The role of perceptual and semantic elaboration in high- and low-imagery sentence recall

DONALD A. WALTER and DANIEL FOX

University of Wisconsin—Parkside, Kenosha, Wisconsin 53140

Sentence imagery effects in recall are predicted by both perceptual and semantic elaboration models. The former attributes superior recall of high-imagery sentences to the addition of perceptual network components to an existing semantic network; the latter claims that additions of semantic components are involved. In order to identify the responsible components, free associates were generated to otherwise similar high- and low-imagery sentences in a short-term memory task. In accordance with the perceptual elaboration model, associates differed in rated imagery, but not in number. In a second study, the causal role of perceptual elaboration in recall was investigated by using high- and low-imagery sentence associates as recall cues. Differential effects of cue imagery were found for high-imagery sentences, indicating that perceptual codes are in part responsible for superior high-imagery sentence recall. Evidence is presented that perceptual and semantic network components are involved in a processing tradeoff, and the adequacy of present network models to explain it is discussed.

High-imagery sentences show a consistent superiority over low-imagery sentences in a variety of processing tasks. Among such tasks are classification speed (Holmes & Langford, 1976), verification times (Kieras, 1978; Klee & Eysenck, 1973), recognition of thematic content (Begg & Paivio, 1969), and recall (Byrne, 1974; Paivio, 1971a, 1971b). It is generally believed that these processing advantages may be due to the formation of additional memory components in high-imagery sentence encoding, which augment components of low-imagery sentences. Two positions that take this point of view are the dual coding theory (Paivio, 1971a) and the perceptual elaboration model (Kieras, 1978). Dual coding posits two distinct encoding systems, one imaginal and the other verbal. Differences in high- and low-imagery sentence processing are explained by the claim that high-imagery sentences may be readily encoded into either imaginal or verbal codes, but low-imagery sentences are relatively limited to encoding in terms of verbal codes. Imaginal codes are also seen to have greater integration and more stability than verbal codes, and they are seen as less closely tied to sentence word order (Begg & Paivio, 1969).

The perceptual elaboration model espouses somewhat the same idea, but it is more explicit. Using a network representation, such as those proposed by Anderson and Bower (1973), Kintsch (1974), and Norman and Rumelhart (1975), it sees high- and low-imagery sentences as having differential access to perceptual networks but equal access to semantic networks. Both are roughly equivalent to dual coding's imaginal and verbal memory codes. An alternative explanation, also expressed in terms of memory networks, is the semantic elaboration model, which sees imagery effects in terms of elaboration of semantic networks only.

Both network models are similar in that they see low-imagery sentences encoded in terms of simple semantic networks. Such networks are schematic representations of propositional systems and consist of sets of nodes (concepts) with relations (links) linking the nodes. A sentence such as "The professor states the obvious blunder" might be encoded into a (simplified) semantic network such as "PROFESSOR—agent—STATES—object—BLUNDER—property—OBVIOUS," where uppercase words represent concepts and lowercase words, relations. Both high- and low-imagery sentences are seen as encoded in terms of semantic networks, but high-imagery sentence encoding results in additional network elaborations that effectively increase the complexity and redundancy of the entire sentence memory code. The semantic elaboration model sees these elaborations as parts of additional semantic networks, whereas the perceptual elaboration model sees them as parts of primarily (or exclusively) perceptual networks having perceptual concepts and/or relations. Semantic relations are seen as functional linguistic (e.g., agent, object, property, etc.) and semantic concepts are seen to represent low- or high-imagery entities (e.g., frog, essence, fortune, etc.), whereas perceptual relations are seen as representing physical proximity and position information (e.g., near, around, under, etc.) and perceptual concepts are limited to high-imagery or concrete entities (e.g., waterfall, window, corner).

Thus, the basic difference between the network models lies in the type of network involved in high-imagery sentence elaboration. Past research has focused on two areas. Early studies, such as Paivio (1969), examined interactions between word and sentence imagery manipulations and instructional sets to use imaginal or verbal mediators, and these studies pro-

vided initial support for the presence of imaginal encoding differences. More recent studies (Byrne, 1974; Davies & Proctor, 1976; Klee & Eysenck, 1973; Segal & Fusella, 1970) have selectively interfered with imaginal and verbal memory codes in an effort to show that high-imagery sentences are more sensitive to spatial or visual interference than are low-imagery sentences. Although generally successful, some failures have occurred (Elliot, 1973). In addition, these studies are known for their fragile effects and are somewhat difficult to replicate (see Crowder, 1976).

Historically, evidence generally supports the concept of an imaginal, visual, or perceptual code. However, there are residual problems with these efforts. First, existing evidence is far from conclusive, and second, details concerning the nature of the memory code involved are not known. Both the "mental picture" (Pylyshyn, 1973) and the dual code positions offer little enlightenment, due to the fact that the former is logically suspect and the latter offers a few details concerning its form and structure (see Kieras, 1978, for a discussion). The use of network models, however, not only makes possible an explicit statement of what an imaginal code might be (a perceptual network) but also allows more or less direct testing of the extent to which both are involved in high- and low-imagery sentence processing.

Both experiments reported here make use of methods designed to the idea of access to components of both perceptual and semantic memory networks. The first experiment examines the extent to which perceptual and semantic networks are involved in the encoding of both high- and low-imagery sentences. The second experiment examines the causal relations between perceptual network encoding and the recallability of high- and low-imagery sentences. Since sentence free association and recall cuing are involved, some quite reasonable assumptions concerning memory networks are needed. First, it is assumed that sentence free associates monotonically reflect the proportion of perceptual and semantic network components in their memory codes, with regard to both number and imagery. Second, it is assumed that perceptual and semantic networks may be accessed by single words, although that access need not be equivalent for both network types.

In the first experiment, sentence free associates are used to determine the extent to which sentence memory network components are semantic or perceptual. The perceptual elaboration model predicts that high-imagery sentence encoding results in a relative increase in perceptual network components. This should be reflected in higher imagery ratings of sentence free associates, since only high-imagery concepts may be used in perceptual networks. The semantic elaboration hypothesis predicts that high-imagery sentence encoding results in additional semantic components. This should be reflected in greater numbers of free associates but no change in imagery level, since semantic network components may

be of any imagery level. In the second experiment, the role of perceptual and semantic components in the recall of sentences is probed by using high- and low-imagery sentence associates as recall cues. To the extent that high-imagery sentences are elaborated in terms of perceptual rather than semantic components, high-imagery cues should be more effective than low-imagery cues in facilitating high-imagery sentence recall.

EXPERIMENT 1

Method

Design. A one-way repeated-measures design was used in which sentence imagery was varied at two levels (high and low). Dependent measures were the number of whole-sentence verbatim recalls and the number and rated imagery of sentence free associates.

Subjects. Sixty University of Wisconsin-Parkside general psychology students served as subjects, 32 males and 28 females. Each subject was randomly assigned to a specific sentence order and was given an increment in his/her general psychology grade for adequate participation.

Materials. Two hundred and thirty sentences of the same grammatical structure were rated on imagery, comprehensibility, and plausibility by 40 undergraduates using a 7-point scale. The highest and lowest 30 sentences were selected as high- and low-imagery sentences, except that substitutions were made to equate mean plausibility, comprehensibility, and frequency (Kučera & Francis, 1967) by word class. Mean imagery ratings (and standard errors) for the high- and low-imagery sentence groups were 5.55 (.086) and 1.76 (.072), respectively. Examples of low- and high-imagery sentences are "Statistics were accurately predicting the correct response" and "Waves were intensely pounding the heavy shale," respectively.

Procedure. The entire procedure was automated on an SOL-20 computer and a 10-in. television monitor. Each subject received 60 identical modified visual short-term sentence recall trials, the first 12 of which were practice. Each subject was seated at a desk approximately 18 in. away from the monitor. On the desk were a key and response sheets on which free associates, digits, and sentence recalls were to be recorded. All displays were centered on the screen and were easily legible. Instruction words were enclosed in asterisks to aid discrimination, and an audible "beep" occurred at the initiation of any instruction word. Here, they are included in parentheses. The subject placed his response sheet face up at the beginning of each trial (READY). He then pressed the key to initiate a 5-sec sentence presentation in which a low- or high-imagery seven-word sentence was displayed. In the 11-sec free association interval that followed (WORDS), the subject generated as many words that came to mind when he was learning the sentence as he could. In the last 1 sec of the interval, the subject reversed his response sheet (TURN OVER YOUR SHEET) and began the 20-sec retention interval (NUMBERS). The intervening activity required the subject to copy 10-digit groups presented for 4 sec each. In order to receive credit for participation, an 80% accuracy level was required. A 10-sec recall interval followed (RECALL), in which the subject attempted to write down the sentence verbatim. He was, however, encouraged to write down any portion of the presented sentence that he could remember. Subjects were told at the beginning of the experiment that there would be an additional task after the recall trials that would require them to remember the general meanings of the presented sentences. This task consisted of an additional sentence free association task in which the subject was asked to "write down any words that the sentence makes you think of now." Trials were identical to the earlier recall trials but were terminated prior to the "TURN OVER YOUR SHEET" instruction. The order of

sentence presentation was randomized for each subject, and the same order of sentences was used for both the recall task and the subsequent free association task.

Results and Discussion

The proportion of correct verbatim sentence recall for high- and low-imagery sentences is shown in Table 1. A *t* test for differences between means of correlated groups showed that high-imagery sentence recall significantly exceeded that of low imagery [$t(59) = 6.32$, $p < .001$].

Sentence free associates were generated both after each sentence and in a postrecall task. Forty-two general psychology students rated the imagery of each free associate on a scale from 1 to 7 (easy to image). Mean numbers and imagery ratings of associates are shown in Table 1. High-imagery sentence associates generated during the recall task were significantly higher in mean rated imagery [$t(59) = 2.35$, $p < .005$], and sentences of both imagery levels generated generally equal numbers of associates. In the postrecall association, the same trend appeared; high-imagery sentence associates were again significantly greater [$t(59) = 2.00$, $p < .025$], and sentence imagery again had no effect on the number of associates generated.

Sets of correlations were computed between the number of words recalled for each sentence and (1) mean associate imagery and (2) the number of free associates generated to that sentence. This was done separately for each sentence imagery level. For both high- and low-imagery sentences, the mean numbers of words recalled per sentence correlated highly with the mean number of associates generated (.37 and .41, respectively) but correlated with imagery only for high-imagery sentences, not low imagery (.32 and .04, respectively). Only one correlation was significant. Respective *t*s ($df = 23$) were 1.87, 2.11, 1.58, and .18 ($ps < .10$, .05, .20, and 1.00).

In addition, the proportion of recall task free associates that were also given in the postrecall task was computed. Approximately the same proportion were repeated, as shown in Table 1. Repeated associates for high-imagery sentences, however, were significantly higher in rated imagery [$t(59) = 6.83$, $p < .001$].

The results tentatively support the choice of the perceptual elaboration model over the semantic elaboration

model for three reasons. First, associates to high- and low-imagery sentences differed only in imagery, not in number. Second, free associate imagery and the number of sentence words recalled were significantly correlated only in the case of high-imagery sentences, for which perceptual elaboration is thought to play a substantial role in recall. Third, repeated associates for high-imagery sentences were of higher imagery, suggesting that greater persistence obtains to perceptual network memory codes. Since free associate imagery is taken to represent the extent to which perceptual elaboration takes place in sentence encoding, it is virtually certain that a positive relationship exists between sentence imagery and the extent of involvement of semantic and perceptual network components in the complete sentence memory code. However, free associate results do not explain the nature of the relationship satisfactorily. Since both sentence recall and free associate imagery were dependent variables in this experiment, only correlations may be established between them. To properly evaluate the viability of the perceptual elaboration model, high-imagery sentence recall must be shown to rely on memory codes in which perceptual networks augment semantic networks and low-imagery sentence recall must be shown to rely on memory codes in which semantic components dominate. Experiment 2 attempts to do this by using differential reinstatement of perceptual and semantic networks via recall cues.

Recall that perceptual network concepts are concrete or high in imagery; therefore, they may be directly accessed by appropriate high-imagery words. Semantic network concepts have no such restriction with regard to imagery and may be accessed by appropriate words of any imagery level. If a recall cue is presented at the time of sentence recall, that cue should facilitate sentence recall to the extent that (1) the cue accesses part of the sentence memory code and (2) the part accessed has been forgotten. Assuming that both semantic and perceptual network components (concepts and relations) are forgotten at the same rate, the facilitation provided by high- and low-imagery recall cues should differ for high- and low-imagery sentences in proportion to the extent that perceptual and semantic network components are present at encoding. The probability that a high-imagery cue accesses perceptual components is

Table 1
Proportion of Verbatim Sentence Recall and Mean Number and Imagery Ratings of Sentence Free Associates

Sentence Recall			Associates												
			Postpresentation				Postrecall Task				Repeated				
			Number		Imagery		Number		Imagery		Number		Imagery		
			Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Imagery	High	.63	.016	1.47	.15	4.79	.14	1.23	.14	4.84	.12	.25	.034	5.49	.16
	Low	.49	.021	1.52	.13	4.30	.21	1.21	.17	4.36	.16	.22	.019	4.28	.10

greater than that of a low-imagery cue, to which perceptual components are not available. The probability of access to semantic network components is relatively equal for both high- and low-imagery cues. Thus, high-imagery recall cues should facilitate high-imagery sentence recall more than low-imagery cues, but cues of both imagery levels should facilitate low-imagery sentence recall equally.

EXPERIMENT 2

Method

Design. A two-way, completely within-subjects factorial design was used with two levels of sentence imagery (high and low) and three levels of cue type. Recall cues were either high or low imagery, or no cue was used at all.

Subjects. Thirty-two female and 16 male University of Wisconsin-Parkside general psychology students served as subjects. All subjects were given additional course credit for adequate participation in the experiment, which again included 80% accuracy on the intervening task used during the retention interval.

Materials. It would have been preferable for subjects to generate their own recall cues, but it would have been impossible to equate high- and low-imagery cues with regard to word class, and so on, and high- and low-imagery sentences with regard to cue imagery level. Recall cues were selected from Experiment 1 single nouns generated as free associates after sentence presentation (54% of the total). For each sentence, nouns that had no apparent relation to their sentences were first eliminated. They were then divided into four equal groups with regard to rated imagery. The extreme groups served as initial pools of high- and low-imagery cues for high- and low-imagery sentences. Substitutions and eliminations were then made so that all four pools were equated with regard to noun frequency [using Kučera & Francis, 1967, or student ratings ($N = 32$), in that order of preference], the probability of cues as sentence free associates, and the mean number of dictionary entries. High- and low-imagery cue pools for both sentence imagery levels were also equated with regard to mean imagery. For high-imagery sentences, mean imagery ratings (and standard deviations) for the resulting high- and low-imagery cue pools were 5.43 (.43) and 3.55 (.32), respectively, and for low-imagery sentences, 5.45 (.48) and 3.41 (.36). This elimination process left from three to five cues in each sentence cue pool. Examples of high- and low-imagery cues for the low-imagery sentence "Statistics were accurately predicting the correct response" were "professor" and "equation," respectively. For the high-imagery sentence "Waves were intensely pounding the heavy shale," examples were "coastline" and "erosion."

Procedure. The procedure was similar to that used in Experiment 1. A series of 60 short-term trials were used, with the first 12 trials serving as practice. Each trial was identical to Experiment 1 trials, except that the free association period was eliminated and two recall cues appeared side by side below the "RECALL" signal. In the no-cue condition, a series of slashes appeared instead. The subject was instructed to make use of cues to remember the sentence if he could.

Of the 24 sentences used in each sentence imagery condition, 8 were assigned to each cue type condition. Sentences assigned to the no-cue condition received no recall cue. Those in the high- and low-imagery cue conditions were presented two randomly selected recall cues from the appropriate sentence pool. Double cuing was used to increase the probability of access to memory network components. A different random order of sentences was used for each subject, and assignment of sentences to cue type conditions was counterbalanced across subjects.

Results and Discussion

Sentences were counted as correct if they were recalled verbatim, with the exception that tense and number changes were allowed. More liberal scoring criteria yielded results with the same significant trends. The proportion of sentences correctly recalled for each combination of cue type and sentence imagery is shown in Table 2. A 2 by 3 repeated-measures analysis of variance, using the number of correct sentence recalls as data, yielded significance for sentence imagery [$F(1,47) = 10.23$, $p < .01$] and the interaction of Sentence Imagery by Cue Type [$F(2,47) = 4.31$, $p < .01$].

The perceptual elaboration model sees perceptual networks as augmenting semantic networks in the encoding of high-imagery sentences. Thus, the critical prediction of the model was that high-imagery recall cues would selectively facilitate high-imagery sentence recall, because of a predominance of perceptual network components in high-imagery sentence memory codes. A 2 by 2 analysis of variance omitting low-imagery cue conditions showed that this was the case, for the interaction of Sentence Imagery by Cue Type was significant [$F(1,47) = 4.58$, $p < .01$]. Low-imagery cuing effects provided additional evidence concerning the augmentative role of perceptual network components, because they were consistent with other indications that perceptual components do not augment semantic components but displace them. These indications are as follows: First, a tradeoff between the semantic and perceptual network encoding makes considerable sense from a fixed memory capacity viewpoint. Second, low-imagery cuing was more effective in facilitating recall of low-imagery sentences than in facilitating that of high-imagery sentences. An analysis of variance omitting data from high-imagery cue conditions showed a significant interaction of Sentence Imagery by Cue Type [$F(1,47) = 4.56$, $p < .01$]. This is evidence that perceptual elaboration (in high-imagery sentences) may have inhibited the use of high-imagery concepts in semantic networks, for low-imagery cues were more effective in facilitating low-imagery sentence recall than in facilitating high-imagery sentence recall relative to uncued recall. Both high- and low-imagery sentences should have been equally facilitated if perceptual elaboration augmented semantic codes, since the same semantic network components would have been present for both. Third, numbers of

Table 2
Proportion of Correct Sentence Recall (PC) for High- and Low-Imagery Sentences Under Three Recall Cue Conditions

Sentence Imagery	Cue Type					
	High Imagery		Low Imagery		No Cue	
	PC	SE	PC	SE	PC	SE
High	.75	.015	.62	.015	.58	.019
Low	.55	.015	.54	.021	.43	.020

free associates in Experiment 1 were equal for both high- and low-imagery sentences. If the rather conservative "monotonically" is replaced by "proportionally" in the assumption concerning representation of network components by free associates, one would expect high-imagery sentences to produce more free associates if perceptual time was allowed, for perceptual encoding must await determination of the semantic relationships of sentence constituents before perceptual relations and concepts can be properly ordered (Kieras, 1978, p. 539). However, ample encoding and free association time were provided (8 and 10 sec, respectively). Fourth, distributional qualities of free associate imagery ratings argue for a tradeoff. If perceptual network components strictly augmented semantic components, their free associate distributions should be combined. Therefore, standard errors (reflecting standard deviations) of imagery ratings for free associates should be greater for high-imagery sentences, because high-imagery sentence associates represent both perceptual and semantic network components, and their free associate imagery distributions have different means. Table 2 shows that this was not the case. In fact, standard errors were reversed (nonsignificantly) from what perceptual augmentation would predict.

GENERAL DISCUSSION

Possibly the greatest advantage that memory network models have is their ability to represent a variety of information; that is, they offer a single representational system (the proposition) that can accommodate different types of knowledge. The need for this has been stated by others (Kintsch, 1974; Marschark & Paivio, 1977) and is strongly reiterated here. It is absolutely essential that perceptual and semantic knowledge interact in the processing of high-imagery sentences, for (as stated earlier) a sentence must receive at least minimal semantic interpretation before perceptual processing may take place. In the sentence "The gopher ran into the hole," details of the appropriate image cannot be ascertained until a semantic interpretation is made dealing with the relationship between the gopher and the hole. "Ran into" produces an image very different from that produced by "stood beside" or even "flew over." In perceptual network terms, perceptual relations and concepts may not be accurately arranged until a minimal semantic network is activated. How minimal the semantic interpretation must be is an interesting question, especially in light of evidence for a perceptual and semantic processing tradeoff. It is well established that imaginal mediation may be used to process a variety of stimuli and that such processing may be used even with very low-imagery or abstract material. Subjects can use images to represent any sentence if they are willing to engage in considerable elaboration and inference to do

so. For example, a highly abstract sentence such as "The essence lay in its qualification" is not directly imageable from information used in a simple "single-code" semantic network. Further semantic processing must occur. In this case, a referent must be established for "it" and "qualifications," and the properties of the "qualifications" that match "essence" in "it" must be determined. Only after considerable mental gymnastics involving semantic memory searches and decisions having little or nothing to do with perceptual processing could sufficient perceptual information be found to represent the sentence in perceptual codes. In addition, it is virtually certain that the perceptual representation of such a sentence would be far removed from the original semantic interpretation and that prior context or extensive tagging of inferential steps would be necessary to provide a link between the two.

Differences in sentences about the "gopher" and the "essence" lie in the amount of semantic processing needed for perceptual processing to begin. If it is assumed that perceptual network representations are preferred to semantic, the reason for a tradeoff is clear. Each sentence receives only complex enough semantic interpretation to allow perceptual interpretation to proceed, which happens unless specific nonperceptual information is required. One possibility is that after simple semantic interpretation, permanent semantic memory networks for semantic concepts are searched for perceptual relations and the permanent memory networks for semantic relations are searched for perceptual (high-imagery) concepts. If a compatibility is found between the resulting concepts and relations (determined by their joint inclusion in still other permanent memory networks), construction and/or activation of perceptual networks begins. Further semantic network elaboration either ceases or continues at a reduced level in parallel with perceptual elaboration (parallel semantic searches have been demonstrated by Anderson, 1974, and Thorndyke & Bower, 1974). Few perceptual blind alleys would occur using this strategy because perceptual network constructions can be semantically anomalous (e.g., "a flying whale"). Subjects under instruction to use imaginal mediators might call perceptual network construction into play sooner, and they would probably construct images more bizarre but semantically closer to the basic semantic network than otherwise.

It should be noted that low-imagery recall cues used in Experiment 2 were free associates generated after considerable sentence processing had occurred and were more likely to reflect semantic networks elaborated from basic semantic networks. Because of this, they were more likely to be superior recall cues for low-imagery sentences in a semantic-perceptual system involved in a tradeoff. Low-imagery cues reflecting initial semantic processing, such as sentence subjects, objects, and verbs, would probably have not been superior, for both high-

and low-imagery sentences would have been processed at this lowest level.

The structure of the perceptual and semantic networks originally proposed in the introduction was quite simple. Differences between the networks involved only content, that is, only nodes and relations. As Kieras (1978) points out, additional differences are possible, specifically in the configuration of nodes and relations. Anderson (1978) states that an adequate propositional model must include both representational and process components and that any processes would have to include specific mechanisms for contact between semantic and perceptual propositions network components to account for the apparent tradeoff between the two. Few existing models are readily adaptable to separation of perceptual and semantic information, and none have specific mechanisms to account for a tradeoff. Both Kintsch (1974) and Schank (1972) propose models that are complex enough to represent both basic and elaborative processing needed to account for such a tradeoff. Kintsch has also had the foresight to suggest that perceptual knowledge needs to be separately accommodated in propositional systems through the use of analog representations. Simple associative "single-code networks" such as HAM (Anderson & Bower, 1973) are inadequate to account for any of the findings here, since only a basic semantic network is used. Furthermore, they cannot account for simple integrative properties that are present in both high- and low-imagery sentences (Foss & Harwood, 1975; Marschark & Paivio, 1977), or for extensive inferential processing that occurs even at the lowest levels of comprehension (Franks & Bransford, 1972). Anderson's (1976) ACT model also includes sufficiently complex processes to account for such a tradeoff, and it deals specifically with the elaboration of semantic and perceptual information in propositional form. A central concept in ACT is that redundancy produced by elaboration of productions is beneficial to the maintenance of memory for sentences, and so on—an assertion shared here. However, in ACT, subjects are thought to be able to memorize concrete sentences more easily because they can elaborate perceptual propositions more readily. This is because they have built up a lifetime of such propositions by experience (Anderson, 1976, p. 404). This role of perceptual elaboration, however, is inconsistent with the results of Experiment 1. High- and low-imagery sentences are found to elicit equal numbers of associates. Perhaps, as Anderson implies, subjects have simply not practiced elaboration of highly abstract material, because such material is rarely encountered out of context in everyday life. Nevertheless, it seems that an adequate model must deal with the possibility that semantic elaboration has as a primary purpose the "reforming" of memory information into a configuration that can easily access perceptual information.

REFERENCES

- ANDERSON, J. R. Retrieval of propositional information from long-term memory. *Cognitive Psychology*, 1974, 6, 451-474.
- ANDERSON, J. R. *Language memory and thought*. Hillsdale, N.J.: Erlbaum, 1976.
- ANDERSON, J. R. Arguments concerning representations for mental imagery. *Psychological Review*, 1978, 85, 249-275.
- ANDERSON, J. R., & BOWER, G. H. *Human associative memory*. Washington, D.C.: Winston, 1973.
- BEGG, I., & PAIVIO, A. Concreteness and imagery in sentence meanings. *Journal of Verbal Learning and Verbal Behavior*, 1969, 8, 821-827.
- BYRNE, B. Item concreteness vs. spatial organization as predictors of visual imagery. *Memory & Cognition*, 1974, 2, 53-59.
- CROWDER, R. G. *Principles of learning and memory*. Hillsdale, N.J.: Erlbaum, 1976.
- DAVIES, G., & PROCTOR, J. The recall of concrete and abstract sentences as a function of interpolated task. *British Journal of Psychology*, 1976, 67, 63-72.
- ELLIOT, L. Imagery versus repetition coding in short- and long-term memory. *Journal of Experimental Psychology*, 1973, 100, 270-276.
- FOSS, D. J., & HARWOOD, D. A. Memory for sentences: Implications for human associative memory. *Journal of Verbal Learning and Verbal Behavior*, 1975, 14, 4-16.
- FRANKS, J., & BRANSFORD, J. The acquisition of abstract ideas. *Journal of Verbal Learning and Verbal Behavior*, 1972, 11, 311-315.
- HOLMES, V. M., & LANGFORD, J. Comprehension and recall of abstract and concrete sentences. *Journal of Verbal Learning & Verbal Behavior*, 1976, 15, 559-566.
- KIERAS, D. Beyond pictures and words: Alternative information processing models for imagery effects in verbal memory. *Psychological Bulletin*, 1978, 85, 532-554.
- KINTSCH, W. *The representation of meaning in memory*. Potomac, Md.: Erlbaum, 1974.
- KLEE, H., & EYSENCK, M. W. Comprehension of abstract and concrete sentences. *Journal of Verbal Learning and Verbal Behavior*, 1973, 12, 522-529.
- KUČERA, H., & FRANCIS, W. *Computational analysis of present-day American English*. Providence, R.I.: Brown University Press, 1967.
- MARSCHARK, M., & PAIVIO, A. Integrative processing of concrete and abstract sentences. *Journal of Verbal Learning and Verbal Behavior*, 1977, 16, 217-231.
- NORMAN, D. A., & RUMELHART, D. E. *Explorations in cognition*. San Francisco: Freeman, 1975.
- PAIVIO, A. Mental imagery in associative learning and memory. *Psychological Review*, 1969, 76, 241-263.
- PAIVIO, A. Imagery and language. In S. J. Segal (Ed.), *Imagery: Current cognitive approaches*. New York: Academic Press, 1971. (a)
- PAIVIO, A. *Imagery and verbal processes*. New York: Holt, Reinhart, & Winston, 1971. (b)
- PYLYSHYN, Z. W. What the mind's eye tells the mind's brain: A critique of mental imagery. *Psychological Bulletin*, 1973, 80, 1-24.
- SCHANK, R. C. Conceptual dependency: A theory of natural language understanding. *Cognitive Psychology*, 1972, 3, 552-631.
- SEGAL, S. J., & FUSELLA, V. Influence of imaged pictures and sounds on detection of auditory and visual signals. *Journal of Experimental Psychology*, 1970, 83, 458-464.
- THORNDYKE, P. W., & BOWER, G. H. Storage and retrieval processes in sentence memory. *Cognitive Psychology*, 1974, 6, 515-543.

(Received for publication September 8, 1980;
revision accepted May 5, 1981.)