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THE EFFECTS OF AROUSAL UPON WORD ASSOCIATIONS: AN INFORMATION PROCESSING MODEL

by

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The Effects of Arousal Upon Word Associations:

An Information Processing Model

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INTRODUCTION

The primary purpose of this investigation is to gain a more precise and coherent understanding of the effects of arousal upon word association processes. To obtain this goal, however, it was first necessary to establish a framework or conceptual model in terms of which the study could be conducted. Evidence is available that a relationship between arousal and associative performance does exist (Spence, Taylor, and Ketchel, 1956; Storms, Broen, and Levin, 1965; Sarason, 1959; Wolff, 1965; Wheeler, 1964). However, there is a noticeable absence of any effort to integrate these results within the framework of current research on verbal behavior.

Most of the recent efforts seeking information regarding the relationship between arousal and associative performance continue to analyze the problem in terms of Hullian learning theory or some modification thereof. While this approach has proven fruitful in shedding light upon many other issues within the general area of the effects of drive upon performance, there is reason to believe that such an analysis of the effects of arousal upon word associations has many shortcomings. One of the chief difficulties arises from the limitations which Hullian theory imposes upon the analysis of the development and modification of the bond between the stimulus word and the response which it elicits. Within this framework the primary parameter affecting the strength of association is the frequency of

past pairings of the stimulus and response. Although few investigators deny that such pairings are of importance in the formation of such language habits, many hasten to point out that other factors may also play an important role in their development.

Included among these factors are individual styles of association which seem consistent across a wide variety of verbal materials. Tendencies to respond in an abstract or concrete fashion together with individual differences in monitoring responses have been cited as examples of these (Moran, 1964). Others have pointed out the influence of contextual factors in producing a given set which can readily influence associations (Jung, 1966). Deese (1962) has demonstrated that characteristics of the stimulus words other than their frequencies of association with other words have been found to affect word associations. Chief among these was the form class of the stimulus word. Finally, the fact that word associations must be organized into the complex conceptual and syntactical structure of language habits dictates caution in interpreting them strictly in terms of stimulus response pairings.

Word association does appear to involve more than the construction of simple Hullian stimulus response habits. Mandler (1967) in discussing the use of the term habit with regard to verbal processes finds the following weaknesses in such usage,

> "I assume that they are referring to Hull's concept of habit and habit strength. But is their use more than an invocation? If it is, then one must assume that all the things we

> know about habits in Hull's theory apply to the verbal habits discussed. This involves the antecedent conditions which determine habit strength, such as frequency, the multiplicative interaction of habit strength and drive, and the conditions for the extinction of habits. Is anybody really willing to assume that the general laws of habits, as developed in simple behavior of lower animals, apply to verbal behavior in man?"

It seems clear that the construct falls far short of this goal and it follows that other principles must be incorporated if an adequate model of the word association process is to be constructed.

The current emphasis upon the importance of rules, strategies, structure and other cognitive factors to account for language behavior (e.g. Cofer, 1967; Dixon and Horton, 1967) suggests a useful point of departure in constructing such a model. If the central nervous system can be assumed to operate as a serial information processing system as suggested by Newell, Shaw, and Simon (1958), the stage is set for an analysis of various cognitive factors such as rules and strategies as sub-processes within the operation of the system.

For the purposes of this analysis the term 'system' will be used as referring to "a whole which functions as a whole by virtue of the interdependence of its parts" (Buckley, 1968). The approach taken to the development of a model of such a system will be that dictated by general systems theory. Within this context the goal of the model is to offer a schema for the analysis of the effects of various stimulus events upon the interrelations of the sub-processes in order to predict

typical patterns of system behavior. It is important to emphasize that the model outlined below is not a finished product. In no way does it ascribe to the status of a formal theory or hold pretense to meeting the requirements for such. At this stage it might best be described as an aide memoire, a foundation which hopefully will provide the basis for future elaboration.

In analyzing free association we are concerned with identifying the processes by which the individual chooses one word from among the many alternative outputs available to him. It should be made clear at this point, however, that the response of concern here is not the actual verbalization of a word but the selection of that word prior to its output. To maintain consistency with the information processing viewpoint, it is proposed that this selection involves the retrieval of a response from a storage system. Mandler (1968) provides the groundwork for such a system by proposing that the structure of storage consists of an hierarchical organization of words or word equivalents. He states

> "at the lowest level of organization, each set contains about five words. These basic sets are organized in categories so that each category subsumes five of these words. At the second level of the hierarchy there is again a set of five categories which belong to a single set. This organization continues upward in the hierarchy, but any five categories belonging to a category set are subsumed under a super-ordinate category."

Although the specific architecture of storage is not of crucial significance at this stage of model development, it is important to stipulate

that the word equivalent contents of storage are organized in terms of some stable scheme which allows ready access to the individual elements. The system just outlined offers an acceptable format for such access.

Mandler (1967) also specifies that access to a given set of units within this structural storage is obtained by means of retrieval rules. Such rules hold a status analogous to that of a library classification system in the process of locating books. A given book may be available in the library but, without the catalogue cards, access to it becomes quite difficult. Three types of rules are proposed by Mandler: associative cues, which are analogous to those specified by a strictly associationist view of learning, general accessibility rules, a broader set which include the use of categorical schema for the production of words from storage, and generative rules, which allow for the production of novel material other than simply reproducing some previous input.

Work has already been carried out by Moran (1966) which suggests a system for the more precise specification of the set of retrieval rules employed in free association. In his factor analytic study of associative response sets he describes four categories within which most responses can be placed. These sets are described below:

(1) object referent The associates in this category may be characterized as functional. The stimulus and response word each separately denote entitles or processes between which there is an explicit functional relationship, for example, FOOT-shoe.

(2) concept referent These are characterized by synonym and superordinate associates. The synonym response must have exactly the same meaning as the stimulus word in one or more ordinary and appropriate contexts, for example, BLOSSOM-flower. Superordinate responses are those in which the stimulus word denotes an immediate member of the class or category denoted by the response word, for example, CABBAGE-vegetable.

(3) perceptual referent The stimulus word and response word are adjective-noun or noun-adjective combinations; the stimulus word denotes an attribute of the object denoted by the response word, or vice-versa, for example, RED-apple, or APPLE-red.

(4) contrast-coordinate This set consists of contrast responses in which the response word negates or contrasts with the meaning of the stimulus word in one or more ordinary and appropriate contexts: for example, DARK-light. Logical coordinates are those in which the stimulus word and response word separately denote immediate members (of equal logical order) of the same class or category, for example, BLUE-yellow.

Sets of the type just outlined fit within the category of output cues designated by Mandler as general accessibility rules. The use of these rules can be viewed as specifying a location area or category within storage from which the response is to be drawn. Selection from within this category, however, is not specified by the category rule. This selection may occur as the result of what Mandler terms an associative rule, e.g., select the most frequently occurring member of the previously defined category, or, select the most recently used member of the previously defined category. The exact nature of these within-category rules remains in doubt but the necessity for their use to obtain any given response word seems clear.

It also seems apparent that the two types of rules described above must be executed in a set order. Thus, the general accessibility rule specifying a category of response must be operated upon before the associative rule for within category response selection can be carried out. Finally, rules should display increasing 'strength' as a result of frequency of past usage. Thus, if the system is presented with a set of stimulus elements to which it has responded previously, those rules which have been most frequently employed in that earlier association task will be more likely to be selected on this second presentation (with the resultant selection of the same response element from storage) than will the rules which were less frequently used.

With the assumption that response selection occurs in the manner described earlier, the word association process may be conceptualized as outlined in Figure 1. Each box in the diagram represents a sub-process and is labelled according to the nature of its function. The process begins with the presentation of a stimulus word. This stimulus is presumed to be of suprathreshold value impinging upon the receptors of the S as a result of either aural or visual presentation of the word. The Input unit then encodes this receptor stimulation arising from the stimulus event and transmit the resulting engram to the Operating Program unit. Here the encoded stimulus information together with information relevant to that stimulus contributed by Prior Experience, Instructions, and Task Contingencies is

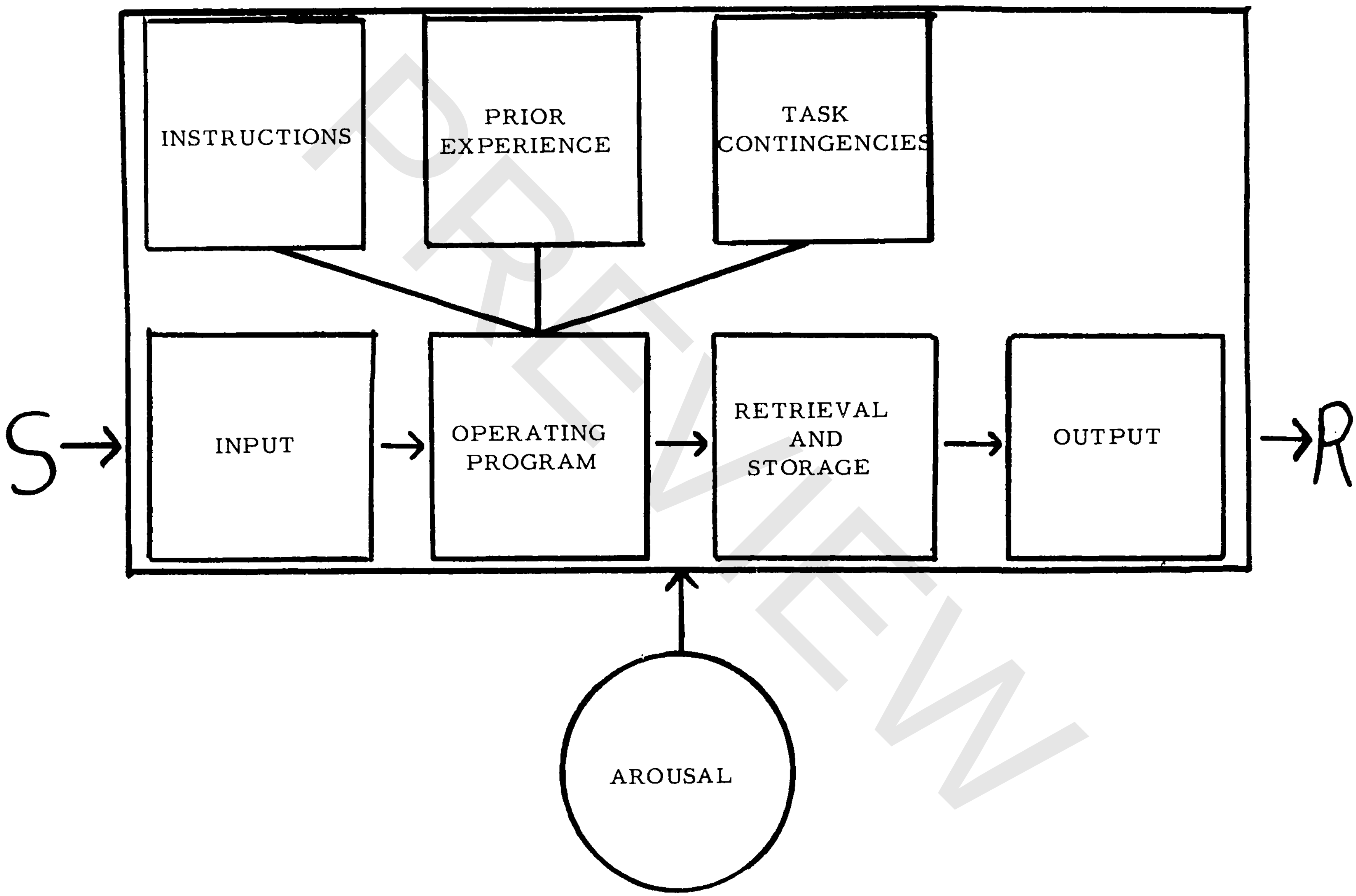

Figure 1. An information processing model of the word association system.

processed to construct a rule set consisting of a category rule and a within-category rule. The rule set is conceived of as providing the location coordinates of the response to be retrieved from storage. The Instructions unit provides information regarding the task provided by E as interpreted by S together with any additional hypotheses or notions as to the nature of that task which might be held by S. Prior Experience input consists of information regarding the formulation and use of rule sets in the past, together with specific information as to the past categorization and retrieval of the encoded stimulus presently in the Operating Program. Task Contingencies contributes information regarding the consequences of outputs or emitted responses resulting from the earlier execution of this or similar tasks. Retrieval then searches Storage and selects that word specified by the rule set. The response selected is then sent on to Output where it is decoded and the response units producing vocalization are activated. The final R is defined as the occurrence of a vocalization following the presentation of S. The role of arousal will be discussed later.

As suggested earlier, it is readily apparent that the model outlined above does not provide an explanation for all associative phenomena. Nor is the associative process likely to be limited to simple uni-directional processing as implied in the diagram. By this it is meant that the operations carried out in a given processing unit may be fed back to a prior unit and influence subsequent responses. Response chaining may illustrate such action.

However, the model does reflect in as direct a manner as possible the basic operations occurring during the process. It represents a starting point essentially in agreement with past data and from which modifications may be undertaken and amplifications made as additional information demands.

Having proposed a model of the associative process, the next step is to define the effects which arousal might have upon the interrelations of the sub-processes within the system. It is suggested that arousal be conceived of as the energy made available to the system which activates the various processing units involved. This potential energy is not considered as carrying information to the system but as making available the impetus for the system to operate upon a signal input. The intensity of this potential energy is considered as varying along a continuum from low to high. In short, arousal is seen as a diffuse energizing system analogous in operation to the ascending reticular activating system.

At low levels of arousal the processing system is viewed as being generally inactive and relatively insensitive to stimulus inputs. In keeping with Malmo's (1962) analysis of the effects of arousal upon neural structures, it is proposed that the circuitry within the processing system becomes increasingly likely to function with initial increases in arousal. This is analogous to the process by which spontaneous impulses stimulate certain neurons within a chain subliminally so that a signal impulse proves sufficient

to fire off the chain. The circuitry within the processing system becomes 'toned up' as arousal increases so that less of a signal is required to initiate sustained activity of the system.

According to this reasoning, failure of an output to occur, given a signal input, becomes increasingly unlikely as arousal increases. Within the processing model for word associations, insensitivity to stimulus inputs at low arousal implies that the system may not only fail to respond to the stimulus word but may also be insensitive to task contingencies, instructions, etc. so that when responses do occur at low arousal they are likely to be quite variable. One might view progressively lower arousal as not only decreasing the probability that a signal input will be processed through to output but as also increasing the probability that the operations performed on that signal in transit will be altered or omitted. Thus, at one low arousal level an S might not follow instructions accurately while at a yet lower level he might not even pay attention to the source of the instructions.

As arousal increases toward a "moderate" level, the variability in responding to a given stimulus will decrease. That is, the system responds accurately and consistently to stimulus inputs, specifies and utilizes all rules in a similarly consistent fashion, and shows little variability in the rules used to select outputs over repeated administrations of a given stimulus input.

It is further proposed that continued increases in arousal beyond the moderate level will result in the development of random activity within the processing system and that this activity will act in a fashion analogous to noise in a communication system. Within the information theory conception of a communication system noise represents distortion, errors, and extraneous material introduced into the channel between transmitter and receiver which increases the ambiguity and equivocation of messages transmitted through that channel. In the words of Frick (1959) "it is as if there were a second source operating through the same channel. The characteristic of this second source is that it introduces messages into the channel which neither the original source nor the destination can predict in detail."

If, within the word association model, the system is viewed as the channel, effects upon the processing can be predicted. With increases in arousal beyond the moderate level noise input into this channel increases with a resulting increase in the ambiguity of messages within the channel. Thus, variability in responding will increase.

Several predictions regarding word association performance over varied levels of arousal can be derived from the preceding analysis. If a free association task utilizing a single list of stimulus words is administered twice to Ss having a level of arousal below the optimum required for most efficient operation

of the association system, it follows from the model that the stability and organization of patterns of responding across trials can be expected to increase with moderate increases in arousal level and to be substantially below the moderate arousal performance level if the arousal increases are very large.

Examination of the contributions of the various sub-processes to the selection and emission of responses suggests a variety of indices of system operation which should reflect the changes described above. As the functioning of each sub-unit is said to be more erratic at lower levels of arousal, it can be expected that the proportion of responses changing over trials will decrease with moderate arousal increases as a result of the increased efficiency and reliability of the processing system. But, as opposed to the moderate level, this proportion will be substantially larger with increases to high arousal because noise is progressively introduced into the system thus reducing processing efficiency. The above relationships should also hold true with the proportion of responses showing a change in category retrieval rules over trials and the proportion of responses changing in the associative rule for within category response selection.

The indices just described provide information regarding the stability of responding over trials. As indicated previously, the model also suggests that the organization of responses should follow a similar pattern. That is, the consistency with which Ss

preferences in the use of rules are reflected in his responses should change with altered arousal. This notion could be tested by examining changes in the degree of randomness displayed in the distribution of Ss responses among the categories described earlier. The entropy of these distributions provides and excellent index of their degree of organization. Thus, the entropy of category response distributions should decrease with moderate arousal increases and be greater than this moderate point in groups with large arousal increases. A similar argument applies to the distribution of responses among the associative within category rules.

If initial arousal is sufficiently low moderate increases in arousal should produce an increase in the probability that a given stimulus element will be responded to in a fixed unit of time for the reasons described previously. However, although the addition of noise to the system at high arousal may alter the response emitted it should not diminish processing activity to affect the likelihood that a response will be emitted. Thus, no difference would be expected between the probability of a response at moderate and at high arousal levels.

The model also provides some suggestions regarding effects which arousal can be expected to have upon response commonality, a score based upon the frequency with which S's responses to a set of stimuli were given by members of a normative population. Although the model used here seeks to individualize the process

of association, it may be expected that to the degree that any S's preferences in rule selection and retrieval processes approximate those of his peers, arousal will affect his response commonality in a fashion similar to the effects predicted upon response organization. That is, maximal organization and highest commonality should occur at moderate arousal levels.

A more detailed analysis of the rationale giving rise to these performance expectations may be found in Appendix A which outlines the operations of each sub-unit in the system at each arousal level.