecortication. Cortex, 12, 191-211, 1976.

DISCUSSION

Q: In the procedures, the subjects had to respond with yes and no and right and wrong which are semantically related words. Did you see if brain damaged people respond with those answers slower than normal people? Do they access the word right just when they want it and the word wrong as fast as normal people do?

A: There were significantly slower response times for the aphasic group in the single response semantic judgment task requiring the right and wrong responses compared to the right-hemisphere lesion group and the normal group. The latter two groups did not differ from each other. There were no significant differences in response times among the three groups for the lexical decision task which required yes and no responses. I think one of the useful things to follow up with this study would be to reverse those answers for the two tasks to determine if there was something different about those two responses. Does using right or wrong, which is probably less commonly used than yes or no, make a difference? The reason I used the two different responses was because the major questions in the study required two responses, so we had to distinguish responses to the two different tasks. I struggled a long time with what are the better kinds of responses -- manual vs vocal, and then what to use as a vocal response. I think your question about the possibility of something different about using right or wrong vs yes or no is a good one. I would like to follow up on that.

C: I think that we see some aphasic patients who have problems saying yes when they mean yes and no when they mean no and occasionally hesitate a little bit and somehow have to reassure themselves that they are saying the right word. Maybe a manual affirmation would be easier for them.

A: Because I used subjects with both left and right hemiparesis, I felt that a manual response would result in additional complications in interpretation. Self-corrections were allowed here too so that the response times reflected that. At times some of the aphasic subjects did say "right, no, I mean wrong." That had to be taken into account.

Q: Can you talk about where this kind of research, and your study is one in a series of studies completed according to certain similar notions, takes us clinically? Do these kinds of observations suggest a set of strategies or an approach to rehabilitation of brain damaged people that you'd like to talk about?

A: I'd like to give you just a little bit of information about my findings in dual task conditions and then make a leap to clinical relevance. I think potentially there is some very relevant clinical information here. The reason that I used two tasks was to see what effect would occur on the responses to the semantic judgment task when they were paired with the lexical decision task which was varied in difficulty. My original hypothesis was that semantic judgment accuracy would be reduced and response times would be longer when those items were paired with abstract lexical decisions. If you really think about the concept of limited capacity, then abstract words should take more processing capacity to decide "Is this a real word?". Abstract words are less imageable and familiar. That was the way my original prediction had been made. In fact, what occurred was that semantic judgments paired with concrete words had significantly reduced accuracy and significantly longer response times in a condition in which the subjects were trying as hard as they could to get both tasks correct and also when they were concentrating 100% of their attention on semantic judgments, and just giving a guess to the lexical decision. At first I thought it didn't work. Then as I reviewed the literature more carefully and thought about it, this in fact makes more sense. It fits the cocktail party phenomenon that we are all familiar with. We will attend to something until there is something very familiar to us that in fact interferes with where our focus of attention is. So then I went back to look at the single response condition, which I reported here today, with respect to the pairing of the semantic judgments with the lexical decisions. Sure enough, the same thing happened. The responses for the semantic judgments paired with concrete words were poorer in accuracy and longer in response time than those semantic judgments paired with abstract words for all three groups. This finding occurred when subjects were not to be paying any attention to the lexical decision task. Both the left- and right-hemisphere lesion groups differed from the normal group by their reduced accuracy, but the two brain damaged groups did not differ significantly from each other.

The concept of mandatory processing that Chiarello (1985) and some other people talk about seems to fit into this very significantly.

When we think about the ways we treat our aphasic patients, most of the time we work with people in a quiet room relatively free of distractions. Perhaps we need to introduce irrelevant stimuli gradually and make some of it very salient, familiar irrelevant stimuli, to help those aphasic patients better able to cope with the real world. This is an extreme pairing of competition, but the real world is also full of competition. That is something that I certainly have not measured in any logical way yet at this point, but I think that thinking about that aspect can really have some direct clinical relevance.

The other thing is that when the system was stressed, the right-hemisphere damaged subjects looked very much like the left-hemisphere lesion aphasic subjects in this auditory processing task.

Q: Did your right-hemisphere lesion patients have neglect?

A: They did not have significant amounts of neglect.

C: The reason I asked that question is that most theories of neglect now look at it as an attentional deficit -- a deficit in directed attention, whether the stimulus is auditory, visual, olfactory or what. Anything where they have to focus and direct their attention to an external stimulus may present a difficulty. So I'm wondering just what effect directed attention might be an issue. Clearly there is a difficulty not just on one side, but those patients with left neglect have a deficit in directed attention to the right side as well. Maybe they are not having trouble with lexical processing, but they are just having trouble attending. Since you brought up the issue of attending, I thought that it's something to consider. Certainly it may play a role. You may see differences with the two different types of subjects.

A: It would be interesting to separate out the two groups of right-hemisphere lesion subjects to determine if there are differences between those with neglect and those without neglect.

Q: Your second conclusion was about the extensive auditory projections bilaterally. I think that recent work by Musiak supports that strongly. Both his evoked response research and his reviews come to the same conclusion, so it's nice to see independent support for totally different tracks to the same question. Your aphasic subjects, in fact all your subjects, seemed relatively mildly impaired. Please comment on why you chose patients which were mildly impaired and what impact their overall severity level might have on your results.

A: I chose aphasic subjects who were relatively mildly impaired because those who were more severely impaired could not meet the pretest criterion level of performance for participation in the study. I had to eliminate three left-hemisphere lesion aphasic potential subjects because they could not do the task. The right-hemisphere lesion subjects were taken as each became available, and I did not have to eliminate any of them for failure to meet the pretest criterion. I think that this particular dual task paradigm had very difficult tasks so that the more severe aphasic patient could not do the tasks. I have to be very cautious about generalizing results too much.

Q: Did you have any individual subjects who did not show the same general pattern?

A: They all showed the same pattern. I would have to go back and look at the individual subjects to be absolutely sure, but there was no outlier in any one of the groups.

Q: Did you have any one with anterior lesions? It looked like you had subjects with anomia, Wernicke's aphasia, and mixed.

A: The subjects with mixed aphasia had more extensive damage so that they could not be classified as either frontal or posterior. The CT scans showed more extensive damage. I did not have any strictly frontal patients. There were a couple with an apraxic component.