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ABSTRACT

A study was designed to examine the contribution of intrinsic arousal (individual differences) and induced arousal to children's comprehension of film content with short- and long-term retention intervals. Intrinsic arousal was measured by a salivary response measure; induced arousal was manipulated by white auditory noise. The latter was presented while the subjects viewed a silent single-concept film on science. Both literal and inferential comprehension measures were used. Results showed that there was no significant main effect of intrinsic arousal level. However, there was a significant interaction between intrinsic arousal and white noise (p less than .0001). There was also a significant interaction between intrinsic arousal and retention level (p less than .0035), and between white noise and retention interval (p less than .0002). The results were discussed in terms of action decrement and inverted-U models of arousal and learning. (Author)

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WISCONSIN RESEARCH AND DEVELOPMENT
CENTER FOR
COGNITIVE LEARNING

Technical Report No. 274

INTRINSIC AND INDUCED AROUSAL IN THE SHORT- AND LONG-TERM RETENTION OF FILM CONTENT BY ELEMENTARY SCHOOL CHILDREN IN PUERTO RICO

by

Salvador Santiago and Frank H. Farley

Report from the Program on Variables and Processes of Learning and Instruction

Program Investigators: Herbert J. Klausmeier, Vernon L. Allen
Frank H. Farley, Joel R. Levin, Larry Wilder

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
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Statement of Focus

Individually Guided Education (IGE) is a new comprehensive system of elementary education. The following components of the IGE system are in varying stages of development and implementation: a new organization for instruction and related administrative arrangements; a model of instructional programing for the individual student; and curriculum components in prereading, reading, mathematics, motivation, and environmental education. The development of other curriculum components, of a system for managing instruction by computer, and of instructional strategies is needed to complete the system. Continuing programmatic research is required to provide a sound knowledge base for the components under development and for improved second generation components. Finally, systematic implementation is essential so that the products will function properly in the IGE schools.

The Center plans and carries out the research, development, and implementation components of its IGE program in this sequence: (1) identify the needs and delimit the component problem area; (2) assess the possible constraints—financial resources and availability of staff; (3) formulate general plans and specific procedures for solving the problems; (4) secure and allocate human and material resources to carry out the plans; (5) provide for effective communication among personnel and efficient management of activities and resources; and (6) evaluate the effectiveness of each activity and its contribution to the total program and correct any difficulties through feedback mechanisms and appropriate management techniques.

A self-renewing system of elementary education is projected in each participating elementary school, i.e., one which is less dependent on external sources for direction and is more responsive to the needs of the children attending each particular school. In the IGE schools, Center-developed and other curriculum products compatible with the Center's instructional programing model will lead to higher student achievement and self-direction in learning and in conduct and also to higher morale and job satisfaction among educational personnel. Each developmental product makes its unique contribution to IGE as it is implemented in the schools. The various research components add to the knowledge of Center practitioners, developers, and theorists.

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Abstract

This study was designed to examine the contribution of intrinsic arousal (individual differences) and induced arousal to children's comprehension of film content with short- and long-term retention intervals. Intrinsic arousal was measured by a salivary response measure; induced arousal was manipulated by white auditory noise. The latter was presented while the *S*s viewed a silent single-concept film on science. Both literal and inferential comprehension measures were used. Results showed that there was no significant main effect of intrinsic arousal level. However, there was a significant interaction between intrinsic arousal and white noise ($p < .0001$). There was also a significant interaction between intrinsic arousal and retention interval ($p < .0035$), and between white noise and retention interval ($p < .0002$).

The results were discussed in terms of action decrement and inverted-U models of arousal and learning.

I
Introduction

There is a growing body of literature which provides strong evidence that memory can be influenced by nonassociative factors (Weiner, 1966, 1967). It seems to be well documented that arousal is a critical variable in the patterning of recall over time. Furthermore, recent literature suggests that learning under conditions of low arousal displays a typical forgetting pattern: immediate recall is good, but decreases rapidly with time. High-arousal learning, on the other hand, shows a marked reminiscence effect: poor immediate recall, but good long-term recall (Lovejoy & Farley, 1969; Farley & Gilbert, 1968; Farley & Dowling, 1971; Kleinsmith & Kaplan, 1964; Osborne & Farley, 1971; Walker & Tarte, 1963; and so on). The general finding is illustrated in Figure 1.

The term *arousal* has been referred to as a general state of alertness (DeCecco, 1968). Hebb (1955) viewed arousal as an energizer. In general, arousal has been studied as a central component in the motivational system of the organism. Arousal has been intimately associated with the Reticular Activating System (RAS) in the Central Nervous System (CNS) (DeCecco, 1968).

Traditionally, arousal has been studied via Delayed Auditory Feedback (DAF) (King, 1963); the Galvanic Skin Response (GSR) (Walker, 1962; King, 1965; Levonian, 1963; Lovejoy & Farley, 1969; Kleinsmith & Kaplan, 1964); "exploratory responses" (Haywood & Hunt, 1963); the "Orienting Response" (OR) (Sokolov, 1963; Anokhin, 1958; Vinogradova, 1959); "taboo" words (Farley, 1969; Walker, 1962; Walker & Tarte, 1963), drugs (Paré, 1961); palmar sweating (Berlyne & Lewis, 1963); "unassimilated percepts" (McReynolds & Bryan, 1956); "complexity of stimulus" (Berlyne, Borsa, Craw, Gelman, & Mandell,

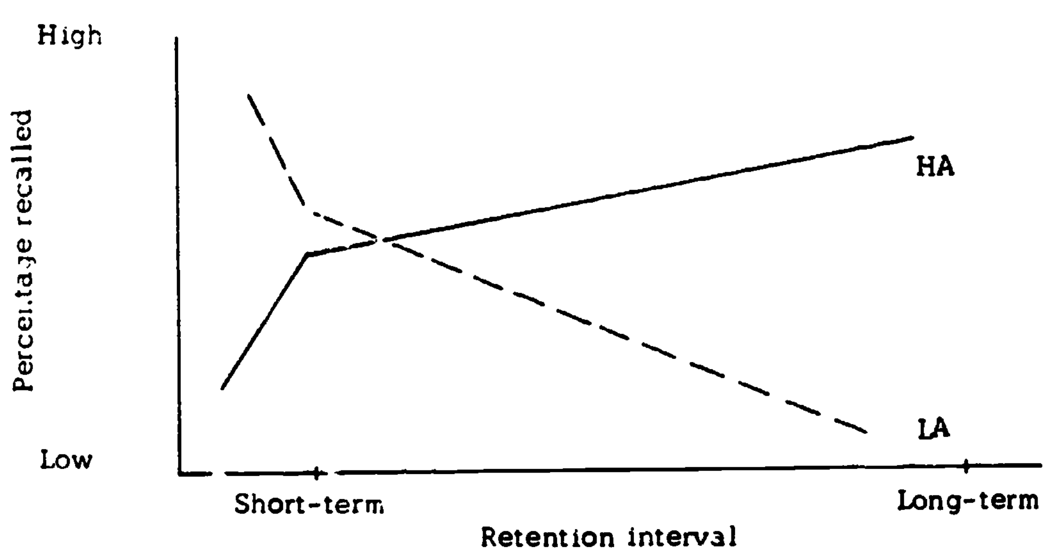

Figure 1. Short- and Long-Term Retention as a Function of Arousal.

1965); film content relative to GSR evocation (Levonian, 1967); "novelty" (Berlyne & Carey, 1968); "ego-involving and related instructions" (Weiner, 1966); stimulus color (Farley & Grant, 1973); white noise (Haveman & Farley, 1969); and salivary responses (Farley, 1970).

Most of these measures will be discussed briefly in this chapter except for the salivary-response technique and white noise. The former will be extensively reviewed later in the paper. The white-noise technique will be discussed in conjunction with the literature on arousal and verbal recall.

King (1963) has reported a pioneer study on the effect of Delayed Auditory Feedback on immediate memory for extended and connected verbal material. The DAF equipment consisted of a set of earphones, tape recorder, and microphone; as the Ss read a story, a 0.2 second delay in vocal feedback between the microphone and earphones occurred. An experimental group was subjected to DAF in the middle of the story, while a control group was not subjected to DAF. King reported a sharp reduction in immediate retention under conditions of DAF. He interpreted these results within the theoretical context of Walker's (1962) approach to arousal and memory.

Smith (1962) has reported a study in which DAF was used to produce emotional disturbance (i.e., high arousal). While Smith did not report any operational measure of arousal, clinical observations of Ss in the experimental group suggested that they were disturbed by DAF (i.e., flushing, sweating, and laughing were often noticed).

One can argue that neither King nor Smith really demonstrated the validity (construct) of DAF as a source of arousal. Nevertheless, the clinical evidence presented by Smith is a first step in that direction.

The GSR is frequently used as an indicator of changes in the level of activation (Duffy, 1962). It appears that electrical resistance of the skin is functionally related to the level of activation of the organism. Wilcott (1958) has reported a high degree of correspondence between the skin-resistance response and the skin-potential response. Peterson (1907) first advocated the use of the galvanometer as a measure of the vividness of emotional experience (arousal). Rowland (1936) reported that increased galvanic skin responses were associated with subjective reports of increased intensity in the accompanying emotion (arousal). It should be noted, however, that in these early reports blind analyses of the GSR were not made.

Perhaps an index of the widespread acceptance of the GSR as a technique to measure arousal is Levonian's (1963) report of more than ten different skin-resistance electrodes commonly used in this area. Levonian has used the GSR in relation to complex learning and arousal and has described a skin-resistance electrode appropriate for classroom-based experimentation.

Haywood (1962) has reported a study in which Ss were presented a sequence of alternatives between looking at pictures of familiar objects and unfamiliar objects, respectively. Groups having high, moderate, and low "manifest anxiety" as measured by a self-report inventory did not differ in frequency of choices of unfamiliar pictures. He further reported that exposure to a message described as "very difficult to comprehend" and presented as a comprehension test decreased the tendency to choose unfamiliar pictures. He found that the confusing message increased arousal, using palmar sweating as an arousal indicant.

The Orienting Response is sometimes considered an indicant of arousal (Manske & Farley, 1971). A view that seems to be popular among Soviet physiologists (e.g., Anokhin, 1958; Vinogradova, 1959) asserts that the OR is defined as a phasic rise in arousal that supplies the cerebral cortex with excitation from the brain stem. Digital vasoconstriction coincident with cephalic vasodilation is sometimes used as an index of the OR (Sokolov, 1963). Some other indices that have been used to measure this phenomenon are GSR magnitude (Maltzman & Raskin, 1965) and heart rate deceleration (Chase & Graham, 1967). Graham and Clifton (1966) and Chase and Graham (1967) support the hypothesis that heart rate deceleration is a major component of the OR. Arousal level during learning has been assessed by heart rate deceleration and finger pulse volume (Manske & Farley, 1971). In recent years the construct of arousal in relation to the OR has emerged as a legitimate field of investigation (cf. Lynn, 1965).

"Taboo" words have also been used in manipulating arousal. Walker and Tarte (1963) have used words like *sex*, *rape*, *slut*, and so on to increase the level of arousal of the Ss while learning, with results indicating the predicted interaction of arousal and retention interval. Using words both as the learning task and as an arousal source may lead to important methodological problems. Unconfounding the effects of word meaningfulness (Noble, 1952), imagery (Paivio & Yuille, 1969), arousal value (Farley, 1973), etc., on learning clearly poses a difficult challenge for the researcher in this area.

Drugs are known to alter the arousal level of the organism. It has been shown that stimulants tend to increase and depressants decrease arousal levels (Eysenck, 1963). Using rats as Ss, Paré (1961) was able to confirm Eysenck's findings. He reported that caffeine, a stimulant, injected into rats led to fewer errors on retention trials than a control condition. By contrast, Ss injected with the depressant Seconal manifested more errors on retention trials than controls.

One of the major difficulties in employing drugs to change arousal levels is the side effects that powerful drugs like amphetamines pose. Some of the drugs with a tremendous potential to change arousal levels and consequently affect learning are highly addictive or habit-forming or related to cerebral strokes. This difficulty seems to sharply limit the potential for using drugs to improve learning efficiency in the classroom, at least in the immediate future.

As mentioned earlier, such variables and constructs as "palmar sweating," "unassimilated percepts," "novelty," "film content relative to GSR evocation," "complexity of stimulus," and "psychological manipulations" have been used in the literature in relation to arousal. Most of them will not be discussed here, as they are beyond the scope of this paper. Suffice it to say that these phenomena may be used in any extension of this field.

Arousal can be studied as an endogenous or organismic variable, *or* as an external variable (induced arousal) that impinges on the organism. Endogenous arousal has also been called "intrinsic" arousal, that is trait-like or (chronic) arousal characteristic in a given S across a wide range of tasks and situations (Farley, 1970).

Most of the research in this area has dealt with either induced arousal (by white noise or electric shock) or arousal changes as they occurred spontaneously in association with learning material. A few studies investigated "intrinsic" arousal, using salivary responses as a reliable and valid measure of such a stable individual difference variable. Furthermore, most of the research in this area has dealt with college students and small samples in laboratory-like situations.

The purpose of the present study is to examine the effects of "intrinsic" arousal and induced arousal in short- and long-term retention in complex cognitive learning. The present research is designed to study the role of experimentally manipulated arousal (induced arousal) and intrinsic arousal as an individual difference variable in short- and long-term retention of school-relevant learning tasks by sixth-grade children. Most of the experiments done in this area have dealt with the effect of intrinsic *or* induced arousal alone. It would seem necessary to explore the conjoint or interactive effects of induced and intrinsic arousal on memory.

II
Review of Related Research

The present chapter will consider selected studies dealing with activation or arousal. The first section will be devoted to a discussion of the historical origins of arousal and different approaches to the analysis of this hypothetical construct, the second to a discussion of critical studies related to arousal and salivation and arousal and verbal learning, and the third will consider the salient aspects of the research discussed and its implications for education.

Historical Origins of Arousal

Early in the historical development of the construct, arousal was referred to as the organism's degree of excitation or energy mobilization (Duffy, 1934, 1941, 1949, 1951). According to Duffy, the intensity dimension of behavior is one major aspect of what is meant by such terms as *emotion* and *motivation*. She considered activation or arousal to be a useful substitute for these constructs.

Hebb (1955) has argued that the concept of arousal (or activation) enables a greater understanding of motivational processes. Increased attention in the psychology of motivation has recently been given to processes of the Central Nervous System, particularly the ascending reticular activating system (ARAS). It is now understood that the ARAS plays a crucial role in the assimilation and retention of new concepts.

Widespread interest in the concept of activation arose with the discovery of the activating function of the reticular system and related brain structures (Moruzzi & Magoun, 1949). Pioneering in this field of research were the early clinical studies of Jasper (1941), the theoretical elaborations of Hebb (1949), and Lindsley's (1957) work in the area of neurophysiology. According to Jasper (1941), early workers in electroencephalography (EEG) reported distinctive wave patterns characterizing the main levels of psychological functioning in the progression from deep sleep to highly alerted states of activity.

Hebb (1949, 1955) has perhaps made the greatest theoretical contribution to this area amongst psychologists, beginning with the task of carefully separating the level of arousal in the nervous system and the pattern of activity within it. He identified arousal as synonymous with a general drive state, attempting to link drives with anatomical structures in an isomorphic fashion. He defined drive and arousal as "energizers" of the organism. Hebb reaffirmed Schlosberg's (1954) position that there is an optimal level of arousal for effective behavior. According to Hebb (1955), when arousal is below an intermediate optimal level, "a response that produces increased stimulation and greater arousal will tend to be repeated" (p. 250). Stronger degrees of stimulation beyond the optimal level will result in loss of efficiency of the performance (excessive stimulation may be disruptive). Hebb (1949) has also discussed a consolidation theory of memory. This analysis contends that learning involves a consolidation process involving two stages: reverberation of neural circuits making up the (short-term) memory trace, followed by organic changes between nerve cells constituting long-term or permanent memory. Closely related to this view is Paré's (1961) argument that neural circuits provide a mechanism capable of accounting for the effects of arousal on consolidation. He argued that under conditions of low arousal, relatively little nonspecific neural activity will be available to support the reverberating trace, resulting in little consolidation and poor long-term retention. In contrast, under conditions of high arousal the increased nonspecific neural activity will result in more reverberation, thus long-term retention should be better. Since Hodgkin (1948) has shown that neurons are sharply limited in their maximum rate of firing, then under high arousal, perseverative consolidation should be effective both in strengthening the memory trace and in making the memory difficult to evoke until the perseveration terminates.

A related theory was advanced by Walker (1958). Walker expanded on Hebb's basic contentions and incorporated them in his "action decrement theory" (Walker's position will be considered in detail elsewhere in this paper).

Activation theory was given great impetus by Lindsley's (1951, 1957) early attempts to describe the physiological and structural aspects of the reticular formation and its relationship to motor activity and its regulatory role in performance and emotion. His extensive use of the EEG pointed to the possibility of using it as an operational definition of arousal. Lindsley complemented Moruzzi and Magoun's (1949) discovery that direct electrical stimulation of the reticular formation leads to the appearance of an "activation pattern" in the EEG.

Although activation models can be traced in some part back to the early work of Féré (1888), Cannon (1929),[1] and Jasper (1941), it is not until Hebb's (1949) consolidation theory, Walker's (1958) action decrement theory, and Duffy's (1962) theoretical work were publicized that activation theory emerged as a pivotal base for research on motivational factors in learning and memory.

There seem to be three main lines of thinking in relation to the concept of activation: (1) through physiological studies of "behavioral energetics," (2) through neurophysiology, and (3) through the learning theorist's search for a satisfactory measure of drive. These three approaches have been thoroughly reviewed by Malmo (1959). An indepth discussion of them is beyond the scope of the present paper. It seems sufficient here to point out some salient aspects of these various lines of analysis and to indicate the conceptual complexities which fall under the umbrella of arousal.

According to Malmo (1959) the neurophysiological approach to activation had its origins in electroencephalography. It is through this approach that the notion of a continuum in arousal levels was advanced. It was hypothesized that the state of the organism can fluctuate from deep sleep at the low activation end to "excited state" at the high activation end. This state of affairs was viewed as a function of cortical bombardment by the ARAS. Further, the relation between activation and behavioral efficiency was conceived as an inverted-U curve (Duffy, 1932).

The inverted U-shaped relationship remained as a theoretical construct rather than a factual operational description until authors such as Freeman (1940), Courts (1942), Schlosberg (1954), Stennett (1957), and others started to investigate it experimentally. These authors worked mainly through physiological studies of behavioral energetics (Malmo's first classification, mentioned previously).

According to Malmo (1959), the writings of Duffy (1951, 1957), Freeman (1948), and others of the "energetics" group had long stressed the importance of the intensity dimension in behavior. In an attempt to operationalize this intensity variable, the "energetics" group relied mostly on palmar conductance (Freeman, 1948) or muscular tension measured through dynamometers (Courts, 1942). The "energetics" group helped to refine and extend the activation paradigm. Their empirical work helped in filling numerous gaps left by the overtheorizing physiological group.

The third approach to the activation principle was represented by the learning theorists, especially those concerned with the construct of drive.

Malmo (1959) advanced the hypothesis that general drive, without the steering component, becomes identical in principle with arousal. Since learning theorists had tended not to use physiological measures in their work, the idea of using arousal as a form of drive helped transform the level of analysis in learning from a molar to a more molecular level.

In general, it seems that the three main lines of thinking described by Malmo are highly overlapping. The most important thing about these a priori classifications is that they help us to organize the innumerable amount of research produced in this area. Furthermore, they suggest the great potential of arousal as a crucial variable in human learning and retention.

Reviewing some of the research which has accumulated in recent years, Berlyne (1967) concluded that arousal is an extremely complex network of interrelated phenomena. Some examples that illustrate this point are: the role of the hypothalamus (Gellhorn, 1961; Feldman & Walker, 1962), the importance of the interaction and balance between reticular and cortical activity (Hugelin & Bonvallet, 1957; Jouvet & Michel, 1958), and so on.

The approach that seems most promising

[1] Féré's and Cannon's work are not described in detail due to their vagueness and peripheral value to this paper.

at this time in terms of methodology and relevance of the material and *Ss* studied (school-like material and human *Ss*) comes from the "energetics" group. Special interest should be paid to situations in which arousal is experimentally manipulated independent of the task to be performed or the material to be learned. The thrust of this approach seems to be structured so as to avoid the confounding effects of the multiple sources of variance in learning, such as meaningfulness of the material to be learned, imagery, and so on. Furthermore, it helps to control confounding sources of arousal such as inherent or chronic arousal and the arousal provided by the nature of the stimulus or task presented to the *Ss* (some of these ideas will be expanded upon later).

Arousal and Salivation

Early studies in salivation can be traced back to the work of Pavlov at the beginning of the century. Pavlov (1928) was one of the first scientists to use salivary measures in controlled experimental situations using dogs. Although his work is related to conditioning, it seems that he laid the foundations for the study of salivation and learning. Feather (1965) has pointed out at least five different techniques for studying human salivary secretions. The most valid and reliable technique reported in the literature in relation to arousal (Farley, Osborne, & Severson, 1970) is the absorbent technique (Razran, 1935). This will be the only technique examined in this paper.

Based on a review of the literature on experiments dealing with human conditioning undertaken in Russian and non-Russian laboratories, Razran (1933) devised the absorbent techn[illegible]ch was formally articulated two yea[illegible]zran, 1935). This technique can [illegible]bed as follows: absorbent dental co[illegible]oils were weighed, placed under the *Ss* tongues, then weighed again, and the increments, or amount of saliva secreted, were recorded.

Theoretical evidence for the use of salivation as an operational measure of arousal can be found in Sternbach (1966). He has noted that salivation is an index of the balance between the Sympathetic Nervous System (SNS) and the Parasympathetic Nervous System (PNS). The effect of the PNS stimulation is to increase the production of saliva. In contrast, SNS effects decreased salivary flow (increase in saliva flow seems to indicate PNS dominance; decrease in saliva flow apparently indicates SNS dominance). Sternbach argues that the PNS/SNS balance may be an indicator of arousal. Farley, Osborne, and Severson (1970) have argued that the effector output of a highly aroused organism is greater than that of a less aroused organism when both are subject to the same stimulation. This was related to Brener's (1954) suggestion that the neurophysiological correlate of high levels of activation is a state of high cortical facilitation.

Eysenck (1953) has attempted to relate salivary measures to clinical or personality taxonomies. He advanced the hypothesis that introverts salivate more profusely than extroverts. He has suggested an intimate relation between personality and central excitation and inhibition by postulating that extroverts are characterized by the particularly rapid rise of cortical inhibition to a relatively high level and with a slow rate of dissipation. In contrast, he postulated the opposite for introverts. In other words, introverts are characterized by a state of higher cortical excitation than extroverts. He suggested that introverts show a high degree of excitation in contrast to the extroverts. Savage (1964) has supported this last point. He found a significant correlation between an EEG alpha rhythm arousal indicator and extroversion. Gale, Coles, and Blaydon (1969) have obtained comparable results, although Broadhurst and Glass (1969) have not.

Adding to the evidence advanced by Savage and Gale et al., Corcoran (1964) showed that four drops of lemon juice placed on the top of the tongue of two groups of introverts and extroverts resulted in a significantly greater output of saliva for the former group. In 1967, Eysenck replicated Corcoran's experiment and obtained the same results.

Farley and Gilbert (1968) undertook the first attempt to use salivation as an index of individual differences (IDs) in arousal in relation to learning and memory. The *Ss* were kindergartners. They were measured for salivary response during twenty seconds of stimulation by four drops of lemon juice. They were stratified on the magnitude of the response and some time later tested in a one-trial pictorial paired-associate task (with immediate vs. twenty-four-hour retention tests). Results showed poorer short-term retention but superior long-term retention of high-arousal *Ss* relative to low-arousal *Ss*.

Few of the studies cited above have dealt with the unavoidable necessity of demonstrating *reliability* and *validity* of salivary responses as a measure of intrinsic arousal from an empirical point of view. Corcoran (1964) mentioned vague reliability estimates in the study cited previously. He reported very high retest correlations in the salivary procedure, but the duration of the retest interval was not reported. In a brief review of this study, Farley, Osborne, and Severson (1970) criticized the fact that Corcoran used only eleven Ss.

Studying the salivary response to lemon juice as a measure of introversion, Eysenck and Eysenck (1967) obtained a test-retest correlation for basal salivation of 0.33, for salivation to lemon juice over a twenty-second period of 0.71, and 0.60 for net salivation (salivation to lemon juice minus basal salivation) Neither Corcoran's nor Eysenck and Eysenck's studies tackled the issue of reliability and validity as their main focus of interest. They only dealt with the issue in a peripheral fashion.

The first study that specifically attacked the issue of reliability and validity was that of Farley, Osborne, and Severson (1970). They reported two studies which attempted to estimate the stability and construct validity of human salivary response as a measure of IDs in physiological arousal. The first study used eighteen female and seven male college students. Twenty-second baseline estimates and twenty-second response levels to four drops of lemon juice were measured, with the former value being subtracted from the latter to form the net salivary score for a given *S*. The authors reported a test-retest correlation over twenty-four hours for the net salivation of 0.78. For basal salivation, the correlation obtained was 0.81. For gross salivation to lemon juice the correlation was 0.75. All the values reported were significant at the $p <$ .001 level. The instructions employed in this study were standardized and the methodology well delineated and shareable, a fact that adds credibility to its results.

Thus it seems that the measurement of salivation to lemon juice by means of the absorbent technique is surprisingly reliable in view of the potential sources of variance reported by Feather & Wells (1966). These authors had argued that the relative amount of swallowing and the mouth measurements of Ss were found to affect the amplitude, latency, and temporal course of salivation. There was a tendency to secrete more saliva during periods of motor activity.

The second study reported by Farley, Osborne, and Severson (1970) involved the measurement of the threshold of fusion of paired light flashes (two flash threshold [TFT]) (Farley, 1969), a previously validated index of arousal, as well as salivation. The authors attempted to estimate the validity of the absorbent technique through construct validation, using twenty-five graduate students as Ss. It might be noted that the two measures were administered many months apart. They reported a significant correlation of 0.57 between net salivation and TFT. This result may be interpreted as supporting the construct validation of salivation as an indirect measure of intrinsic arousal. The study of Farley et al. seems to be one of the most important methodological steps thus far in the area of intrinsic arousal. The psychometric properties of the absorbent technique for use in ID research seem to be very promising.

Arousal and Verbal Learning

The decades of the 1950s and 1960s have been notoriously deficient with regard to research on arousal and learning. According to Haveman and Farley (1969) the great majority of traditional verbal learning research has dealt with classical associative factors only.

Early in the past decade, two symposia on verbal learning and behavior were reported (Cofer, 1961; Cofer & Musgrave, 1963). Neither of these symposia reported studies in nonassociative or motivational factors and learning. The few studies that seemed to be relevant to the constructs of arousal and learning were undertaken by W. D. Obrist (1950), P. A. Obrist (1962), and Berry (1962a). Using the GSR and the EEG to measure changes during serial learning of nonsense syllables, Obrist (1950) attempted to relate the *S*'s level of arousal associated with individual items to the efficiency of learning the list. He was able to demonstrate that while Ss were engaged in learning, mean GSR magnitude was higher than during control or nonlearning conditions. About the time that each syllable was beginning to be correctly anticipated, the GSR and the EEG reflected a tendency to produce the highest arousal levels. Using heart rate and electrodermographic levels as measures of arousal in another experiment with a social learning task, Obrist (1962) found correct anticipation on different days to be linearly related to the arousal measures for two Ss, but with a curvilinear relationship for three Ss.

Measuring skin conductance during exposure to paired-associates (PA), Berry (1962a) found that recall was highest in *S*'s with an intermediate level of conductance.

Much of the recent work in arousal and learning has stemmed from two main sources: (1) the assumption of an inverted-U relationship between learning (vis-a-vis performance) and level of arousal (Hebb, 1955; Duffy, 1932; Berry, 1962b; Stennett, 1957), and (2) the action decrement theory of Walker (1958).

An inverted-U relationship implies that for any given value of performance there will be two possible values of arousal. An exception to this rule is the optimal level of arousal

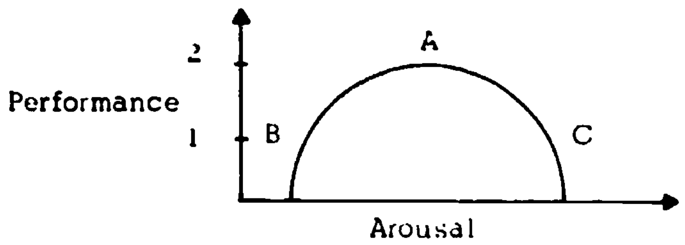

Figure 2. The Inverted-U Model of Arousal and Performance.
As shown, the value 1 on the performance scale has two possible values of arousal. Value 2 on the performance scale corresponds to only one value of arousal (value A).

for which only one value in the performance scale will correspond to the arousal level (see Figure 2).

Other things being equal, the inverted-U relationship allows hypothetical prediction of the level of performance of the organism, given the level of arousal. In the early development of this relationship it was practically impossible to reverse this prediction. In other words, prediction of the level of arousal could not be made merely from knowledge of performance. Corcoran (1965) was able to develop a method whereby prediction from arousal to performance could be ascertained, and vice versa. He suggested that information could be gained about the level of arousal at which the *S* was operating by increasing or decreasing his level of arousal and noting the direction of the corresponding change in performance. Walker's (1958) action decrement theory has been summarized by Walker and Tate (1963, p. 113) as follows:

> (1) The occurrence of any psychological event, such as an effort to learn an item of a paired-associate list, sets upon an active, perseverative trace process which persists for a considerable period of time.
>
> (2) The preservative process has two important dynamic characteristics, (a) permanent memory is laid down in a gradual fashion; (b) during the active period, there is a degree of temporary inhibition of recall; i.e., action decrement (this negative bias against repetition serves to protect the consolidating trace against disruption).
>
> (3) High arousal during the associative process will result in a more intensely active process. The more intense activity will result in greater ultimate memory but greater temporary inhibition against recall.

The hypothesis that arousal produces temporary inhibition of recall and preservation of the trace during storage for permanent memory probably has the most heuristic value of all three propositions. This hypothesis predicted that immediate retention would be adversely affected by arousal, but later retention would be facilitated. Several studies have yielded results consistent with the foregoing analysis (Walker & Tarte, 1963; Kleinsmith & Kaplan, 1964; King & Wolf, 1965; King & Dodge, 1965; Berlyne et al., 1965; Batten, 1967; Farley & Gilbert, 1968; Farley & Lovejoy, 1968; Lovejoy & Farley, 1969; Manske & Farley, 1971; Osborne & Farley, 1971).

Walker's analysis received initial support in the area of verbal learning from Kleinsmith & Kaplan's (1963) study in which arousal was correlated with the learning material. In this study *S*s were asked to learn a set of PAs composed of words as stimuli and single-digit numbers from 2 to 9 as responses. The words were chosen to differ in their arousal value (as measured by GSR). In terms of Walker's (1958) hypothesis, word-number pairs of high-arousal value should be recalled poorly at first, but should be recalled well at a later time. Low-arousal pairs, by contrast, should be remembered better at first and should show a gradual decay (forgetting) with time.

The *S*s were forty-eight undergraduates divided into six groups of eight *S*s each. They were given a single learning trial with a list of eight word-number pairs. Eight words expected to produce different arousal levels were chosen as stimulus words (in an arbitrary fashion). During the training trial, *S* was first presented the stimulus word alone, and then saw the word repeated with a single digit response. To separate the arousal effects from one PA to the next, two slides containing four colors each were inserted between the paired-associates, and *S* was instructed to name the colors. In order to determine the arousal effects of each stimulus word, skin resistance was recorded during learning. The intervals between learning and recall were two minutes (immediate recall), twenty minutes, forty-five minutes, one day, and one week. The results reported showed that at immediate recall, numbers associated with low-arousal words were recalled five times as often as numbers associated with high-arousal words. The capacity to recall numbers associated with low-arousal words decreased as a function of time in a normal forgetting curve pattern. In contrast, the capacity to recall numbers associated with high-arousal words showed a considerable reminiscence effect. After twenty minutes, the increase was more than 100 percent, and after forty-five minutes it increased 400 percent. The high recall of high-arousal pairs persisted for at least a week—the longest interval employed. In summary, there was significantly poorer long-term retention under low arousal and superior long-term retention under high arousal. It was concluded that the results were in accordance with the expectation that there would be more consolidation and thus better learning under high arousal. One of the important aspects of Kleinsmith and Kaplan's results stems from the impetus they gave to the almost forgotten consideration of reminiscence in verbal learning (as contrasted with motor learning, where much work on reminiscence has been undertaken [Farley, 1971a]).

The same type of results, that is, poor immediate recall but higher long-term recall of items learned under high arousal, was also obtained by Kleinsmith and Kaplan (1964) in a related experiment. They used six nonsense syllables of zero association value as stimulus words and six single digits as responses with only one learning trial. They reported that at immediate recall, numbers associated with low arousal (measured through GSR deflections) were recalled four times as often as numbers associated with high-arousal nonsense syllables. The capacity to recall numbers associated with low-arousal stimuli decreased as a function of time in a characteristic forgetting pattern. In contrast, the capacity to recall numbers associated with high-arousal nonsense syllables showed a considerable reminiscence effect. After twenty minutes the increase was 100 percent and after one week, 200 percent.

Using homogeneous and mixed lists of high- and low-arousal words, Walker and Tarte (1963) also obtained results comparable to Kleinsmith and Kaplan (1963). They used seventy-two female undergraduates as Ss. The stimulus material for the high-arousal list consisted of the words *money*, *rape*, *slut*, *embrace*, *kiss*, *vomit*, *passion*, and *sex*. The stimulus material for the low-arousal list consisted of the words *white*, *pond*, *berry*, *flower*, *walk*, *pencil*, *glass*, and *carrot*. The mixed heterogeneous list was composed of a selection of four words from the high-arousal list and four from the low-arousal list. The response items were digits 2 through 9. Three groups of Ss learned a low-arousal list, three groups learned a high-arousal list, and three groups learned a mixed list. Skin-resistance measures were taken at the time the Ss attempted to learn the words. The interval between learning and recall was two minutes for one group, forty-five minutes for another, and one week for the third for each of the three lists. The results reported showed that the capacity to recall the number associated with the low-arousal words dropped as a function of time.

Haveman and Farley (1969) have studied the capacity to recall nonsense syllables associated with an independent source (white noise) during PA, serial learning (SL), and free learning (FL). The results of the first two of these experiments (PA and SL respectively) did not show significantly better long-term recall with white noise presented during learning of PA and SL tasks. In the experiment in which the FL paradigm was used, white-noise-induced arousal had a significantly facilitative effect on long-term recall. Finally, the authors reported that arousal did not have a detrimental effect on immediate recall in any of the three verbal learning paradigms. They concluded that the effects of arousal are dependent on the nature of the material to be learned.

The importance of the Haveman and Farley (1969) study is that it points out the necessity to qualify our statements in relation to arousal and learning. When attempts at predicting the effects of arousal on learning are made, (1) the source of arousal, (2) the nature of the material to be learned, and (3) the learning paradigm should be taken into consideration. It seems that a trend toward specifying the contingencies under which a particular type of arousal takes place, added to a restraint in generalization of results, may be more fruitful, considering the status of the field.

In relation to point (2), Maltzman, Kantor, and Langdon (1966) questioned the theoretical generality of the Michigan (Kleinsmith & Kaplan [1963]; Walker & Tarte [1963]) results. They argued that the effects of arousal during learning and retention were confounded, since the stimulus words were presented as cues in the retention test as well as in the single learning trial. Furthermore, they argued that physiological data are accumulating which indicate that the concept of nonspecific arousal based on the activity of the reticular activating system in the brain stem is greatly oversimplified (e.g., Anokhin, 1959). The authors argued that the GSR measures used in the Michigan group's studies are correlates of the orienting reaction and not of the consolidation process. In a study with undergraduate Ss, they employed a performance task less complex than the PA paradigm. In order to remove the external arousal stimulus from the recall session, a one-trial free learning task was used. Palmar GSR was recorded along with cephalic vasomotor activity during learning and used as measures of the OR. The authors results showing that retention was better for high-arousal words at both the immediate and the long-term retention interval . The authors concluded that the lack of interaction between retention interval and type of word was a contradiction to Walker's action decrement hypothesis.

In an answer to the above study, Kaplan and Kaplan (1968) noted that the procedural changes that Maltzman, Kantor, and Langdon (1966) made in their study may have been responsible for the difference in the results. Maltzman, Kantor, and Langdon used free recall of familiar words rather than stimulated recall of unfamiliar PAs. One may add that PA and FL paradigms involve two distinct processes. On the other hand, Mandler (1967) has suggested that the two methods are not simply different procedures for studying the same learning processes, but that each involves unique properties. Kaplan, Kantor, and Langdon also noted that in the reanalysis of their previous data, recall performance was predicted only by GSRs during learning and not by GSR administered during recall. They used different retention intervals—thirty minutes for the long-term retention interval—in contrast to the Michigan group's usage of twenty-four-hour or one-week retention intervals. Manske and Farley (1971) suggested that perhaps the consolidation process is still going on at the point in time used by Maltzman, Kantor, and Langdon, and that the memory trace is still relatively unavailable. It can be argued that Maltzman, Kantor, and Langdon did not control differential rehearsal of high- and low-arousal words. The use of a ten-second interval without the use of an interpolated task points to this possibility.

Farley (1969) also used an FL paradigm in order to control the overt presence of the arousal stimulus during recall. He argued that the effects of arousal on retention may be due to the presence of the arousing stimulus during learning, during recall, or both, when PA or serial learning is the paradigm employed. Farley also considered the possibility that the arousal effect may be enhanced or degraded by the context of the high- and low-arousing words. The context of a list was varied to include (1) high-arousal words only, (2) low-arousal words only, and (3) half high- and half low-arousal words. The results obtained for this last condition were very similar to those of Maltzman, Kantor, and Langdon. High-arousal words were recalled better at both immediate and three-day retention intervals. In contrast, the data from the homogeneous lists showed that high-arousal words were recalled better only at the three-day retention interval. These results suggested that the findings of Maltzman, Kantor, and Langdon may have been due to their mixed-list design.

In relation to point (3), Farley (1969) noted that there are some methodological handicaps in the studies that define arousal in terms of the material being learned. He suggested that a more desirable paradigm is one in which the arousal source is manipulated independent of the learning material. When arousal is manipulated in such a way that it precludes the confounding effects of general arousal level and the effects of the arousal elicited by the material to be learned, interpretation of the results seems to be less ambiguous. In other words, a more desirable paradigm is one in which arousal is manipulated through independent sources such as DAF, instructions, drugs, white noise, and so on.

Alper (1948) used "ego-oriented" instructions (she informed one group of Ss that the task was a measure of intelligence) to induce arousal in a PA learning task. On the other hand, another group was given task-oriented instructions. A test for recall was administered immediately and again one day later (repeated measure design). Alper reported that the "ego-oriented" Ss recalled more new items on the long-term retention test than on the short-term retention test. She also found that the recall of the "ego-oriented" Ss for those same items tested in the long-term retention interval was better than on the short-term retention interval. All the scores of the "ego-oriented" Ss were superior to the task-oriented Ss at both intervals. All the differences were significant.

Using drugs as a form of inducing arousal, Batten (1967) attempted to study Ss' short- and long-term recall in a PA paradigm. He manipulated arousal by giving each of his Ss dexedrine (arousing) or phenobarbital (dearousing) prior to PA learning. The PA stimuli were words judged emotionally neutral on an a priori basis. The responses were single digits. Following one learning trial he tested for retention at two, twenty, and forty-five minutes, one day, and one week later. He found that the results were very similar to the findings of the Michigan group (that is, in the same direction), but were not statistically significant.

Some research has been reported which demonstrates memory facilitation due to drug-induced arousal. McGaugh (1958) has obtained superior performance in experimental animals learning a simple alley maze while under the influence of mild strychnine doses. Lashley (1918) obtained similar results using the same type of drug. According to Paré (1961) it seems that stimulants tend to enhance memory due to increase in arousal, and depressants tend to limit it.

The DAF technique has been extensively used to induce arousal independent of the learning task (Harper & King, 1967; King, 1963; King & Dodge, 1965; King & Walker, 1965; King & Wolf, 1965). Researchers in the area have found that immediate recall of connected meaningful material practiced under 0.2 second of DAF is significantly poorer than under appropriate control conditions. On the other hand, prose material practiced under DAF yielded greater retention relative to the initial amount of material recalled, in comparison to the control group. In general, the DAF group showed more reminiscence than the control group.

In recent years there has been a steadily increasing amount of research in which white noise has been used as a method for experimentally manipulating arousal. The assumption that white noise raises arousal can be traced back to Davis (1948). He reported that auditory tones raised one index of arousal—skeletal muscular tension. McLean (1969) reported skin-resistance data indicating white noise to be effective in inducing arousal. Berlyne and Lewis (1963) were able to demonstrate that white noise raised one index of arousal, skin conductance, and kept it raised for at least ten to fifteen minutes. White noise has been shown to increase multiple-unit activity in the reticular arousal system (Podvoll & Goodman, 1967). Berlyne, Borsa, Hamacher, and Koening (1966) summarized the relationship between arousal and white noise as follows:

> The assumption that white noise raises arousal is supported by (a) neurophysiological evidence that all extereoceptive stimulation activates the reticular arousal system, (b) the finding that continuous white noise causes skin resistance to drop significantly over a period of 15-20 minutes in conditions that would otherwise leave skin resistance virtually unchanged, (c) the finding that sounds increase muscular tension and (d) the concordance between the effects of white noise on PA learning and the results of the Michigan experiments.

Additional evidence that white noise activates the reticular arousal system has been reported by Berrien (1946), Costello and Hall (1967), and Gibson and Hall (1966).

According to Berlyne and Carey (1968) and Haveman and Farley (1969) the advantage of using white noise is that at all times the experimenter can control the output. In other words, the experimenter can switch it on and off at will, and it can be used to raise arousal during learning and not during the recall test (and vice versa).

Some studies using white noise have been concerned with arousal prior to learning (Archer & Margolin, 1970), others during learning (Berlyne et al., 1965; Berlyne et al., 1966; Haveman & Farley, 1969, etc.), and others after learning (Kumar & Farley, 1971; Farley & Lovejoy, 1968).

Berlyne, ᐧrsa, Craw, Gelman, and Mandell (1965) manipulated white noise as a means of inducing arousal in a PA experiment. They used disyllabic male first names as response terms and visual patterns as stimulus terms. They used two levels of noise and three training trials. They found that items learned under white noise were recalled less often than others during initial training but more often during a test given one day later. These findings are generally in line with those reported by the Michigan group (Kleinsmith & Kaplan, 1963; Walker & Tarte, 1963).

In a subsequent experiment, Berlyne et al. (1965) used single disyllabic adjectives (e.g., glassy), heterogeneous disyllabic adjectives (e.g., glassy, crucial), and homogeneous disyllabic adjectives (e.g., crucial, crucial) as stimuli. The response terms were disyllabic male first names. One-fourth of the items were learned under white noise (WN) and tested one day later under WN. The next quarter were learned with WN and were tested without WN. One quarter were learned without WN but were tested under WN, and one quarter were learned and tested without WN. Five groups of *S*s received different intensities of WN ranging from thirty-five to seventy-five decibels. It was found that on the training day there was significantly less recall for items learned under WN as compared to items learned without WN. On the test day twenty-four hours later, items learned under WN the day before were recalled significantly more often than non-WN items. No significant effect due to WN during the test trial appeared. Variations in WN intensity had no effect. On the basis of these two experiments it was concluded that WN-induced arousal has a facilitative effect on learning rather than performance.

After reviewing the literature in the area of arousal and WN, Haveman and Farley (1969) reported a basic inconsistency throughout the studies reviewed involving the relationship of arousal to immediate memory. They summarized their findings as follows:

> The Michigan group (Kleinsmith & Kaplan, 1963, 1964; Walker & Tarte,

1963), Berlyne et al. (1965), King & Dodge (1965), and King & Wolf (1965) found arousal to have a detrimental effect on immediate recall. On the other hand, Alper (1948), Berlyne et al. (1966) and Farley (1967) found arousal to have no significant inhibiting effect on immediate recall but to increase long-term recall relative to non-arousal conditions. Berlyne et al. (1966) in discussing their results have suggested that the effects of arousal may be dependent on the nature of the learning material used.

Kumar and Farley (1971) suggested that the Berlyne studies may not be strictly comparable to the Michigan group studies from the point of view of the procedures employed and parameters used. In some of these studies the experimenter generated WN from a white noise generator and others from tape recorders. The interval for testing immediate and long-term memory was different in almost all the studies. None of the experimenters had questioned the actual reliability of the tests used, this perhaps being a factor responsible for the discrepancies observed in the results. Berlyne et al. (1966) suggested that the effect of arousal may also be dependent upon the nature of the learning material used, a point that also concerned Haveman and Farley (1969). In view of this state of affairs, Osborne and Farley (1971) concluded that the relationship between arousal and immediate recall was still obscure.

Salient Aspects of the Research Discussed and its Implications for Education

Arousal has recently received attention as an operational motivational construct significantly involved in learning and memory. However, not a great deal of work has been undertaken on subject variables and arousal, in particular in relation to school-like learning tasks with elementary-school-age children.

Most of the research undertaken thus far has studied either induced arousal (i.e., as brought about by white noise, "taboo" words, and so on) (Berlyne et al., 1965; Haveman & Farley, 1969; Walker & Tarte, 1963) or arousal changes as they occur spontaneously in association with learning material (Levonian, 1967; Lovejoy & Farley, 1969). A few studies have investigated intrinsic arousal, that is, arousal that is trait-like or (chronically) characteristic of a given S across a wide range of situations, using salivary response as a reliable and valid measure of such a stable individual difference variable (Farley, 1970; Farley & Gilbert, 1968; Osborne & Farley, 1971).

Where induced arousal was concerned, Haveman and Farley (1969) investigated the effects of arousal induced by WN on learning and retention in PA, serial, and free-recall learning paradigms. Results indicated that only in the free-recall learning paradigm did high arousal lead to significantly better long-term retention relative to low arousal. The results also suggested that the effects of arousal were dependent on the nature of the material to be learned and the intensity of induced arousal. Assuming that these results in the free-recall paradigm are consistently demonstrable, there is still the problem of whether the findings can be generalized. There is a necessity to investigate the relationships of intrinsic arousal and induced arousal and their effects on recall in a wide range of learning situations. If the phenomena of induced arousal and intrinsic arousal hold also for the complex learning situation of the classroom, the implications for instruction would be considerable. Levonian (1967) attempted to investigate the retention of information in relation to arousal in a classroom-like situation with teenagers. Using a driver education film, and skin resistance as an arousal measure, he was able to demonstrate that material learned during high arousal showed poor short-term retention but enhanced long-term retention, relative to material learned during low arousal. Levonian's experiment seems to represent an attempt toward Hilgard's fifth step in the basic-to-applied learning research continuum. Recent research on arousal and prose learning is also in this category (Farley, 1971b).

It would seem that to facilitate progress in the application of such a basic theoretical construct as arousal and also in order to study the relative contributions of induced and intrinsic arousal to complex cognitive processes, the Farley and Gilbert (1968) intrinsic-arousal approach, the Haveman and Farley (1969) induced-arousal approach, and the Levonian (1967) use of film might converge in a study using intrinsic arousal (salivary response), induced arousal (WN), and short- versus long-term retention of film content. In addition, the use of elementary-school-age children as Ss would increase the educational relevance of the study, as it is likely that the phenomenon of arousal as an enhancing memory variable is most effective here. At the elementary level learning is more directed and controlled, and the problems of motivation can still be significantly shaped.

Two models have been discussed in relation to the role of arousal in memory. One, the so-called "action decrement model," would predict an interaction between arousal level (arousal defined both as intrinsic and induced) and retention interval such that learning under high arousal would lead to poor short- but good long-term retention relative to low-arousal learning. The other, the "inverted-U model," would predict that learning or performance would be more complexly related to arousal such that arousal increments up to a certain level would facilitate performance but that too high levels would degrade performance. Applied to the concepts of intrinsic arousal and manipulated or induced arousal, poorest performance would be expected when values of both were either very high or very low. Best performance would be expected for intermediate arousal levels on both intrinsic and manipulated arousal, or high-intrinsic low-induced arousal, or low-intrinsic high-induced arousal. The performance rank order of the latter two conditions might suggest the relative importance of the two sources of arousal in influencing performance and their possible additive effects.

This study is the first to examine children's comprehension of film content as a function of the major motivational variables of induced and intrinsic arousal. It has taken both an experimental-manipulative and individual-differences approach to the problem of motivation and cognitive learning, and as such has allowed, within the confines of the measures and manipulations used, for an estimate of the relative contribution to short- and long-term retention of these two sources of variance. It has also provided a closer approximation to the naturalistic classroom learning task than is characteristic of most previous arousal and learning research.

III
Method

Subjects

The Ss were 215 female sixth-grade middle-class students drawn from different elementary schools in an urban community in Bayamon, Puerto Rico. Participation in the study was completely voluntary. All the Ss were administered the absorbent test (Razran, 1935) (by female graduate student Es) to determine the magnitude of their salivary response. A distribution of these magnitudes was made, and 160 Ss were selected on the basis of their extreme values in net salivation. The teachers of the Ss were informally interviewed to rule out any possible S with hearing problems, mental retardation, sight troubles, or color blindness. Prior to starting the experiment per se, a comparable group of one hundred Ss was used to validate a multiple choice test intended to be used for the long- and short-term memory test.

Design

A 2 x 2 x 2 design (independent measures) was used, employing all possible combinations of two levels of intrinsic arousal (low and high), two levels of white noise (eighty-five decibels and no-noise), and two retention levels (short-term recall and long-term recall). The four groups that were assigned to the short-term recall cells were tested five minutes after learning; the other four cells were tested at the same time a day later (1440 minutes). The five-minute interval was filled by a maze tracing task.

Material and Equipment

The following equipment was used: stainless steel forceps, a sterilizer, tongs, a 1 cc. glass syringe, lemon juice, standard cotton dental swabs, one hundred test tubes with rubber stoppers, a stopwatch, a mirror, a Right-a-Weigh electronic balance, one Super-8 projector for single-concept film, a three-and-a-half-minute silent color film, a white noise generator (Grason-Stadler model 901-B), and paper-and-pencil mazes.

Learning Material

A silent color film was used as the task to be learned. It was a three-and-a-half-minute single-concept color film: "Conditions Necessary for Combustion." This film was chosen on the basis of its being a relatively unfamiliar topic for sixth graders, and its low arousal potential (judged on an a priori basis).

Arousal Equipment

White noise was generated by a Grason-Stadler 901-B white noise generator. The signal from the generator was shaped and pulsed (125 msecs. on, 125 msecs. off, with a rise and decay time of 25 msecs.). Prior to running the experiment the acoustic output of the system was calibrated to eighty-five decibels (reference level of .0002 dynes/cm. 2SPL) with a Bruel and Kjaer apparatus consisting of the following components: artificial ear H152, 6 cc. coupler NBS-9A, condensor microphone 1432, cathode follower 2613, and audio-frequency spectrometer 2112. The output of the system was checked by monitoring the voltage across the terminals of the earphones, and the values of tolerance were found to be ± 1.5 decibels. All the apparatus was covered with a white sheet in order to keep it out of the sight of the Ss.

Procedure

A measure of the salivary response to lemon juice was taken from each *S* by means of the absorbent technique (Razran, 1935). Standard cotton dental swabs were used throughout. Equipment coming into contact with the *S*'s mouth was sterilized. The *S* was told that this measure was one of a series of buccal measures being taken in a study of individual differences. Each *S* was told that a standard dental swab would be placed under her tongue, with some harmless fluid being dropped onto the tongue, which she was to hold there for twenty seconds. At the end of this interval she was told to simultaneously raise her tongue (for the swab to be removed) and swallow the fluid. A request was made for the mouth to be kept as widely open as possible during the operation for ease of access. The *S* was instructed not to make any attempt to manipulate the swab with her tongue. Before the experiment began the experimenter demonstrated the two basic tongue movements involved: namely, touching the roof of the mouth with the tip of the tongue halfway back (for reception of the swab) and hollowing out the tongue (for reception of the lemon juice). A mirror was provided to permit brief rehearsal by the *S*.

The swab was placed upon the sublingual salivary gland with forceps. Then four drops of lemon juice (0.1747 grams mean weight) were delivered to the tongue by means of a 1 cc. glass syringe. In order to be sure of stimulating the "sour" taste receptors, the juice was dropped onto the lateral margins of the tongue, allowing it to run towards the center. At the end of twenty seconds the moistened swab was removed to be placed in a sealed test tube which had been previously weighed while containing the same swab in a dry state. The test tube and swab were weighed a second time, the difference between wet and dry weights constituting the amount of salivation to lemon juice. This operation was carried out with the utmost possible speed and precision. The *S* was seated so that the equipment tray was out of view. A cloth covered the tray when the *S* entered the room. Care was taken not to use the words "lemon" or "juice" or let the *S* have a close look at the syringe. Every effort was made to minimize distraction in the room in order to avoid spatial inhibition.

From the distribution of the salivary responses of 215 *S*s, the 80 highest-scoring *S*s (salivation > .51 grams) and 80 lowest-scoring *S*s (salivation < .31 grams) were selected for the second stage of the experiment. The second stage of the experiment was to present the silent film to the *S*s. The instructions were the following: "You are going to see a short, silent film. Please pay close attention to it. Some of you will hear a hissing sound through the earphones; that sound is completely harmless, please maintain your attention on the film." The learning task was a three-and-a-half-minute color film not previously presented to the students within the curriculum. The presentation was not multimedia in nature, as no auditory information was presented. The film was presented only once. *S*s were tested in yoked dyads. To avoid rehearsal *S* was not specifically told that he would be tested for recall, thus learning was presumably incidental as opposed to intentional.

Prior to the main experiment, forty-six multiple-choice items were constructed. The original forty-six items were reduced to twenty-seven on the basis of the validation test done with one hundred *S*s. The final test of film comprehension included both literal and inferential items. The phi coefficient was used to determine the internal reliability of the test. The minimum acceptability item reliability was .28. This measure was used to eliminate the items that were too easy or too difficult to answer for the pilot sample of *S*s. The final twenty-seven items were randomly ordered and presented one at a time to *S*s in a book-like fashion. All *S*s were administered a five-minute booklet of paper-and-pencil mazes (an irrelevant task) prior to the retention test. This procedure was used to avoid white noise trace effects in the experimental groups and was in line with practice in previous arousal and memory experiments, using the same mazes as Kumar and Farley (1971).

IV
Results

The distribution of salivary responses to lemon-juice stimulation in the 160 *Ss* is presented in Figure 3. The cut-off points for the 80 highest and the 80 lowest salivators were $> .51$ grams and $< .31$ grams, respectively. The shaded area of Figure 3 represents the 55 *Ss* who fell between the high and low cut-off points.

The scores used for the measure of recall consisted of the total number of correct responses to the twenty-seven-item multiple choice test. The mean scores for each of the cells are presented in Table 1. It should be noted that no subject achieved a perfect score. Data were treated in a three-way (fixed effects) analysis of variance (ANOVA). The results of this ANOVA are summarized in Table 2.

The differential recall of high- and low-arousal *Ss* as a function of time is illustrated in Figure 4. For the immediate test, the high-intrinsic-arousal/no-white-noise *Ss* demonstrated greater recall (number of items correct) than the remaining groups—low-intrinsic-arousal/white-noise (LA/WN), low-intrinsic-arousal/no-white-noise (LA/NWN), and high-intrinsic-arousal/white-noise (HA/WN).

As can be seen in Table 2, there was no significant main effect of intrinsic-arousal level. However, there was a significant interaction between intrinsic arousal and white noise ($p < .0001$). In other words, presence or absence of white noise did not have the same effect on retention within low-intrinsic-arousal and high-intrinsic-arousal *Ss*. Collapsing over recall conditions it appears that white noise has relatively little effect on the low-intrinsic-arousal *Ss* while producing a decrement in the performance of high-intrinsic-arousal *Ss*.

There was a significant interaction effect between intrinsic arousal and retention interval ($p < .0035$). The difference between immediate recall and recall the next day was not the same for low-intrinsic-arousal and high-intrinsic-arousal *Ss*. The low-intrinsic-arousal group demonstrated more recall than the high-intrinsic-arousal group.

There was also a significant interaction between white noise and retention interval ($p < .0002$).[2] The *Ss* in the white noise condition tested after twenty-four hours (as a main effect) evidenced the poorest recall (see Table 1).

Although the triple interaction was significant, an interpretation will not be attempted since it would not be meaningful within the context of the present design.

In order to locate the specific differences contributing to the significant main effects and interaction, Scheffé's (1959) post hoc analysis of individual comparisons was performed. A significant contrast was obtained between white-noise, short-term recall (Cell A in Table 3) and the other cells (Cells B, C, and D), ($\hat{\psi} = 3.00$, $p < .05$).

No significant differences were obtained between Cells A, C, and D. The white noise condition demonstrated a significant detrimental effect on short-term recall compared with the NWN condition. The detrimental effect of white noise on long-term recall was not so apparent.

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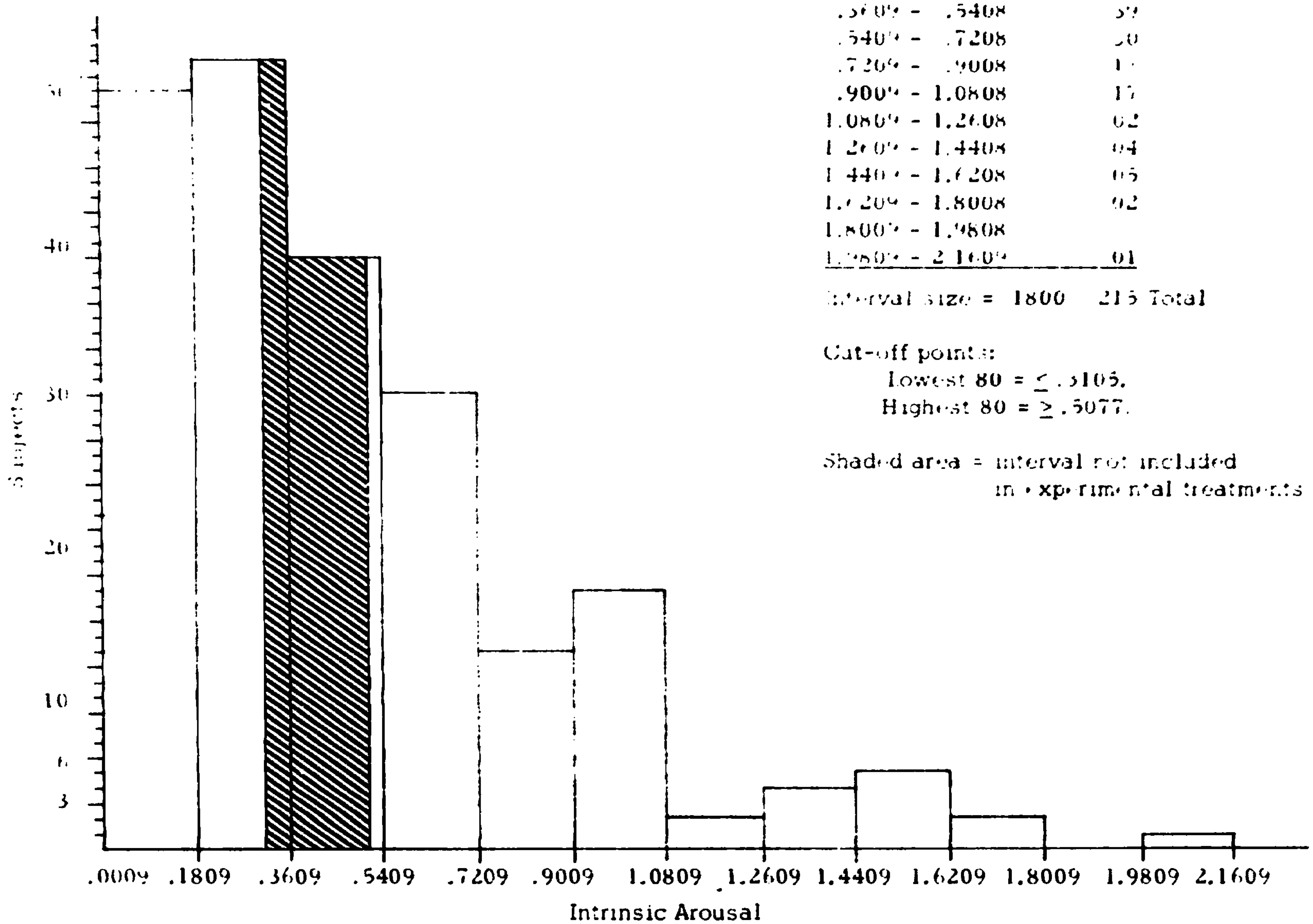
[2]The difference between immediate recall and recall the next day is not the same for *Ss* receiving no white noise as for those for whom white noise was present (see Table 1, direction of change) (i.e., the mean STR minus LTR difference for the WN condition = -4.52; the comparable difference for the NWN condition = 0.55).



Data

Interval	N
.0009 - .1808	50
.1809 - .3608	52
.3609 - .5408	39
.5409 - .7208	30
.7209 - .9008	1[illegible]
.9009 - 1.0808	17
1.0809 - 1.2608	02
1.2609 - 1.4408	04
1.4409 - 1.6208	05
1.6209 - 1.8008	02
1.8009 - 1.9808	
1.9809 - 2.1609	01

Interval size = 1800   215 Total

Cut-off points:
Lowest 80 = ≤ .3105.
Highest 80 = ≥ .5077.

Shaded area = interval not included in experimental treatments

Figure 3. Distribution of Net Salivation in Grams.

TABLE 1

TOTAL RECALL SCORES OF MATERIAL LEARNED AS
A FUNCTION OF AROUSAL AND RECALL INTERVAL

Arousal level	Recall condition		Recall condition collapsed
	Short-term	Long-term	
High arousal - white noise	13.85	14.00	13.92
High arousal - no white noise	20.55	20.60	20.57
Low arousal - white noise	13.50	22.40	17.95
Low arousal - no white noise	16.85	15.70	16.27

N = 20 for each group.

TABLE 2

SUMMARY OF THREE-WAY ANALYSIS OF VARIANCE OF
RECALL SCORES AND AROUSAL CONDITIONS

Source	SS	D.F.	F
Intrinsic arousal (IA)	7562	1	0468**
White noise (WN)	247.5062	1	15 3127*
Retention interval (RI)	158.0063	1	9 7755*
(IA) X (WN)	693 0562	1	42 8779*
(IA) X (RI)	142.5062	1	8 8166*
(WN) X (RI)	257.5062	1	15 9344*
(IA) X (WN) X (RI)	247 5062	1	15.3127*
Error	2456.8503	152	-
Total	4203.6938	159	

* $p < .01$.
** N.S.D.

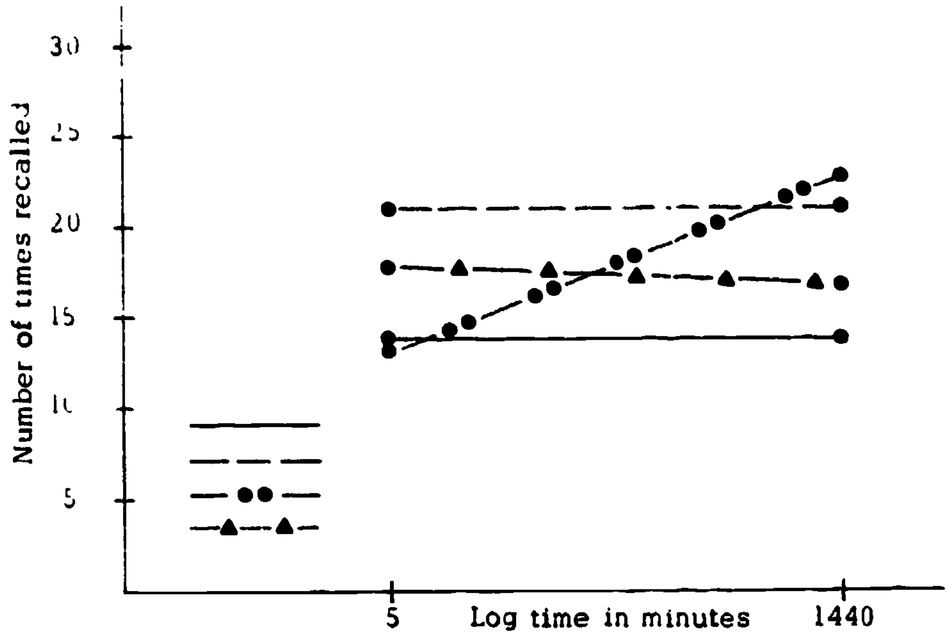


Figure 4. Differential Recall of High- and Low-Arousal *S*s as a Function of Time.

TABLE 3

MEAN DISTRIBUTION OF THE WHITE NOISE CONDITION
AND ITS EFFECTS ON THE RETENTION INTERVAL DIMENSION
(IGNORING INTRINSIC AROUSAL)

Retention interval	White noise: Present	White noise: Absent
Short-term	13.68 A	18.70 B
Long-term	18.20 C	18.15 D

N = 40 per cell.

V
Discussion

The results of this experiment failed to fit the "action decrement model" (see Figure 1), but seem to be in some accord with an inverted-U model (see Figure 2). Although the inverted-U model clearly does not account for all detailed results obtained in this work, it permits an explanation as to why the low-intrinsic-arousal/white-noise group performed best in the long-term retention test. According to the inverted-U model it would be predicted that a low-intrinsic-arousal/white-noise combination would enhance long-term recall. This condition would be true if we assume that this particular cell (see Figure 5) was in position B in Figure 2 before being exposed to the experimental condition of white noise. In other words, the LA/WN group moved from position B in Figure 2 to position A. The HA/WN group probably moved from an assumed original position A to position C in Figure 2. According to the inverted-U model, HA/WN would be expected to decrease the reminiscence level of *Ss*. This speculative idea must be viewed with caution due to the significant triple interaction.

Another factor that must be taken into consideration in using the inverted-U model is that there is a significant amount of memory research supporting the action decrement analysis (Walker & Tarte, 1963; Farley & Gilbert, 1968; Farley & Dowling, 1971; Kleinsmith & Kaplan, 1964; Osborne & Farley, 1971; Levonian, 1967; etc.).

The results of the present experiment may also be viewed in terms of validity and paradigmatic questions. Historically, the present work can be placed in what Kuhn (1962) called the "pre-normal period" of science, where solid paradigms about an obscure phenomenon are not yet warranted. There seem to be a number of problems to solve before an attempt is made to establish a precise relationship between arousal levels (intrinsic or induced) and recall. In the first place, an assumption was made at the beginning of this work concerning the long-term reliability of the salivary measure based on Farley, Osborne, and Severson's (1970) study, in which a significant twenty-four-hour stability estimate of .78 was obtained. After the experimental phase of the present work was finished, Hernandez and Santiago (1973) in an independent-groups design (sixty *Ss* per group) studied five-minute, one-day, and one-week reliability of the salivary measure in children. They found reliability estimates of .24 ($p < .06$), .02 (NS), and .26 ($p < .05$) for the three temporal intervals, respectively. On the basis of this study, there seems to be a trend toward a U-shaped relationship of reliability to time!

In the second place, there seem to be different methods of constituting high- or low-arousal groups in this field of research. High or low arousal is traditionally defined in terms of the relative extreme values of th. . ample available to the experimenter at a particular time. What one experimenter may be calling "high arousal" might not be the same for other researchers. An illustration of this point is evident in the work of Osborne & Farley (1971, p. 12), where a distribution of salivation scores is presented indicating cut-off points for low and high arousal at .10 and .40 grams, respectively. Comparing this index of arousal with the cut-off points presented in the present work (.31 and .51 grams, respectively; see Figure 3), one can see that the ranges assigned to high and low arousal do not match. In other words, what Farley, Osborne, and Severson (1970) considered "extreme" high-arousal values (from .4 to .5 grams) were considered as "normal" arousal values in the present experiment. It seems that the so-called "high" and "low" arousal values are defined as a function of relatively small sample size and not on the basis of larger sample size. This problem is very similar to the determination of what is to be considered a "normal" pulse

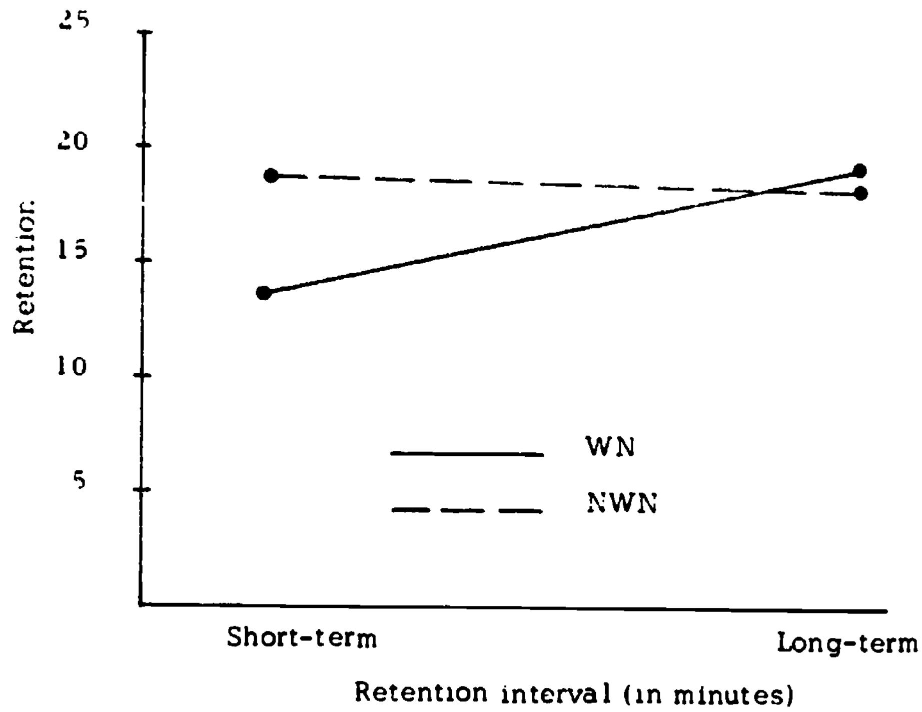


Figure 5. Experimental Conditions Representing All Sources of White Noise Present and Absent, Respectively (white noise collapsed, intrinsic arousal ignored).

for a given population in clinical medicine. The specialist in this field has had to determine what constitutes "normality" (or extreme values) of pulse rate on the basis of long clinical experience. That experience is lacking in the field of arousal experimentation. Even in medicine they have to consider geocultural differences when attempting to determine the "normality" of the pulse of some particular population. It seems that in the field of arousal research we are still far from mastering all of the complexities and subtleties that this physiological construct poses. Historically, science seems to study new phenomena (like arousal and recall) in a monolithic fashion. It is when experiments like the present one are conducted (in which individual differences are taken into consideration), that the intricacies of the phenomenon under study begin appearing. These very intricacies are the stepping stones of what Kuhn (1962) has called the formation of new paradigms in science.

There seems to be need for exploring basic issues in the area of arousal. For instance, there is a tremendous need to investigate the parameters that the arousal (intrinsic or extrinsic) variable encompasses. In relation to the parameters of arousal, information is needed on what constitutes the nature of an arousing stimulus. The relationship between the amount of stimulation that is needed to cause variations in arousal is still somewhat ambiguous. Research can be suggested in the area of induced arousal, specifically white noise. Variations in white noise can be appraised in terms of decibels, and direct measures of galvanometric skin responses can be taken as an assumed correlated variable while Ss learn, or after learning has taken place. This type of fundamental research could contribute to formalizing the basis for future applied investigations.

Another area that seems very relevant and is in need of basic research is the relationship of arousal and human development. For instance, the need to clarify what constitute the optimum levels of arousal for learning in children and/or adolescents is a question that has not yet been answered. A related issue is the role of sex differences in levels of arousal. Once the need for basic research in this area is reasonably fulfilled, one of the most important issues seems to be under what conditions we can predict the efficiency of learning of Ss under arousal, and how well the findings can be generalized to applied education.

Though recent research appears to indicate that arousal plays an important part in the learning and recall processes, the effects are not yet confirmed across a wide range of groups. The present study was conducted with middle-class children from a different cultural milieu (Puerto Rican) than previous studies. Therefore, the implications for applied learning situations are necessarily speculative in relation to the North American population. Obviously, research is necessary in situations in which different ethnic groups are compared in order to enhance our psycho-anthropological understanding of arousal.

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