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The Effects of Visual and Inferential Complexity on the Picture Descriptions of Non-Brain-Damaged and Right-Hemisphere-Damaged Adults

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Many of the descriptions of communication impairments associated with right hemisphere damage (RHD) come from studies in which patients have been asked to talk about complex pictorial stimuli. Investigators have found that RHD subjects have problems in interpreting or drawing inferences from pictorial materials such as (1) line drawings depicting metaphors and idioms (Myers & Linebaugh, 1981; Winner & Gardner, 1977); (2) cartoons depicting humorous situations (Bihrle, Brownell, & Powelson, 1986; Dagge & Hartje, 1985); (3) scenes portraying indirect requests (Hirst, LeDoux, & Stein, 1984; Foldi, 1987); (4) pictures presenting emotions conveyed through facial expression and body language (Borod, Koff, Lorch, & Nicholas, 1986; Cicone, Wapner, & Gardner, 1980); and (5) scenes depicting stories and events (Joanette, Goulet, Ska, & Nespoulous, 1986; Mackisack, Myers, & Duffy, 1987; Myers, 1979; Rivers & Love, 1980).

There are at least two competing explanations for these deficits. One is that they arise from a general inference deficit across modalities. Another is that they arise from a modality-specific problem in visual perception.

RHD is said to be associated with a variety of visual perceptual deficits, such as problems in recognizing pictured objects. These deficits surface when objects are embedded, incomplete, or rotated (Layman & Green, 1988; Warrington & James, 1967; Warrington & Taylor, 1973), and they may contribute to impairments in picture interpretation. Because pictures are two-dimensional, objects in these scenes are often depicted as embedded or incomplete to give depth to the picture. The more objects in the picture, the more likely objects will be depicted as embedded.

Left-sided neglect may also contribute to RHD patients' perceptual deficits by inhibiting their attention to left-side detail, and perhaps to contextual information anywhere in the stimulus array. For these reasons, RHD patients may have difficulty interpreting pictured scenes because they have problems perceiving what is in the pictures.

On the other hand, a common feature of the pictorial stimuli used in studies of RHD communication deficits is that their meanings tend to be implied rather than directly stated. That is, one must draw inferences about the pictorial stimuli to express their meanings fully. Evidence of inference deficits has been found in studies using verbal stimuli (Brownell, Potter, Bihrle, & Gardner, 1986; Molloy, Brownell, & Gardner, 1989; Weylman, Brownell, Roman, & Gardner, 1989) and may be a factor in studies using pictorial stimuli.

The issue of the relative influence of visuoperceptual and inferential deficits on the picture description impairments of RHD patients remains unresolved because few studies have controlled for visual complexity in their stimuli, and fewer have manipulated the inferential complexity of pictured scenes. The purpose of this study was to investigate the effects of visual and inferential complexity on the picture descriptions of RHD and non-brain-damaged (NBD) adults by manipulating the visual and inferential complexity of pictured stimuli within the same task. We asked whether communication deficits in response to pictured scenes result from a modality-specific problem with visual input or from a more general problem with inferring implied meaning. The results reported here are part of a larger study investigating the effects of visual and inferential complexity on RHD subjects' pictured scene interpretation.

METHOD

Subjects were 24 adults with unilateral right hemisphere damage (RHD) caused by a cerebrovascular accident and 30 non-brain-damaged (NBD) adults. RHD subjects had a mean age of 64 years (S.D. 12.73; 41–85 years), and a mean education level of 12.8 years (S.D. 3.81; 8–21 years). They were at least 1 month post onset. NBD subjects had a mean age of 78 years (S.D. 5.85; 66–88 years), and a mean education level of 14.2 years (S.D. 3.00; 8–21 years). All subjects were right-handed.

The stimuli were eight colored photographs of Norman Rockwell illustrations differing from one another in visual and inferential complexity. Visually complex (VC) pictures contained from 14 to 57 visually distinguishable objects; visually simple (VS) pictures contained from 2 to 10 objects. Inferentially simple (IS) pictures conveyed straightforward activities requiring little interpretation, whereas inferentially complex (IC) pictures required a greater number of inferences for accurate interpretation.

There were four sets of two pictures, representing the following four categories: (1) visually complex/inferentially complex; (2) visually simple/inferentially complex; (3) visually complex/inferentially simple; and (4) visually simple/inferentially simple.

The eight pictures came from a set of 32 Norman Rockwell illustrations. A series of validation trials with normal judges yielded the set of eight, two in each of the four categories. Eight of 10 judges independently agreed on the categorization of each of these eight pictures.

In the experimental task, subjects were asked to "tell what is happening" in each of the eight pictures. They were verbally cued to the left if they failed to mention any left-side information. Pictures were presented one at a time in four random orders counterbalanced across subjects. A training task was administered prior to the experimental task. The subjects were asked to describe from one to four pictures, depending on how quickly they learned the task. To participate in the study, subjects had to describe actions, as well as objects, in two consecutive training pictures.

Responses were tape-recorded and orthographically transcribed. A list of concepts (accurate and inaccurate) generated for each picture by the RHD and NBD subjects was compiled by the first author. The main concept measure came from the work of Nicholas (Brookshire & Nicholas, 1994; Nicholas & Brookshire, 1993) on discourse production in adults with brain damage. Each distinguishable idea contained in the transcripts was considered a concept. Any concept mentioned by at least two subjects was entered into the list. The total number of concepts per picture ranged from 12 to 27.

Those concepts identified by at least 30% of the NBD subjects were labeled "major concepts." To determine the proportion of major concepts identified for a given picture by a given subject, the number of major concepts mentioned by that subject in response to that picture was divided by the total number of major concepts for that picture.

Point-to-point agreement between the first author and a second speech-language pathologist on the presence or absence of specific concepts was calculated on randomly selected picture descriptions representing 10% of the sample. Point-to-point agreement on the presence or absence of specific concepts was 97% for both subject groups.

The effect of neglect on the proportion of major concepts mentioned was examined by dividing the RHD group into two subgroups. In addition to performing the experimental task, all subjects were given three tests of neglect—copying a simple scene, four line bisections, and a line cancellation task. Each subjects' scores on the neglect tests were combined to create an individual composite neglect score. RHD subjects with low neglect scores were placed in a "low neglect" (RHD/LN) group, and RHD subjects with high neglect scores were placed in a "high neglect" (RHD/HN) group. The low neglect group comprised 14 subjects with a mean neglect score of 6.8 and a range of 0–13; the high neglect group comprised 10 subjects with a mean score of 61.1 and a range of 14–159.

RESULTS

Subjects' responses to the eight pictures were divided among four conditions, with responses to four pictures in each condition: (1) visually simple; (2) visually complex; (3) inferentially simple; and (4) inferentially complex (see Table 1). In each condition one variable (e.g., visual complexity) was held constant while the other changed (e.g., inferential complexity). Thus, for example, the stimuli in the visually simple condition included both inferentially simple and inferentially complex pictures that were visually simple.

A groups by conditions repeated measures analysis of variance was calculated on the proportion of major concepts mentioned by the NBD, RHD/LN, and RHD/HN groups in the four conditions. The results yielded a significant main effect for groups ($F_{2,51}$ = 15.69; p. < .001); a significant main effect for conditions ($F_{3,153}$ = 36.58; p. < .001); and a significant groups by conditions interaction ($F_{6,153}$ = 3.72, p. = .002).

Effects of Conditions

To determine whether the conditions (visual or inferential complexity) affected the proportion of major concepts mentioned by subjects, *t*-tests were calculated for each group on the differences (a) between the proportion of concepts mentioned by subjects in response to visually simple and

Table 1. Picture Types in Each of Four Picture Conditions

Condition	*Picture Types*
Visually simple (**VS**)	**VS**IS (pictures 7 and 8) **VS**IC (pictures 3 and 4)
Visually complex (**VC**)	**VC**IS (pictures 5 and 6) **VC**IC (pictures 1 and 2)
Inferentially simple (**IS**)	VS**IS** (pictures 7 and 8) VC**IS** (pictures 5 and 6)
Inferentially complex (**IC**)	VS**IC** (pictures 3 and 4) VC**IC** (pictures 1 and 2)

Note: VSIS = Visually simple/inferentially simple; VSIC = Visually simple/inferentially complex; VCIS = Visually complex/inferentially simple; VCIC = Visually complex/inferentially complex.

visually complex pictures and (b) between the proportion of major concepts mentioned by subjects in response to inferentially simple and inferentially complex stimuli. The familywise error rate for multiple comparisons was adjusted by setting the Type I (alpha) error rate at .004 (.05/12; the Bonferroni technique). There was no significant effect of visual complexity on the performance of any of the three groups (NBD: $t(29) = 1.34$, $p > .10$; RHD/LN: $t(13) = 0.23$, $p > .10$; RHD/HN: $t(9) = -1.31$, $p > .10$). In contrast, all three groups mentioned a significantly smaller proportion of major concepts in response to inferentially complex stimuli than in response to inferentially simple stimuli (NBD: $t(29) = 4.65$, $p < .001$; RHD/LN: $t(13) = 5.84$, $p < .001$; RHD/HN: $t(9) = 5.90$, $p < .001$; see Figure 1).

Effects of Groups

To examine the role of the group effect in the interaction, the simple effects of groups (NBD, RHD/LN, RHD/HN) within conditions (VS, VC,

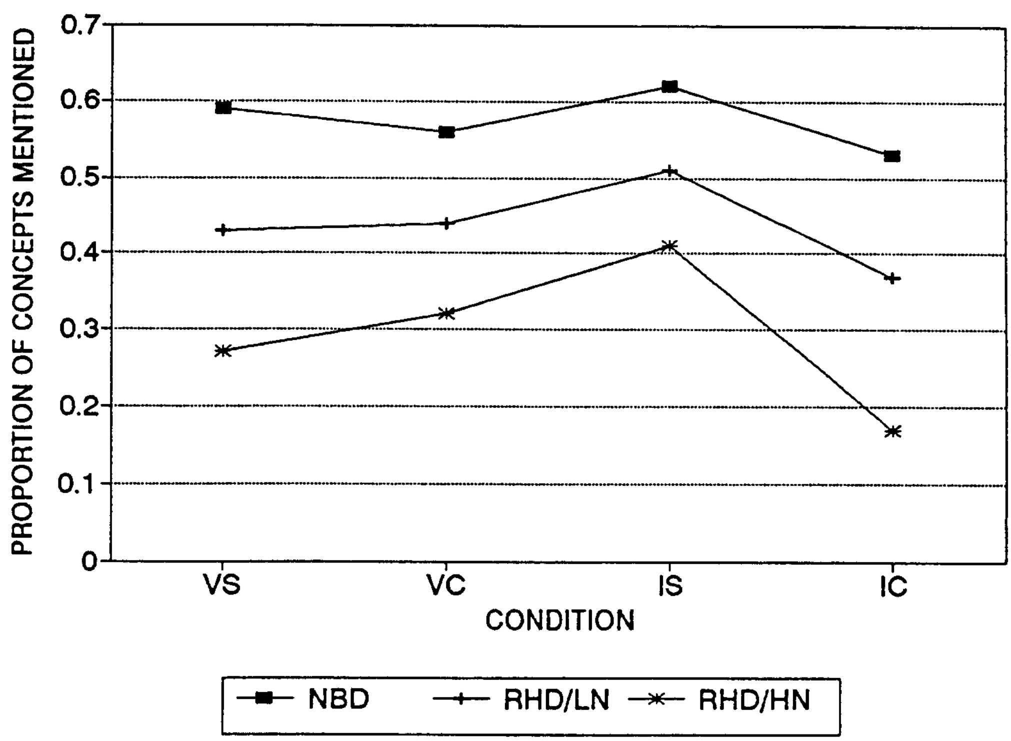

Figure 1. Average proportion of major concepts mentioned by non-brain-damaged (NBD), right-hemisphere-damaged with low neglect (RHD/LN), and right-hemisphere-damaged with high neglect (RHD/HN) subjects in the visually simple (VS), visually complex (VC), inferentially simple (IS), and inferentially complex (IC) conditions.

Table 2. Proportion of Major Concepts Produced by High Neglect (RHD/HN), Low Neglect (RHD/LN), and Non-Brain-Damaged (NBD) Groups

Condition	*Significant Differences**
Visually simple	RHD/HN < RHD/LN < NBD
Visually complex	RHD/HN < NBD
Inferentially complex	RHD/HN < RHD/LN < NBD
Inferentially simple	RHD/HN < NBD

*$p < .05$.

IS, IC) were evaluated by means of a one-way analysis of variance for each of the four conditions. These analyses yielded significant group differences in all four conditions [(VS: $F_{2,51} = 17.65$; $p < .001$), (VC: $F_{2,51} = 9.04$; $p < .001$), (IS: $F_{2,51} = 7.82$; $p < .001$); and (IC: $F_{2,51} = 21.62$; $p < .001$)]. Post hoc Tukey HSD tests revealed that in all four conditions the RHD/HN group produced a significantly smaller proportion of major concepts than did the NBD group ($p <.05$; see Table 2). The RHD/HN group also produced a significantly smaller proportion of major concepts than did the RHD/LN group, but only in two conditions—visually simple and inferentially complex ($p <.05$). The RHD/LN group differed significantly from the NBD group in these same two conditions ($p <.05$), but not in the other two. This seemingly odd result, in which the visually *simple* condition appears to have an effect, turns out not to be so odd when one considers the effect of the inferentially complex pictures within the visually simple condition.

The effect of inferential complexity within the visually simple condition can be seen in the accuracy of subjects' inferences as depicted in Figure 2. Space does not permit a discussion of this measure, but the y-axis of the graph shows the percent of subjects' inaccurate inferences (IWIT) in response to the pictures in this condition. RHD subjects produced far more inaccurate inferences in response to visually simple/ inferentially complex (VSIC) pictures than they did in response to visually simple/inferentially simple (VSIS) pictures. The VSIC pictures were among the most difficult for subjects to interpret, perhaps because they had so few visual cues or so little visual redundancy. The differences in performance accuracy clearly implicate inferential rather than visual complexity as the reason for the findings in the visually simple condition. Subjects, especially RHD subjects, had much more difficulty interpreting the two inferentially complex pictures than the two inferentially simple pictures that made up the visually simple condition.

To further evaluate the effects of neglect on the production of major concepts, the five major concepts for each picture that were mentioned

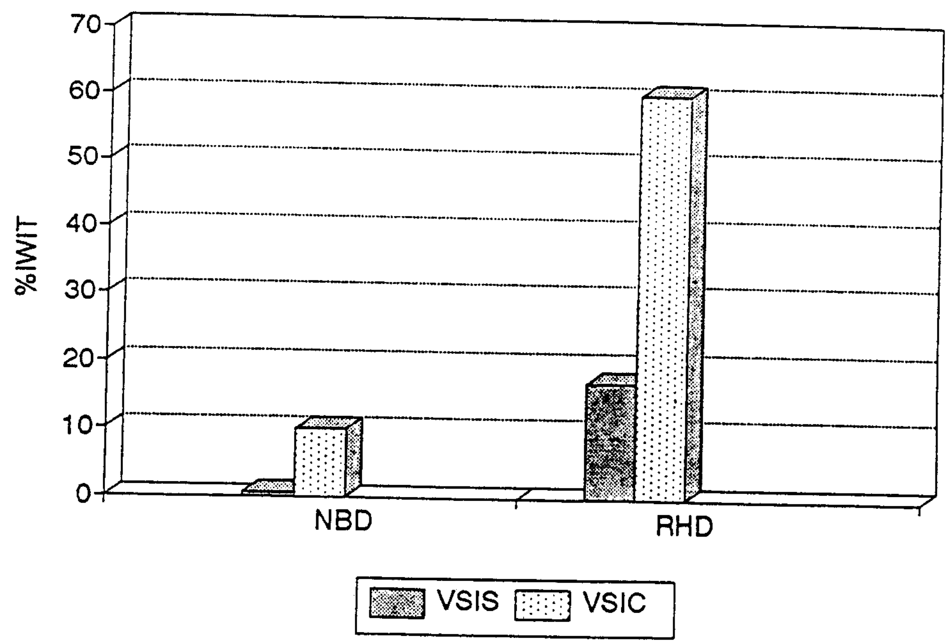

Figure 2. Effects of inferential complexity on visually simple pictures as demonstrated by percent of inference errors (%IWIT) made by non-brain-damaged (NBD) and right-hemisphere-damaged (RHD) subjects in response to visually simple/inferentially simple (VSIS) and visually simple/inferentially complex (VSIC) pictures.

most frequently by the NBD subjects were identified, and the correlation between the proportion of these concepts mentioned by each subject in the RHD group and his or her neglect score was calculated. The resulting Pearson correlation coefficient was –.60, suggesting that neglect has a moderate negative relationship to the proportion of major concepts mentioned by subjects in the RHD group. In other words, subjects with high neglect tended to mention a smaller proportion of major concepts than did subjects with low neglect.

DISCUSSION

The results of this study suggest that visual complexity has little effect on subjects' descriptions of complex pictured scenes. Both NBD and RHD subjects mentioned essentially the same number of major concepts in response to visually simple pictures as they did in response to visually complex pictures.

On the other hand, inferential complexity consistently affected subjects' performance. Both RHD and NBD subjects produced a significantly smaller proportion of major concepts in response to inferentially complex pictures than they did in response to the inferentially simple pictures. (A possible qualifier deserves mention. This study did not operationalize and measure how many main concepts were explicitly represented in the pictures, and how many were inferred.)

The RHD group as a whole tended to generate fewer major concepts in all conditions than the NBD group did, which suggests that RHD subjects are less able than NBD subjects to interpret and describe pictures. The high neglect RHD group produced significantly fewer major concepts in all conditions than the NBD group did, which was not the case for the low neglect RHD group. Subjects with high neglect performed similarly to subjects with less neglect, but they tended to be more impaired. There was also a moderate to strong correlation between subjects' neglect scores and the number of major concepts they produced, suggesting that the production of concepts may be associated with the severity of RHD subjects' neglect.

In addition, other measures too lengthy to report here demonstrated that both the RHD and NBD subjects were highly accurate in identifying pictured elements but that RHD subjects, particularly those with high neglect scores, were significantly impaired relative to NBD subjects in inferential accuracy. These findings suggests that RH subjects did not have difficulty recognizing isolated items in the pictures but that they did have trouble interpreting what they saw within the context of a given picture.

In general, the results of this study suggest that the impaired communication of RHD patients describing pictured scenes is more strongly related to the inferential than to the visual complexity of the pictured stimuli and that inference deficits are a more powerful explanation than visuoperceptual deficits for the observed impairments. Consequently, pictured scenes and pictured story sequences seem to be appropriate stimulus materials for testing RHD patients, despite the fact that RHD may be associated with visuoperceptual deficits. The results also suggest that manipulating the level of inferential complexity within pictured scenes may be a useful strategy for measuring at least some of the communication deficits exhibited by this population.

The results of this study also have implications for how RHD communication impairments are conceptualized. Some RHD patients seem to have inference deficits, regardless of the modality of stimulus input, verbal or visual. And in the visual modality, these deficits seem to be independent of visuoperceptual impairments. These results lend weight to the notion of an underlying or central inference deficit suggested by Myers (1991).

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