A Study of Imagery in Sentence Verification with Adult Aphasic Subjects

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Introduction

Many speech language pathologists have wondered about the impact on aphasia rehabilitation that may be related to the fact that, for most adults with aphasia, the right hemisphere remains structurally intact. Could the right hemisphere be a source of alternative modes of communication? Could the right hemisphere also be a resource for the purpose of improving language functioning in the damaged left hemisphere? This study is related to the latter speculation.

When these questions are posed in terms of cerebral function, the answers are largely speculative because related methods have been purely behavioural. Clinical investigators introduce a form of nonverbal processing or behaviour (e.g., music) into the manipulation of language behaviour. The most prominent example of this attempt at "intersystemic reorganization" is Melodic Intonation Therapy (MIT) (Sparks and Deck, 1986). Mechanistic explanation of results is based on the familiar finding that the left hemisphere is related to verbal functions and the right hemisphere is related to nonverbal functions such as music recognition and singing (Berlin, 1976; Helm-Estabrooks, 1983). With the right hemisphere also being associated with imagery, especially visual imagery, clinicians have wondered whether there might be applications similar to those achieved with MIT.

Background

Somewhat independently from neurological theory, cognitive scientists have developed theories of how the mind represents information in working memory. In cognitive psychology, the computation of these representations is called *encoding* with hypothesized mental formats referred to as *codes*. It has been generally proposed that the human cognitive system makes use of at least three coding formats, namely, a verbal code, an imagery code, and an abstract conceptual code that is formally described with propositions indicating relationships among concepts (Cohen, 1983). Basic to the notion of multiple codes is the *dual coding* theory which distinguishes between verbal and nonverbal (or imagery) codes (Paivio and Begg, 1981). This distinction corresponds with the well-documented and thoroughly reviewed functional asymmetry between the two cerebral hemispheres as to their apparent processing preferences (Beaton, 1985; Bryden, 1982; Segalowitz, 1983; Springer and Deutsch, 1985).

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When the right hemisphere is the experimental "subject" compared to the left hemisphere, it has been shown that the right hemisphere's functional specialization is not necessarily for the type of stimulus (i.e., verbal or nonverbal); but instead it is specialized for the mode of processing applied to the stimulus no matter what form the stimulus takes (e.g., Springer and Deutsch, 1985). In cognitive psychology, the distinction between stimulus format and encoding format has been demonstrated with verbal stimuli that may be processed with either verbal codes, imagery codes, or both (Paivio, 1969; Paivio and Begg, 1981).

In normal processing of words, encoding may entail some *visual imagery* in addition to verbal encoding. Occurrence of imagery may depend on whether a word is concrete or abstract. Concrete words (e.g., *tree, horse*) evoke more imagery than abstract words (e.g., *love, truth*) as shown by Paivio, Yuille, and Madigan, 1968, with their imagery and concreteness ratings for 925 nouns. However, imagery may not be involved in simple word recognition (Paivio and O'Neill, 1970), but it may be helpful in associative learning and recall (Paivio, 1969). One problem in interpreting such studies is that concreteness or imagery value can be accompanied by other variables that could account for experimental results. Kosslyn and Holyoak (1982) noted that "it is virtually impossible to identify and control every potentially relevant source of variation in verbal materials" (p. 321). Possible semantic differences between concrete and abstract words can be controlled by equating examples of each according to familiarity. However, abstract words may have greater "lexical complexity" than concrete words (Kintsch, 1972).

Sentences have also been distinguished as to whether they are concrete (e.g., *The rich physician carried a black umbrella*) or abstract (e.g., *The exact quotation lacked a rational foundation*) (Paivio and Begg, 1971). In a study of normal adults, concrete sentences required more time to comprehend or verify than abstract sentences (Paivio and Begg, 1971). Similarly, sentences rated at a high-imagery value took longer to verify than low-imagery sentences (Glass, Eddy, and Schwanenflugel, 1980). One explanation is that all sentences involve some form of verbal encoding, while concrete or high-imagery sentences involve additional imagery encoding that accounts for the increase in response time. One issue raised with these studies is whether imagery encoding is involved in comprehending or is only incidental to comprehension.

Other concerns arise from apparently contradictory results, as Holmes and Langford (1976) found that concrete sentences were comprehended faster than abstract sentences. Eddy and Glass (1981) commented on the slippery nature of the imagery variable. It is most likely that "there are still unspecified factors that influence verification and comprehension that may be correlated with imagery in a particular item set and these factors were not controlled in the studies of Holmes and Langford (1976) and Glass et al. (1980)" (p. 334). For example, in the verification experiment, high-imagery statements had stronger agreement among subjects as to truth value (Glass et al., 1980).

Eddy and Glass (1981) established tighter controls over stimuli to maximize the likelihood that "high-imagery" sentences (e.g., *A Star of David has six points*) and "low-imagery" sentences (e.g., *The prince will some day be king*) differ primarily on the basis of imagery value. The key distinction was not in terms of concreteness of concepts conveyed in the sentences but rather was in terms of whether imagery was necessary to determine truth value. In selecting stimuli for subsequent study, subjects were asked to rate imagery on this basis. For example, *Salt is used more often than pepper* included concrete nouns but was judged to require low-imagery in determining truth value. Sentences were also equated as to agreement concerning truth value. With a reading task, Eddy and Glass found that high-imagery sentences took longer to verify than low-imagery sentences. However, these sentences were equivalent in an auditory task.

The longer response time for reading high-imagery sentences was explained with respect to selective interference. Interference occurs when like-modality perception (e.g., visual input) competes with imagery encoding (e.g., visuospatial) for the same limited pool of processing resources in working memory (Kosslyn and Holyoak, 1982). Reading materials may involve both grapheme-phoneme recoding and visual image encoding, causing a difference between high- and low-imagery printed sentences to be greater than any similar difference that might be found with auditory sentences. Because interference occurred with high-imagery sentences for verification and comprehension tasks, Eddy and Glass concluded that a system of dual-coding is involved in the comprehension process.

A few speech language pathologists have examined the encoding research with verbal and nonverbal materials, have related it to hemisphere asymmetry of cognitive function and processing style, and have concluded that visual imagery may provide a special source of stimulation for aphasic patients (West, 1977; Myers, 1980). Their proposals centered largely on the use of very concrete, image-provoking pictures in stimulating verbal production. However, Fitch-West (1983) argued with the following basic principle: "...if one code is able to assist in indirectly arousing the other, then arousal of the visual code may in some cases facilitate arousal of the verbal code ... Using visual imagery to its fullest extent can serve as an effective mediator between what is visualized and what is verbally encoded" (p. 226-227). While imagery increases response time in normal adults, this may indicate that imagery might provide additional information to an aphasic person that might contribute to comprehension accuracy.

Statement of Problem

Because aphasia treatment capitalizes on the stimulability of clinical manipulations (e.g., Darley, 1982; Davis, 1983), a minimal requirement of any new idea for treatment hinges on whether the proposed clinical manipulation is stimulable. That is, if we deliberately introduce imagery into a linguistic stimulus, would it produce better performance than when imagery encoding is less likely to occur? Of course, an affirmative answer to this question says nothing about whether treatment that includes imagery would result in greater progress in natural language ability. However, demonstration of stimulability is a necessary first step toward this end, when we consider traditional notions of how aphasia treatment is supposed to work.

In the present study, we compared sentence verification performance with a group of aphasic subjects on verbal-spatial (high-imagery) stimuli and verbal-analytical (low-imagery) stimuli. Our main question was whether aphasic patients would verify high-imagery sentences more accurately than low-imagery sentences. The sentences were created initially in a manner similar to those developed by Eddy and Glass (1981). Imagery and truth values of our sentences were determined empirically with a preliminary study using normal adults. Most of our aphasic subjects were compared in auditory and reading tasks to determine whether reading would interfere with high-imagery encoding as occurred with normal adults in Eddy and Glass' study. A common sentence verification paradigm was employed, involving true and false versions of sentences differing in polarity (i.e., affirmatives and negatives).

Method

A factorial design for repeated measures was employed to examine the effect of imagery encoding on sentence verification with adult aphasic subjects. Four factors were studied: imagery value of sentences (i.e., high or low), comprehension modality (i.e., auditory or reading), polar value of sentences (i.e., affirmative or negative), and truth value of sentences (i.e., true or false). The dependent variable was accuracy of sentence verification.

Subjects

Ten male aphasic adults were identified at a Veterans Administration Medical Center. Each was diagnosed as being aphasic from the *Porch Index of Communicative Ability* (PICA) (Porch, 1981), and each subject had a focal lesion in the left hemisphere without evidence in medical records of damage to the right hemisphere. All subjects were more than two years post onset at the time of the study. PICA overall scores ranged from 9.92 to 13.28 with a mean of 11.65. Seven cases were caused by thromboembolic CVA in the left middle cerebral artery, one had a subdural hemorrhage, and two had suffered focal traumatic injury. Four had right hemiplegia. Ages ranged from 33 to 72 with a mean age of 56.1 years, and subjects had a minimum of a high school education.

We wanted to ensure that subjects possessed a minimum level of auditory and visual processing ability for managing the experimental tasks. As determined with an audiometric screening evaluation, all had hearing acuity within normal limits; and only one subject, with a score of 14.60 (and two missing fingers), was below 15.00 on visual matching subtests of the PICA. With 12.00 as a selection criterion, all subjects were at 13.00 and above as a mean for the two auditory language comprehension subtests of the PICA; and so 10 subjects were evaluated as to auditory comprehension. Based on a minimum of 11.50 for the two reading subtests, seven of these subjects were evaluated as to reading as well as auditory comprehension. To ensure ability to make verification judgements, each subject was able to make true-false decisions at 100% accuracy in comparing spoken words to pictures.

Because of the reading criterion, two of the three non-thromboembolic CVA subjects were separated from the group. Therefore, the seven subjects studied with both modalities were more homogeneous as to etiology, and they had a mean PICA overall score of 12.06 (range of 10.86 to 13.28) with a reading score of 12.93 (range of 11.55 to 14.65). The other three who received only auditory presentation had overall means of 9.92, 10.62, and 11.55, and reading scores of 6.95, 8.25, and 11.10, respectively.

Stimulus Materials

High-imagery sentences were initially created by making a comment about a physical attribute of a topic (e.g., *Bourbon is bronze-coloured*). Low-imagery sentences were created by making a conceptual-categorical or purely informational remark about a topic (e.g., *A ruby is a precious gemstone*). Imagery and truth values of such statements can be subjective, based on preferred cognitive style or individual world knowledge. Therefore, experimental stimuli were selected from a pilot investigation designed to validate truth value and imagery classification of such sentences. As in Eddy and Glass' (1981) study, our intent was to equate high- and low-imagery sentences on truth value agreement. We also wanted to equate the sentences on normal adults' confidence in their truth value ratings.

In the preliminary study, 232 sentences were presented randomly to non-brain-injured graduate students who verified the truthfulness of each sentence, rated their confidence in their answer on a seven-point scale, and rated the amount of imagery involved in verification on a seven-point scale. Experimental sentences were chosen based on the following criteria: consistency of verification response by at least 80% of subjects; a mean confidence rating of no less than 6.0 for the truth value response; low-imagery ratings of 1.0 to 3.5, and high-imagery ratings of 5.0 and above. This difference in mean imagery rating was statistically significant.

Based on this investigation, 87 sentences met the criteria so that we could present 42 verbal-spatial (high-imagery) sentences and 45 verbal-analytical (low-imagery) sentences to the aphasic subjects. Within the high-imagery category, 21 were judged confidently by normals to be true, and 21 were false. Within the low-imagery category, 23 were true and 22 were false. Each of these categories was balanced as to containing affirmative and negative sentences. With high- and low-imagery affirmative and negative sentences that were true and false, eight experimental conditions were created; and each of these conditions contained 10 to 12 sentences. Each sentence was typed on an unlined index card. The words "true" and "false" were also printed on cards for the verification response.

Examples of each high-imagery condition are as follows: affirmative true (*The edge of a quarter is rough*); negative true (*The Sphinx is not a pyramid*); affirmative false (*Marilyn Monroe had brown hair*); negative false (*Mushrooms do not look like small umbrellas*). Examples of each low-imagery condition are as follows: affirmative true (*A quarter is worth one-fourth of a dollar*); negative true (*A sapphire is not a fruit*); affirmative false (*Nancy Reagan is the President's daughter*); negative false (*A cantaloup is not a fruit*).

Within each of the eight conditions, sentences were divided for auditory and visual presentation to the seven subjects meeting the reading criterion, generating a total of 16 experimental conditions with five or six sentences in each condition. The conditions were balanced for sentence length.

Procedure

Each subject was tested individually in a standard clinical facility with the investigator and subject seated facing each other at a table. Five practice sentences, not included in the experimental sentences, were given prior to auditory and reading tests. For subjects examined in both modalities, the auditory version was presented first with four subjects and after the reading version with three subjects. The three subjects receiving only auditory presentations were evaluated with all 87 sentences. To minimize fatigue, three-minute breaks were given after each group of 20 sentences.

In the auditory version, the investigator read each sentence to the subject, and the subject was required to decide whether the statement was true or false. A decision was indicated by pointing to the appropriate choice as described earlier. To make the processing demands of auditory and reading tasks somewhat comparable, sentences were repeated in the auditory condition when requested or when a response was delayed for at least five seconds. In the reading version, subjects were asked to read each sentence, decide on its truth value, and respond by pointing to the appropriate choice. Subjects were given 20 seconds to respond before proceeding to the next item. In both versions, responses were scored as to accuracy. The final response was scored upon self-correction, and guesses were encouraged when a subject was not providing a response.

Results

Auditory and Reading Comparison

For the seven subjects receiving auditory and reading versions, an analysis of variance for repeated measures was computed with the *Statistical Package for the Social Sciences* in order to examine effects of imagery, modality, polarity, and truth value (Nie, Hull, Jenkins, Steinbrenner, and Bent, 1975). The primary effects of interest are those of imagery and modality. Mean percent correct and standard deviations are shown in Table 1 for each condition. Results of the analysis of variance are shown in Table 2 for main effects and only the significant interactions. Because proportions were used, arcsin transformations were applied in order to stabilize the variances (Winer, 1971). There was no effect of imagery across the varied conditions, and there was no effect of modality. Polarity was the only main effect, with affirmative sentences being more accurate than negative sentences. Table 1 shows that high-imagery sentences tended to be easier than low-imagery sentences across six of the eight other conditions, with exceptions being false affirmatives and true negatives in the reading version.

The only significant interaction was between polarity and truth value. Follow-up analysis showed that, with affirmatives, true sentences were more accurate than false sentences ($F=8.478$, $p=.013$). Also, affirmatives were more accurate than negatives when sentences were true, but not when sentences were false ($F=27.913$, $p=.0002$). Table 1 shows that there was a tendency for true affirmatives to be easier than false affirmatives, but false negatives tended to be easier than true negatives.

In order to assess the effect of subjects on verification acuracy, another analysis of variance was done with auditory and reading versions collapsed. This analysis showed no main effect of the seven subjects, indicating that they performed as a homogeneous group. Other results were similar to those in Table 2. Again, polarity was the only main effect, and polarity and truth value provided the only interaction.

Table 2. Analysis of variance summary of the main effects and significant interactions for the seven subjects in the auditory and reading tasks. (Significance criterion of $p<.05$).

Source	SS	df	MS	F	p
Total	414.1274	1			
Imagery	.2942	1	.2942	.55	.4858
Error	3.2016	6	.5336		
Modality	1.0569	1	1.9569	2.21	.1879
Error	2.8730	6	.4788		
Polarity	6.7795	1	6.7795	19.20	.0047
Error	2.1190	6	.3532		
Truth Value	.1637	1	.1637	.32	.5904
Error	3.2016	6	.5068		
Polarity x Truth Value	5.2693	1	5.2693	10.51	.0177
Error	3.0090	6	.5015		

Auditory Comprehension

There was a tendency for high-imagery sentences to be verified more accurately than low-imagery sentences in the auditory task (see Table 1), but this was not a significant main effect in the previous analysis. The auditory scores of all ten subjects were analyzed together using another analysis of variance with arcsin transformations. Mean percent correct performance is shown in Table 3, and results of the statistical analysis are shown in Table 4. The same tendency regarding imagery can be

Table 1. Mean percentage of correct responses and standard deviations for subjects ($N=7$) in both the auditory and reading tasks.

	High-imagery				Low-imagery			
	Affirmative		Negative		Affirmative		Negative	
	True	False	True	False	True	False	True	False
Auditory								
% Correct	83.3	76.2	57.1	71.4	81.0	62.9	43.3	63.3
(SD)	(21.3)	(14.7)	(26.9)	(30.0)	(15.0)	(13.8)	(26.9)	(23.2)
Reading								
% Correct	85.7	54.3	38.6	57.1	79.0	64.8	54.3	48.1
(SD)	(11.5)	(25.1)	(31.5)	(21.4)	(17.3)	(22.7)	(22.3)	(39.4)

Table 3. Mean percentage of correct responses and standard deviations for the auditory task (N=10).

	High-imagery				**Low-imagery**			
	Affirmative		Negative		Affirmative		Negative	
	True	False	True	False	True	False	True	False
Auditory								
% Correct	75.2	78.8	50.9	78.2	72.8	62.4	42.2	65.2
(SD)	(27.1)	(15.5)	(29.6)	(26.9)	(21.6)	(22.0)	(25.4)	(19.8)

Table 4. Analysis of variance summary for the auditory task (N=10). (Significance criterion of $p < .05$).

Source	**SS**	**df**	**MS**	**F**	**p**
Imagery	1.6908	1	1.6908	4.37	.0662
Error	3.4857	9	.3873		
Polarity	2.3697	1	2.3697	9.84	.0120
Error	2.1666	9	.2407		
Truth Value	1.8457	1	1.8457	1.90	.2017
Error	8.7547	9	.9727		
Polarity x Truth Value	3.6227	1	3.6227	9.54	.0129
Error	3.4119	9	.3797		

seen in Table 3, but there was still no main effect of imagery. Again, polarity was the only main effect, and the only interaction was found between polarity and truth value.

Analyses of variance were conducted for each subject regarding auditory verification performance. To obtain sufficient data points per factor, the truth value data were collapsed so that individual ANOVA's included only the imagery and polarity factors. There were no significant main effects for any of the subjects. Two subjects had a significant interaction between imagery and polarity, and both were among the seven who were studied with both modalities. For one subject, high-imagery sentences were more accurate than low-imagery sentences with negatives, but not with affirmatives. Close inspection of data showed a pronounced failure on low-imagery sentences in the true negative condition which was the most difficult of all the polarity conditions generally. For another subject, high-imagery sentences were equal to low-imagery sentences in the negative condition, and high-imagery sentences were more accurate in the affirmative condition. Inspection of the data indicated that the most powerful variable for this subject was truth value, as this subject scored very low generally with true sentences.

Discussion

There was little evidence in this study that imagery value played a role in sentence comprehension accuracy as measured by a verification task. The only significant factor was polarity, as affirmative sentences were easier than negative sentences to comprehend. This has been a typical finding for normal and aphasic adults. Also, the polarity and truth value interaction has been a common finding in verification studies measuring response time with normal adults involving negation that is noncontradictory to its affirmative counterparts (Carpenter and Just, 1975, and the interaction is consistent with previous results of verification research with aphasic adults (Just, Davis, and Carpenter, 1977). The overall pattern of results was homogeneous with respect to eight of ten individual subject analyses. The two exceptions were from the group that received auditory and reading tasks. For one subject, imagery facilitated accuracy only for the most difficult polarity condition. The other subject, one of the two with head trauma, had the odd result of having discrete problems with true sentences. Therefore, neither of these subjects distinguished themselves in terms of a pronounced imagery effect.

In Eddy and Glass' (1981) study with normal adults, comparison between auditory and reading tasks indicated that reading interferes with high-imagery verification, a finding that has been used to support the theory that imagery encoding occurs. The interference effect did not appear to be operative in the present study with aphasic persons. The lack of main effect for modality indicates that our subjects did not differ according to modality. More telling with respect to interference was the finding that there was no interaction between imagery and modality. However, when we pay attention to the trends, it does appear that imagery may have had an impact on auditory comprehension that was weaker in the reading condition. This would be the opposite of what has occurred with normal subjects. It might be argued that imagery facilitated reading, bringing it closer than usual to the level of auditory comprehension. However, if this were so, an effect of imagery in the reading condition should have been observed. Another possibility is that aphasic people do not use imagery as effectively as normal adults. Special training in the conscious use of intact imagery processing may have resulted in a more normal pattern.

The failure of imagery to affect verification in the present study is not encouraging for the notion that imagery encoding from an intact right cerebral hemisphere might spontaneously stimulate the language mechanism of the damaged left hemisphere. Contrary to MIT, in which a melodic pattern is objectively introduced in a stimulus and response, imagery encoding was introduced in this and previous studies as merely an assumption of what might occur in the cognitive processor given certain characteristics of the verbal stimuli. Also, the effects of MIT on language production have been pronounced in certain cases (Helm-Estabrooks, 1983). However, we look for effects of imagery on encoding in sentence comprehension through a verification task. Any spontaneously facilitating influence of presumably right hemispheric imagery may be extremely subtle for comprehension. Perhaps, its effect would be evident if pictures were involved in the task or if direct training of imagery to stimulate verbal processes had been attempted. In any case, there are many ways of examining this issue further, and the case for imagery as a facilitator should not be closed.

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