MENTAL IMAGERY IN ASSOCIATIVE LEARNING AND MEMORY

ALLAN PAIVIO

University of Western Ontario

Nonverbal imagery and verbal symbolic processes are considered in relation to associative learning and memory. These two hypothesized processes are operationally distinguished in terms of stimulus attributes and experimental procedures designed to make them differentially available as associative mediators or memory codes. The availability of imagery is assumed to vary directly with item concreteness or image-evoking ($I$) value, whereas verbal processes are presumably independent of concreteness but functionally linked to meaningfulness ($M$) and codability. Stimulus characteristics are hypothesized to interact with mediation instructions, presentation rates, and type of memory task. Performance and subjective-report data resulting from experimental tests of the model indicated that imagery-concreteness is the most potent stimulus attribute yet identified among meaningful items, while $M$ and other relevant attributes are relatively ineffective; that both processes can be effectively manipulated by mediation instructions, but imagery is a "preferred" mediator when at least one member of the pair is relatively concrete; and that the two mechanisms are differentially effective in sequential and nonsequential memory tasks. The findings substantiate the explanatory and heuristic value of the imagery concept.

This paper is concerned with the functional significance of nonverbal imagery and verbal processes in associative meaning, mediation, and memory. As every psychologist knows, imagery once played a prominent role in the interpretation of such phenomena. It was widely regarded as the mental representative of meaning—or of concrete meaning at least. William James, for example, suggested that the static meaning of concrete words "consists of sensory images awakened [1890, p. 265]." As manifested in the "wax tablet" model of memory, imagery was the prototype of stimulus trace theories (Gomulicki, 1953) and, as associative imagery, it was assumed to play a mediational role in mnemonic techniques which originated long ago as a practical art (see Yates, 1966). Despite the criticisms that have been repeatedly directed at such views, common-sense experience continues to make their acceptance compelling. Thus, in a recent discussion of the possible role of nonverbal schemata in verbal learning, Shepard (1966) writes,

if I am now asked about the number of windows in my house, I find that I must picture the house, as viewed from different sides or from within different rooms, and then count the windows presented in these various mental images. No amount of purely verbal machinations would seem to suffice [p. 203].

The crucial point here is that the eliciting question and the behavioral expression of re-
call may be entirely verbal, but the mediating mechanism apparently is not.

It is precisely such views that were rejected by Watson (1913). Partly on philosophical grounds and partly on the basis of the experimental evidence then available, he concluded that mental images are mere ghosts, without any functional significance whatever. The mediating functions that had been attributed to images in thought and memory became the burden of implicit verbal responses or their gestural substitutes (e.g., see Goss, 1961; Watson, 1930, pp. 265-268) and until very recently this emphasis continued to dominate research on problems of meaning and mediation processes in verbal learning, memory, and language. The meaningfulness of verbal units has been defined most commonly in terms of such verbal associative measures as association value (Glaze, 1928) and meaningfulness (m) (Noble, 1952). Consistent with this definition, effects of meaningfulness on associative learning and memory have been interpreted in terms of the availability of implicit associates as mediators of stimulus-response (S-R) associations, as in the associative probability (Underwood & Schulz, 1960, p. 296) or “grapnel” theory (Glanzer, 1962). A similar verbal emphasis has been generally apparent in research on mediated transfer and generalization, clustering in free recall, association in language, and natural language mediators (e.g., Bousfield, 1961; Cofer, 1965; Deese, 1965; Jenkins, 1963; Martin, Boersma, & Cox, 1965; Montague, Adams, & Kiess, 1966; Underwood, 1965). The possible role of imagery in such phenomena has been largely ignored.

Deese (1965) aptly summarizes the current view in the context of association theory as follows:

The modern experimental psychologist works almost exclusively with linguistic associations for the good reason that these provide controllable material for his laboratory studies; he ignores the existence of perceptual imagery. . . . Without necessarily denying either their reality or their importance, [he] finds images difficult to manage in empirical study. Partly for this reason and partly for others, association theory in modern psychology has become a theory of the succession of elements in verbal behavior [p. 4].

This is the classical behavioristic argument—imagery is subjective and inferential, words are objective and manageable. It constitutes a valid case against imagery if the interests of contemporary psychologists remained at the empirical level, but they do not. As Deese goes on to say,

We study associations in order to make inferences about the nature of human thought. . . . The whole of the current concern is with the associative properties of explicit verbal behavior as a model for the implicit verbal processes of thought [p. 4, italics added].

Here ends the empirical superiority of words, for implicit verbal processes are no less inferential than images. It may seem more direct and parsimonious to infer a verbal mediator when the response is verbal but this follows only if one assumes a one-to-one relation between an associative reaction and the mental process that caused it. Such an assumption would be unwarranted for one can respond verbally to pictures as well as to words and so, by analogy, one's verbal response could just as logically be mediated by a "mental picture" as by "mental words." Both are pure inferences and which one it is more logical to infer in research concerned with such problems depends on the total set of conditions in a given study, including such variables as stimulus attributes, instructional sets, and introspective reports, not merely on the nature of the overt response. That is not a problem, however, if one chooses to ignore the extra existence of imagery.

The situation as portrayed is changing. On the one hand there is evidence of growing dissatisfaction with traditional behavioristic approaches to verbal learning and behavior (Dixon & Horton, 1968). On the other, the negative attitude that Watson fostered in regard to imagery has softened and the concept has received considerable attention from theorists with diverse interests (e.g., Beritoff, 1965; Hebb, 1966; Holt, 1964; Mowrer, 1960; Singer, 1966; Skinner, 1953; Tomkins, 1962). More specifically in regard to verbal behavior, Osgood (e.g., 1961) has long argued in favor of nonverbal mediating processes and Staats (1961) has indicated how imagery can be incorporated into such a model. Finally, active research
on the possible role of mediating imagery in verbal learning and memory is proceeding apace (e.g., Bower, 1967; Bugelski, Kidd, & Segman, 1968; Paivio, 1965; Reese, 1965; Smith & Noble, 1965; Rohwer, 1966; Wood, 1967), suggesting that systematic consideration of some of the relevant issues may be timely. The following is a review of such problems, organized around a particular empirical-theoretical approach. The main features of the approach are first outlined briefly, followed by a more elaborate treatment in the context of relevant research.

An Overview of the Approach

The possible role of nonverbal imagery will be emphasized without denying the obvious relevance of verbal mechanisms. Images are regarded as symbolic processes which are linked developmentally to associative experiences involving concrete objects and events. In relation to language, they could be regarded as conditioned sensations for which appropriate words function as conditioned stimuli (cf. Mowrer, 1960; Sheffield, 1961; Skinner, 1957; Staats, 1961), or as constructions that are actively generated by the individual (e.g., Neisser, 1967; Piaget & Inhelder, 1966). Acceptance of a particular hypothesis is not essential here. Both images and verbal processes are operationally defined and the concern is with their functional significance rather than their origin. The two processes are assumed to function as alternative coding systems, or modes of symbolic representation (cf. Bruner, 1964). These may be relatively directly aroused in the sense that a concrete object or event evokes a perceptual trace, and a word, an implicit verbal response. Or, they may be associatively aroused in the sense that an object elicits its verbal label, or memory images of objects of the same class; and a word, if it is concrete, arouses an object image. In addition, chains of associative transformations involving either words or images or both (cf. Berlyne, 1965) presumably can occur and serve a mediational function in verbal learning.

The mediational function and arousal of imagery are theoretically coordinated to an abstract-concrete dimension of stimulus meaning, which is defined in terms of directness of sensory reference. For present purposes, it can be understood as extending from abstract nouns to concrete nouns to pictures and objects, in increasing order of concreteness. The higher the concreteness of stimulus items, the more likely are they to evoke sensory images that can function as mediators of associative learning and memory. Verbal mediators, on the other hand, are not assumed to be functionally linked to concreteness, but may be correlated with verbal associative meaning as indexed by such measures as association value and $m$. In addition, the arousal and mediational potential of both symbolic modes presumably can be influenced by instructional sets and other experimental procedures. Stimulus attributes and instructional sets thus may be regarded as different operations that define the postulated symbolic processes.

The research to be discussed in relation to the theory has involved both classes of definitions, and inferences are also based on the kinds of mediators subjects (Ss) report using in a learning situation. One series of studies is concerned with the relative effects of the two kinds of stimulus meaning on associative learning. Other studies involve both stimulus attributes and instructional sets, inferences concerning images and verbal processes being based on the interactive effects of these variables on performance scores and reported mediators. A final section of this paper extends the theoretical views and variables to memory tasks other than paired associates. The central question throughout is whether or not it is theoretically necessary, or at least useful to postulate both kinds of symbolic processes, imaginal as well as verbal, to account for the observed effects.

Stimulus Attributes and Mediating Imagery in Associate Learning

Memory techniques based on mediating imagery form the point of departure. Numerous versions have been devised during their long history (see, e.g., Hunter 1964; Yates, 1966), but the one that is analytically most relevant here involves the use of a numerical rhyme such as one-bun, two-shoe,
three-tree, four-door, and so on, together with bizarre images of the objects named (see, e.g., Bugelski et al., 1968; Miller, Galanter, & Pribram, 1960, pp. 134–138). Thus, to memorize a series of new objects, one imagines the first object, say a chair, inside a huge hamburger bun. The objects can be recalled sequentially or in any order given the number as a cue, which in turn reinstates the image; for example, “one” evokes the image of the bun and chair. This technique changes what is essentially a free-recall situation into paired-associate (PA) learning in which the stimulus items are highly familiar and highly differentiated units, and ostensibly makes use of perceptual imagery to mediate response retrieval. The technique is apparently simple in practice. It is psychologically complex, however, involving multiple stages of symbolic transformation or coding, from words to images and back to words, together with the implicit assumption that memory for concrete objects is somehow superior to memory for words (otherwise, why bother to make the transformation from words to concrete images at all?). The research described below has been in part an exploration of the effective variables, assumptions, and complexities implicit in such a technique, but extended to more conventional associative learning problems. In particular, the use of word “pegs” and the imagery instructions appear to be the crucial features of the technique, and both have been systematically investigated, first in the context of standard PA learning and more recently in relation to the mnemonic technique in its pristine form.

The Conceptual Peg Hypothesis

The implication in regard to the word pegs, one-bun, etc., is that their image-arousing potential may be an important variable independent of the instruction to make use of imagery, and that such word imagery may be effective as a stimulus variable in PA learning. This hypothesis was tested in a series of experiments, first with adjective-noun pairs (Paivio, 1963) and later with noun-noun pairs. The latter situation is most directly relevant to the central issues to be considered here and the hypothesis will be described in that context. The argument is that the stimulus member of a pair serves as a “conceptual peg” (a term first introduced, without reference to imagery, by Lambert & Paivio, 1956) to which its associate is hooked during learning trials when stimulus and response members are presented together, and from which the response member can be retrieved on recall trials when the stimulus member is presented alone. On the assumption that imagery can serve a mediating function, as the imagery memory technique suggests, it follows that the ease of learning the stimulus-response association will depend partly on the image-arousing capacity of the individual nouns and of the stimulus member in particular. The imagery value of both stimulus and response would contribute to the formation of a compound image, consisting of images evoked by the individual items when the two are presented together, thereby affecting the formation of the mediated association. On recall trials, however, when the stimulus is presented alone, its image-arousing value would be particularly important, for the stimulus member must serve as the cue that reinstates the compound image from which the response component can be retrieved and recoded as a word. The hypothesis leads to the prediction that a positive effect of noun imagery will be greater on the stimulus side than on the response side of pairs. Assuming, further, that concrete nouns such as “house” elicit images more readily than abstract nouns such as “truth,” it would be expected that PA learning of nouns will be particularly facilitated when the stimulus noun is concrete. To extend the metaphor, concrete nouns should be more “solid” conceptual pegs than abstract nouns.

The hypothesis was tested (Paivio, 1965) using 16 pairs of nouns, four of each possible combination of stimulus and response abstractness-concreteness. The specific prediction was that the four types of pairs would rank in the order, concrete-concrete, concrete-abstract, abstract-concrete, and abstract-abstract, in increasing order of difficulty, thus reflecting the greater potency of concreteness on the stimulus side. The results were exactly as predicted, with ab-
stractness-concreteness of stimulus members accounting for eight times the variance attributable to response concreteness. Interpretations aside for the moment, it may be noted that this finding contrasts sharply with the common empirical generalization (e.g., Goss & Nodine, 1965, pp. 219-220; Noble & McNeely, 1957) that response factors are crucial in PA learning whereas stimulus factors are relatively unimportant. In the present instance, the stimulus attribute turned out to have much more weight than the response attribute, indicating the heuristic value of the hypothesis that generated the novel finding.

The assumption that concrete nouns exceed abstract nouns in their image-evoking value was also confirmed by ratings obtained from a different group of Ss, and stimulus imagery scores correlated more highly than response imagery scores with PA learning. These findings have been confirmed and extended in subsequent experiments that were designed to clarify problems of interpretation arising from the initial study.

The Problem of the Effective Word Attribute

The identification of the effective meaning dimension is a major problem. Is noun imagery, as indexed by the ratings, "really" the effective empirical attribute or is it some correlated attribute such as $m$? If the observed relations involving word imagery can be attributed to some other empirical variable, the theoretical argument for stimulus-evoked imagery as the effective underlying process is obviously weakened.

Imagery versus $m$. The most important alternative to imagery is $m$, which has been empirically related to learning in a variety of situations and theoretically linked to verbal mediating processes. Concrete nouns generally surpass abstract nouns in $m$ as well as rated imagery (Paivio, Yuille, & Madigan, 1968), and $m$ and imagery correlated equally with learning in the Paivio (1965) experiment. It seemed unlikely that $m$ could be the effective variable because its effect is usually greater on the response rather than the stimulus side in PA learning (see Goss & Nodine, 1965; Underwood & Schulz, 1960), whereas the covarying noun attributes in the concreteness study were much more effective on the stimulus side. The superior effect of response $m$ has invariably been obtained with nonsense words as low-$m$ items, however, and the possibility remained that $m$ is more potent on the stimulus side when varied entirely among familiar words.

The problem has been clarified by a series of experiments. Paivio, Yuille, and Smythe (1966) varied image evoking ($I$) and $m$ independently in different lists and found the usual stimulus effect for $I$ despite a restricted range of variation, while $m$ was effective on both stimulus and response sides when varied within low-$I$, abstract, noun pairs but not when varied within concrete, high-$I$ pairs. Other studies (Paivio, 1967; Paivio & Olver, 1964) have shown that partialing out $m$ had little effect on the positive correlation between learning scores and $I$ but, with $I$ similarly controlled, any effect of $m$ was reduced to zero. More rigorous control over the range of variability in the contrasting variables has been achieved recently using words from a sample of 925 nouns on which normative data are available on rated concreteness, rated $I$, and production $m$ (Paivio, Yuille, & Madigan, 1968). Experiments involving these words (Paivio & Yuille, 1967; Smythe & Paivio, 1968) have demonstrated conclusively that $I$ is more effective than $m$ when the two variables are independently varied over an equivalent range in terms of standard score units based on the normative sample. In one of these studies (Smythe & Paivio, 1968), the only effect of $m$ was a slight negative one occurring.

The size of the word pool makes it feasible to hold $m$ constant while varying $I$, or vice versa, despite a positive correlation of $72$ between these variables. Imagery and concreteness, which correlate $.83$ in the sample, have generally been allowed to covary in the studies, although item selection has usually been on the basis of the $I$ scale because it appears to be superior to rated concreteness as a predictor of learning (Paivio, 1968a). Except for certain unusual items (see Paivio, Yuille, & Madigan, 1968; Yuille, 1968), however, the two scales appear largely to be alternative measures of the same variable and the terms, noun imagery and concreteness, are used here interchangeably except where an attempt is made to be particularly precise about the variable involved.
The effects of $I$ have been demonstrated with varied procedures, whereas the $m$ effects just described always involved a mixed-list design. A final experiment was accordingly done using homogeneous lists of the four possible S-R combinations of high and low $m$, with $I$ controlled. The results revealed no significant effects, although the trend again was for somewhat better recall of low-low $m$ pairs than of the other combinations.

The conclusion from these studies is clear. The relations between noun imagery and PA learning not only can not be interpreted in terms of $m$, but imagery is the more potent of the two empirical variables. The effects of $m$ have, in fact, varied from slightly positive, to zero, to slightly negative in the different experiments, which may be relevant to the "interference paradox" of associative probability theory (cf. Barnes & Schulz, 1966), but not the interpretation of $I$ effects. The significance of these findings extends beyond the present context. A number of studies ostensibly concerned with effects of $m$ have involved nouns that obviously vary in concreteness (e.g., Mueller & Travers, 1965; Saltz, 1967) and the observed effects could be reinterpreted in terms of imagery rather than $m$. Furthermore, the conclusion that $m$ is relatively ineffective in PA learning involving real words extends to word classes other than nouns (Kanungo, 1968).

Other confounding semantic attributes. Although ruling out $m$, the above findings do not eliminate the possibility that some other unidentified correlate of $I$ might be responsible for the effects. This issue was clarified by a factor-analytic study (Paivio, 1968a) of 96 nouns for which mean scores were obtained on ease of learning and various semantic and associative characteristics. The learning variables were recall scores for the nouns when they served as stimulus terms and when they served as response terms in PA learning, as well as scores from a free-recall experiment. The other noun attributes, 27 in all, included several measures of concreteness and imagery, and other potentially effective variables such as $m$, familiarity, distinctiveness, associative reaction time, semantic differential meaning dimensions, and so on. The results showed
that only nine of the noun attributes correlated significantly with one or more of the learning scores and, of these, rated I was the best predictor of learning (the highest correlation was between stimulus-term I and PA scores), closely followed by the other indexes of imagery and concreteness. In addition, the imagery and concreteness variables defined a strong factor on which PA learning scores with the items as stimulus members also showed a substantial loading. Such an imagery-concreteness factor has been recently confirmed by Frincke (1968), who found it to be the best of a number of predictors of free recall. The conclusion that rated I defines the effective attribute better than rated concreteness has also been substantiated (Yuille, 1968).

The caveat that causal relations cannot be inferred from correlational data obviously applies fully to these findings. Nevertheless, it is apparent that concreteness-imagery is a major dimension of word meaning—or, at least noun meaning—which is noteworthy because such a factor has not emerged in the multitude of studies that have been conducted on semantic dimensions (e.g., Osgood, Suci, & Tannenbaum, 1957). Moreover, the evidence indicates that this dimension is the most potent one yet identified among familiar words.

The Imagery Hypothesis and Response Attributes

The plausibility of the imagery hypothesis given certain characteristics of the response members of pairs can also be questioned. An analysis in terms of stimulus-elicited mediating imagery is relatively straightforward and intuitively plausible when both members of the pair can be assumed to evoke sensory images readily. It is less straightforward when a concrete noun is paired with an abstract noun, but here too it can be seen how a concrete stimulus might “prime” imaginal encoding of an abstract response. For example, “religion” as a response term might be encoded as a church, given a concrete stimulus as the cue. It is more difficult similarly to interpret the finding (Yarmey & Paivio, 1965) that noun concreteness is relatively more effective on the stimulus side even when the other member of the pair is a nonsense syllable. A mediational interpretation of the effect apparently requires a theory of multiple stages of coding in which it is assumed that a high-imagery stimulus term somehow increases the probability that a nonsense-syllable response will be encoded into a meaningful word and then further translated into concrete imagery. It must be assumed further that decoding from the mediator back to the nonsense syllable response is not difficult, otherwise decoding errors would occur (Underwood & Erlebacher, 1965). This analysis suggests that the effectiveness of any mediating imagery in such a case should be a function of both the I value of the noun stimulus and the ease with which the nonsense syllable response can be encoded as a word.

Paivio and Madigan (1968) tested the hypothesis using high-I and low-I nouns as either stimulus or response members for nonsense syllable associates, which in turn were either high or low in association value. The hypothesis would be supported if the differential superiority of high-I nouns on the stimulus side of pairs is greater with high-association-value than with low-association-value associates, since the former items more readily suggest meaningful words that could enter into image-mediated linkage with the high-I stimuli. No such interaction should emerge with nouns as response members. The results were clearly as predicted for the first two of four study-test trials, although stimulus I was effective by Trial 4 even with low-association-value (CCC) trigrams as responses.

These results together with those previously described for noun-noun pairs support the following conclusion: To the extent that a differential effect of noun concreteness or I on the stimulus side is crucial to the imagery mediation theory, such mediation is most probable when the response term is a meaningful word, although it may also be involved to some extent when the response is a nonsense syllable provided that it readily suggests a word. In addition, noun I seems to be generally effective on both sides of pairs regardless of the nature of the associate, sug-
gesting that some nonmediational process, such as differentiation based on semantic dissimilarity or distinctiveness (cf. Goss, 1963; Saltz, 1963), may be involved. The latter hypothesis has been tested using associative overlap (Paivio, 1965) and rating scale data (Paivio, 1968a) as measures of distinctiveness, with negative results, but the problem deserves more systematic research for it is an attractive theoretical possibility that word imagery facilitates item differentiation as well as mediation.

A TWO-PROCESS THEORY OF MEANING AND MEDIATION

Further important problems arising from the research concern the positive contribution of verbal processes, and the provision of more direct evidence that mediation of any kind is involved in the observed effects. While it was never assumed that imagery alone determines the associative learning of nouns, the relation between imaginal and verbal processes was not explicitly stated in the conceptual peg hypothesis. Verbal mechanisms are explicitly postulated in the following analysis, which relates availability of verbal associative processes as well as imagery to the abstract-concrete dimension of stimulus meaning. Mediation processes have been directly investigated in the context of the hypothesis, which, it should be noted, is in no way intended as a complete theory of meaning, but rather as a heuristic approach to what has been termed associative meaning (e.g., Deese, 1965). The hypothesis is that concrete terms such as “house” derive their meaning through association with concrete objects and events as well as through association with other words, and thereby acquire the capacity to evoke both nonverbal images and verbal processes as associative (meaning) reactions, which could function as alternative coding systems affecting mediation and memory. Abstract terms such as “truth,” on the other hand, derive their meaning largely through intraverbal experiences and more effectively arouse verbal associative than imaginal processes. Such a view of associative meaning is not new (cf. James, 1890, p. 264; Staats, 1961), but its implications have not been stated or explored in relation to association and learning. It may be noted that the hypothesis subsumes the conceptual peg hypothesis in that any differential effects associated with abstract and concrete stimuli are still attributed to the greater I capacity of the latter.

The implications of the hypothesis have been tested using Ss’ reports of associative strategies in PA learning as evidence of the postulated mediation processes, and by the use of mediation instructions to encourage their arousal.

Evidence from Subjective Reports

The assessment of learning strategies using subjective reports has yielded evidence of mediating imagery as well as verbal mechanisms (e.g., Bugelski, 1962; Reed, 1918; Underwood & Schulz, 1960). However, the most systematic recent approaches have stressed “natural language mediators” (e.g., Martin et al., 1965; Montague et al., 1966) without reference to imagery, although it is likely that Ss would have classified some of their mediators as nonverbal images if given a choice, as was done in the following studies.

The two-process theory of associative meaning implies that Ss will report frequent use of both images and verbal mediators to learn noun pairs in which at least the stimulus member is concrete, whereas verbal mediators should predominate in the case of abstract pairs. The results of a number of experiments have partly supported these expectations. Paivio et al. (1966) used a postlearning questionnaire which described mental images and verbal mediators as possible associative strategies along with a no-mediation category. The Ss indicated for each noun pair which technique they had used, followed by a description of the specific mediator. A striking pattern of relations emerged in which images were predominantly reported for concrete pairs, followed by verbal mediators for abstract pairs. The results of a number of experiments have partly supported these expectations. Paivio et al. (1966) used a postlearning questionnaire which described mental images and verbal mediators as possible associative strategies along with a no-mediation category. The Ss indicated for each noun pair which technique they had used, followed by a description of the specific mediator. A striking pattern of relations emerged in which images were predominantly reported for concrete pairs, whereas verbal mediators predominated in the case of abstract pairs.
est for unmediated pairs, suggesting that imagery was the most effective mediator.

The associative strategies specified in the questionnaire have been extended in subsequent research to include rote repetition and a general "other" category. Of greatest interest theoretically, only the image, verbal, and repetition strategies are considered here. The data are generally consistent with the two-process theory of associative meaning, with the modification that images are either more available than words, or that Ss have a preference for using (or at least reporting) imagery in the case of pairs in which at least the stimulus member is concrete and high I. Verbal mediation reports have generally shown smaller relations to item attributes than in the initial study (Paivio et al., 1966). These points are illustrated by the Paivio, Smythe, and Yuille (1968) experiment, described earlier, in which noun I was varied in one list, m was varied in a second, and the two were covaried in a third. Figure 2 shows the mean frequencies of imagery, verbal, and repetition strategies for the four types of pairs in the I-varied and m-varied lists. Reported imagery was strongly related to noun I, particularly of stimulus members, whereas verbal mediators and repetition showed no such pattern. The findings were similar for the list (not shown in the figure) with I and m covaried. In the case of the list in which only m was varied, however, it can be seen that none of the reported strategies was significantly related to m. A correlational analysis involving item attributes, learning scores, and frequency of reported mediators for individual items over all three lists confirmed the inference that the strongest relations were those between I, reported use of imagery, and learning scores when the items served as stimulus members of pairs. Furthermore, reported imagery correlated significantly with learning even with stimulus I partialed out, increasing the plausibility of the argument that associations were in fact mediated by imagery. Although the causal sequence obviously remains equivocal in such data (alternative interpretations are discussed in detail by Paivio et al., 1966; Paivio, Smythe, & Yuille, 1968), the observed relations are remarkable, especially if one takes the traditional behavioristic view that the mediation process involved must be entirely verbal. If this were so, why should verbal mediators fail to show strong relations to item attributes and learning when Ss have as much opportunity to report such mediators as they do imagery? Introspective reports alone are unlikely to settle the issues, however, and we turn to another approach.

Evidence from Research Involving Instructional Sets

Instructional sets have been used in a series of studies to test deductions from the two-process theory. One prediction is that the latency of an associated image to a stimulus word will be longer when the stimulus word is abstract and low I than when it is concrete and high I whereas verbal associative latency will be less affected by variation in concreteness. To test this, Paivio (1966) had Ss press a key either when a mental image or an implicit verbal associate occurred to a stimulus word. The results showed that reaction times were longer to abstract than
concrete words under both the verbal and imaginal associative instructions but, as predicted, the difference was much greater under the imagery set. Yuille and Paivio (1967) obtained analogous results for noun pairs. The latency of discovery of imaginal mediators was slower for pairs with abstract, low-/ stimuli than for those with concrete, high-/ stimuli, but this difference did not occur under a verbal mediation set.

According to a verbal mediation approach such as Glanzer and Clark's (1962) verbal loop hypothesis, it might be argued that abstract nouns simply arouse a longer covert verbal response chain under imagery instructions. Such an interpretation fails to account for the interactions between stimulus concreteness and instructional set for, if imagery instructions simply increase covert verbalization, why would they not increase imaginal reaction time to concrete words as much as to abstract? Direct evidence on the role of verbalization in such a situation was incidentally obtained in a recent study (Simpson & Paivio, 1968), an aspect of which required S to press a key when an image occurred to a stimulus word, with or without a subsequent description of the image. The keypress latency increased significantly when verbalization was required, but it did so equally for concrete and abstract stimulus words. This finding indicates that differential (covert) verbalization alone cannot account for the interactions obtained in the reaction time studies involving both imagery and verbal sets.

The hypothesis was extended to PA learning studies in which Ss were given instructional sets to use verbal or imaginal mediators to learn lists of noun pairs varying in concreteness. The predictions were that a set to use imagery would facilitate the learning of pairs in which at least the stimulus member is concrete but not pairs with abstract stimuli, whereas a verbal mediation set should be equally effective with concrete or abstract items. Paivio and Yuille (1967) compared the two mediation set conditions with a control condition in which Ss were instructed to use rote repetition and found that the imaginal and verbal sets produced much better learning than did the repetition set, but the predicted interaction with concreteness did not occur. That is, the imagery set was no less effective than the verbal even with abstract pairs. Yuille and Paivio (1968) attempted to induce stronger mediation sets by having Ss first practice associating pairs of nouns using images or verbal links, after which they learned another PA list using the technique they had practiced. Both imaginal and verbal sets again facilitated learning relative to a repetition control condition (more so when at least one member of the pair was concrete), but the differential effects predicted for imaginal and verbal sets again failed to appear. Moreover, the effects of the set variable had disappeared by Trial 3 whereas the effects of noun concreteness persisted throughout learning. A possible explanation suggested by mediation report data (Paivio & Yuille, 1967) was that associative strategies are only partly controlled by the experimental sets and that, over trials, Ss increasingly revert to associative habits aroused by the semantic characteristics of the to-be-learned items. They may abandon the use of rote repetition generally, resorting to imagery in the case of concrete pairs and verbal mediators in the case of abstract pairs, and so on.

Paivio and Yuille (1969) tested the hypothesis using a trial-by-trial probe of associative strategies as a function of instructional set and noun concreteness. Different groups were given one of four instructional sets (Imagery, Verbal, Repetition, and No Set) and subgroups within each were questioned after 1, 2, or 3 trials concerning the type of strategy they had used to learn each pair. The results confirmed and extended the previous findings in that the verbal and imaginal mediation sets facilitated learning in comparison with the No Set as well as the Repetition condition, and the effects of set had essentially disappeared by Trial 3 whereas concreteness remained highly effective throughout. Some of the expected changes in the pattern of reported mediators over trials also occurred. The Ss given the imagery and verbal mediation sets most often reported having used the corresponding type of mediator to learn the pairs, and this was true for all trials. In the case of the Repeti-
tion set, on the other hand, rote repetition was frequently reported after one learning trial and decreased thereafter despite the fact that the two- and three-trial groups had been reminded before each trial to use repetition. The pattern of reports suggested that verbal mediators to some extent replaced repetition on the second trial whereas imagery was clearly favored at Trial 3.

The effects were also qualified by the item attribute. Repetition and verbal mediation reports were relatively little affected by concreteness, although verbal mediators tended to show a greater increase over trials for pairs in which both members are abstract than for other pair types. By contrast, imagery reports were strongly affected by concreteness in a manner closely resembling its effect on learning. The parallel effects on reported imagery and recall scores as a function of concreteness and trials are shown in Figure 3. In addition to the identical ranking of the four types of pairs on both response measures, it can be seen that concrete-abstract pairs show the most striking increase over trials on each dependent variable.

The findings consistently point to imagery as a preferred and an effective mediation strategy in the case of pairs in which at least the stimulus is concrete and high I, whereas verbal mediation is less affected by concreteness. In these respects the data accord with the two-process theory of associative meaning and mediation, but the results provide only weak support for the suggestion that imagery set Ss resort to verbal mediators in the case of abstract pairs. Such changes could actually have occurred but were not detected by the mediation questionnaire. Alternatively, it may be that some Ss can make effective use of imagery even in the case of abstract pairs. Support for such an interpretation was obtained by MacDonald (1967) in a study of the retention of imaginal and verbal mediators and recall of PAs. The Ss instructed to use images frequently reported the use of a concrete image to symbolize one or both members of abstract pairs (e.g., “boy scout” for the pair, chance-deed) and the mnemonic effectiveness of such mediators was evidenced by high recall of the pair only when the mediator was correctly recalled (cf. Montague et al., 1966). Still, it should be relatively more difficult to generate appropriate mediating images for abstract than for concrete pairs, as indicated by the mediation latency data, whereas verbal mediators should not be similarly affected. A further alternative is that verbal mediators, although easily discovered, are relatively ineffective unless accompanied by imagery (Yuille & Paivio, 1968). This view is not likely to find many supporters, but it is a logical alternative that should not be lightly dismissed, particularly since verbal mechanisms were also found to be deficient as the basis of effective m.

Other investigators have contributed relevant data in the area but have not clarified the theoretical issues. Imagery mnemonic instructions have produced effects of varying potency (e.g., Bower, 1967; Bugelski et al., 1968; Seibel, Lockhart, & Taschman, 1967; Smith & Noble, 1965), possibly because widely different procedures have been employed in regard to presentation rates, characteristics of the items, and so on. Hulicka and Grossman (1967) found both imaginal and verbal mediation instructions to be effective with concrete noun pairs, but imagery had the stronger effect. Wood (1967), who also found both types of sets to be facilitating, tested the prediction of an interaction between type of set and noun concreteness, with negative results, although the differences tended to be in the expected direction. Yarmey and Csapo (1968) found support for the two-process hypothesis in that Ss given an imagery set did more poorly than those given a verbal set when the pairs were abstract, but
not when they were concrete. They ran intact groups under the different experimental conditions, however, and the possibility of group sampling error cannot be ruled out even though the results are fully consistent with predictions from the theory.

Concreteness, Imagery, and the Rhyme Mnemonic System

Coming around full circle to generalize from the data thus far presented to the "one-bun" technique which provided the framework for the analysis, it would seem reasonable to conclude that the $I$ value of the rhyming peg words is indeed a most important feature of the mnemonic system. The usefulness of the instructions to use imagery has also been supported, although this factor appears to account for less of the variance in recall scores than does stimulus concreteness when both are varied. Neither conclusion is fully warranted by the evidence presented. The effect of the concreteness of the peg words was not tested by any of the PA learning studies involving noun pairs inasmuch as the peg words are not explicitly presented as stimuli in the mnemonic system as they are in PA learning. Instead, the recall cues in the technique are numerals, and the pegs, together with any images they may arouse, must be implicitly supplied by $S$.

The effects of the imagery instructions also have been generally investigated using noun PAs rather than the one-bun technique, as in the pioneering study by Wallace, Turner, and Perkins (1957) and the more recent research described above. Wood (1967) recognized that the explicit presentation of peg words during learning and recall trials departed from the mnemonic system, and that generalizations from his own results may therefore be limited. He nevertheless reasoned that the procedure is justified inasmuch as it should maximize the effectiveness of the mnemonic system. It will be seen, however, that precisely this conclusion is unwarranted.

Where the mnemonic system has been directly investigated, the adequacy of the control for the mnemonic instructions is in question. Bugelski et al. (1968) found much higher recall after $S$s had been taught the imagery mnemonic technique than under prior control conditions. A standard non-mnemonic control group and a rhyme control group that learned the rhyme but was not informed of its mnemonic function showed no such facilitation. Unfortunately, the effectiveness of the imagery component of the mnemonic instructions was left indeterminate since the study did not include a rhyme control group that had been given mnemonic instructions without being told to use images.

Such a control was included in a study (Paivio, 1968b) which directly tested the effect of the imagery instructions and the concreteness of the mnemonic rhyme in the one-bun technique. The $S$s were presented one study and test trial with each of two 10-item lists of concrete nouns. The conditions for the first list excluded prior mnemonic instructions and were identical for all $S$s. The items were presented auditorially at a 4-second rate, the to-be-recalled nouns being preceded by the numerals 1–10. On the test trial, the numerals alone were read in random order and $S$ attempted to recall the corresponding items. The second list was preceded by mnemonic instructions, with or without reference to the use of imagery, and training on either a concrete or an abstract rhyme. The concrete rhyme consisted of the familiar one-bun, two-shoe device, in which the "peg" words bun, shoe, etc., are concrete and relatively high $I$. The abstract rhyme included peg words such as fun, true, free, bore, etc., all of which have lower $I$ values than do the corresponding concrete pegs.

The $S$s given the imagery set were instructed to use mental images along with the rhyme in order to recall the items. The $S$s not given the imagery instructions were instructed to recall the list by saying to themselves the rhyming words along with the to-be-remembered item, for example, one-bun-pencil. Following the instructions, all $S$s learned the appropriate rhyme, after which they were presented one study-test trial with the second list of nouns.

The results were quite unequivocal. Significant main effects obtained for control versus mnemonic conditions and for no-imagery versus imagery instructions were completely qualified by a highly significant
interaction of the two variables, presented in Figure 4. It can be seen that recall was comparable for all groups on the first non-mnemonic list, and that recall increased dramatically on the second list for Ss given the imagery set regardless of whether the mnemonic rhyme was concrete or abstract. The mnemonic instructions without imagery had no beneficial effect—in fact, recall tended to be lower under the mnemonic than under the control condition.

The unexpected outcome was that concreteness showed no effects approaching significance. The only suggestion of an effect was that the reduction in recall for the second list was significant on a post hoc test for the no-imagery abstract-rhyme group, but their performance on the second list did not differ significantly from that of the concrete-rhyme group. These findings contrast with those obtained using the standard PA procedure, where imagery-concreteness has consistently been highly effective with or without the addition of imagery instructions. Indeed, as already mentioned, item I accounts for more of the variance in recall scores than does the instructional set when both are included in the design. The relative effects of the two variables are completely reversed, therefore, in the context of the mnemonic system.

How are the contrasting effects to be explained? They can be interpreted in terms of the relative weights of the cues that determine the arousal of mediating imagery. In the case of the PA studies, the stimulus pegs are explicitly presented on both study and recall trials, and their image-evoking capacity is more potent than instructional sets in determining mediation strategies and response recall, as indicated by the mediation reports and performance data in the studies described above (e.g., Paivio & Yuille, 1969). In the mnemonic system, however, the pegs are implicit and even ones that are concrete cannot function as effective cues for the arousal of mediating images. The contribution of concreteness as a variable is accordingly depressed while that of the imagery instructions is relatively enhanced.

The analysis suggests that the discovery and utilization of mediating images should be more efficient under the standard PA procedure, when both the concrete stimuli and imagery instructions are explicitly presented. A comparison of the effects of presentation rates in different experiments provides indirect support for the deduction. Bugelski et al. (1968) found the one-bun procedure to be facilitative at exposure rates of 4 or more seconds, but not at 2 seconds, whereas Gruber, Kulkin, and Schwartz (1965) found that imagery instructions facilitated recall of word pairs at rates as fast as 1 second. The presence of the pairs together with the instructional set apparently permitted faster mnemonic processing than did the rhyme technique. The problem deserves further investigation, particularly since it appears to be related to the more general issue of the nature of retrieval cues and the conditions under which they are effective (cf. Tulving & Osler, 1968).

It can be concluded from the Paivio (1968b) results that the imagery instructions are indeed an effective component of the mnemonic techniques. It might still be argued that the instructions simply arouse effective verbal mediators, although the control instruction simply to associate the rhyming pegs with the to-be-remembered words

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4 A further control group that was merely presented two successive lists without mnemonic instructions showed no practice effect, replicating Bugelski et al. (1968).
could be regarded as a kind of verbal mediation set, and it proved quite ineffective. Buggelski et al. (1968) also reported informally that Ss given sentence mediators did not do at all well, and Bower has found such mediators to be inferior to imagery. Nevertheless, the problem is complex and requires further research to determine the conditions that affect the potency of each type of (operationally defined) mediator. A further alternative to the imagery hypothesis is that the mnemonic instructions simply increase motivation or interest (e.g., Selbel et al., 1967). To the extent that this is so, it could be interpreted to mean that motivated Ss make more use of effective mediators (cf. McNulty, 1966), or that mnemonic processing is effective because it works (Gruber et al., 1965). In other instances, such as the experiment on the one-bun mnemonic described above, it is difficult to understand how the mere addition of brief instructions to use imagery could enhance the motivational effect of already elaborate instructions and mnemonic training sufficiently to produce the dramatic increment in recall. This conclusion applies at least as strongly to results obtained by Bower (1967), who has used a variety of techniques to manipulate imagery with dramatic effects in memory tasks.

The upshot of the argument thus far is that the alternative hypotheses are strained to account for the effects attributed to the operations that define imagery. This is not to deny the effectiveness of verbal mediators and other variables, but rather to affirm what has long been denied, that imagery is a viable explanatory concept in associative learning and memory.

**Some Empirical and Theoretical Extensions**

The variables and theoretical views discussed in relation to PA learning of nouns have been extended to include picture-word comparisons, learning situations other than PAs, and further theoretical distinctions between images and verbal symbolic processes. These are briefly considered in the remainder of the paper.

G. H. Bower, personal communication, October, 1967.

**Picture-Word Comparisons in PA Learning**

The abstract-concrete dimension of stimulus meaning can be extended to include objects or pictures of objects at the concrete end of the scale, providing a further means of investigating the conceptual peg hypothesis and the general contribution of nonverbal factors in associative learning. Objects or their pictorial representations arouse nonverbal perceptual images directly and, to the extent that such images facilitate the formation of associative connections with response members, pictures should be even more effective than concrete nouns, at least as stimulus members of pairs.

A number of experiments (e.g., Epstein, Rock, & Zuckerman, 1960; Rohwer, 1966) have shown that object-pairs or picture-pairs are easier to learn than pairs comprised of their concrete noun labels, and Iscoe and Semler (1964) found object-pairs to be easier than pictures. Wimer and Lambert (1959) reported, further, that PAs with nonsense syllable responses were better learned when the stimulus members were objects rather than the names of the objects. These studies did not compare objects and words on stimulus and response sides, however, and such a comparison is necessary to test the conceptual peg hypothesis. Paivio and Yarmey (1966) obtained support for the hypothesis in a study in which pictures and their noun labels were factorially varied on stimulus and response sides of pairs. Similar findings were obtained with young children as Ss (Dilley & Paivio, 1968), at least with respect to the stimulus side of pairs. As a stimulus variable in PA learning, therefore, concreteness appears to function as a single effective dimension that extends from abstract nouns, to concrete nouns, to objects or pictures, in increasing order of effectiveness. Such an ordering of three levels of concreteness has been demonstrated within a single experiment by Csapo (1968) and Dominowski and Gadlin (1968). Since the stimulus effect has been obtained without words being inferior in m (Dominowski & Gadlin, 1968; Wimer & Lambert, 1959), it is difficult to explain the superiority of objects and pictures over words in terms of verbal mechanisms alone. Differentiation has been pro-
posed as an explanation by Dominowski and Gadlin (1968) and Wimer and Lambert (1959), whereas mediating imagery is implied by the conceptual peg hypothesis. As suggested earlier in the case of noun I, perhaps "picturability" contributes to both differentiation and mediation.

The linear effect of the concreteness dimension does not obtain on the response side of pairs. Whereas learning has generally been easier when response nouns are concrete rather than abstract, pictures as response members are not facilitative in comparison with concrete nouns, possibly because the former involve a symbolic labeling or decoding problem. That this may be the case is indicated by the negative main effect of pictures as response terms in the case of young children (Dilley & Paivio, 1968), which was predicted from the hypothesis that they may experience greater difficulty than adults in transforming the concrete memory image of a pictorial response item into an overt verbal response.

A number of investigators (e.g., Epstein et al., 1960; Milgram, 1967; Reese, 1965; Rohwer, Lynch, Levin, & Suzuki, 1967) have compared pictorial and verbal (e.g., sentence context) depictions of pair relations, with interesting results. For example, pairs are easier to learn when the context provided by either mode of representation makes a good "conceptual unit" of the pair than when it does not (Epstein et al., 1960); and, in the case of children, learning was facilitated by moving as compared to stationary objects, and by verb phrases more than by prepositions or conjunctions (Rohwer, 1966). Although here, too, it has been difficult to tease out the separate contributions of visual imagery and of verbal symbolic processes, and the investigators are generally cautious in their interpretations (and sometimes negative concerning the contribution of imagery, e.g., Milgram, 1967), the findings point to the operation of both processes.

Extensions to Memory Tasks Other than PA Learning

The discussion thus far has centered on imagery as a stimulus variable and as a mediator of associative connections in PA learning, but imagery variables have been found effective in other memory tasks as well. Following a brief review of the relevant findings, an attempt will be made to explain them in terms of a theoretical model that incorporates and extends the concepts already discussed.

Recognition memory. Results from the relatively few studies that have been conducted on the problem suggest that recognition memory increases directly as a function of concreteness. Recognition scores are higher for concrete than abstract nouns (Gorman, 1961; Jampolsky, 1965) even when m is held constant (Olver, 1965), and pictures in turn are easier to recognize than are their names or words generally (Fozard & Lapine, 1968; Jenkins, Neale, & Deno, 1967; Shepard, 1967). Taken together, these findings indicate that recognition memory increases from abstract words, to concrete words, to pictures. The differentiation hypothesis is obviously applicable here in the sense that image-arousing value or picturability may contribute to an item's distinctiveness, but direct supporting evidence is lacking.

Free recall. Several investigators (e.g., Dukes & Bastian, 1966; Olver, 1965; Winiick & Kressel, 1965) have found that free recall also is higher for concrete nouns than for abstract nouns, while others (Bowers, 1931; Paivio, 1967; Tulving, McNulty, & Ozier, 1965) have reported better recall for nouns rated high on measures of imagery than for nouns rated low in imagery. These effects cannot be interpreted in terms of m, which was controlled in several of these studies. Paivio, Yuille, and Rogers (1969) demonstrated further that noun I is significantly more effective than m in free recall, as it was shown to be in PA learning, when the two attributes are varied over an equivalent range.

The effective dimension again extends to concrete objects. As early as 1894, Kirkpatrick found that free verbal recall was higher for familiar objects than for the names of the objects, and this has been repeatedly confirmed in studies comparing either objects or pictures with verbal stimuli (Calkins, 1898; Ducharme & Fraisse, 1965; Lieberman
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& Culpepper, 1965; Paivio, Rogers, & Smythe, 1968). The finding is of uncommon theoretical interest because the required response is verbal in both cases and the to-be-remembered name therefore should be more readily available when the stimulus is a word rather than a picture. Since it is not, verbal processes alone seem insufficient to account for the findings.

These results are open to alternative interpretations that have been suggested as explanations of free-recall learning (for a discussion of these, see Tulving, 1968). According to one hypothesis, free recall is a function of the response strength or availability of the items as independent units. According to the other, some kind of associative principle operates to reduce the memory load involved by facilitating interitem organization or clustering. With respect to noun imagery, Tulving et al. (1965) found that the better recalled, vivid words were also organized to a greater extent than less vivid words, and accordingly suggested the hypothesis that “vividness or picturability is an important component of meaning of words that affects the ease with which words can be grouped into higher-order memory units [p. 250].”

Such an interpretation of the superiority of pictures is also supported by Scott’s (1967) finding of higher clustering scores for objects than for words. On the other hand, Paivio, Yuille, and Rogers (1969) did not find greater clustering for the better recalled, high-I words, and Frincke (1968) found noun imagery to be significantly related to free recall with ease of clustering held constant. The higher recall for pictures obtained by Paivio, Rogers, and Smythe (1968) also could not be explained in terms of subjective organization. Thus, while the organization hypothesis of the imagery-concreteness effect in free recall has some support, the independence hypothesis cannot be rejected.

**Serial learning and memory span.** An implication of the organization interpretation of the effect of imagery-concreteness in free recall is that the effect should diminish if the learning situation does not permit S to reorganize the input series into associated clusters, as is the case in serial memory tasks. The finding that memory span does not differ for concrete and abstract nouns (Brener, 1940) is consistent with such an interpretation. The same might be expected in serial learning, except that imagery could facilitate associative chaining over trials just as it facilitates PA learning. Recently, however, the validity of the chaining hypothesis has been seriously questioned (e.g., Jensen & Rohwer, 1965) and, while it cannot be entirely rejected (cf. Postman & Stark, 1967; Saufley, 1967; Shuell & Keppel, 1967), it appears likely that serial learning is not the prototype of stimulus-response association that it was once thought to be. From that viewpoint, therefore, as well as from the organization hypothesis, imagery as an associative mechanism should be less potent in serial than in free-recall learning. With this argument in mind, Paivio, Yuille, and Rogers (1969) investigated serial learning as a function of I and m using the same lists that had been used in the free-recall study referred to above. Again, I was positively effective, the only suggestion that it might be relatively less so than in free recall being that its effect did not significantly exceed that of m. This could be taken as support for the view that imagery indeed facilitates interitem associations in serial learning, or it may mean that imagery somehow makes the nouns more available as response units, or both.

Analogous information on picture-word comparisons in serial learning and memory span is generally lacking, but some recent data will be presented in the context of the following theoretical model, which deals with the relation between the concreteness dimension and performance in the various memory tasks that have been considered.

**The Availability and Functions of Concrete-Image and Verbal Coding Systems in Memory**

The theoretical analysis involves an assumption concerning the relative availability of concrete (visual) images and verbal memory codes as a function of stimulus concreteness, and a hypothesis concerning the functional distinction between the two coding
systems. The availability assumption can be regarded either as a special case or an extension of the two-process approach to associative meaning described earlier. It differs from it in that the verbal code refers specifically to an implicit labeling or naming response (like the representational response of Bousfield, 1961) rather than to verbal associates. Concrete imagery is used in the same sense as previously to refer to associative images, aroused in this case by pictures as well as words. In the case of pictures, it is important to note that the reference is not to a short-duration perceptual trace of the stimulus (cf. Sperling, 1960), which should in no way differ whether the stimulus is a printed word or a picture. Instead, the reference is to long-term memory representations of objects, the evocation or generation of which is no less an associative process when the stimulus is a picture than when it is a word.

Given these definitions, the assumptions concerning availability are straightforward. Pictures, if familiar and unambiguously labeled, readily evoke both concrete imagery and verbal coding, but the availability of the latter is relatively lower because an extra transformation is involved, and would be lower still if the pictures are unfamiliar. The verbal code is directly and equally available in the case of concrete and abstract words but the former are more likely to evoke images. Empirical support for and a rough quantification of the assumptions is provided by reaction time data. Words can be read faster than objects can be named (Fraisse, 1964), indicating the higher availability of the verbal code in the former case. As previously mentioned, the latency of image arousal as indicated by a key press is faster for concrete than abstract words (Paivio, 1966). A comparison of the reaction time means reported in the different experiments indicates further that image arousal to words is slower than verbal coding of words or familiar pictures. No comparable data are available on image arousal to picture stimuli but it can be assumed that the latency would be no greater than that involved in the implicit reading of a word. A ranking of the availability, or arousal probability, of each code for the different stimuli can be inferred from these data. Image arousal in the case of pictures and verbal coding in the case of words have the highest availability, the verbal code to pictures second, imagery to concrete words third, and images to abstract words fourth. Thus, the summative availability of both codes is highest in the case of pictures, intermediate for concrete nouns, and lowest for abstract nouns.

The effect of concreteness on memory is hypothesized to be a direct function of the availability of each code in that the appropriate verbal responses can be retrieved from either. Their availability could contribute to unit retrieval in accordance with the independence hypothesis, or both processes may facilitate associative connections and the formation of higher order memory units. The picture, concrete word, abstract word ordering of free recall and recognition memory in the above studies is thus interpreted to be a function of the differential availability of concrete imagery as a supplementary coding system, which enhances the probability that items will be correctly retrieved on the test trial.

The hypothesis concerning the functional distinction is related to assumed modality differences in the nature of the representational mechanism. Visual images are assumed to be functionally related to visual perception and are specialized for spatial representation—visual imagery is primarily a parallel processing system. It is not specialized for serial processing unless linked to an integrated (symbolic) response sequence, such as might be involved in imagining oneself moving along a familiar route, or sequentially “tracing” the outline of a familiar figure, or unless the imagery is linked to a sequentially organized verbal system, as in the one-bun mnemonic technique. The verbal symbolic system, on the other hand, is assumed to be specialized for sequential processing by virtue of the temporal nature of the auditory-motor speech system, although it undoubtedly functions also as an operationally parallel system in that verbal units can be processed independently of each other (see Neisser, 1967). While the ra-
The rationale just described has not always been made explicit, a spatial-serial distinction between visual and verbal memory systems has been previously suggested by others (for a relevant discussion, see Bryden, 1967). One implication of the analysis is that the addition of imagery should have no effect in a task which involves only verbal sequential processing. Brener's (1940) finding of equivalent memory spans for concrete and abstract words is consistent with this interpretation.

The theory was explicitly tested by Paivio and Csapo (1969), who attempted to vary the availability of the two memory codes along with the necessity of sequential processing in the memory task. Availability was manipulated by varying stimulus concreteness and the rate of presentation. Since words can be read faster than objects can be named, the arousal of the verbal code presumably can be prevented during input in the case of pictorial (P) stimuli without eliminating it in the case of concrete (CW) or abstract (AW) words by using a sufficiently fast presentation rate. That is, at a fast rate S could implicitly read a word without having time to label a picture.

Given the hypothesized distinction between parallel and sequential processing functions and a discrete stimulus series without any intrinsic serial order, it follows that memory should be poorest at a very fast rate for P stimuli in tasks such as immediate memory span and serial learning, which require sequential processing. Pictures should not suffer even at a fast rate in free recall and recognition memory tasks, however, since serial order information need not be retained and the appropriate verbal labels presumably can be retrieved from concrete memory images after the stimulus series has been presented. At a slower rate, where S can supply a verbal label, P stimuli should not be inferior to words even in the serial memory tasks, and they would be expected to surpass words in the free recall and recognition tasks on the basis of previous findings (e.g., Paivio, Yuille, & Rogers, 1968; Shepard, 1966), presumably because the high availability on both codes enhances the probability of their retrieval. No difference would be expected between CW and AW on any task at the fast rate, since only the verbal code can be utilized. At the slower rate, however, CW should exceed AW in free recall, recognition, and serial learning because of the arousal of associative imagery which can enhance unit retrieval or the formation of higher order units, as suggested above, but not in immediate memory span which involves only verbal memory for serial order. A corollary prediction is that variation in rate should have the greatest effect generally on memory for P stimuli and the least effect on AW.

The experimental test of the predictions involved the presentation of a nine-item list of P, CW, or AW stimuli over a series of trials at either a fast (5.3 items per second) or a slow rate (2 items per second), in one of the four memory tasks. The results were remarkably consistent with the predictions. The rate effect was significant over all and a double interaction of Rate X Stimulus Attribute indicated, as predicted, that the effect was clearly greatest for pictures and least for abstract words. The double interaction was further qualified by a triple inter-
action of Rate × Stimulus Attribute × Task, which is presented in Figure 5. A series of comparisons revealed the following effects. Consistent with predictions, memory span and serial learning scores were significantly poorest for pictures at the fast rate. At the slow rate, pictures remained inferior in memory span, although none of the differences between stimulus types was significant. By contrast, pictures, along with concrete words, were superior to abstract words in serial learning, a complete crossover from the fast rate. The effects for free recall and recognition memory were similar to each other and differed from the patterns for the serial memory tasks. At the fast rate, none of the differences between stimulus types was significant within either task. At the slow rate, pictures were remembered best, abstract words most poorly, and concrete words were intermediate, as in previous free recall and recognition experiments. Finally, the effect of presentation rate was significant for pictures on all tasks; for concrete words in memory span, serial learning, and marginally in free recall; and, for abstract words, only in serial learning.

In summary, memory for pictures tended generally to suffer at the fast rate but the effect was significant only in the sequential memory tasks, presumably because the verbal code essential to performance was least available. The slow rate benefited picture memory most, presumably because both memory codes could be utilized. Memory for abstract words was least affected by rate, presumably because only (or mainly) the verbal code was involved.

The theoretical model obviously requires further testing before its strengths and weaknesses can be adequately assessed. However, it has already demonstrated considerable heuristic value and integrative potential as an extension of the two-process theory of mediation discussed in relation to PA learning. In addition, it makes contact with recent proposals by others concerning multiple modes of symbolic representation and functional distinctions between them (e.g., Koen, 1966; Taylor & Posner, 1968). Taylor and Posner, for example, concluded from their experimental results that the visual memory code is organized to represent the environment spatially, whereas the verbal memory code is organized so that at any point in time items are retrieved in a fixed order. This proposal is obviously consistent with the model presented here. Others (e.g., Brooks, 1967; Dornbush, 1967; Glucksberg, Fisher, & Monty, 1967; Wallach & Averbach, 1955) have suggested functional distinctions based on the sensory modalities to which the symbolic systems are presumably linked. Their contributions must be taken into account in any future tests and modifications of the model.

Further Empirical-Theoretical Extensions of the Approach

The hypotheses and research reviewed in this paper involved operational definitions of imaginal and verbal coding systems in terms of the semantic attributes of stimuli, and instructional sets. The approach can be extended to take into account individual differences in relevant symbolic habits, such as imagery ability and verbal associative skills. Successful prediction of interactions involving the three classes of independent variables—stimulus attributes, experimentally manipulated mediators, and individual differences—would yield convergent evidence that their effects are mediated by common intervening processes. The third approach is likely to prove difficult considering the relative failure of individual differences to be predictive of memory in the research on imagery in the early part of the century, but encouraging evidence has been provided recently by Kuhlman (1960), and Stewart (1965), who found that imagery ability can predict performance in situations involving pictorial and verbal material. On the dependent variable side, the approach can take advantage of physiological measures as possible indicators of the processes aroused by imaginal and verbal associative tasks (e.g., Paivio & Simpson, 1966; Simpson & Paivio, 1968). It can be extended also to natural language by investigating the effects of such variables as concreteness in the production and understanding of language (Reynolds & Paivio, 1968), and imagery as a possible "surrogate structure" (Pompi & Lachman,
that might mediate memory for connected discourse. Whatever the outcome of such extensions, it is clear that imagery has reestablished itself as a scientifically useful concept, even in areas long dominated by an emphasis on verbal mechanisms.

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