JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR **11**, 671–684 (1972)

Levels of Processing: A Framework for Memory Research[1]

FERGUS I. M. CRAIK AND ROBERT S. LOCKHART

University of Toronto, Toronto 181, Ontario, Canada

This paper briefly reviews the evidence for multistore theories of memory and points out some difficulties with the approach. An alternative framework for human memory research is then outlined in terms of depth or levels of processing. Some current data and arguments are reexamined in the light of this alternative framework and implications for further research considered.

Over the past decade, models of human memory have been dominated by the concept of stores and the transfer of information among them. One major criterion for distinguishing between stores has been their different retention characteristics. The temporal properties of stored information have, thus, played a dual role: Besides constituting the basic phenomenon to be explained, they have also been used to generate the theoretical constructs in terms of which the explanation is formulated. The apparent circularity has been avoided by the specification of additional properties of the stores (such as their capacity and coding characteristics) thereby characterizing them independently of the phenomena to be explained. The constructs, thus formulated, have been used to account for data across a variety of paradigms and experimental conditions. The essential concept underlying such explanations is that of information being transferred from one store to another, and the store-to-store transfer models may be distinguished, at least in terms of emphasis, from explanations which associate different retention characteristics with qualitative changes in the memory code.

In the present paper we will do three things: (*a*) examine the reasons for proposing multistore models, (*b*) question their adequacy, and (*c*) propose an alternative framework in terms of levels of processing. We will argue that the memory trace can be understood as a byproduct of perceptual analysis and that trace persistence is a positive function of the depth to which the stimulus has been analyzed. Stimuli may also be retained over short intervals by continued processing at a constant depth. These views offer a new way to interpret existing data and provide a heuristic framework for further research.

MULTISTORE MODELS

The Case in Favor

When man is viewed as a processor of information (Miller, 1956; Broadbent, 1958), it seems necessary to postulate holding mechanisms or memory stores at various points in the system. For example, on the basis of his dichotic listening studies, Broadbent (1958) proposed that information must be held transiently before entering the limited-capacity processing channel. Items could be held over the short term by recycling them, after perception, through the same transient storage system. From there, information could be transferred into and retained in a more permanent long-term store. Broadbent's ideas have been developed and extended by Waugh and Norman (1965), Peterson (1966), and Atkinson and Shiffrin (1968). According to the modal model (Murdock, 1967), it is now

[1] This research was supported by Grants A8261 and A0355 from the National Research Council of Canada to the first and second author, respectively. We thank our colleagues who read a preliminary version of the paper and made many helpful suggestions.

widely accepted that memory can be classified into three levels of storage: sensory stores, short-term memory (STM) and long-term memory (LTM). Since there has been some ambiguity in the usage of terms in this area, we shall follow the convention of using STM and LTM to refer to experimental situations, and the terms "short-term store" (STS) and "long-term store" (LTS) to refer to the two relevant storage systems.

Stimuli can be entered into the sensory stores regardless of whether or not the subject is paying attention to that source; that is, sensory stores are "preattentive" (Neisser, 1967). The input is represented in a rather literal form and can be overwritten by further inputs in the same modality (Neisser, 1967; Crowder & Morton, 1969). Further features which distinguish the sensory registers from later stores are the modality-specific nature and moderately large capacity of sensory stores and the transience of their contents.

Attention to the material in a sensory register is equivalent to reading it out and transferring it to STS. Here, verbal items are coded in some phonemic fashion (Shulman, 1971) or in auditory–verbal–linguistic terms (Atkinson & Shiffrin, 1968). The STS is further distinguished from sensory memories by virtue of its limited capacity (Miller, 1956; Broadbent, 1958), by the finding that information is lost principally by a process of displacement (Waugh & Norman, 1965), and by the slower rate of forgetting from STS: 5–20 seconds as opposed to the $\frac{1}{4}$–2-second estimates for sensory storage. While most research has concentrated on verbal STS, there is evidence that more literal "representational" information may also be held over the short term (Posner, 1967), although the relationship between such modality-specific stores and the verbal STS has not been made clear.

The distinctions between STS and LTS are well-documented. Whereas STS has a limited capacity, LTS has no known limit; verbal items are usually coded phonemically in STS but largely in terms of their semantic features in LTS (Baddeley, 1966); forgetting from STS is complete within 30 seconds or less while forgetting from LTS is either very slow or the material is not forgotten at all (Shiffrin & Atkinson, 1969). In the free-recall paradigm, it is generally believed that the last few items are retrieved from STS and prior items are retrieved from LTS; it is now known that several variables affect one of these retrieval

TABLE 1

COMMONLY ACCEPTED DIFFERENCES BETWEEN THE THREE STAGES OF VERBAL MEMORY (SEE TEXT FOR SOURCES)

Feature	Sensory registers	Short-term store	Long-term store
Entry of information	Preattentive	Requires attention	Rehearsal
Maintenance of information	Not possible	Continued attention Rehearsal	Repetition Organization
Format of information	Literal copy of input	Phonemic Probably visual Possibly semantic	Largely semantic Some auditory and visual
Capacity	Large	Small	No known limit
Information loss	Decay	Displacement Possibly decay	Possibly no loss Loss of accessibility or discriminability by interference
Trace duration	$\frac{1}{4}$–2 Seconds	Up to 30 seconds	Minutes to years
Retrieval	Readout	Probably automatic Items in consciousness Temporal/phonemic cues	Retrieval cues Possibly search process

components without affecting the other (Glanzer, 1972). Further persuasive evidence for the STS/LTS dichotomy comes from clinical studies (Milner, 1970; Warrington, 1971). The distinguishing features of the three storage levels are summarized in Table 1.

The attractiveness of the "box" approach is not difficult to understand. Such multistore models are apparently specific and concrete; information flows in well-regulated paths between stores whose characteristics have intuitive appeal; their properties may be elicited by experiment and described either behaviorally or mathematically. All that remains, it seems, is to specify the properties of each component more precisely and to work out the transfer functions more accurately.

Despite all these points in their favor, when the evidence for multistore models is examined in greater detail, the stores become less tangible. One warning sign is the progressively greater part played by "control processes" in more recent formulations (for example, Atkinson & Shiffrin, 1971). In the next section we consider the adequacy of multistore notions more critically.

The Case Against

The multistore approach has not been without its general critics (Melton, 1963; Murdock, 1972). Other workers have objected to certain aspects of the formulation. For example, Tulving and Patterson (1968) argued against the notion of information being transferred from one store to another. Similarly, Shallice and Warrington (1970) presented evidence against the idea that information must necessarily "pass through" STS to enter LTS.

In our view, the criteria listed in the previous section do not provide satisfactory grounds for distinguishing between separate stores. The adequacy of the evidence will be considered with reference to the concepts of capacity, coding, and finally, the retention function itself.

Capacity

Although limited capacity has been a major feature of the information flow approach, and especially a feature of STS in multistore models, the exact nature of the capacity limitation is somewhat obscure. In particular, it has been unclear whether the limitation is one of processing capacity, storage capacity, or is meant to apply to some interaction between the two. In terms of the computer analogy on which information flow models are based, the issue is whether the limitation refers to the storage capacity of a memory register or to the rate at which the processor can perform certain operations. The notion of a limited-capacity channel (Broadbent, 1958) appears to emphasize the second interpretation while later models of memory, such as that of Waugh and Norman (1965), appear to favor the storage interpretation. Both interpretations are present in Miller (1956) but the relationship between the two is not explicitly worked out.

Attempts to measure the capacity of STS have leant towards the storage interpretation, and considered number of items to be the appropriate scale of measurement. Such attempts have provided quite a range of values. For example, recent estimates of primary memory size (Baddeley, 1970; Murdock, 1972) have yielded values between two and four words. However, measures of memory span (which have been said to reflect the limited capacity of the STM box) are typically between five and nine items, depending on whether the items in question are words, letters or digits (Crannell & Parrish, 1957). Finally, if the words in a span test form a sentence, young subjects can accurately reproduce strings of up to 20 words (Craik & Masani, 1969). Thus, if capacity is a critical feature of STM operation, a box model has to account for this very wide range of capacity estimates.

The most widely accepted explanation of this variation is that capacity is limited in terms of chunks, and that few or many items can be recoded into a chunk depending on the meaningfulness of the material. Apart from the difficulty of defining a chunk independently from its memorial consequences, this view entails a rather flexible notion of STS as a storage compartment which can accept a variety of codes from simple physical features to complex semantic ones.

From the standpoint of the present paper, the concept of capacity is to be understood in terms of a limitation on processing; limitations of storage are held to be a direct consequence of this more fundamental limitation.

Coding

Working with verbal material, Conrad (1964) and Baddeley (1966) provided one plausible basis for distinguishing STS and LTS. They concluded that information in STS was coded acoustically and that coding was predominantly semantic in LTS. Further research has blurred this distinction, however. First, it has been shown that STS coding can be either acoustic or articulatory (Levy, 1971; Peterson & Johnson, 1971). Second, recent papers by Kroll and his colleagues (Kroll *et al.*, 1970) have demonstrated that even with verbal material, STS can sometimes be visual. Apparently STS can accept a variety of physical codes.

Can STS also hold semantic information? The persistence of contradictory evidence suggests either that the question has been inappropriately formulated or that the answer depends on the paradigm used. When traditional STM paradigms are considered, the answer seems to be "no" (Kintsch & Buschke, 1969; Craik & Levy, 1970), although Shulman (1970, 1972) has recently presented persuasive evidence in favor of a semantic STS. While type of coding may originally have seemed a good basis for the distinction between short-term and long-term memory, the distinction no longer appears satisfactory. A defender of the multistore notion might argue that STS coding is flexible, but this position removes an important characteristic by which one store is distinguished from another.

We will argue that the coding question is more appropriately formulated in terms of the processing demands imposed by the experimental paradigm and the material to be remembered. In some paradigms and with certain material, acoustic coding may be either adequate or all that is possible. In other circumstances processing to a semantic level may be both possible and advantageous.

Forgetting Characteristics

If memory stores are to be distinguished in terms of their forgetting characteristics, a minimal requirement would seem to be that the retention function should be invariant across different paradigms and experimental conditions. While this invariance has not been rigorously tested, there are cases where it clearly breaks down. We will give two examples. First, in the finite-state models of paired-associate learning, the state commonly identified as STS shows forgetting characteristics which are different from those established for STS in other paradigms (Kintsch, 1970, p. 206). In the former case, STS retention extends over as many as 20 intervening items while in the free-recall and probe paradigms (Waugh & Norman, 1965), STS information is lost much more rapidly. As a second example, the durability of the memory trace for visual stimuli appears to depend on the material and the paradigm. According to Neisser (1967), the icon lasts 1 second or less, Posner (1969) and his colleagues have found evidence for visual persistence of up to 1.5 seconds, while other recent studies by Murdock (1971), Phillips and Baddeley (1971) and by Kroll *et al.* (1970) have yielded estimates of 6, 10, and 25 seconds, respectively. Estimates are even longer in recognition memory for pictures (Shepard, 1967; Haber, 1970). Given that we recognize pictures, faces, tunes, and voices after long periods of time, it is clear that we have long-term memory for relatively literal nonverbal information. Thus, it is difficult to draw a line between "sensory memory" and "representational" or "pictorial" memory.

We will argue that retention depends upon such aspects of the paradigm as study time, amount of material presented and mode of test; also upon the extent to which the subject has developed systems to analyze and enrich particular types of stimuli; that is, the familiarity, compatibility, and meaningfulness of the material.

Although we believe that the multistore formulation is unsatisfactory in terms of its capacity, coding, and forgetting characteristics, obviously there are some basic findings which any model must accommodate. It seems certain that stimuli are encoded in different ways within the memory system: A word may be encoded at various times in terms of its visual, phonemic, or semantic features, its verbal associates, or an image. Differently encoded representations apparently persist for different lengths of time. The phenomenon of limited capacity at some points in the system seems real enough and, thus, should also be taken into consideration. Finally, the roles of perceptual, attentional, and rehearsal processes should also be noted.

One way of coping with the kinds of inconsistencies we have described is to postulate additional stores (see, Morton, 1970; Sperling, 1970). However, we think it is more useful to focus on the encoding operations themselves and to consider the proposal that rates of forgetting are a function of the type and depth of encoding. This view is developed in the next section.

Levels of Processing

Many theorists now agree that perception involves the rapid analysis of stimuli at a number of levels or stages (Selfridge & Neisser, 1960; Treisman, 1964; Sutherland, 1968). Preliminary stages are concerned with the analysis of such physical or sensory features as lines, angles, brightness, pitch, and loudness, while later stages are more concerned with matching the input against stored abstractions from past learning; that is, later stages are concerned with pattern recognition and the extraction of meaning. This conception of a series or hierarchy of processing stages is often referred to as "depth of processing" where greater "depth" implies a greater degree of semantic or cognitive analysis. After the stimulus has been recognized, it may undergo further processing by enrichment or elaboration. For example, after a word is recognized, it may trigger associations, images or stories on the basis of the subject's past experience with the word. Such "elaboration coding" (Tulving & Madigan, 1970) is not restricted to verbal material. We would argue that similar levels of processing exist in the perceptual analysis of sounds, sights, smells and so on. Analysis proceeds through a series of sensory stages to levels associated with matching or pattern recognition and finally to semantic–associative stages of stimulus enrichment.

One of the results of this perceptual analysis is the memory trace. Such features of the trace as its coding characteristics and its persistence thus arise essentially as byproducts of perceptual processing (Morton, 1970). Specifically, we suggest that trace persistence is a function of depth of analysis, with deeper levels of analysis associated with more elaborate, longer lasting, and stronger traces. Since the organism is normally concerned only with the extraction of meaning from the stimuli, it is advantageous to store the products of such deep analyses, but there is usually no need to store the products of preliminary analyses. It is perfectly possible to draw a box around early analyses and call it sensory memory and a box around intermediate analyses called short-term memory, but that procedure both oversimplifies matters and evades the more significant issues.

Although certain analytic operations must precede others, much recent evidence suggests that we perceive at meaningful, deeper levels before we perceive the results of logically prior analyses (Macnamara, 1972; Savin &

Bever, 1970). Further elaborative coding does not exist in a hierarchy of necessary steps and this seems especially true of later processing stages. In this sense, "spread" of encoding might be a more accurate description, but the term "depth" will be retained as it conveys the flavor of our argument.

Highly familiar, meaningful stimuli are compatible, by definition, with existing cognitive structures. Such stimuli (for example, pictures and sentences) will be processed to a deep level more rapidly than less meaningful stimuli and will be well-retained. Thus, speed of analysis does not necessarily predict retention. Retention is a function of depth, and various factors, such as the amount of attention devoted to a stimulus, its compatibility with the analyzing structures, and the processing time available, will determine the depth to which it is processed.

Thus, we prefer to think of memory tied to levels of perceptual processing. Although these levels may be grouped into stages (sensory analyses, pattern recognition, and stimulus elaboration, for example) processing levels may be more usefully envisaged as a continuum of analysis. Thus, memory, too, is viewed as a continuum from the transient products of sensory analyses to the highly durable products of semantic–associative operations. However, superimposed on this basic memory system there is a second way in which stimuli can be retained—by recirculating information at one level of processing. In our view, such descriptions as "continued attention to certain aspects of the stimulus," "keeping the items in consciousness," "holding the items in the rehearsal buffer," and "retention of the items in primary memory" all refer to the same concept of maintaining information at one level of processing. To preserve some measure of continuity with existing terminology, we will use the term primary memory (PM) to refer to this operation, although it should be noted that our usage is more restricted than the usual one.

We endorse Moray's (1967) notion of a limited-capacity central processor which may be deployed in a number of different ways. If this processing capacity is used to maintain information at one level, the phenomena of short-term memory will appear. The processor itself is neutral with regard to coding characteristics: The observed PM code will depend on the processing modality within which the processor is operating. Further, while limited capacity is a function of the processor itself, the number of items held will depend upon the level at which the processor is operating. At deeper levels the subject can make greater use of learned rules and past knowledge; thus, material can be more efficiently handled and more can be retained. There is apparently great variability in the ease with which information at different levels can be maintained in PM. Some types of information (for example, phonemic features of words) are particularly easy to maintain while the maintenance of others (such as early visual analyses —the "icon") is apparently impossible.

The essential feature of PM retention is that aspects of the material are still being processed or attended to. Our notion of PM is, thus, synonymous with that of James (1890) in that PM items are still in consciousness. When attention is diverted from the item, information will be lost at the rate appropriate to its level of processing—slower rates for deeper levels. While PM retention is, thus, equivalent to continued processing, this type of processing merely prolongs an item's high accessibility without leading to formation of a more permanent memory trace. This Type I processing, that is, repetition of analyses which have already been carried out, may be contrasted with Type II processing which involves deeper analysis of the stimulus. Only this second type of rehearsal should lead to improved memory performance. To the extent that the subject utilizes Type II processing, memory will improve with total study time, but when he engages in Type I processing, the "total time hypothesis" (see Cooper & Pantle, 1967) will break down. Stoff and Eagle (1971) have reported findings in line with this suggestion.

To summarize, it is suggested that the memory trace is better described in terms of depth of processing or degree of stimulus elaboration. Deeper analysis leads to a more persistent trace. While information may be held in PM, such maintenance will not in itself improve subsequent retention; when attention is diverted, information is lost at a rate which depends essentially on the level of analysis.

Existing Data Reexamined

Incidental Learning

When memory traces are viewed as the product of a particular form of processing, much of the incidental learning literature acquires a new significance. There are several reviews of this literature (Postman, 1964; McLaughlin, 1965), and we will make no attempt to be comprehensive. An important characteristic of the incidental learning paradigm is that the subject processes the material in a way compatible with or determined by the orienting task. The comparison of retention across different orienting tasks, therefore, provides a relatively pure measure of the memorial consequences of different processing activities. According to the view of the present paper, and in agreement with Postman (1964), the instruction to learn facilitates performance only insofar as it leads the subject to process the material in a manner which is more effective than the processing induced by the orienting task in the incidental condition. Thus, it is possible, that with an appropriate orienting task and an inappropriate intentional strategy, learning under incidental conditions could be superior to that under intentional conditions.

From the point of view of this paper, then, the interesting thing to do is to systematically study retention following different orienting tasks within the incidental condition, rather than to compare incidental with intentional learning. Under incidental conditions, the experimenter has a control over the processing the subject applies to the material that he does not have when the subject is merely instructed to learn and uses an unknown coding strategy.

We will consider several examples which illustrate this point. Tresselt and Mayzner (1960) tested free recall after incidental learning under three different orienting tasks: crossing out vowels, copying the words, and judging the degree to which the word was an instance of the concept "economic". Under the last condition, the number of words recalled was four times higher than that of the first and twice that of the second condition. Similar results using the free-recall paradigm have been obtained by Hyde and Jenkins (1969), and Johnston and Jenkins (1971). The experiments by Jenkins and his colleagues showed that with lists of highly associated word pairs, free recall and organization resulting from an orienting task which required the use of the word as a semantic unit, was equivalent to that of an intentional control group with no incidental task, but both were substantially superior to an incidental group whose task involved treating the word structurally (checking for certain letters or estimating the number of letters in the word). These results are consistent with those of Mandler (1967) who showed that incidental learning during categorization of words yielded a similar recall level to that of a group who performed the same activity but who knew that their recall would be tested.

Experiments involving the incidental learning of sentences (Bobrow & Bower, 1969; Rosenberg & Schiller, 1971) have shown that recall after an orienting task that required processing the sentence to a semantic level was substantially superior to recall of words from equivalently exposed sentences which were processed nonsemantically.

Schulman (1971) had subjects scan a list of words for targets defined either structurally (such as words containing the letter A) or semantically (such as words denoting living things). After the scanning task, subjects were given an unexpected test of recognition memory. Performance in the semantically defined target conditions was significantly better than that in the structurally defined conditions although scanning time per word was approximately the same in most cases.

These results support the general conclusion that memory performance is a positive function of the level of processing required by the orienting task. However, beyond a certain stage, the form of processing which will prove optimal depends on the retrieval or trace utilization requirements of the subsequent memory test. There is clear evidence in the incidental learning literature that the relative value of different orienting tasks is not the same for all tests of memory.

This conclusion is supported by comparisons of the differential effects of orienting tasks on recognition and recall. Eagle and Leiter (1964) found that whereas free recall in an unhindered intentional condition was superior to that of an incidental group and to a second intentional group who had also to perform the orienting task, these latter two conditions showed superior recognition performance. Such a result poses no difficulty provided it is assumed that optimal processing does not take the same form for both memory tests. In the Eagle and Leiter (1964) experiment, the orienting task, while almost certainly involving some degree of semantic analysis, might have served to prevent the kind of elaborative processing necessary for later access to the stored information. On the other hand, such elaborative coding might hinder subsequent discrimination between target words and the associatively related distractors used in this experiment. Results consistent with this kind of analysis have also been reported by Dornbush and Winnick (1967) and Estes and DaPolito (1967).

While the orienting tasks used by Wicker and Bernstein (1969) in their study of incidental paired-associate learning all required analysis to a semantic level, they did not facilitate subsequent performance to the same degree. When the orienting task involved the production of mediating responses, performance was equal to that of unhindered intentional learning and superior to when the orienting task was rating words for pleasantness. In single-trial free recall, this latter orienting task produces performance equal to that of intentional learning (Hyde & Jenkins, 1969). Identical orienting tasks do not seem to have equivalent effects across different paradigms. The interaction between initial encoding and subsequent retrieval operations is worth emphasizing. Although the distinction between availability and accessibility (Tulving & Pearlstone, 1966) is a useful one, the effectiveness of a retrieval cue depends on its compatibility with the item's initial encoding or, more generally, the extent to which the retrieval situation reinstates the learning context.

Selective Attention and Sensory Storage

Moray (1959) showed that words presented to the nonattended channel in a dichotic listening test were not recognized in a later memory test. Similarly, Neisser (1964) has shown that nontarget items in a visual search task left no recognizable trace. Thus, if stimuli are only partially analyzed, or processed only to peripheral levels, their record in memory is extremely fleeting. This point was neatly demonstrated by Treisman (1964). When the same prose passage was played to both ears dichotically, but staggered in time with the unattended ear leading, the lag between messages had to be reduced to 1.5 seconds before the subject realized that the messages were identical. When the attended (shadowed) ear was leading, however, subjects noticed the similarity at a mean lag of 4.5 seconds. Thus, although the subjects were not trying to remember the material in either case, the further processing necessitated by shadowing was sufficient to treble the durability of the memory trace. Treisman also found that meaningfulness of the material (reversed speech versus normal speech, and random words versus prose) affected the lag necessary for recognition, but only when the attended channel was leading. If the message was rejected after early analyses, meaningfulness played no part; but when the message was attended, more meaningful material could be processed further and was, thus, retained longer. The three estimates of memory persistence in these experiments (1.5 seconds for all nonattended material, 3 seconds for attended reversed speech and attended strings of random words, and 5 seconds for attended prose) can be attributed to the functioning of different stores, but it is more reasonable, in our view, to postulate that persistence is a function of processing level.

While further studies will not be reviewed in such detail, it may be noted that the findings and conclusions of many other workers in the area of sensory memory can also be accommodated in the present framework. Neisser (1967, p. 33) concluded that "longer exposures lead to longer-lasting icons." Studies by Norman (1969), Glucksberg and Cowen (1970), and Peterson and Kroener (1964) may all be interpreted as showing that nonattended verbal material is lost within a few seconds.

Massaro (1970) suggested that memory for an item is directly related to the amount of perceptual processing of the item, a statement which is obviously in line with the present proposals, although his later arguments (Massaro, 1972), that echoic memory inevitably lasts only 250 milliseconds, are probably overgeneralizations. Shaffer and Shiffrin concluded from an experiment on picture recognition that "it might prove more fruitful to consider the more parsimonious view that there is just a single short-term visual memory. This short-term visual memory would decay quickly when the information content of the visual field was high and more slowly when the information content was greatly reduced" (Shaffer & Shiffrin, 1972, p. 295). Plainly this view is similar to our own, although we would argue that the continuum extends to long-term retention as well. We would also suggest that it is processing level, rather than information content, which determines the rate of decay.

The STS/LTS Distinction

The phenomenon of a limited-capacity holding mechanism in memory (Miller, 1956; Broadbent, 1958) is handled in the present framework by assuming that a flexible central processor can be deployed to one of several levels in one of several encoding dimensions, and that this central processor can only deal with a limited number of items at a given time. That is, items are kept in consciousness or in primary memory by continuing to rehearse them at a fixed level of processing. The nature of the items will depend upon the encoding dimension and the level within that dimension. At deeper levels the subject can make more use of learned cognitive structures so that the item will become more complex and semantic. The depth at which primary memory operates will depend both upon the usefulness to the subject of continuing to process at that level and also upon the amenability of the material to deeper processing. Thus, if the subject's task is merely to reproduce a few words seconds after hearing them, he need not hold them at a level deeper than phonemic analysis. If the words form a meaningful sentence, however, they are compatible with deeper learned structures and larger units may be dealt with. It seems that primary memory deals at any level with units or "chunks" rather than with information (see Kintsch, 1970, pp. 175–181). That is, we rehearse a sound, a letter, a word, an idea, or an image in the same way that we perceive objects and not constellations of attributes.

As pointed out earlier, a common distinction between memory stores is their different coding characteristics; STS is said to be predominantly acoustic (or articulatory) while LTS is largely semantic. According to the present argument, acoustic errors will predominate only insofar as analysis has not proceeded to a semantic level. There are at least three sources of the failure of processing to reach this level; the nature of the material, limited available processing capacity, and task demands. Much of the data on acoustic confusions in short-term memory is based on material such as letters and digits which have relatively little semantic content. The nature of this material itself tends to constrain processing to a structural level of analysis and it should be no surprise, therefore, that errors of a structural nature result. Such errors can also occur with meaningful material if processing capacity is diverted to an irrelevant task (Eagle & Ortoff, 1967).

A further set of results relevant to the STS/LTS distinction are those that show that in free recall, variables such as presentation rate and word frequency, affect long-term but not short-term retention (Glanzer, 1972). Our interpretation of these findings is that increasing presentation rate, or using unfamiliar words, inhibits or prevents processing to those levels necessary to support long-term retention, but does not affect coding operations of the kind that are adequate for short-term retention. It follows from this interpretation that diverting processing capacity as in the Eagle and Ortoff (1967) experiments should result in a greater decrement in long-term than in short-term retention and, indeed, there is good evidence that such is the case (Murdock, 1965; Silverstein & Glanzer, 1971).

Conversely, manipulations that influence processing at a structural level should have transitory, but no long-term, effects. Modality differences (Murdock, 1966) provide a clear example. Finally, long-term recall should be facilitated by manipulations which induce deeper or more elaborative processing. We suggest that the encoding variability hypothesis as it has been used to account for the spacing effect in free recall (Madigan, 1969; Melton, 1970) is to be understood in these terms.

The Serial Position Curve

Serial-position effects have been a major source of evidence for the STS/LTS distinction (see Broadbent, 1971, pp. 354–361; Kintsch, 1970, pp. 153–162). In free recall, the recency effect is held to reflect output from STS while previous items are retrieved from LTS (Glanzer & Cunitz, 1966). Several theoretical accounts of the primacy effect have been given, but perhaps the most plausible is that initial items receive more rehearsals and are, thus, better registered in LTS (Atkinson & Shiffrin, 1968; Bruce & Papay, 1970). We agree with these conclusions. Since the subject knows he must stop attending to initial items in order to perceive and rehearse subsequent items, he subjects these first items to Type II processing; that is, deeper semantic processing. Final list items can survive on phonemic encoding, however, which gives rise to excellent immediate recall (since they are still being processed in primary memory) but is wiped out by the necessity to process interpolated material. In fact, if terminal items have been less deeply processed than initial items, the levels of processing formulation would predict that in a subsequent recall attempt, final items should be recalled least well of all list items. The finding of negative recency (Craik, 1970) supports this prediction. An alternative explanation of negative recency could be that recency items were rehearsed fewer times than earlier items (Rundus, 1971). However, recent studies by Jacoby and Bartz (1972), Watkins (1972), and Craik (1972) have shown that it is the type rather than the amount of processing which determines the subsequent recall of the last few items in a list.

In serial recall, subjects must retain the first few items so that they can at least commence their recall correctly. The greatly enhanced primacy effect is thus probably attributable, in part at least, to primary-memory retention. The degree to which subjects also encode initial items at a deeper level is likely to depend on the material and the task. Using a relatively slow (2.5 seconds) presentation rate and words as visually presented stimuli, Palmer and Ornstein (1971) found that an interpolated task only partially eliminated the primacy effect. However, Baddeley (1968) presented digits auditorily at a 1-second rate and found that primacy was entirely eliminated by the necessity to perform a further task.

Repetition and Rehearsal Effects

One suggestion in the present formulation is that Type I processing does nothing to enhance memory for the stimulus; once attention is diverted, the trace is lost at the rate appropriate to its deepest analyzed level. Thus, the concept of processing has been split into Type I or same-level processing and Type II processing which involves further, deeper analysis of the stimulus and leads to a more durable trace. Similarly, the effects of repeated presentation depend on whether the repeated stimulus is merely processed to the same level or encoded differently on its further presentations. There is evidence, both in audition (Moray, 1959; Norman, 1969), and in vision (Turvey, 1967), that repetition of an item encoded only at a sensory level, does not lead to an improvement in memory performance.

Tulving (1966) has also shown that repetition without intention to learn does not facilitate learning. Tulving's explanation of the absence of learning in terms of interitem organization cannot easily be distinguished from an explanation in terms of levels of processing. Similarly, Glanzer and Meinzer (1967) have shown that overt repetition of items in free recall is a less effective strategy than that normally used by subjects. Although both Waugh and Norman (1965), and Atkinson and Shiffrin (1968) have suggested that rehearsal has the dual function of maintaining information in primary memory and transferring it to secondary memory, the experiments by Tulving (1966) and by Glanzer and Meinzer (1967) show that this is not necessarily so. Thus, whether rehearsal strengthens the trace or merely postpones forgetting depends on what the subject is doing with his rehearsal. Only deeper processing will lead to an improvement in memory.

Concluding Comments

Our account of memory in terms of levels of processing has much in common with a number of other recent formulations. Cermak (1972), for example, has outlined a theoretical framework very similar to our own. Perceptually oriented attribute-encoding theories such as those of Bower (1967) and Norman and Rumelhart (1970) have a close affinity with the present approach as does that of Posner (1969) who advocates stages of processing with different characteristics associated with each stage.

If the memory trace is viewed as the by-product of perceptual analysis, an important goal of future research will be to specify the memorial consequences of various types of perceptual operations. We have suggested the comparison of orienting tasks within the incidental learning paradigm as one method by which the experimenter can have more direct control over the encoding operations that subjects perform. Since deeper analysis will usually involve longer processing time, it will be extremely important to disentangle such variables as study time and amount of effort from depth as such. For example, time may be a correlate of memory to the extent that time is necessary for processing to some level, but it is possible that further time spent in merely recycling the information after this optimal level will not predict trace durability.

Our approach does not constitute a theory of memory. Rather, it provides a conceptual framework—a set of orienting attitudes—within which memory research might proceed. While multistore models have played a useful role, we suggest that they are often taken too literally and that more fruitful questions are generated by the present formulation. Our position is obviously speculative and far from complete. We have looked at memory purely from the input or encoding end; no attempt has been made to specify either how items are differentiated from one another, are grouped together and organized, or how they are retrieved from the system. While our position does not imply any specific view of these processes, it does provide an appropriate framework within which they can be understood.

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(Received June 3, 1972)