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ABSTRACT

This paper attempts a unified explanation of such apparently non-utilitarian behaviors as curiosity, manipulation, and exploration as manifestations of "playful behaviors" on the one hand and stereotyped responses on the other. Sensorhesis names the new theory offered to explain the existence and nature of playful behavior. Play and stereotyped behaviors are juxtaposed on the same continuum by virtue of their possible opposite action in maintaining optimal stimulus input in an organism (O). Play generates large information loads by virtue of its elements of novely; stereotyped behavior generates minimal information either as a substitution for stressful stimulus input or a bacuum activity under conditions of perceptual deprivation. The adaptation of the O to a given level of stimulus complexity requires an increasingly complex interaction with the environment to maintain the information flow and optimal arousal. (WY)

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SENSORHESIS AS A MOTIVE FOR PLAY AND STEREOTYPED BEHAVIOR[1]

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Erstwhile, organisms (Os) were assumed to emit behaviors in response to the primary drives of hunger, thirst, etc. Primary drives can be characterized as mechanisms seeming to have as their outcome the maintenance of the fabric of the O or of the species, and to this extent may be called utilitarian. However, critical analyses of the range of behaviors emitted by Os have produced many activities that do not seem to an observer to be so motivated. White (1959), for example, reviewed a variety of behaviors that did not appear utilitarian, demonstrating that the explanatory power of the old drive reductionist theories of behavior has waned. As a result new concepts of motivation have developed to explain these behaviors, like the manipulative and exploratory drives demonstrated by Harlow (1953) and the motive for effectance or the production of effects in the environment, suggested by White (1959). Two major classes of non-utilitarian energy expenditure await satisfactory explanation. They are playful and stereotyped behaviors.

Play has proved difficult to define. A common feature of attempted definitions of play is that behavior is considered "playful" if it does not have a biological function that can be recognized by the observer. However, Schlosberg (1947) pointed out that such a definition is largely valueless since it begs the question by imputing that play consists of all behaviors without determinable motive and to classify an activity by reference to the observer's perception of its motivelessness says little.

Despite the difficulty in operationalizing play as a process, it has historically generated a great interest in behavioral science. The literature extant on the subject is extensive (Herron, Haines, Olsen & Hughes, 1967), but there has been limited recent theorizing about play since the old theories were dismantled by Beach long ago (1945). Contemporary concern with the role of play in the early development of the child and an interest in manipulating the informal environment of the young to optimize their development renders it timely to attempt new theories explaining the existence and nature of playful behavior.

Stereotypic behavior, the other major class of non-utilitarian behaviors, has been characterized by Davenport and Menzel as "frequent, almost mechanical, repetition of a posture or movement which varies only slightly in form from time to time, and which serves no obvious functions" (1963, p. 99). This type of behavior has been observed in a large variety of zoo animals by Hediger (1950), in chimpanzees (Davenport & Menzel, 1963; Berkson, Mason & Saxon, 1963; Menzel, Davenport & Rogers, 1963; Berkson & Mason, 1964), in canaries (Sargent & Keiper, 1967), chickens (Levy, 1944) in normal children (Olson, 1929; Koch, 1935; Lourie, 1949; Kravitz, Rosenthal & Teplitz, 1960), and in retarded and/or institutionalized children (Levy, 1944; Berkson & Davenport, 1962; Davenport & Berkson, 1963; Hollis, 1965; Hutt & Hutt, 1965; Kaufman & Levitt, 1965; Levitt & Kaufman, 1965). Some authors feel that stereotyped responses are normal early in development (Gesell & Amatruda, 1941; Lourie, 1959) but they persist in Os either reared under aberrant conditions of deprivation (Levy, 1944; Davenport & Menzel, 1963) or exhibiting mental retardation.

Stereotyped behaviors while influenced by some environmental factors are not immediately contingent on specific stimuli nor do the responses produce contingent changes in the environment. To this end the behavior satisfied the definition of being maladaptive or non-utilitarian. Stereotypes present a major problem in the management of the Os emitting them. The responses are often repeated so frequently that the O becomes damaged through wear and tear. Such self-destructive behavior among the institutionalized mentally retarded is common and the need for theories concerning the motivation for such behavior is pressing.

This paper attempts a unified explanation of such apparently non-utilitarian behaviors as curiosity, manipulation, exploration, as "playful behaviors", on the one hand, and stereotyped responses on the other. It is postulated that these behaviors are the mechanisms whereby the O maintains an optimal arousal level under normal circumstances by emitting playful behaviors when its arousal is sub-optimal, and stereotyped behavior when trapped in an over-arousing situation.

That Os have an optimal level of arousal and act to maintain that is supported cogently by Leuba (1955) and Hinde (1966) concurs that animals evince behavior that results in their stimulation or information flow remaining within certain limits. Information exists when the consequences of a situation or action are not predictable by the O, or are uncertain. Information flows when the uncertainty is reduced. Thus, in learning the properties of a situation and forming more reliable predictions concerning its outcomes, an O processes information.

Over-arousal is created by information overloads, and under-arousal by too small an information flow. Both over- and under-load situations are aversive (Miller, 1960; Zubeck, 1964; Schultz, 1965) but require opposite strategies to achieve optimal arousal. The motive for maintaining the information flow through the organism is provided by research on arousal. Duffy (1957) shows arousal to lie on a continuum from deep sleep to intense emotion, and argues that this continuum produces the inverted "U" function relating performance to arousal. Hinde (1966) reviews the extensive work so far undertaken on the arousal mechanisms in the brain and the evidence supports the existence and function of the reticular system as a monitor and filter of the afferent stimuli passing to the higher centers, and of the stimuli generated in the cortex. The reticular system acts to arouse the C.N.S. in response to input from the periphery or from higher centers. Presumably the reticular system is capable of selectivity and redundant (familar) stimuli do not have the same arousal potential as those carrying information. Thus, it may be that the reticular system arouses the O in response to the passage of information.

The information load carried by an O's interaction with the environment is determined by its complexity, the number and probability of possible outcomes, and the extent to which the probabilities of the various outcomes are known (Crossman, 1964). If the O has experienced a particular situation sufficient times to have learned the outcome then repeated interactions will carry no information, while an O unable to predict the outcome, may be challenged by the quantity of information in contains.

It follows that when an O is sub-optimally aroused it generates interactions with the environment that carry an appropriately arousing information load. Conversely when supra-optimally aroused the interactions are altered to reduce the load. Stereotyped responses, by virtue of this high redundancy, carry little information and should reduce the arousal of the O by occupying some of its channel capacity to reduce the information flow. In this case the selectivity of the reticular system must be reversed, in that the O be able to attend to this redundant deactivating rather than the arousing stimuli. Thus, there must be an interaction between the direction of attention and the state of arousal of the O.

Schultz (1965) coins the word sensoristasis to label a process in which the organism acts to maintain an optimal arousal level, constantly acting to maintain an informational or sensory milieu internale in a way analogous to the homeostatic mechanisms of the body described by Cannon (1932). Thus, epistemic behavior and stereotyped behavior are opposite in effect, being the specific behavioral mechanisms maintaining sensoristasis.

These statements follow from the above:

1. Os have optimal levels of arousal.
2. Os act to optimize their arousal level.
3. The passing of information is arousing, and the passage of redundant stimuli is deactivating.

The system of postulates developed throughout this paper depends on the species under consideration being "neophilic". Morris (1964) assigns animals to two basic groups, the neophilic and the neophobic. He characterizes the neophilic or novelty-liking animals as those with a wide behavioral repertoire living in plastic environmental niches where adaptive responses and up-to-date information about the environment are at a selective premium. He refers to these as the entrepreneurs of the animal kingdom, e.g., rats, dogs, and primates. On the other hand, neophobic animals are those that are highly specialized, living in rigid niches with small behavioral repertoires, like the reptiles. The set of postulates laid out herein apply to the extent that the organism under consideration can be characterized as neophilic. This system is useful since this author is primarily concerned with the non-utilitarian behavior of humans, the most neophilic of animals, and since the more neophobic the animal the less non-utilitarian behavior there is to explain.

To illustrate the postulates enumerated above a series of schemata follow:

Schema I suggests a continuum of responses from sleep through stereotyped responses to adaptive behavior which carry increasing information loads. Sleep may not be at the origin of the graph, producing no responses and information, but a discussion of sleep per se is beyond the scope of this paper. Suffice it to say that it represents in general the most deactivating state of the O.

Further along the continuum are stereotypies which by definition are not individual responses adaptive to the stimuli from the environment, but are responses that are repeated time and again. It is suggested that these responses generate feedback within the organism via proprioception that has high, but not complete, redundancy. Proprioceptive feedback from muscle action generates information describing the position of the limbs and forces[2] in the muscles acting on the limbs. Thus, high redundancy in the proprioceptive feedback requires responses of high spatial and temporal similarity, which characterize stereotypies.

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[2] The forces developed within an O act on finite and essentially constant masses to create constant accelerations ($f = ma$), and since position is encoded directly by position sensors the basic information generated by force cues is in fact the time taken for a given force to produce a given displacement.

Insert Schema I about here

Even the most redundant stereotyped response carries some information. It is not possible to reproduce a response exactly since the barrage of efferent stimuli must be modified constantly to nullify errors likely to be created by changes in the substrate of conditions from which the response is generated (Bernstein, 1967), i.e., posture, locale, age, fatigue, etc. Thus, perfectly stereotyped responses require the processing of information to allow the nullification of disturbing influences. Further, information will be generated by the errors contained in each response that must be sensed and corrected to maintain it. Further, the organism can attend selectively to different aspects of the barrage of afferent stimuli resulting from the response. Thus, it seems that expression of stereotyped responses provides the wherewithal for the subject to maintain minimal flow of information under circumstances in which there is limited environmental complexity or perceptual deprivation.

Schema II shows an increasing arousal resulting from increased passage of information. Thus, low and high information loads lead to a sub- and supra-optimal arousal levels respectively, while some intermediate load generates optimal arousal.

Insert Schema II about here

Since the O is motivated to behave in a way likely to move it towards an optimal arousal level, Schema III indicates which kind of behavior will be emitted if the organism is not optimally aroused. When over-aroused the O attempts to reduce its arousal by modifying its responses so that they contain fewer novel elements, i.e., they produce predictable outcomes. On the other hand, an O with a sub-optimal arousal level will act to generate information by interacting with the environment to produce less predictable outcomes.

Insert Schema III about here

The O, in playing, gains knowledge or information about the environment. Thus, the content of non-utilitarian play behavior is conditioned by the necessity for it to provide information. Information exists only when the consequences of a situation or action are not predictable, or are uncertain, and uncertainty is reduced by the passage of information. Berlyne (1966) used the word "epistemic" to describe play behavior. His term, from the Greek episteme or knowledge, characterizes play as knowledge-seeking behavior. This notion has been carried a step further by Burgers (1966) who asserts that Os maintain their adaptive relationship to their environment by preserving their options through playing "a game with the environment, striving to have the game continue, and preventing its being driven into a dead end (p. 1681)." Thus, Burgers sees the pathway of the O's life as lying between a stochastic and deterministic model, in which the organism by choosing, passes information.

The concept of sensoristasis may explain much of the behavior in normal animals that cannot be connected directly to some life-support activity. When a normal O's arousal falls below an acceptable level, and there being, temporarily, no life-support activities called for to maintain it, then Os act to generate interactions of uncertain outcome that maintain information flow (Morris, 1962). When there is too much information, then stereotypies are substitutes for adaptive behavior that deactivate the O. Thus, adaptive behavior should occur in states of sub-optimal arousal and stereotypies when supra-optimally aroused. However, the exhibition of stereotyped behavior by animals and humans when under conditions of extremely limited stimulation seems to controvert this (this seeming contradiction will be dealt with later).

The assumption that an O will interact with the environment adaptively to generate an optimally arousing information flow depends on the organism having opportunities to generate interactions of sufficient information load to move upward along its arousal function towards the optimal range. In environments of low complexity such as cages, solitary confinement cells, etc., there are severe limitations on the information that can be generated. Dember and Earl (1957) and later, following from their lead, Sackett (1965) recognized that experience or learning some of the outcomes of interactions within an environment increases the complexity of the organism. Thus, the more things are known, the less information the old interactions with the environment carry.

Insert Schema IV about here

As the effects of previous interactions accumulate, the more complex the organism becomes and the greater the complexity of the interactions necessary to maintain the passage of information. Dember and Earl (1957) add that an organism has a limited capacity for uncertainty. Thus, an organism of given complexity can cope with complexities in the environment that only just exceed its current ability to process.

Sackett (1965) then makes explicit the concept of an optimal disparity between the organismic and environmental complexity, labelling those stimuli that just exceed the organism's complexity as _pacers_. Thus, pacers advance the organism upward along the scale of complexity (Schema IV). Waddington (1957) clarified thinking about biological phenomena like the pacer concept above when he coined a new word _homeorhesis_. He defined homeorhesis as a property exhibited by ". . . a system (that) exhibits a tendency towards a certain kind of equilibrium which is restored after a disturbance; but this equilibrium is not centered on a static state, but rather on a direction or pathway of change" (p. 32). Sensorhesis, the new word in the title, follows from Waddington and refers to the equilibrium in the arousal of an _O_ created by an optimal flow of information, that requires increasingly complex environmental interactions as _O_'s complexity increases as a result of prior interactions.

The potential limit for the upward trend in organism complexity is reached when the environment ceases to provide pacers, or interactions of appropriate complexity to yield information flow. Under these circumstances, the cage stereotypies described by Hediger (1950) seem to be the result of chronic states of perceptual deprivation since it is no longer possible for the organism to generate large enough information loads for optimal arousal. This is supported by the observation that the incidence of stereotypies is inversely related to the opportunities for the O to indulge in alternate activity (Berkson, Mason & Saxon, 1963; Davenport & Berkson, 1963; Berkson & Mason, 1964).

Individual differences in arousal function (See Schema IV), postulated by Duffy (1957), suggest that there are individual differences in the arousal produced by the flow of unit information. This leads to a similar information load (x) creating different behavior. Thus, O_a has a shallower arousal function than O_b such that the load that optimally arouses O_a causes supra-optimal arousal in O_b. The opposite would occur if both organisms were placed in an environment that optimally aroused O_b, and O_a would then rapidly become perceptually deprived.

This suggests a means of differentiating the stereotypies created by supra-optimal arousal whence they are substitutions for too complex environmental stimuli, and stereotypies that serve to maintain minimal information flow due to limitations in environmental complexity. Increasing opportunities for the organism to indulge in more complex interactions to increase the information flow should allow organisms with a normal arousal function to stop their stereotyped behavior and

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Insert Schema V about here

start to be paced towards higher complexity. These opportunities should increase the stereotyped behavior of the organism with the steeper arousal function since the increased complexity of the environmental stimuli should increase its supra-optimal arousal still further. It may be that lengthy experience of perceptual deprivation like those reported for zoo animals by Hediger (1950) and for rats by Lore (1968), may permanently disorganize the organisms, whereas only short periods like those reported for humans by Bexton, Herron and Scott (1958) produce disorganizations that are reversible.

It seems reasonable to suggest that for a given environmental niche there is a common or normal level of information flow and that the occupants of that niche will be selected so that they possess appropriate arousal functions. Thus, they come to possess arousal functions that produce optimal arousal under normal conditions. This is not so necessarily with humans because those at a selective disadvantage are protected. Thus, many individuals are preserved with inappropriate arousal functions that create disorganizing supra-arousal and vice versa. Those children exhibiting chronically high levels of the stereotypies and who are emitting their stereotypies to reduce arousal, may have a steep arousal function for two reasons (if this system of postulates is true). If their intellectual apparatus is poor, the pacer's extant in the normal environment, may not advance the subject in complexity. Contingencies that are learned by normal children quickly, may not be learned by or become predictable for the exceptional child. Thus, what eventually becomes redundant and therefore less arousing for normal children may remain as a very high information load for the inferior child. If this is the case, organism complexity increases only as fast as stimuli become redundant, allowing an adaptive arousal level. Alternatively, the function of the reticular arousal system may be disturbed such that unit flow of information produces an abnormally great increase in the arousal of the organism.

Discriminating between supra-arousal due to faulty arousal mechanisms or to an exceptionally high information load in the normal environment due to its properties not being learned, will depend on manipulating the complexity of the environment and/may be altering the arousal function by drugs (Kornetsky & Eliasson, 1969). Reducing complexity of the stimulus input should reduce the information load and lower the incidence of stereotypies if they are under environmental control. Conversely, if inhibition via drugs decreases stereotypies in the presence of complex stimuli then this argues for their being under central control.

There is evidence to support the notion that stereotyped behavior is a response to supra-optimal arousal. Berkson, Mason and Saxon (1963) and Davenport and Menzel (1963) all noted an increase in the stereotypies emitted by chimpanzees when in a fear-inducing or new environment. Menzel, Davenport and Rogers (1963) observed different behavior in wild and lab-born chimps. The feral-born and raised chimps emitted high activity on being placed in a "distressing" room, but the domestically born and raised chimps immediately emitted stereotyped behavior. The two sets of chimps responded as though they possess different levels of complexity, the wild chimps were at a level such that the new room created adaptive interactions immediately, while the domestic chimps were over-aroused giving way to stereotyped behavior in response.

Berkson and Mason (1964) tested the supra-arousal hypothesis more directly by elevating the arousal level of lab-born chimps. They used white noise and deprivation to increase the chimp's arousal and significantly increased the stereotypies that had high temporal and spatial coherence. This was replicated by Kaufman and Levitt (1965) who noted stereotypies increased in retardates at times when they were under tension (just before meals) and by Levitt and Kaufman (1965) who observed a positive relationship between stereotypies and sound level in institutionalized retardates. Hutt, Hutt, Lee and Ounsted (1965) and Hutt and Hutt (1965) on bases of research with a highly atypical group, autistic children, claimed that increased environmental compplexity increased the incidence of stereotypies. Thus, increased arousal resulting from fear, intensification of the stimuli or the "tension" resulting from deprivation increases the level of stereotyped behavior, at least in the atypical Os cited above, i.e., chimps and in a restricted environment, institutionalized retardates and children diagnosed as autistic.

In summary, playful and stereotyped behaviors are seen to lie on a continuum. Stereotypies provide minimal stimulation functioning to displace stressful input from the environment or to provide minimal input during perceptual deprivation. Playful behavior generates a large variety of novel stimuli via adaptive interactions with the environment. It was suggested that the motives for these two classes of behaviors lay in a propensity for the O to behave in a way likely to optimize arousal by generating appropriately arousing or deactivating information loads. The concept of information flow through the O being controlled by the O's behavior allows the juxtaposition of play and stereotyped behaviors on the same continuum.

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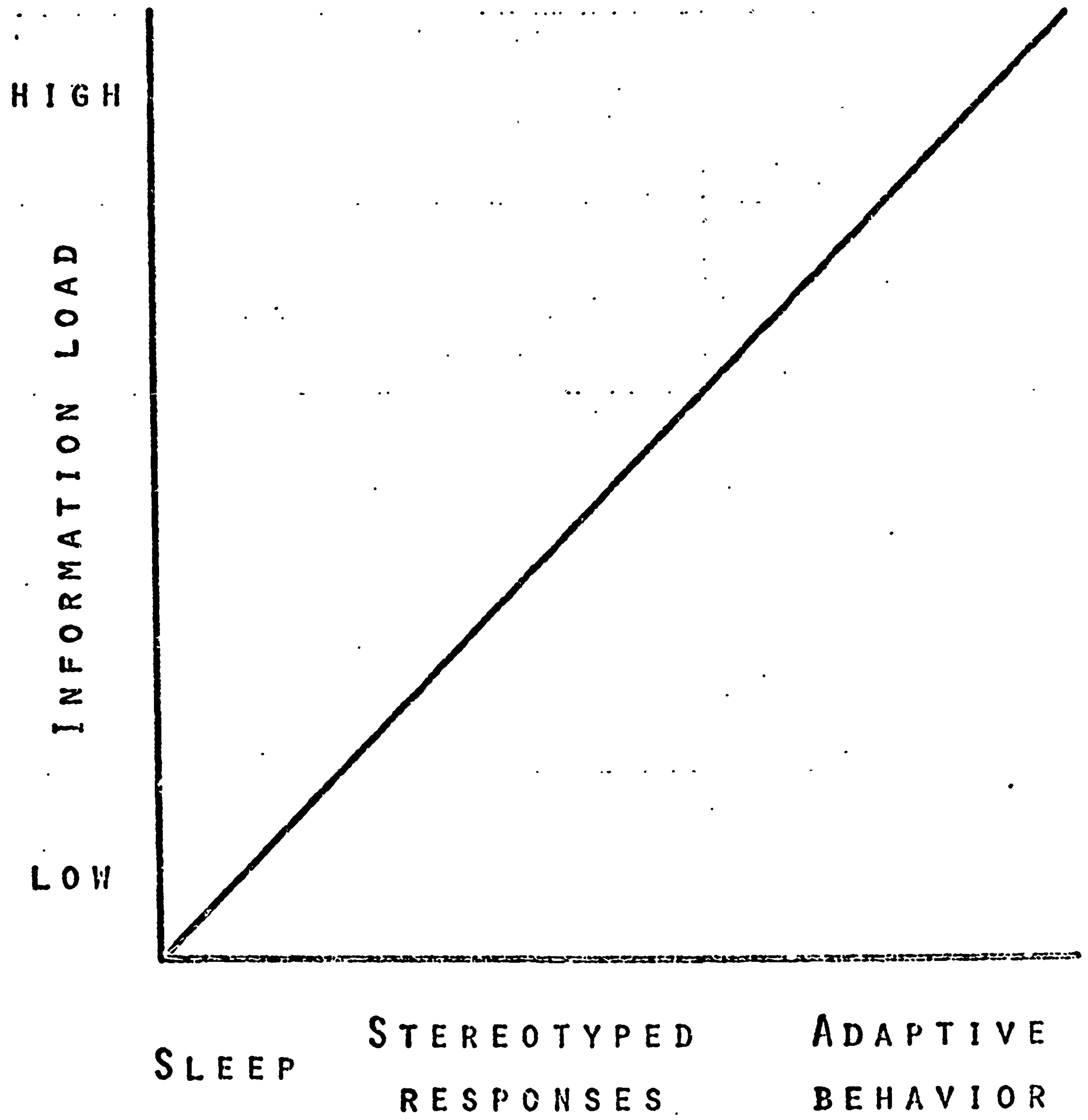
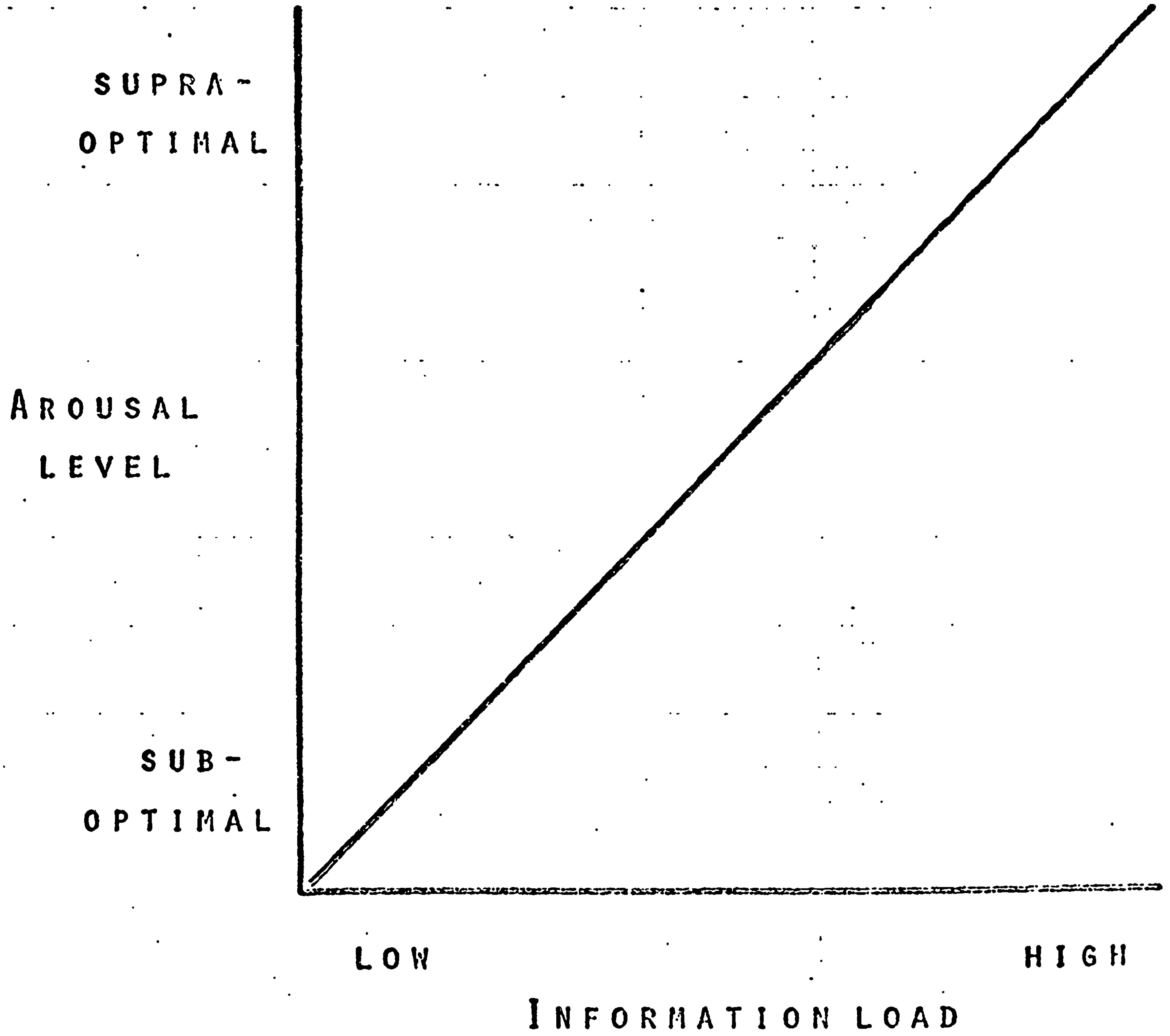
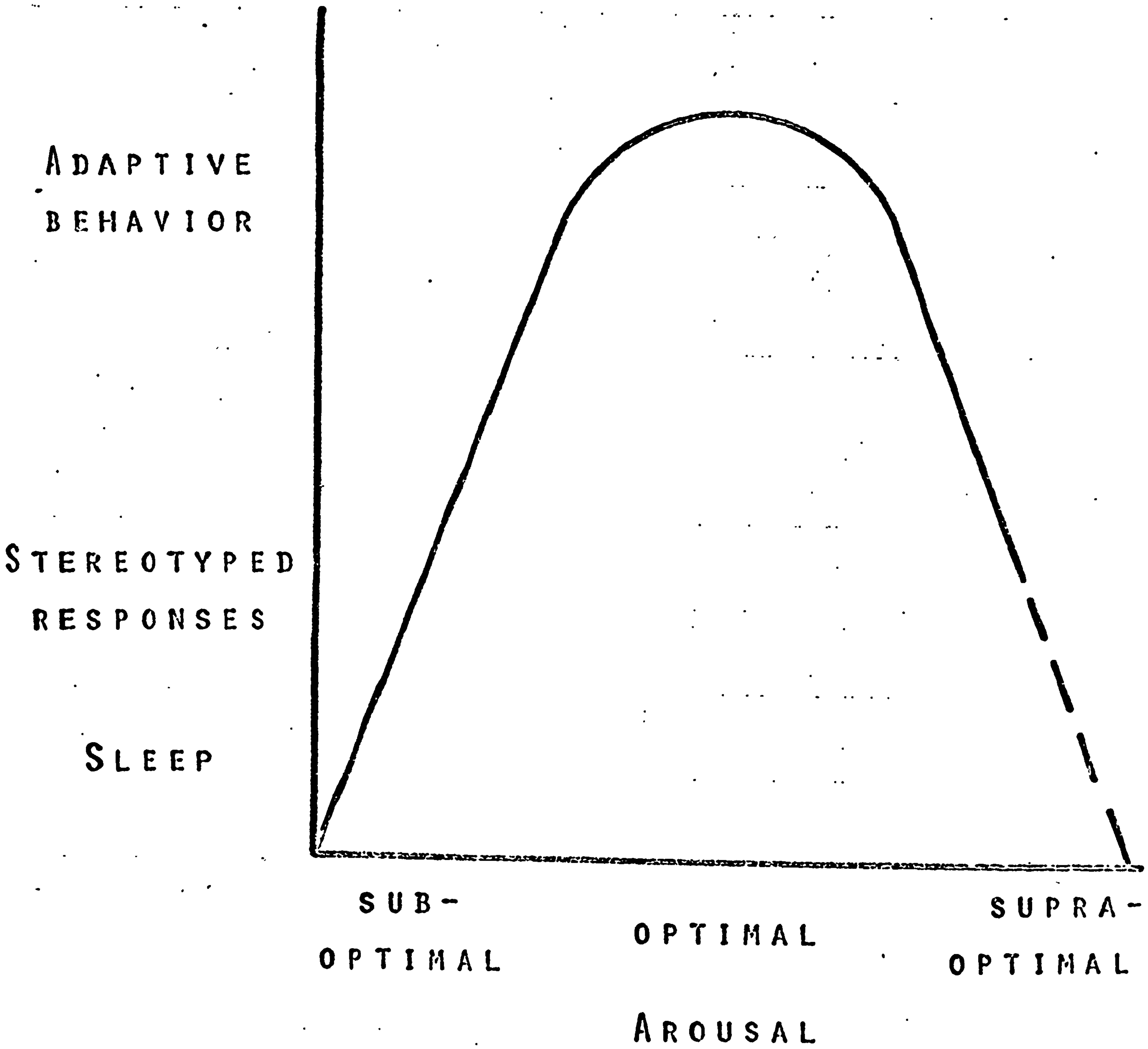
Figures


HIGH
INFORMATION LOAD
LOW
SLEEP
STEREOTYPED RESPONSES
ADAPTIVE BEHAVIOR

SCHEMA I :


SUPRA-
OPTIMAL
AROUSAL
LEVEL
SUB-
OPTIMAL
LOW
HIGH
INFORMATION LOAD

SCHEMA II :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STEREOTYPED RESPONSES
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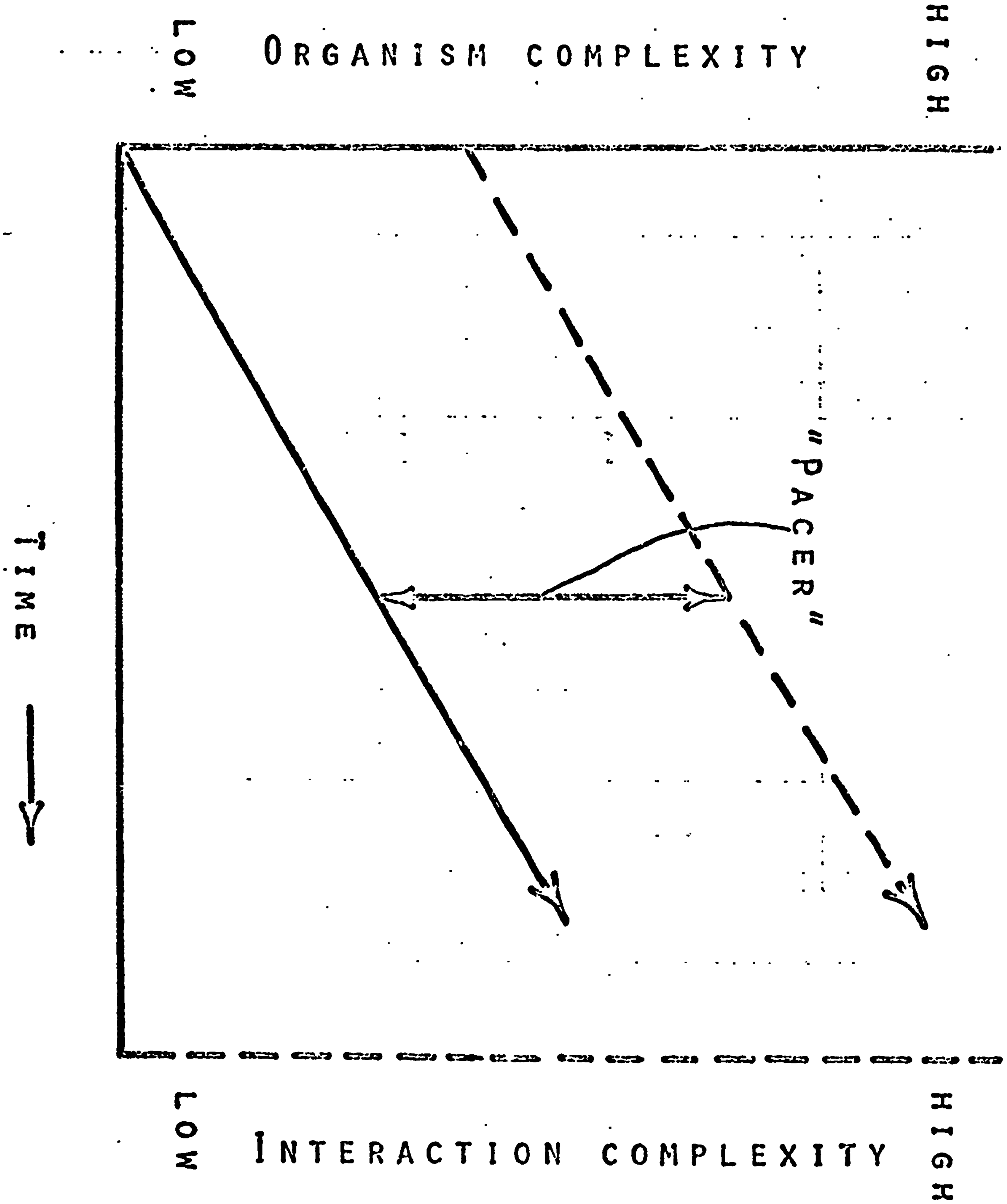
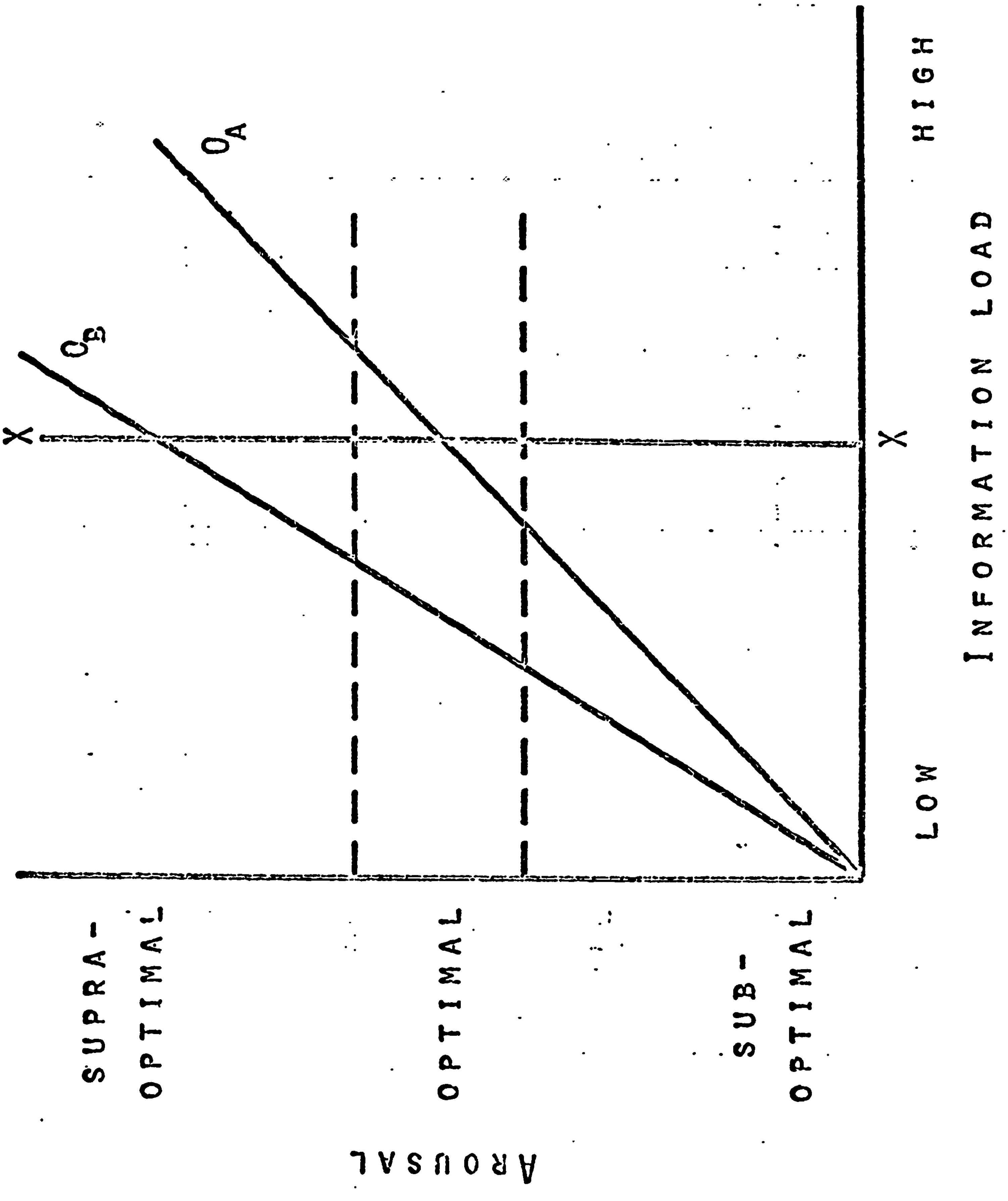
SUB-OPTIMAL
OPTIMAL
SUPRA-OPTIMAL
AROUSAL

SCHEMA III :


LOW
ORGANISM COMPLEXITY
HIGH
TIME
"PACER"
LOW
INTERACTION COMPLEXITY
HIGH

SCHEMA IV :


AROUSAL
SUPRA-OPTIMAL
OPTIMAL
SUB-OPTIMAL
INFORMATION LOAD
LOW
HIGH
X
X
O_A
O_B

SCHEMA V: