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ABSTRACT

A skilled cognitive theorist might help behaviorists resolve inconsistencies found from their experimentation with imaginal mnemonics in paired-associate and serial learning tasks. Iconic cognition which relegates verbal processes to short-term storage and output systems is inadequate to explain the verbal coding and elaboration processes suggested by some recent research findings. Moreover, verbal elaboration plus imagery has been found to be effective in promoting learning not only for college students and older children but also for kindergarten children and older preschool children. For young preschool children imaginal elaboration seems to be less effective than verbal elaboration. Experimental results themselves seem contradictory and are contradictory to Bruner who theorizes that cognition in young children has an iconic basis rather than a verbal basis. In behavioristic models, images are conditioned sensations while in cognitive models they are dynamic and change according to formistic principles. A total of 31 postulates and 17 deductions illustrate some considerations necessary in demonstating that mnemonics data may seem inconsistent with behavioristic theories, but are consistent with a cognitive theory. Cognitivists are invited to engage in research on the problem. (WY)

Implications of Mnemonics Research for Cognitive Theory[1]

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Background

Research has shown that performance in paired-associate and serial learning tasks is facilitated by the use of mnemonics. The use of mnemonics by the subjects has been manipulated experimentally by giving different instructions to experimental and control groups and by using specially prepared or specially selected materials. It has long been accepted in psychology that such mnemonics can be verbal; but reviews of the research have shown beyond reasonable doubt that the mnemonics can also be images (see Bugelski, 1970; Paivio, 1969; Reese, 1970b, 1970d). Some investigators have suggested that even when the mnemonic appears to be verbal it is actually based on imagery (Bugelski, 1968, 1970; Reese, 1970a). That view will be discussed later, but now the point is that it is no longer reasonable to question the reality of imagery in general, nor its effectiveness in at least some learning tasks.

Like Bugelski (1970), I will avoid the kinds of mentalistic questions about imagery that beguiled classical psychologists--questions about the qualities that distinquish images from sensations (e.g., Angell, 1908, p. 198; Calkins, 1916, p. 185; Cattell, 1903, p. 583; Condillac, 1754; Huey, 1908, p. 79; Hume, 1739-40; James, 1890, Vol. 2, pp. 45, 72; Külpe, 1909; Ladd, 1894; Lindworsky, 1931, p. 135; Perky, 1910; Sully, 1891, p. 225; Titchener, 1911, pp. 197-200) and questions about the qualities of the images themselves (e.g., Ladd, 1894, pp. 247-248; Lotze, 1886, p. 28). For present purposes, it is sufficient to use a dictionary definition: an image is the experience of a sensation in the absence of the original stimulus.

Role of Inference. Since neither verbal nor imaginal mnemonics are objectively observable, the basis for identifying them must be inferential. Even if in fact an objectively observable event--physiological or behavioral--were perfectly correlated with a given mnemonic, or with a given kind of mnemonic, inference would still be required in practice. For example, if when the subject reports a visual image there is always a characteristic electroencephalographic pattern recorded, the perfect correlation is not between imagery and brain activity, but between a verbal report (about imagery) and brain activity. It is impossible to verify the fact of the perfect correlation between the unobservable event and the observed event, and therefore there is no escape from the use of inference (for further discussion of this point, see Reese, 1970e). Nevertheless, the correlations between reported imagery and observed events--for example, the observation that eye movements during reported visual imagery may be similar to eye movements during visual sensation (Totten, 1935)--provide an inferential basis that is somehow more satisfying than verbal reports alone, perhaps because we know that verbal reports are influenced by so many extraneous variables.

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The inference that verbal or imaginal mnemonics were used can be based on subjects' reports about their activities during learning, or on correlated activity, or it can be based on the nature of the instructions or materials presented. Thus, if some theory predicts that imagined events will have a certain effect, and if appropriate instructions or materials are used, then observation of the predicted effect implies that imagery occurred. An example is Cautela's work on "covert conditioning" (e.g., Cautela, 1970), in which both the behavior and the reinforcer seem to be imaginal.

Coding and Elaboration. In addition to the verbal-imaginal dichotomy, there is another system for classifying mnemonics. Mnemonics can be used to code the material or to elaborate it. Coding can involve substitution or reduction. In substitution, the material to be learned is replaced by a word, phrase, or imagined scene. For example, one image may be used to replace two separate sensations or images: "Two (or more) impressions may become closely associated with one another by a special act of conjoint [or connective] attention at the time....by attending closely to the two things together,...[the] mind in a manner makes one object of them" (Sully, 1891, p. 238; see also Lindworsky, 1931, pp. 230-231).

In reduction, according to Rohwer, "the learner simplifies his task by selecting for attention and complete processing only those aspects of stimulus materials that are essential for correct performance" (Rohwer, 1967, p. 1). Reduction involves elimination of materials, but the elimination is only temporary (when the technique is effective), in that the eliminated material can be reproduced when it is needed. Thus, reduction seems to involve substitution or encoding more essentially than it involves elimination.

Elaboration "involves the addition of units to those the learner is formally asked to acquire such that the nominal result is more material to be processed than required by the task as it is originally presented" (Rohwer, 1967, p. 1). However, in a sense the addition may be temporary, in that the subject may omit the added parts when not required to reproduce them.

Perhaps examples will aid an understanding of the material presented thus far. Tables 1 and 2 summarize examples for paired-associate tasks with nonsense CVC materials and with meaningful words. For serial learning with meaningful material, verbal elaboration can take the form of generating a story to connect the words (see Ladd and Woodworth, 1911, p. 579, for discussion of a related topic). Using a variant of this technique, the subject might verbally encode each word on the basis of its first letter, then elaborate the encoded material. An example is the use of the doggerel "On old Olympus' tiny top, a Finn and German viewed some hops" to remember the 12 cranial nerves (obscene versions are also extant). Similarly, it appears to be possible to use imagery by adding one item after another to build a more and more complex image (Bugelski, 1970). In both of the last two examples, note that the material is first encoded then elaborated. "Pure" coding may be ineffective in serial learning. The use of imagery in the "one-bun, two-shoe" technique, favored by Bugelski, is an example of imaginal elaboration. The subject learns a rhyming code for the numbers, then forms an image of an interaction between each word in the list and the code for the number that designates its serial position. However, the use of this technique transforms the serial-learning task into a paired-associate task, and therefore does not exemplify imaginal elaboration in serial learning.

For serial learning with nonsense materials, in this case letters of the alphabet, examples include learning the musical scale as the word

Table 1

Illustrative Verbal Mnemonics in Paired-Associate Tasks

Pair	Reduction	Substitution	Substitution	Reduction & Substitution	Elaboration
GEH-NUR	G-N	Gee (i.e., to the right), north	Gainer,[a] or Mitzi Gaynor[a]	Gone	John Gay wrote "Nur man is an island"
TUV-LAH	T-L	Tough law,[a] or Tough lox	"Tuvling" (for Tulving), or Tula	Till	Tough meat should be against the law
KAR-WEH	K-W	Karen, wayward[a]	Carwash	Kaw (river)	Karen is wayward, or The car is on the highway
LEV-MIB	L-M	Lever, mid (i.e., pivot)	Lumen	Lunar module	The lever has a pivot in the mid
WUG-ZAM	W-Z	Wig, Samson	Wigwam	"Wuz" (i.e., "was")	The wig worn by Samson
SHOE-WINDOW	S-W	Show window	Short-Winded	Shaw	The shoe is thrown out the window
CAT-UMBRELLA	C-U	Fat umbrella	(Joe) Cautela	Cue	The cat is carrying the umbrella[b]
BOY-STONE	B-S	Boy's tone (i.e., high pitch)	Bistro, or boisterous	Bulls	The boy throws the stone
DOG-GATE	D-G	Dog ate	"doggate" (i.e., like dogs)	Dog	The dog behind the gate,[c] or The dog closes the gate[c]
LIBERTY-GREEN	L-G	Library green	Libertine	Log	The liberty bell is green

a. From Bugelski (personal communication, 1970)
b. From Reese (1965)
c. From Rohwer (1967)

Table 2

Illustrative Imaginal Mnemonics in Paired-Associate Tasks

Pair	Coding	Elaboration
GEH-NUR	A diver executing a gainer, or Mitzi Gaynor	An effeminate man writing "nur"
TUV-LAH	Judge Hoffman (for "tough law")	?
KAR-WEH	"Karen" in a wanton pose ("wayward")	A car traveling along a highway
LEV-MIB	A lever with pivot at middle	A lever twirling around a pivot
WUG-ZAM	A wigwam	Samson donning a wig
SHOE-WINDOW	A show window	A shoe flying through a window
CAT-UMBRELLA	A fat umbrella	A cat carrying an umbrella
BOY-STONE	A cocktail bar ("bistro")	A boy throwing a stone
DOG-GATE	A dog eating ("ate")	A dog closing a gate
LIBERTY-GREEN	A green Statue of Liberty	A man painting the Statue of Liberty green

"face" and the sentence "every good boy deserves fun"--verbal coding and elaboration, respectively, although the latter also involves first coding the letters into words. Exactly the same kind of elaboration is involved in using the sentence "a rat in Tom's house might eat Tom's ice cream" for the correct spelling of ARITHMETIC. Perhaps a more "pure" kind of elaboration is to use "pa is on" for spelling POISON, but even here the first word in the mnemonic sentence is an encoded version of the first syllable in the word to be spelled. Examples of the use of imaginal elaboration--mixed with imaginal encoding, as in the case of verbal elaboration of nonsense material--are provided by Luria's (1960) account of the way Shereshevskii memorized a mathematical formula and perhaps Müller's (1911) discussion of the use of imagery by Ruckle. (See also Hunter, 1964, Cha. 4.)

Survey of Recent Findings. Research on imaginal mnemonics has been limited to visual images, and most has involved elaboration or the combination of coding and elaboration. Therefore, even though the coding versus elaboration distinction seems to be important (see Footnote 2), only elaboration will be considered in the rest of this paper. Verbal elaboration--or verbal context, as it is sometimes called--and imagery have been found to be highly effective not only for college students and older children (see reviews cited earlier), but also for kindergarten children and older preschool children (see Reese, 1970b), and imagery has been found to be effective for older deaf children (Bugelski, 1970). For young preschoolers imaginal elaboration seems to be less effective than verbal elaboration, although the evidence for this is not clear-cut. Table 3 summarizes findings from several studies; in general, verbal elaboration and imagery are about equally facilitative in older groups, but the facilitation in imagery conditions is less in younger groups than in older groups. However, the age difference in the effectiveness of the imagery condition was not significant in one study (Reese, 1965) and was not even obtained in another study (Reese, 1970c). More research is needed to determine why the generallity of the trends is limited, but it is clear that imagery is not more effective than verbal elaboration in young children, and it is usually less effective.

The fact that imagery is no better than verbal elaboration in young children seems contradictory to the proposition of Bruner (1964), among others, that cognition in young children has an iconic basis rather than a verbal basis. Theoretical explanations of the effect have been proposed by Paivio (1970), Rohwer (1970), and Reese (1970a), and all except some of Reese's are contradictory to the "iconic" position.

In addition, certain findings from mnemonics research with adults suggest that the image is not a mediator of the terminal behavior, but functions rather as a kind of "marker" aiding retrieval of material that is stored in some other form. Specifically, Paivio has found that imagery on the stimulus side facilitates paired-associate performance even when the response is low in imagery (indeed even when the response is a nonsense syllable), and imagery has a reduced but sometimes still facilitative effect on the response side even when the stimulus is low in imagery (see Paivio, 1969, 1970). Wood (1967, Exp. V) has confirmed these results. Although obtained from adults and not young children, this evidence casts further doubt on the plausibility of the assumption of iconic cognition, in that the iconic element (the image) seems to have an adjunctive or auxiliary function in memory, and other elements--probably verbal--are primary. This is no doubt too speculative to be convincing by itself, but in conjunction with the other evidence it is perhaps persuasive.

The evidence discussed in the preceding paragraph is anomalous from a behavioristic position--even if imagery itself is not anomalous from such a

Table 3

Age Differences in Effectiveness

Of Imaginal Mnemonics

Study	Outcome	Remarks
Reese (1965)[a]	Imagery condition less effective in young children, verbal condition equally effective at all ages studied	Age by treatments interaction nonsignificant
Milgram (1967)	Same as Reese (1965)	Interaction significant
Rohwer (1967)	Same as Reese (1965)	Differences significant in post hoc analyses
Reese (1970c)	Both conditions equally effective, in younger as well as older groups	No significant interaction, and trend of means favored imagery condition
Bugelski (1970)	Imagery less effective in younger than older children	The subjects were deaf children (no verbal condition included)

a. Data not reported in published paper, but summarized by Reese (1970a, 1970d).

position. The problem is that the image clearly does not function as mediators are supposed to function. Other evidence points to the same conclusion, as Rohwer (1967), Palermo (1970), and Reese (1970e) noted. For example, images are rich in details that seem to be irrelevant (e.g., Bugelski, 1968), but contrary to the reasonable expectation that interference would be produced, these details do not occur as intrusions. In fact, the use of imagery reduces not only errors in learning one list, but also reduces retroactive and proactive interference (Bugelski, 1968), and the reduction may be especially great when the subject uses images and adds to them the new items to build ever more complex images (Bugelski, 1970). Surely, these complex images should be expected--from a behavioristic point of view--to interfere rather than to facilitate.

Finally, the frequently obtained finding that verbal mnemonics in older children and adults are not more facilitative than imaginal mnemonics (e.g., Wood, 1967)--and may usually be less facilitative[2]--is contradictory to the still popular views of early cognitive theorists who held that cognition is primarily verbal (e.g., James, 1890, Vol. 1, pp. 265-266; Stout, 1896, Cha. X; Watson, 1929, p. 365; see also Reese, 1965). Thus, the evidence appears to contradict not only the "iconic" position, but also the "verbal" position.

A Cognitive Theory

It seems reasonable, in view of the foregoing considerations, to seek a nonbehavioristic account of the effects of imagery. One such account, suggested by Reese (1970a), is derived from a cognitive model. In the cognitive model, images are not conditioned sensations, as they are in behavioristic models (e.g., Allport, 1955, p. 449; Bugelski, 1960, pp. 110-112; Staats & Staats, 1963; Watson, 1929, footnote 1, p. 362; see also Bugelski, 1970). Rather, images are cognitions, are dynamic (i.e., not static), and change in accordance with formistic principles. The specific hypothesis to account for the reduced effectiveness of imagery in young children, relative to older children, also includes an assumption of "figurative conceptions," borrowed from Piaget (see Elkind, 1970). Figurative conceptions are presumably iconic.

The theory agrees with Sully (1891, p. 238), Köhler (1929, pp. 287-288), and Lindworsky (1931, pp. 230-231), among others, that images are most effective as mnemonics when they combine separate images of the items to be learned. This proposition could be presented as an assumption, but then the theory would be rather circular. To break the circularity, it is desirable to introduce other principles from which this proposition can be deduced. These principles, or assumptions, are summarized in Table 4 and are discussed below.

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[2] Verbal mnemonics are sometimes found to be inferior to imaginal mnemonics (e.g., Bugelski, 1970; see also Asch, Ceraso, & Heimer, 1960, p. 32; Calkins, 1916, p. 215; Sully, 1891, p. 284), sometimes found to be equal (e.g., Reese, 1965; Rohwer, 1967), and sometimes found to be superior (e.g., Foster, 1911; Jenkin, 1935; Kurtz & Hovland, 1953; London & Robinson, 1968; Rankin, 1963). A casual survey suggests that verbal elaboration is inferior or equal to imaginal elaboration, and verbal coding is superior to imaginal coding. However, this is a speculative and tentative suggestion--really a hunch--and it needs to be checked out by a thorough review or by experimentation. There is also some evidence that the retention interval has an interactive effect, in that verbal mnemonics are more effective with long intervals, and imagery is more effective with short intervals, but there is also some contradictory evidence (London & Robinson, 1968; Reese, 1970c).

Table 4

Summary of Theoretical Assumptions

1. a. Input material--verbal and visual--persists briefly in short-term storage.
   b. Input can be decoded as imagery.
   c. Simple images represent isolated elements.
   d. Compound images represent stimulus and response items in interaction.
   e. There are figurative conceptions. (Definition.)
   f. Images differ from figurative conceptions in details.
2. a. The formation of a compound image results from attention to elements and their interaction.
   b. Addition of details to images is an active process.
   c. Young children attend to interections less than older children.
   d. Young children are less likely than older children to add details.
   e. Materials can facilitate both processes.
3. Images change in the direction of figurative conceptions.
4. Repetition strengthens images.
5. a. Presentation of the stimulus arouses the compound image if one is available, and not only a stimulus image or only a response image.
   b. The subject scans the compound image.
   c. As each element is attended to (scanned), it arouses a simple image.
   d. The subject can compare simple images with short-term storage material.
   e. The subject can compare the strengths of simple images.
6. a. There is a verbal output system.
   b. Imagery can be encoded as verbal output.
   c. The subject can actively determine output, by inhibition or selection.
   d. The subject can use the comprisons (5d & 5e) to determine the output.
   e. This determination is influenced by set.

f. Set can be influenced by the task demands.

7. a. Conditioning can occur between the verbal input and output systems.

b. Conditioning can occur between the verbal input and imagery systems.

c. Conditioning can occur between the imagery and verbal output systems.

d. Conditioning can occur between images.

e. Conditioned responses are produced mechanistically.

Postulates.

(1) Input material--whether verbal or visual--persists briefly in short-term storage, but can be decoded as imagery. The arousal of imagery by a word is a decoding process, because the word is a "reduction" type of code for a complex of imagery and feelings (compare Bugelski, 1968). Simple images represent isolated elements; compound images represent stimulus and response items in interaction (in paired-associate tasks).

Figurative conceptions are ideal forms of images, and represent classes of elements with differences within a class eliminated. There may be figurative conceptions of elements in interaction, but it is very doubtful that these are useful in paired-associate tasks, because of the way the pairs are selected.

Simple images differ from figurative conceptions in details, because simple images include the details that differentiate among the elements within the class represented by a given figurative conception.

(2) The formation of a compound image results from attention to the elements presented and their interaction. If no interaction is presented, it can sometimes be formulated by the subject. The subject can also sometimes add details to the image; therefore, the formation of a compound image and the addition of details are sometimes active processes. The materials presented can facilitate both processes, by explicitly including the interaction or the details.

Young children are less likely than older children to attend to interactions, even when presented explicitly, and are less likely to add details spontaneously. Evidence supports this assumption (D.P. Bradley, personal communication, 1970; Elkind, 1969, p. 3).

(3) Images tend to change with the passage of time. The direction of change is determined by laws like the Gestalt laws of perception, except that ideal forms are like figurative conceptions rather than like Gestalten. Actually, the only principle needed seems to be one that works somewhat like Wulf's (1938) "leveling" process. Specifically, when images change they become more like the figurative conceptions of the original material.

(4) According to Berol (1913), "It is a fundamental law of nature that ocular impressions are easily retained and never forgotten" (p. 11). This seems somewhat extreme. It is more reasonable to assume that repetition strengthens images, that is, makes them more enduring and stable (compare Kohler, 1929, p. 293).

(5) When a compound image has been formed--to connect imaginally a stimulus item and a response item--presentation of the stimulus item arouses the complete compound image and not just the part of it representing the response item (compare Lindworsky, 1931, p. 230). It is assumed that the subject scans the compound image, and that as he does so, each element arouses a further image. Each of these further images is usually a simple image, that is, not another compound image. One of these will be an image of the stimulus item, one will be an image of the response item, and others will represent the irrelevant details in the compound image. The subject can compare the strengths of these simple images. He will find that the two simple images most strongly fixed in memory are the stimulus image and the response image, because of repetition of the original material (assumption 4). The subject can also compare the simple images with items in short-term storage. Since the stimulus item will be present in short-term storage, the subject can recognize one of the two strong simple images as representing the stimulus, and can therefore select as a basis for responding the other strong simple image, that is, the one representing the response item.

(6) There is a verbal output system, allowing imagery to be encoded as verbal output. The arousal of a verbal response by an image is an encoding

process because the word is a "reduction" of the imagery, as mentioned previously. The subject can actively determine the output, by inhibition or selection. The results of the comparisons (in assumption 5) can be used by the subject to determine the output. How he uses them is influenced by set, and set is influenced by the demands of the task.

(7) There is also a system for direct association between the input and output verbal units, based on simple conditioning: the input item functions as a conditioned stimulus (or discriminative stimulus) and eventually acquires the capacity to arouse the output item as a conditioned response (or discriminated operant). Thus, it is possible to learn a paired-associate list without compound imagery, but in the use of this process the subject plays a reactive role rather than an active role. It seems likely that this system is important only when items arouse no imagery, that is, when they are nonsense materials and are not coded or when they are presented to young children. It is also possible that simple images can be conditioned to other simple images or even to verbal items, yielding the conditioning sequences diagrammed in Figure 1.

Deductions. The theory contains 31 postulates, including definitions. I have worked out 17 deductions, which is not too bad a yield. Many more can be generated, but discussion of these 17 will illustrate the way the theory works. (The numbers in parenthesis refer to the postulates as numbered in Table 4.)

I. Imagery can occur in paired-associate tasks, even when the materials are verbal. (From 1a, 1b.)

II. The process of change results in disintegration of compound images. (From 1d, 1e, 3.) Thus, although images may tend to persist, they may begin as compound images but change into simple disconnected images that ever more closely resemble the figurative conceptions.

The salient parts of a compound image are the stimulus and response items and their interaction. In Piaget-type terms, the stimulus and response parts become assimilated to figurative conceptions; but the interaction is not assimilated, and therefore the interactive relation between the stimulus and response items is lost from memory. The conjunctive relation may persist, but research has shown that in paired-associate learning, the conjunctive relation is not facilitative (Rohwer, 1967) or at best produces very little facilitation (Reese, 1970c, comparison of "replicated" and "new" control conditions).

For example, a compound image of a cat carrying an umbrella should gradually change into two separate images, one of a cat and one of an umbrella, and furthermore the separate images should be more like the subject's figurative conceptions of cats and umbrellas than they are like the cat and umbrella actually presented. Subjects have figurative conceptions of cats and umbrellas--if they know what these words mean--but they have no figurative conception of cats carrying umbrellas. It is as though the figurative conceptions pull apart the elements in the compound image, and eventually replace it. This is what I meant by "leveling between figurative conceptions and memory images" in my first presentation of the theory (Reese, 1970a).

III. Details in images retard the process of change. (From 1f, 3.)

IV. Details preserve compound images. (From II, III.) When few details are present in a compound image, there is less leveling needed to change the elements in it into the figurative conceptions. Palermo (1970) has reported that color photographs are slightly more effective than line drawings for adults, in line with this deduction.

V. A compound image does not arouse overt output of the stimulus item. (From 1a, 5a-5d, 6a-6f.)

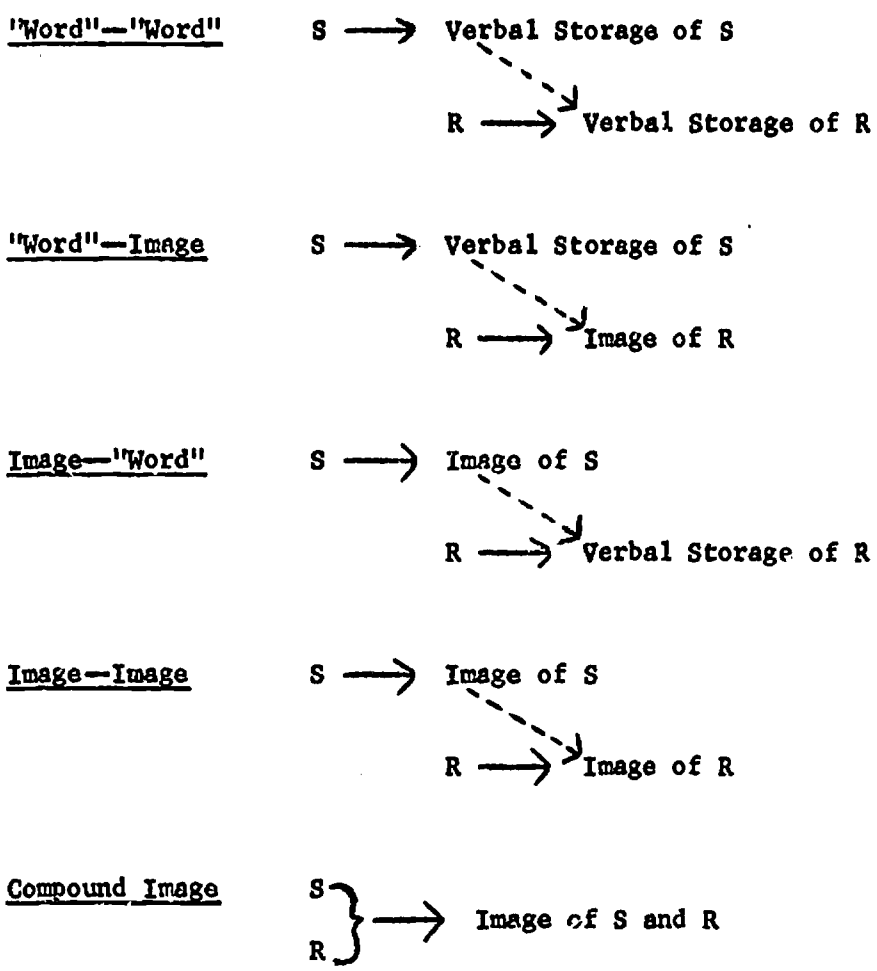

Fig. 1. Hypothetical associations between stimulus (S) and response (R) items. Solid arrows indicate associations presumed not to require conditioning; broken arrows indicate conditioned associations.

VI. A compound image arouses the appropriate response. (From same assumptions as V, plus V.)

VII. "Built-up" images are effective. (From same assumptions as VI, plus 4.) In a "built-up" compound image, the older response images have been rehearsed more than the more recent ones, yielding a hierarchy of response images differing in strength. This hierarchy provides a basis for selection of the appropriate response image; the subject is set by the task demands to select as a basis for overt responding the response image that is lowest (weakest) in the hierarchy. The subject should also be able, on demand, to select the images in order of their strength, and hence to repeat in correct order the items in a given position across successive lists (as some of Bugelski's subjects were able to do).

VIII. Without compound imagery, cognition does not improve performance. (From 1c, plus absence of all of 5 and 6.) When a compound image has not been formed, or when one has been formed but has undergone so much change that it no longer includes the response item, presentation of the stimulus item arouses the image of the stimulus item alone. In that case, no response image is aroused and the stimulus imagery fails to facilitate performance.

IX. Young children are less likely than older children to form compound images. (From 1d, 2a, 2c.)

X. If formed by young children, compound images are less likely to persist than in older children. (From 2b, 2d, IV.)

XI. With appropriate materials, young children can perform as well as older children. (From 1d, 2a, 2e; 2b, IV, 2e.) The reduced effect of imagery in young children results from either a failure to form compound images or a failure to include irrelevant detail in compound images. The first of these could result from a failure of the young child to "read" pictures of stimulus-response interactions (Reese, 1970a). Adults can--and often do--spontaneously form images of the items and combine these images even when not specifically instructed to do so (e.g., Bugelski, 1970). Children are presumed to be less likely to do this, and because of the difficulty of conveying instructions to them, they are usually given the procedure in which the experimenter attempts to manipulate imagery by the use of specially prepared materials, typically pictures of stimulus-response interactions. The child will derive no benefit from these pictures if he sees in them only the stimulus and response elements and not their interaction. Alternatively, the young child's images could be deficient in irrelevant details, because experimenters have presented pictures with few irrelevant details (see Reese, 1970a).

XII. Paired-associate learning can occur without compound imagery. (From 7a-7e.)

XIII. Compound imagery is more effective than conditioning. (From VI, VIII, 7e.)

XIV. Verbal input persists longer if decoded into an image. (From 1a, 1b, 4.)

XV. Conditioning with an image as the conditioned stimulus is faster than with a word as the conditioned stimulus. (From XIV plus laws about trace conditioning.) Therefore, image-image and image-word conditioning are faster than word-image and word-word conditioning, and hence produce better performance.

If it is further assumed that verbal output is more accurate when it is an encoding of an image than when it is an output from verbal storage, then image-image conditioning should be superior to image-word conditioning, and word-image conditioning should be superior to word-word conditioning. This would yield the ordering of the conditioning sequences shown in Figure 1, from least effective (top) to most effective (bottom). The ordering

accounts for Paivio's and Wood's findings on high and low imagery on the stimulus and response sides, but it is a circular account because their findings were the source of the required assumption.

XVI. Elaboration should be superior to coding, because in elaboration an interaction between the stimulus and response elements is explicit, while in coding it seems to be implicit. That is, elsboration is more likely to involve compound imagery than is coding. (From 2a.)

XVII. Relatively short-term retention should be facilitated more by imagery than relatively long-term retention. (From 3, II, VIII.)

Concluding Remarks

The theory seems to be complete enough to handle the vast majority of facts about imagery in paired-associate and serial learning; but there is one salient problem. Specifically, the theory assumes only iconic cognition, relegating verbal processes to short-term storage and output systems. This seems unrealistic in view of the finding--obtained by Paivio and others under controlled conditions (see Paivio, 1969) and common in anecdotal reports--that many subjects report the use of verbal mnemonics. According to the theory, these subjects were actually using imagery, which requires an explanation of why they did not know (or did not report) that they were, or acceptance of their report and inclusion of assumptions about a verbal mnemonic system. There are other problems, which at this stage seem relatively minor. For example, a rigorous theory would require fuller specification of the meaning of "short-term storage," to distinguish it from immediate memory and long-term storage.

In conclusion, I would like to say something relevant to the title of the paper. First, I have tried to show that mnemonics data seem to be inconsistent with behavioristic theories, and consistent with a cognitive theory. Second, the aspect of the topic covered in this paper has been ignored by cognitivists, and therefore it has been necessary for a behaviorist interested in the problem to struggle through the creation of a cognitive theory without knowing the ground rules for this kind of endeavor. It would be useful to mnemonics researchers to engage the interest of a skilled cognitive theorist in the problem, and it should be useful to cognitivists to engage in research on the problem.

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