is the fact that Ss were working under considerable time pressure in those experiments but not in the present one. In the latter case, Ss could examine the characters for a full second and could, therefore, take a more analytical approach to the task than was possible in Brand and Ingling's experiments. A study similar to the present one, but in which exposure duration is varied instead of noise level, might help to reconcile the findings.

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MPA SYMPOSIUM ON CODING PROCESSES IN HUMAN MEMORY

The present series of papers by Johnson, Martin, Melton, Postman and Burns, Restle, and Wickens are minor modifications of talks that were presented at a symposium at the Midwestern Psychological Association in Cleveland, May 1972. The papers by Johnson, Martin, and Wickens are variants upon chapters that appear in *Coding Processes in Human Memory.* The full reference to this book is given in the References at the end of Wickens's paper.

The objective of the symposium was to present different views of the coding processes under conditions leading to discussion, with overall reactions to and critiques of the papers being given by Melton.

Delos D. Wickens

Some characteristics of word encoding*

DELOS D. WICKENS†
Ohio State University, Columbus, Ohio 43210

This paper presents the results of a series of experiments using the release from proactive inhibition technique for identifying the salient encoding attributes of words. The technique uses the Brown-Peterson paradigm, but, after three trials on words of one class, a fourth trial is given with words of another class. The power of the class encoding is inferred from the extent of gain (release from PI) found on the shift trial. The studies reported show a high degree of effectiveness for semantic variables; practically no effectiveness for grammatical variables; a moderate amount for physical variables (i.e., figure-ground shift); and varying amounts for other shifts such as word frequency, imagery, language of the presentation to bilingual Ss. Some evidence is also given for the occurrence of simultaneous multiple encoding.

My talk tonight will deal with the richness and the intricacy with which we encode words—the symbols that make up what we call language, and I will attempt to show that we are extraordinarily efficient, fertile, and rapid processors of an almost unbelievable amount of information. I think that such cognitive processing is highly automatic and compulsive, but, because of lack of time, I must pass over that aspect of encoding and shall concentrate chiefly upon the evidence for the complexity and the competence in the verbal information processing of the ordinary literate individual. Much of the research we have done on this subject has appeared earlier (Wickens, 1970, 1972), but the present paper includes additional work by me and others. I shall present briefly the results of this work, and also some data on multiple encoding.

The topic can be investigated in many ways—by a sorting task, by false positives in a recognition memory task, or by other methods—but I shall restrict myself to our particular approach to encoding, a technique that

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†Requests for reprints should be sent to the author at the Department of Psychology, Ohio State University, 1945 North High Street, Columbus, Ohio 43210.

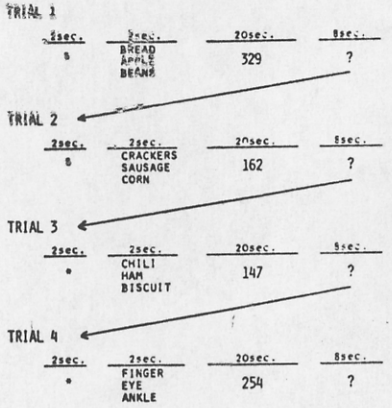

Fig. 1. A typical Brown-Peterson set of trials for a study of the nature of encoding.

seems to be highly sensitive to differing aspects of words and one that we have called release from proactive inhibition.

The experimental situation we use is familiar to many, but, nevertheless, I will briefly summarize it. It is illustrated schematically in Fig. 1. Before the experiment begins, we tell Ss that we are interested in their ability to remember words and their ability to count backward by threes and that we would like them to do as well as possible on both tasks. The first presentation is a projected asterisk which remains visible for 2 sec and is a warning that Ss should prepare to read and to remember the contents of the next slide. This consists of three words whose exposure time is also 2 sec. This slide is followed immediately by one of three-digit numbers from which Ss are supposed to subtract by threes at a rapidly paced rate. The number remains projected for 20 sec, and the purpose of the activity is, of course, to keep Ss from rehearsing the three words. The question mark of the final slide of a trial signals a request for recall, and Ss have 8 sec to respond before the next warning signal appears, indicating the beginning of another trial. The procedure is repeated until four trials are completed.

The materials shown in Fig. 1 represent materials for one of our experimental groups. It will be noted that the words of the first three trials all come from the category of foodstuffs. On Trial 4, the category was changed and the Trial 4 words refer to parts of the body. For the particular control group matching these experimental group materials, there would have been no change on Trial 4; all items of all trials would have been drawn from the same category, the category employed on the final trial.

When materials such as these are presented in the experimental design described, typically the results are as shown in Fig. 2. The curve marked "experimental" shows a progressive decrement in performance on Trials 2 and 3, then an increment of considerable magnitude on Trial 4. The control group shows the decline across all four trials. The performance decline can be readily attributed to the development of proactive inhibition; the experimental group's increment on Trial 4 has been termed release from proactive inhibition. One interpretation made of data such as these is that materials that are encoded in a similar fashion interfere with each other and produce a performance deficit: hence, the decline in performance for both groups during the first three trials. When, however, a different class of materials is introduced—as on Trial 4 for the experimental group—the interference is reduced and performance is improved (Wickens, 1970). If one is

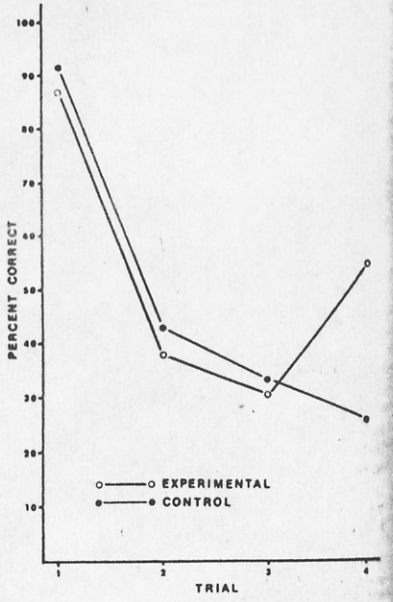

Fig. 2. Expected results for recall across trials for the operations described in Fig. 1 (experimental group) and a control group.

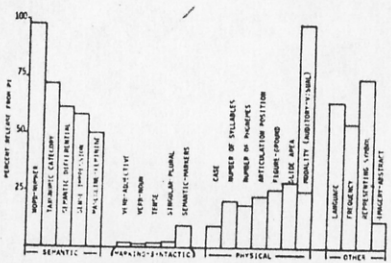

Fig. 3. The percentage release from PI as a function of changes in various attributes.

willing to accept the hypothesis that the improvement occurs because of differential encoding, then it is apparent that this type of procedure can be used to determine whether or not formally different classes of materials are indeed encoded differently at the psychological level of these experiments. The method might be called a projective technique of cognitive organization. We have used the method frequently, and Fig. 3 shows the results for over 30 experiments that have been conducted for the most part in the laboratory at Ohio State University. I should add that no experiment referenced had less than 48 Ss, and many of the experiments cited used several hundred Ss each.

Before this figure can be fully understood, the method of calculating the values on the Y axis (the percentage of release from PI) must be explained. First, one determines the total amount of decline for the control group from Trial 1 through Trial 4. Second, the difference between the scores of the control and experimental groups on Trial 4 is determined. Finally, one calculates what percentage the experimental group's gain is of total decline of the control group.

There is not space available to discuss each of the experiments represented, but rather an emphasis will be placed upon the significance of the descriptive classifications of the solid lines below the bar graph clusters. Some detail on each of these experiments is presented in Table 1.

The cluster on the left shows the amount of release obtained from shifts that were semantic in nature. There are many of these: changes from word triads to number triads; shifts from one to the other end of the three dimensions of the Osgood semantic differential; changes in categories, as house-part words to food words; changes in sense impressions, as from words for objects that are characteristically white—*rice, bandage, teeth*—to words for objects that are characteristically round in form—*ball, glove, dome*—and, finally, changes in the sex suggested, as from the word triad of *uncle, tuxedo, actor*, to the triad of *hostess, hen, nylon*. It will be noticed from an examination of the figure that all such semantic shifts are highly effective.

Before leaving the semantic dimension, a recent experiment by Wickens and Lindberg, as yet unpublished, should be mentioned. Bentler and La Voie (1972) have suggested that four more dimensions should be added to the original Osgood three. These dimensions are *density* (gang-few), *organization* (structured-scrambled), *reality* (authenic-fake), and *familiar* (routine-novel). Their conclusions were based on a factor analysis of words connoting these dimensions. The usual release from PI experiment was conducted with each of these dimensions, using 96 Ss for each dimension. The two dimensions produced significant release, *density* at 26% and *reality* at 36%. The other two were quite ineffective.

Table 1
Description of the Attributes Referred to in Fig. 3

1. Words to numbers, as *book, chair, doctor* to *three, nine, one.* (Reutener)
2. Taxonomic categories, as *door, window, cellar* to *bread, carrots, potatoes.* (Goggin & Wickens, 1971; cf. Loess, 1967)
3. Semantic differential (Wickens & Clark, 1968), *hate, fire, kill* to *able, mother, wise.* (Wickens & Clark, 1968)
4. Sense impression, as *dome, knob, wheel* to *rice, teeth, bandage.* (Wickens, Reutener, & Eggeneier, 1972)
5. Masculine-feminine, as *queen, nylons, cow* to *butler, rooster, tuxedo.* (Ickes, unpublished)
6. Verbs to adjectives. (Wickens, Clark, Hill, & Wittlinger, 1968)
7. Verbs to nouns, as *roam, destroy, listen* to *earth, house, pony.* (Wickens, Shearer, & Timmons, unpublished)
8. Tense, as *ride, dig, take* to *wrote, stood, ran.* (Wickens, Shearer, & Timmons, unpublished)
9. Singular-plural, as *oxen, feet, men* to *child, tooth, mouse.* (Wickens, Shearer, & Timmons, unpublished)
10. Semantically marked to unmarked, as *foul, dim, bland* to *long, clean, sane.* (Deese & Wickens, unpublished)
11. Uppercase to lowercase nouns. (Shearer & Wickens, unpublished)
12. One- to two-syllable nouns, as *bread, Maine, nose* to *rifle, spider, airplane.* (Baldwin, 1969)
13. Number of phonemes in one-syllable words—two to three phonemes to four or five, as *dumb, hay, eel* to *branch, wrist, month.* (Baldwin, 1969)
14. Articulation (closed front to open back), as *splint, pig, sea* to *fork, gauze, swan.* (Baldwin, 1969)
15. Figure-ground: CCCs white on black to black on white. (Reutener, 1972)
16. Illuminated area of the slide background: Large area to small. (Turvey, Egan, 1969)
17. Modality of presentation: Auditory to visual. (Wittlinger, 1967; Rubin, 1967).
18. Language of common words with bilinguals: English to Spanish. (Goggin & Wickens, 1971)
19. Thorndike-Lorge high- to low-frequency nouns and verbs. (Swanson & Wickens, 1970)
20. Representing symbol, as 397 to eight, five, two. (Reutener, 1972)
21. Imagery (abstract words to concrete words), as *advantage, boredom, position* to *palace, acrobat, factory.* (Wickens & Engle, 1970)

In a second experiment, the words from each category were given to Ss to rate on the three Osgood dimensions, and differences between the bipolar words were obtained. The results indicated that the Bentler and La Voie dimensions which produced significant release differed significantly on all three Osgood dimensions, and the others differed on only two.

The interpretation of the results of this and the first experiment is not simple. They are concerned with null hypothese conclusions, and these always rest upon thin ice. This null hypothesis effect operates in both the first and second experiments. On the other hand, the findings do raise questions about the encoding power of moderate values of one or two dimensions in the release from PI paradigm and suggest the need for additional research along this line.

As an aside, it should be pointed out that the failure to find release from PI for two of their dimensions is not grounds for invalidating the Bentler and La Voie factor analysis. It is entirely possible that the PI release paradigm is keyed upon limited semantic features and that the more leisurely rating method permits less salient features to be brought into play.

The next cluster deals with grammatical shifts, or, to use the language of the linguist, with marked vs unmarked words. The experiments represented investigated shifts in such forms as: singular words to plural words (*mouse* to *mice*); words denoting past tense to words denoting the present (*ran* to *run*); verbs to adjectives; and verbs to nouns. There is little evidence that these grammatical aspects of a word play any important role in the immediate encoding process as measured by this STM technique.

An additional study should be mentioned. Judith Goggin (personal communication), using Spanish speaking students, measured the shift effect with nouns requiring the feminine article to nouns requiring the masculine article, and the reverse. Essentially, no release from PI was found on the shift trial. These results are quite consonant with those of the other marked-unmarked studies. The gender of many nouns is a superfluous concept that is not embedded in the intrinsic characteristics of the word and apparently is not a part of the encoding process of the word even among those who are highly familiar with the language in question. Those native English speakers among us who have struggled with the gender of nouns in some scholastic foreign language learning will recognize the validity of this research. It should be pointed out that there is no contradiction between this study and the previously mentioned effective masculine-feminine shift under the semantic class. In the former instance, sex is clearly a part of the denotative characteristic of the words, but it is not so in the latter instance.

The third cluster consists of shifts in physical characteristics, i.e., in aspects of the physical presentation of the words. Here we worked with such shifts as changes in the background or color of the slide area, changes in the number of syllables of the words used, and changes in the pronunciation (as open or closed). With two exceptions, one of which is really a shift in method of presentation, i.e., visual to auditory, the physical shifts produced results of only marginal significance.

The first exception is found in a study by Lachar and Goggin (1969). They shifted from two-syllable words of four-letter length to two-syllable compound words of 10 letters in length. The increment on the shift trial was .95%, considerably greater than the other physical shifts.

The other exception is with modality shifts. The lower shift value in Fig. 3 was obtained by Wittlinger (1967) and the higher one by Rubin (1967). Except for the fact that the two experiments differed in their method of visual presentation, the cause of the discrepancy is difficult to identify. The ambiguity of this type of shift is further confounded by the work of Hopkins, Edwards, and Gavelek (1971), who found the shift effect in going in one direction but not the other. Obviously this attribute needs further research.

The last cluster is called "other" only because its items are not easily classified. It represents, from left to right, shifts from Spanish to English nouns with bilinguals as Ss, changes from high- to low-frequency words, shifts from spelled-out numbers to arabic numerals, and, finally, shifts from words of high-imagery value to those of low, the least effective shift of this cluster.

A recent study by Goedal (1972) obtained a more potent effect from the abstract-concrete shift, achieving an increment of about 38%. There were a number of differences between his experiment and that of Wickens and Engle (1970), and it is not exactly clear as to why the results should be as discrepant as they are, although, of course, Wickens and Engle did find some shift effect. A potentially important difference between the two experiments is exposure duration of the materials. In the Wickens and Engle work, the word triad was exposed for 2.5 sec and, since it takes a carousel projector about .7 sec to change to the next slide, this produces a presentation period of about 3.2 sec. In the Goedal work, the words of the triad were presented individually for 1 sec. If one adds .7 sec for slide change time to each word, his triad presentation is calculated at 5.1 sec, and the increased time very likely gives more opportunity for imagery encoding. This differential in presentation time and/or simultaneous vs individual presentation of these words may contribute to difference in the results of the two experiments. However, it should be pointed out that it is quite appropriate to demand as a base of comparison of imagery against other attributes that experimental procedures using basically the same methodology as the Wickens and Engle research be employed.

These studies, when taken all together, seem to tell us something about the tremendous richness of the information processing that goes on when we experience isolated words for very brief spans of time. We excel in encoding the various semantic aspects of the word, its frequency of use in the language, and various aspects of its method of presentation and pronunciation, but we seem to disregard its grammatical form.

The fact that the semantic aspects of words are uniformly dominant encoding dimensions could, it seems to me, derive from the same type of mechanism that James Gibson (1965) considers to be responsible for the development of visual perception. Gibson was wrestling with the fact that stable percepts can develop despite the continuous flux of the visual word where retinal stimulation varies from moment to moment. He concluded that the percept is a product of the invariance of certain aspects of the changing situation. This interpretation also could be true for the semantic attributes of words. Typically, a word has the same denotative and connotative meaning, regardless of who says it, where it is said, whether it is written or spoken, whether it appears in a book, a brochure, or on the flashing lights of a neon sign. This fact is strikingly brought home to us in a passage from Lewis Carroll's *Through the Looking-Glass.*

Humpty Dumpty had just argued to Alice that un-birthday presents are far more desirable than birthday presents since there are 364 days when one might get an un-birthday present.

"And only *one* for birthday presents, you know. There's glory for you!"

"I don't know what you mean by glory," Alice said.

Humpty Dumpty smiled contemptuously. "Of course you don't—till I tell you. I meant there's a nice knock-down argument for you!"

"But 'glory' doesn't mean there's a nice knock-down argument for you!"

"When I use a word," Humpty Dumpty said, in a rather scornful tone, "it means just what I choose it to mean—neither more nor less."

"The question is," said Alice, "whether you *can* make words mean so many different things."

"The question is," said Humpty Dumpty, "which is to be the master—that's all."

To return to the real world—the world of Alice's and the reader's identification—we realize that the humor of the passage derives from the absurdity of Humpty Dumpty's position; for we know that, if we are to communicate with each other, words must—and usually do—have semantic invariance. Indeed, this characteristic of words is so powerful that certain politicians use this principle to cover their dubious actions by choosing a favorable word for them when these actions are less than admirable.

One may use the same principle to account for the failure to obtain release from PI when shifting from nouns to verbs or making other grammatical shifts. A very large number of words have a dual grammatical function and can serve, at our wish, in either capacity. Hence, the formal noun-verb differentiation of a single word is an unreliable cue for encoding.

But despite the fact that, as I stated above, a word may come to us through many different media, with the method of presentation usually irrelevant to the purposes of communication, we do pick up some of these irrelevancies—as indicated by the mild effectiveness of physical attributes in the bar graph. If, for example, you happen to recall some months from now certain of the thoughts that have been expressed tonight, you will almost certainly remember that you heard them spoken rather than that you read them, and you may remember that you heard them at MPA. Such facts as these, and the experiments mentioned earlier that bear upon them, give further testimony of the incredible and, in a sense, unnecessary richness of our cognitive encodings.

Now it must be recognized that these conclusions have been drawn from a series of separate experiments, each one testing a different aspect or attribute. Does the conclusion really hold for a given individual in a given single experience with a semantic event? Does the average college student, on hearing the word "mother," for example, simultaneously encode it as evaluative positive on the semantic differential, as feminine, as a high-frequency word, as a member of a relative grouping, and so on; or would he, perhaps, encode the word according to one, or possibly two, dominant attributes? Answering a question of this sort presents a somewhat difficult experimental challenge, but I believe that we have made some headway in achieving an answer.

I shall describe an experiment conducted by Thomas Eggemeier and me. We chose as a constant fourth trial, i.e., the shift trial, items from the category of names of fruits, then formed four experimental groups whose category experiences differed from each other across the first three trials. For one group, the words of the first three trials were names of meats or meat products; for another, the names of vegetables; for a third, the names of flowers; and, for the last experimental group, the names of professions. There was, of course, a control group with names of fruits used throughout all four trials. Our aim should be clear. Fruits and vegetables might be encoded by means of two common attributes. They are things to be eaten and things grown from the ground. The meats are appropriate to the first attribute (they are edible) but not to the second (they do not grow from the ground). Flowers, however, grow from the ground but are not usually edible. Names of professions share neither attribute. Would the four groups, with their very different first-three trial histories, differ from each other in release from proactive inhibition on their fourth shift trial which was always the same for all groups?

I shall report the second of two experiments of the type just described in Fig. 4. Happily, both sets of results agree. We choose the second (even though it was completed only recently), since it used *five* categories

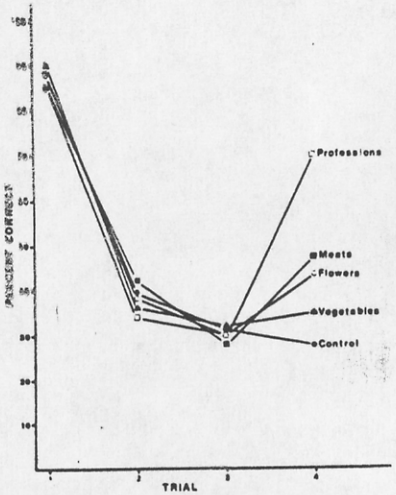

Fig. 4. The effects of shifting to a common category–fruits as a function of category employed on the first three trials.

(meats added) rather than the four of Experiment I. We have not yet finished the statistical analysis of the data, but I do not think such analysis is necessary to be able to make some sense of the meaning of the data points on Trial 4. The group that shares no obvious attribute with the category of *fruits* is, of course, *professions*, and this group shows the largest increment on the shift trial. Intermediate are the two groups that have only one attribute in common with the *fruit* control, although each of these two groups shares a different aspect with the *fruit* category. The lowest experimental group, the one showing the least increment on the shift trial, uses, across the first three trials, the *vegetable* category, one which overlaps the controls in *two* attributes. Even with this overlap, the *vegetable* group does slightly excel the control group, implying a differential encoding of some other unidentified attribute–taste, perhaps. All in all, we think the correlations between group performances and number of attributes in common with the controls seem to indicate the existence of multiple encoding.

The first set of experiments reported have shown that we are able to encode words in a number of different measurable ways. I believe that the last experiment reported offers some evidence for multiple encoding, evidence for a view that those of us who live with and by words tend to encode each word (perhaps excepting articles and conjunctions) on a multiple number of attributes. How we can do so in such a short period of time as is allowed to us in the give and take of a flowing conversation or in the austerity of a 2-sec presentation of three words in the laboratory is something quite remarkable. It seems to me that it is behavior that is surely worthy of further research, particularly research at a developmental level.

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Higher Order Encoding: Process or state?*

NEAL F. JOHNSON
Ohio State University, Columbus, Ohio 43210

While prior data has seemed to suggest that learning occurs as a result of encoding information into higher order memory units, rather than the formation of interitem associations, the process whereby the encoding occurs has been left relatively unspecified. Two encoding models were outlined which differed to the extent that one assumed that encoding occurred as an active process after the specific items of information were registered in memory, while the other assumed that information is initially registered in memory in the encoded state. The results from two studies seem to offer the most support for the second of these two models.

During the past few years, there has been an increasing tendency to move away from traditional associative explanations of learning and descriptions of what is learned toward conceptions of the process that presume a somewhat more active organism. Traditional conceptions of learning were quite mechanistic and, to a large degree, the empirical effort was aimed at identifying the conditions under which an assumed atom of learning (i.e., an association) was established. The nature of the learning atom was more or less assumed and not subjected to empirical investigation, and, consequently, the explanatory adequacy of the construct was never seriously questioned. It was simply assumed that what Ss learned were two-place direct relationships, or associations, between observable items and that all knowledge states ultimately could be analyzed into compounds of such associations. Furthermore, an assumption, which was more or less implicit to the approach, was that to conceptualize the domain of learning in that manner would eventually lead to a more thorough understanding of the phenomenon than would conceptualizing it in any other manner.

An alternative approach is to view the learner as an active processor of information and attempt to understand learning through an understanding of the mechanisms and the processes whereby he acquires information. That is, rather than trying to understand the phenomenon of learning in terms of the conditions under which an assumed single type of relationship is acquired, it might be more profitable to try to define the mechanisms and processes the learner engages when he attempts to register information in memory. Furthermore, such an approach does not rest on any rigid assumption of what is learned, but rather it leaves that issue open to empirical investigation. In fact, as will be noted below, one approach to examining the processing mechanisms engaged by a learner is to explore the nature of what has been learned.

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LEARNING AS ORGANIZATIONAL PROCESSES

One conception of the learning process, which has implications for both the mechanisms whereby information is acquired and the issue of what is learned, is the hypothesis that learning is, in fact, an active process of organizing the to be learned material and then including the learned material within an existing organized network of information within memory. It is assumed that learning results from the coding processes entailed by the organization.

While the term organization implies some set of relationships, the nature of these relationships depends upon a particular conception of organization. For example, a Markov process might be viewed as an organizational net, and it would represent a linear conception of organization. An alternative model is to view the organization in terms of unitizing or chunking (Miller, 1956), with small item sets encoded into higher order units, which themselves can be encoded into yet higher order units, etc. For example, words can be encoded into phrase units, which in turn can be encoded into subject and predicate units, and, at a higher level, those units can be encoded into sentence units. It is this hierarchical conception of organization that will be used here, and a specific organization for a sequence can be defined by the hierarchical encoding pattern.

It is assumed that the unitization process, regardless of the level at which it occurs, is the establishment of a higher order memory code which is a single device that represents the information in the lower order codes (as opposed to some notion of a simple amalgamation of that information) (Johnson, 1970, 1972). Following from such a coding notion, one can operationally define a response unit or chunk as a response set that tends to be recalled or forgotten in an all or none manner, and the stage the unitization or encoding process has