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CODING SYSTEMS IN PERCEPTION AND COGNITION

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CODING SYSTEMS IN PERCEPTION AND COGNITION

A Final Technical Report on a Five-Year Project*

Principle Investigator: Ray Hyman

Co-Investigators:

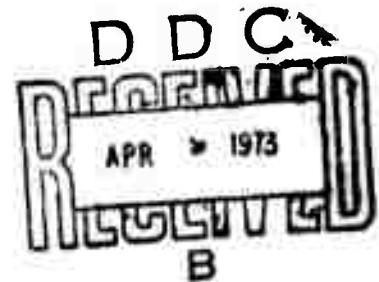
- Barry Anderson (8/3/67 to 8/31/68)
- Fred Attneave
- Jacob Beck (9/1/70 to 8/31/71)
- Richard W. Haller
- Douglas L. Hintzman (6/15/69 to 8/31/72)
- Steven W. Keele
- Michael I. Posner
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13. ABSTRACT

The variety of experiments completed under the contract successfully isolated ways that humans encode and employ information to meet task demands. The results indicate that, when a stimulus is presented, two or more separate coding processes proceed in parallel. One process may build up an iconic representation of the stimulus object; another process is the retrieval of one or more name codes for the stimulus pattern. For some tasks the response depends completely on the iconic code; for others it depends on the name code. Not only do humans typically convert iconic codes into name codes (abstraction), but, when the occasion is appropriate, they can reverse the process and generate iconic representations from name codes. The build up or construction of the iconic representations appears to take place in a three-dimensional analog medium. The particular representation that is achieved is dependent upon a hill-climbing procedure that is guided by the minimum principle. The build up of information apparently proceeds independently of the individual's state of alertness. Alertness affects the speed of response by changing the subject's criterion for responding. Under high alertness he is willing to respond with less information. Speed of responding can also be affected by selectivity. Selectivity operates on particular aspects of a stimulus enabling the subject to begin constructing some aspects of the representation prior to actually receiving the stimulus (expectancy). Alertness increases speed at the expense of errors; selectivity increases speed without increasing errors. Work also progressed on the third component of attention--conscious processing.

14.

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FINAL TECHNICAL REPORT*
CODING SYSTEMS IN PERCEPTION AND COGNITION

ARPA Order 966

Program Code 1D20

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the Oregon State Board of Higher Education
on behalf of the University of Oregon

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2.0. Technical Report Summary

The purpose of the project on Coding Systems in Perception and Cognition was to bring together and focus upon a common theme the skills of experimental psychologists in perception, psychophysics, memory, attention, and human performance. The common theme was the way humans represent or code information in order to accomplish a variety of tasks. When the project was initially proposed in 1966, the experimental work on human performance was already making it clear that humans code information in a variety of different formats--visual, auditory, articulatory, kinesthetic, symbolic or verbal. Moreover, these different codes seemed to differ in a variety of ways that could be important for various task demands. We wanted to investigate such questions as which codes were most effective for various tasks and situations; to what extent is the employment of one code rather than another optional; how do the codes interact with one another in various tasks; what is gained and what is lost in converting from one code to another; etc.

More specific objectives were spelled out in our contract as follows:

- "1. Conduct research on the interaction between coding systems and stimulus events in perceptual and cognitive tasks in human subjects.
- "2. Conduct experiments on perceived tridimensionality, spatial coding, similarity grouping, and pitch as a medium in which patterns occur.
- "3. Construct and test a general model of human pattern recognition.
- "4. Conduct research on immediate recall, semantic memory, and the effects of similarity and repetition on memory.

- "5. Conduct research on human performance, including experimental studies of attention, memory storage, memory retrieval, movement control, motor skills, and pattern recognition."

Just about all of the experiments in the project deal with the first objective in one way or another. Posner's work on abstraction and generation is an especially good example of how we tackled this objective. In dealing with a stimulus pattern our results suggest that two or more coding processes may proceed in parallel. One process, for example, is a build up or construction of an iconic representation of the stimulus; another is the contact or retrieval of one or more "name" codes for the stimulus pattern. Posner and his colleagues have learned a great deal about how these codes function by devising techniques which enable us to separately manipulate or affect these different codes. For some tasks the subject depends completely upon the iconic code; for other tasks he needs to employ the name code. When our project began, it was assumed by many investigators that processing inevitably went from an iconic code to a name code. The results from our studies indicate that the process can go in the reverse way (generation) as well.

The second objective has been the focus of all of Attneave's work on this project, as well as some of the work of Beck. Attneave's experiments on tridimensionality have led to a model of how humans represent perceptual information at the preprocessing stage. The evidence strongly suggests that this representation is analog (rather than digital) in nature. Of the infinite number of representations of a stimulus pattern that can be constructed, the human perceiver seems to achieve that representation that minimizes a "description" of the pattern within a three-

dimensional, Euclidean framework. As a general principle, the minimization principle has little predictive value because it is not always obvious what the system is minimizing and with respect to what criteria it guides such minimizing. But Attneave has made considerable progress in defining what will be minimized within specific task situations. The findings seem to have surprising generality, including not only tasks involving directly perceiving tri-dimensionality in projective drawings, but in tasks involving ambiguous figures, and similarity grouping.

The third objective of testing a general model of human pattern recognition has been tackled by Hyman and his colleagues, building upon the previous and concurrent work of Attneave, Posner and Keele. The original model, postulating three successive and overlapping stages in pattern mastery has not fared well in the face of data resulting from a series of experiments. The work is continuing with the attempt to fit a new model to the data. In general, however, the data suggest that subjects employ both an analog and digital coding system simultaneously in learning to classify stimulus patterns into one of two categories. The "digital" component of the system corresponds to what Attneave calls a "schema" and Posner and Keele refer to as a "prototype". The subject seems to abstract from various representatives of the category an idealized or "composite" prototype of that category. Subsequent patterns are then classified or identified in terms of how similar they are to one of these idealized prototypes. The "analog" part of the process refers to the continuum or space within which the subject detects degree of similarity and dissimilarity to prototypes. When the model is more fully worked out,

we hope it will give us a way of reconciling models of coding that are based on continua or analog metaphors and those which are based on discontinuities or digital metaphors.

The fourth objective has been tackled by a variety of experiments in memory by Reicher, Hintzman, Schaeffer and Wickelgren. Hintzman's findings show that subjects store many other aspects of a memory task than just a list of items which vary in strength--they can retrieve information about the frequency, spacing, and modality of such items as well. While such work implicates a variety of more or less separate trace columns in which the various occurrences of the "same" items are stored, Wickelgren's work focusses upon how the repetitions of the "same" item increment some single surrogate or representative for that item. This problem of remembering the unique setting in which an item occurs as opposed to storing that item in a single location comes up in a variety of ways in our work. The so-called logogen model which Keele employs has to deal with this problem and it is intimately related to the iconic and name codes that Posner studies.

The fifth objective, like the first, cuts across almost all the experiments we have conducted. But the work of Posner and Keele is especially pointed towards this objective. Keele's work seems to point to a system in which memory retrieval is automatic and in parallel and in which various bottlenecks in performing a skilled task occur at the level of movement control. At the level of human thinking, Posner has shown how our various experiments on memory codes, memory organization and mental operations can be brought to bear upon how humans solve

problems. The key concept is that of the working memory in which information retrieved from long-term memory is brought into conjunction with information in short-term memory which depends upon immediate stimulation. It is the limited capacity of this working memory that constrains how well the individual will be able to bring his knowledge to bear upon a given problem. The thinker's task is to get just that combination of informational items into working memory that can solve the problem. Very frequently, the thinker has all the information available for the solution, but he fails to solve the problem because he does not manage to assemble the information in such a way that it can be grasped or combined as a unit. Posner, in his forthcoming book, shows how the kinds of experiments we have done in this project can be helpful in pointing the way towards both theory and techniques that will suggest how to help the thinker overcome the constraints of his working memory.

In addition to the many findings that have emerged from our many experiments, the project resulted in the development and perfection of a number of methodological tools for studying coding systems. Fagot's work on separately testing underlying assumptions when using human subjects as measuring instruments, Attneave's method for studying tri-dimensionality, Posner's matching procedures and his new techniques for studying the physiological concomitants of preparation, Schaeffer's and Conrad's methods for assessing semantic structures and Warren's technique for detecting how far abstraction has proceeded are just a few of the many new tools, techniques and paradigms that we have developed. Our most important methodological achievement was the construction and development of an automated

laboratory based upon the two laboratory computers we purchased under this contract (a PDP-9 and a PDP-15). About 70% of the research was controlled by this laboratory. Now that we have finally obtained a permanent place to house this laboratory, we expect that this facility can serve almost all of our experimental psychologists who will continue, under various governmental grants, to build upon the work that was initiated under this project.

It is, of course, impossible to summarize all the findings from such a fruitful project that already has produced a bibliography of more than 130 items and will eventually result in anywhere from 160 to 200 published documents. Fortunately, many integrative summaries are or will soon be available of large portions of our work. In addition, the principal investigator hopes to write a later integrative summary of the project when sufficient time has elapsed to allow much of the uncompleted work to be finished and to digest the implications of the work as a totality. Meanwhile, the present final technical report will give a very general overview and point to particular studies that will help provide partial integration of our work. As an aid to the reader, in addition to a regular alphabetized bibliography of our work, we also provide a cross-referenced listing of our work under various key words.

3.0. Introduction

Our initial proposal to do research on Coding Systems in Perception and Cognition described our intentions in the following words:

"The proposal deals with the interaction between coding systems and stimulus events in perceptual and cognitive tasks. This interaction is viewed as a reciprocal relation between the form of the coding system and the characteristics of the stimulus event. On the one hand, we want to investigate the ways in which the characteristics of the coding system are determined by the qualities and organization of components of the stimulus event. On the other hand, we want to study how the efficiency with which an individual operates upon the stimulus information is determined by the characteristics of the coding system which he employs in the situation. The general plan is to attack this issue by means of a series of different, but closely coordinated, research projects. The projects will individually investigate the same problem from a variety of different viewpoints--from perceptions, multidimensional psychophysics, scaling, decision and choice theory, concept learning, skill learning, inductive logic, and problem solving. We will coordinate the projects by means of several devices: 1) the formulation and application of a common terminology, notation, and system of concepts; 2) the use of identical stimulus sets; 3) the use of common tasks, dependent variables, equipment, and experimental designs; 4) the rotation of research assistants among projects; and 5) a single individual as principal investigator who has the authority to decide,

at each choice point, whether a given experiment does or does not directly contribute to the overall goal of helping us understand how the characteristics of a coding system affect an individual's ability to use information in perceptual and cognitive tasks."

Those intentions were written approximately seven years before this present report. The Final Technical Report on Contract F44620-67-C-0099 summarized what we did during the first four years of our project to fulfill these intentions. The present Final Technical Report (on Contract F44620-71-C-0126) attempts to convey what we accomplished over the five-year period spanned by both contracts on Coding Systems in Perception and Cognition.

Ideally, this final report would consist of an integrated presentation of our findings about how coding systems operate in human performance. Instead, the report will fall far short of that ideal. One reason is that this report has to be written only a short time interval from the end of the contract. This does not allow time for appropriate digestion and interweaving of the more than 130 written documents that have already been completed on the basis of research supported by the project. Also, many of the experiments supported by the project have not yet been brought to completion. Some are waiting to be written up; others still are in the data-analysis stage; and many projects started under the contract are being continued under other auspices. So the full story is not yet in.

Consequently, this report will suggest the direction of the final integration without actually providing it. Fortunately, some of the monographs already written by some of the investigators or being planned by them provide at least partial integrations of large segments of our

work. Also, the principal investigator hopes to write a fuller and more integrated summary of the overall project at a later date when most of the returns will be in and when sufficient time has occurred. As a step in this direction he will conduct a graduate seminar in the Spring of 1973 whose objective will be to develop an integrated overview of our accomplishments on this project.

Because the bulk of the work on this project originates with the human performance tradition, integrating much of this work within a common framework will not be too difficult. Indeed much of this integration has already been accomplished in Steve Keele's book Attention and Human Performance and Posner's forthcoming book on Memory and Thought. Between them, these two books provide an integrated framework within which to organize the experiments of Reicher, Schaeffer, Posner, Keele, Hintzman and their associates. All of the experiments done by these investigators under this project fit naturally into the human information processing viewpoint.

But this still leaves the work of Attneave, Deek, Fagot, Wickelgren and their associates to be brought into the picture. The work of these latter investigators, although also oriented towards coding systems, originates in different traditions. Attneave and Beck represent the more classical approach to perceptual problems, especially those problems of organization, segregation and patterning that the Gestalt psychologists challenged us with. Attneave pioneered in the application of information theory to Gestalt problems such as that of "good figure". But this aspect of information theory stems from Claude Shannon and emphasizes the

description and quantification of structures or sets of possibilities. But the information processing conceptions used in the human performance area stem more from cybernetics and modern computer programming. This latter viewpoint emphasizes the flow of information from one isolable subsystem to another rather than the specification of the ensemble of possibilities at any one point in the process. Perhaps for this reason the way to integrate Attneave's work with that of Posner and Keele has not yet been resolved to our satisfaction. But the direction that such an integration will take seems discernible. Within our current framework, Attneave and Beck, and to some extent Fagot as well, focus on the dynamics and structure of the coding process that occurs at a single stage, in this case the preprocessing or preselection stage. The major concern is with how the stimulus information is represented prior to contact with memory. The human performance viewpoint tends to take this stage for granted because it is interested not in specifying what goes on at a particular stage, but rather in describing the flow of information between stages. In other words, it is more concerned with the interfaces between components of the system rather than in the components themselves.

Fagot's work on the psychophysical law is even more difficult to fit into the total picture. In this case, the problem might be that the task given to subjects in these sorts of studies is rather an unnatural one. The subject is asked to make focal what is ordinarily part of the background. But what is relevant to the other research projects is the methodological achievements of Fagot and his associates in showing us how to employ subjects as calibrators of their own phenomenal experience. Independent of the substantive contribution, this work on the psychophysical law has

produced tools and techniques for knowing when subjects are estimating magnitudes according to some meaningful measurement process. The work has also resulted in interactive computer procedures for fitting a variety of functions to data. Both these latter contributions have already proved valuable in enabling investigators such as Hyman to use subjective data in rigorous fashion and to fit complicated models to the output.

Wickelgren's work stems from still another tradition that is not easy to integrate with human information processing. That is the classical associationistic tradition with its emphasis upon strength and decay of associational traces. Again, without claiming to have achieved a satisfactory resolution, we can see glimmerings of how this integration with the other work may take place. Keele and Posner, among others, have been making increasing use of Morton's Logogen concept to describe certain aspects of the coding of information in their experiments. This logogen concept, in turn, behaves very much like a concept in the associationistic theories of Wickelgren in that inputs referring to the same concept, regardless of specific differences in modality and form, add increments of strength to that concept.

In the following parts of the report we will briefly indicate some of the major themes or foci around which the final integration will be made. We begin with Attneave's work on tri-dimensionality and minimum principle. This work in itself can serve as the basis for integrating the contributions of Beck, Hyman, and Fagot to some extent. It focusses on coding and perceptual dynamics that are preprocess in the sense that contact with memory is not necessarily involved. The next section deals

with Keele's work, especially with his book on Attention and Human Performance. This book integrates much of the work done by Reicher, Hintsman, Posner, Keele and their associates. Keele's book overlaps with, as well as complements, Posner's forthcoming book on Memory and Thought. Posner's work is the topic of the next section. In a very real sense, Posner and his associates provide the cement that binds the whole project together. The emerging theory from Posner's work comes closest to including all of the experimental research conducted under this project. Indeed, this principal investigator believes that if he can comfortably mesh the work of Attneave with that of Posner, he will have solved the problem of how to completely integrate all of the project. Posner's work is followed by a brief account of the still unfinished work of Hyman and his associates on pattern recognition. This work and its emerging theoretical formulation is seen as one way in which the bridge between Attneave and Posner might be built. Finally, in our overview of experimental results there is a brief section on the contributions by the remaining investigators and some suggestions as to how their work will fit into the ultimate unified picture.

We then say a few words about our automated laboratory and about the number and variety of people who have contributed to this project. This is followed by a few words on the ramifications and implications of our work.

Jacelyn Weddell, under the supervision of the principal investigator, prepared the key word section under which the various articles are cross-referenced.

4.0. Accomplishments

During the five years of the project we accomplished many things. We had special classes and colloquia; we constructed the automated laboratory and developed it into a unique and effective facility; we produced many MA theses and Ph.D. dissertations; we gave talks at conventions, meetings and universities all over this country and abroad; we brought in visitors as visiting scholars, speakers, or consultants; we produced many publications and more are on the way; and we completed many experiments with a variety of results. In this section the accomplishments we speak about will be those related to the results of our experimental research.

4.1. Analog Systems and Preprocessing: the work of Attneave

The work of Attneave on this project has been particularly satisfying because it has led to an unexpected integration of a wide range of perceptual phenomena--ambiguous figures, figure-ground, depth perception; "pragnanz", etc. A good start at getting the flavor of this integration is Attneave's Scientific American article on multistability in perception (1971). A more systematic summary of his work and his emerging ideas about the minimum principle and its operation in perception is his chapter on "Representation of Physical Space" (Attneave, 1972). The article on "Triangles as ambiguous figures" (Attneave, 1968) provides an excellent illustration of the power of Attneave's ideas about an internal Cartesian coordinate system in dealing with a rather challenging perceptual phenomenon.

The coding system that Attneave has been studying is one that operates at the preprocessing level. Even before it contacts memory, the stimulus

input is coded and organized in a rather sophisticated way. Of all the ways in which the same stimulus input can be represented, that way which minimizes complexity with respect to a hypothetical internal reference system is selected. This internal reference system, as revealed by Attneave's experiments, appears to be a three dimensional, Euclidean coordinate system with preferred axes corresponding to phenomenal vertical, horizontal and front-back. It is a continuous analog medium within which simplifications, according to a principle of perceptual economics, are made even before contact is made with memory. Once memory is contacted, of course, further revisions and interpretations can be carried out on the stimulus material. But Attneave's work emphasizes what the Gestalt psychologists also wanted to emphasize; much of the important operations upon stimulus input occur prior to the operation of "experience" in terms of past associations.

What is pleasantly surprising about this analog coding system is its universality. It seems to be importantly implicated not only in almost all those tasks that are classically referred to as "perceptual", but also in many other tasks that are considered to be cognitive and require problem solving.

4.2. Attention and Human Performance: the work of Keele

Keele's book on Attention and Human Performance (1973) presents a framework and theory around which much of the work of this project can be organized. Keele organizes the book around the processing tasks of storage, retrieval and movement. A central feature of this book is the

theory of attention that Keele develops on the basis of his own work and much of the work conducted on this project. Both the storage of information and the operations made upon information require attention according to Keele's theory. But the retrieval of information from memory does not require attention. Among the advantages of such a system is that the selective mechanism of attention operates ^{on} information that is activated in memory rather than on sensory information itself. Sensory information that is meaningless, for example, will not contact information from memory and thus, will not furnish the selective system with anything to operate upon.

Keele's theory relies upon Morton's logogen model. In this case the logogens, corresponding to concepts, are what are activated by sensory inputs. Those logogens which receive sufficient input above a preset threshold are activated sufficiently to be retrieved in memory. Sensory input goes to a set of logogens in parallel. The bottleneck in performance of a given task does not come about because of the number of logogens which happen to be activated. Rather, it occurs as a result of the operations which are subsequently performed upon those logogens which have been activated. Operations require attention; only one operation can be applied at a time.

Keele applies his theory to a wide variety of phenomena ranging from the Von Restorff effect through semantic memory to social applications such as noise control. The book provides not only a coherent view of Keele's own contributions to our project, but it also encompasses about a third of the research conducted under this project.

4.3. The Interfacing of Systems: the work of Posner

Posner's work and emerging theoretical framework has been central to this project. The many ways in which Posner's ideas, paradigms, methods and techniques have provided links to all the other investigators and students on our project were detailed in the Final Technical Report for the first four years. Even more so than Keele's book, Posner's forthcoming book on "Memory and Thought" provides a framework within which one can organize much, if not all, of the various experiments on the project. While Keele's book organized the material on human performance in its strict and narrower sense, Posner applies the same sorts of principles to the more complex and broader area of human thought and cognition. As a result he casts a broader net. To Keele's coverage, Posner adds the work of additional investigators such as Attneave, Schaeffer, Beller and their associates. Together, Keele's and Posner's books provide a framework for integrating just about all the work on the project with the possible exception of Fagot's work and some of Beck's and Attneave's work.

In 1964, Holt wrote an article "Imagery: The return of the ostracized." (American Psychologist, 1964). The return of the "ostracized" could equally be applied to the concept of "consciousness". Much of Posner's efforts during the five-year project have contributed to the return of "consciousness" as a viable topic for experimental psychology. What was once banished for being so elusive has now gained respectability because of the new "mental chronometry" which enables us to operationally specify when a mental operation does or does not involve conscious processing. Posner and Keele in

their paper on "Time and space as measures of mental operations" (1970) make an important distinction for the problem of measuring mental operations. Operations may require both time and "space". An operation requires "space" if it interferes with the performance of other voluntary activities. . . . Whether an operation requires space can be measured by occupying the central processor with a task that is known to require conscious attention. If the operation being studied interferes with the execution of the standard task (or, alternatively, is interfered with), then it can be said to require conscious attention.

One of the most important paradigms for measuring and isolating mental operations is the form of mental chronometry introduced by Posner and Mitchell (1967). This paradigm requires subjects to match given stimulus pairs as "same" or "different" according to specified criteria such as physical or name identity. This paradigm was developed and elaborated as one of the major tools, not only for Posner and his associates, but also for the other investigators on the project (such as Schaeffer on semantic memory). It was with this paradigm, for example, that Posner and his associates demonstrated that physical and name codes for the same stimulus were isolable subsystems and gave rise to codes with different properties. Moreover, they further demonstrated that the matching of physical forms and the abstracting of the names for these same forms were mental operations that were performed in parallel.

Posner has provided us several integrative summaries of his work over the course of the project. An early and important integration appeared in his chapter on "Abstraction and the process of recognition" (1970).

Here the work resulting from the matching paradigm was tied to his work with Keele on the genesis and retention of abstract ideas. This bridge to pattern recognition also served as a bridge to some of Attneave's work and that of Hyman and his associates on pattern learning. Other important integrative papers are "Coordination of internal codes" (1972), "Attention demands of movements" (with Keele, 1969), "Skill learning" (with Keele, in press), "On the functions of consciousness" (with Klein, 1972), "Traces, concepts, and conscious constructions" (with Warren, 1972), "Components of attention" (with Boise, 1971), and "On the selection of signals" (with Klein, Summers and Bugge, 1973).

The framework provided by the forthcoming book on Memory and Thought divides the study of cognition into two categories: statics and dynamics. The statics of cognition deals with how information is represented in memory. Memory systems differ in their characteristics and in the codes they employ. The two major characteristics are long-term memory and activated memory. Activated memory consists of both short-term memory (immediate memory of stimulus input or sensory analysis) and operational memory (items retrieved from long-term memory). It is activated memory that provides the key to thinking. It is in activated memory, with its limited capacity, that the right combination of information for solutions to problems will or will not occur.

The memory codes are iconic, enactive, and symbolic. These codes usually develop in parallel and which is most salient depends upon a variety of contextual, strategic, and other factors.

The dynamics of cognition deal with the mental operations which are performed on these codes. Operations require time and they may also

require space. When they require space, of course, they involve consciousness. The effectiveness of the problem solver may depend on such things as which operations he can automate (so as to bypass consciousness) and on developing effective ways to retrieve information from long-term storage in such a way that just that combination required will occur together in activated memory.

Posner's most recent work studies the components of attention from both the behavioral and the physiological perspective. Using both his matching paradigm and his newer techniques which measure the evoked potential, Posner has demonstrated how alertness and selectivity, while both enhancing speed of reaction, are separate and independent processes. Alertness, for example, affects the speed of reaction to both same and different reactions alike; selectivity affects the reaction to only one of these components (usually "same"). Selectivity reduces errors as well as facilitating speed of response to the primed target; alertness increases speed of reaction in general without reducing errors and may increase errors. This work suggests an organism that constructs models of the input (expectation) to which it reacts with efficiency and minimal capacity. When the input does not match the internal model, however, an orientation reaction occurs and organism devotes its limited capacity and conscious attention to the discrepancy.

Here we have another potential bridge between Attneave and Posner. In Attneave's earlier work, he developed the notion of perceptual economics. The perceiver was attuned to strip redundancy from the input so as to attend to or cope with points of maximum information (deviation from expectancy). This was a schema-with-correction notion. It is a notion which

now provides a bridge between Attneave, Reicher and others and Posner.

4.4. Analog and digital: The work of Hyman

One attribute on which coding systems seem to differ is that of analog versus digital. In the perceptual area, such as the psychophysical models of Fagot and the spatial model of Attneave, the system into which stimulus input is coded or represented is characterized as a continuous medium or space. Even the language and the mathematics is that of continua and analysis. In the cognitive area, on the other hand, the system into which the stimulus input is coded is more often characterized as a discrete set of categories or nodes. The language and mathematics, when applied, is usually that of set theory, the algebra of classes and graph theory. We all agree that both continuous and discontinuous systems characterize human perception and cognition. The problem has been how to coordinate this knowledge into one model or theory. At the moment, most formal models seem to be exclusively analog or digital in nature.

In our project when we talk about "abstraction" and "generation" or when we talk about the "coordination of internal codes" we explicitly or implicitly refer to analog-to-digital and digital-to-analog transformations. One possible link between analog and digital codes is that analog codes seem to characterize more naturally that form of information processing that is done outside the central processor. Preprocessing of stimulus information seems heavily analog in nature; execution of motor programs below the level of conscious control or awareness also seems analog in nature. Some versions of the logogen model and statistical decision theory may suggest clues as to how the analog-digital interaction can be handled.

The logogen model implies an analog-to-digital conversion in that stimulus input to a logogen adds up continuously until a certain threshold point and then the logogen is set off in a discrete manner. Statistical decision making also implies the imposing of a discontinuity upon a continuous space or dimension.

Hyman and his associates began a series of experiments on pattern classification with this analog-to-digital relation in mind. We deliberately set out, in these experiments, to provide a bridge between the work and theories of Attneave and those of Posner. The experiments and concepts were based upon the earlier work of Attneave on "schema-with-correction" and the more recent work of Posner and Keele on the genesis and retention of abstract ideas. The stimulus patterns and the experimental paradigm was taken directly from the Posner and Keele studies. The stimulus patterns were dot patterns. Subjects are shown examples of these patterns and learn to classify them into two categories. Once they can correctly classify the exemplars into the appropriate categories they are then tested on a wide variety of patterns, many of them new, to see how they will classify patterns not previously encountered. Our experiments differed from those of Posner and Keele in two ways. We used only two categories. And, more importantly, our patterns did not differ from each other in random ways, but rather in systematic ways along two dimensions--height and width.

Our patterns could be seen as being drawn from the same continuous Euclidean space with dimensions of height and width. In fact, our multidimensional scaling of similarity judgments made by a panel of judges,

confirmed our belief that subjects would respond to these patterns as if they were drawn from a continuum of patterns that vary in two dimensions that correspond to the physical dimensions of height and width. Our requirement that subjects learn to classify patterns within this space as belonging either to one or another of two categories in effect requires the subject to impose a digital code upon an analog system.

We were concerned with three possible models of how subjects could accomplish this task. One model, the Exemplar Model, says the subject stores a unique description of each exemplar along with the associative bond corresponding to name of the category to which it belongs. In this model, the subject recognizes a new pattern by comparing it, either serially or in parallel, with all of the stored exemplars. If, on the average, the test pattern is closer to the exemplars representing category A, he classifies it as an A; otherwise as a B.

The second model, the Prototype Model, is based on the findings of Posner and Keele. This model says that, during learning or later, the subject will construct a composite figure or surrogate pattern (the prototype) based upon the central tendency of all exemplars for that category. In this case, when presented with a test pattern, the subject need retrieve and compare it to the surrogate of each category. Such a strategy could achieve considerable economy, especially if there were many exemplars and if comparisons were done serially.

The third model, the Rule Model, sees the subject abstracting a rule for classifying the patterns based upon the dimensions on which they vary. He might learn during acquisition or the test phase that all exemplars of A are taller than they are wide. In this case, he need not retrieve either

stored exemplars or prototypes when confronted with a test pattern. Instead, he need only determine if the pattern is taller than it is wide; if yes, then he classifies it as an A; if no, he classifies it as a B.

Our original expectations were that subjects, in fact, use strategies consistent with all three models, but each model is more appropriate at different stages of mastering the pattern task. At the earliest stage of learning, especially when first presented with an exemplar, we felt that the subject would have to rely on a process implied by the Exemplar Model. At a somewhat later stage, especially when there were several exemplars, we felt that the Prototype Model would become appropriate. And, finally, especially during the testing phase in which a large variety of patterns would emphasize the dimensions of variation, the Rule Model might become dominant.

As can be expected, the Exemplar Model and the Prototype Model are quite difficult to distinguish. Our results suggest that subjects perform according to one or the other of these models, but no transitions within a subject take place. More clearly, our subjects rarely, if ever, perform according to the Rule Model. This was so even when we told the subjects the rule in advance.

We are currently reanalyzing the data according to a model more in line with statistical decision theory and Thurstonian models of classification. It is clear from both our scaling and pattern recognition data that subjects perceived our patterns as differing from one another along a single dimension within a Euclidean space. The "A's" tend to be skinny (taller than wide) and the "B's" tend to be squat (broader than tall).

A qualitative picture of their behavior would be something like this. A test pattern is located on this dimension. If it is near the border

between category A and category B, the subject will be inconsistent in how he classifies the pattern and he will take a long time to classify it. If the test pattern is not near the border, he will consistently classify as an A or a B depending upon its direction from the border. His speed of classification, however will depend upon how far the test pattern is from the border. If it is moderately far from the border, he will be reasonably fast and accurate. But if it is very far from the border, his speed of classification will begin to slow down again. It is this last fact that makes the Rule Model inapplicable.

What is suggested is a model of this sort. The subject codes the test pattern simultaneously in two ways. He codes it in terms of where it is located on a continuum (analog coding) and he codes it in terms of how close it is to an idealized member of a given class (the prototype). The prototype is a digital code in the sense that it is a discrete region of the space. The classification is digital as well, since it represents a partition of this space.

This work will probably be completed within the next six months.

4.5. Other Inputs: Fagot, Beck, Haller, Hintzman, Reicher, Schaeffer, Wickelgren.

The Final Technical Report for the first four years adequately covers the contributions of the remaining investigators as well as the visiting scholars. These investigators used whatever time they devoted to the present project during its fifth year to finish and write up work already reported in the preceding report. Some new work was initiated by Dr. Jeannette Silveira as followup on her dissertation on incubation in

problem solving. She confirmed some of the results of that dissertation, but failed to come up with any new findings in a series of experiments to see how different methods of instruction would facilitate later problem solving.

Reicher and Illyan initiated some preliminary experiments on reading and comprehension. These provided the basis for a new research proposal to apply findings from the present project to the study of how subjects comprehend instructional materials. Charles Snyder completed his doctoral dissertation on individual differences in imagery. Snyder conducted four experiments in which he related the vividness and controllability aspects of imagery ability to performance in a variety of tasks, including sketching, problem solving, spatial relations, same-different matching, and detection, naming and classification of letters. Controllability of imagery was significantly correlated with sketch quality, problem solution time, scores on a test of space relations, several aspects of letter detection, same-different matching times, and rate of 'mental rotation' in matching and classification tasks. Vividness of imagery was related to sketch quality and to reproduction measures in general.

Carol Conrad also completed her doctoral dissertation during the fifth year. She used the procedure that Warren developed during his dissertation to determine if abstraction continues beyond the point necessary to perform certain tasks. In Conrad's case, she wanted to see if, when words are interpreted in the context of a sentence, the alternative meanings not implied by the context are also looked up. She was able to demonstrate that, in fact, there does seem to be a separate lexical lookup

stage that precedes the disambiguation of a word when it occurs in a sentence. For example, when subjects are confronted with the sentence, "The sailors sailed into the port", they apparently retrieve the meaning of port that refers to "wine" as well as that which refers to the appropriate meaning of "harbor".

5.0. The Automated Laboratory

A full description of the development and current status of our Automated Laboratory was provided in the Final Technical Report for the first four years. In that description we mentioned plans for developing a higher level language called Experiment Writer. Since then, we have perfected and implemented this language so that it is now being used on a routine basis. Graduate students and experimenters who have never learned Fortran or computer programming can now be taught within a matter of hours how to use our Automated Laboratory to set up and run a variety of experiments.

We also have finally cleared all hurdles for renovating the basement of Straub Hall to serve as the new site for the Automated Laboratory. By moving into this new location, we overcome the few remaining hurdles towards making the laboratory a facility that can be used simultaneously and effectively by all the experimental psychologists who have governmental contracts.

6.0. Extensions and Ramifications

The major focus of the five-year project on Coding Systems in Perception and Cognition was on gaining maximal generality of our findings across all the areas of experimental psychology from sensory psychophysics through semantic memory. For the most part, we used stimulus inputs

that were relatively meaningless and confronted our subjects with tasks that required them to focus upon the "medium" rather than the "message". Not only were our stimulus inputs semantically meaningless, they were emotionally neutral as well.

Such constraints were deliberate. They served the purpose of enabling us to isolate subsystems of human processing that cut across a wide variety of tasks. And they provided us with a basis for what we hope is an integrated picture of the human as a general processor of information.

But, by the same token, these constraints limit our generalizability in the sense that we have still to demonstrate that the same processes and codes apply when we place the human in naturalistic settings where the information he must cope with is rich in semantic significance and emotional coloring.

Actually, even before the end of this project, some of the work was moving towards more realistic stimulus inputs and real-life tasks. The work of Schaeffer and Conrad on semantic memory is one example. Hyman and Reicher's preliminary experiments on reading and comprehension is another. Still other cases would be Haller and Reicher's study of high skilled performance such as sight-reading in musicians; Schwank's study of the Oregon electoral ballot; and Silveira's dissertation on incubation in problem solving.

Currently, many of the investigators on the project are engaged in, or making plans for, research that will help to extend and apply our findings to social and practical problems. Keele has been working on

ways to employ our findings in coping with environmental problems such as noise, pollution, crowding and over-population. In our renovated facility at Straub Hall, we have included an environmental room which will be used to study the effects of noise and pollution upon human information processing.

We have already mentioned how Posner has extended the range of applicability by applying our findings to the problem of human thinking and problem solving. We have also mentioned the extension to physiological indices as well as our behavioral indices in our study of attention. Posner's work on attention and alertness has provided one way in which emotional and arousal components are naturally entering into what had up to now been the study of "cold cognition". Indeed, because of our interest in bringing emotional aspects of coding into the picture, we have organized a seminar with our social psychological colleagues on "hot cognition". We have also been using emotionally toned words to study the coding and retrieval aspects of the emotional affect as well as the cognitive content of stimuli.

Along with this, Hyman has completed a series of studies on aesthetic preference as another aspect of pattern recognition and retrieval.

The area of semantic memory is being expanded in a major project to apply our findings to a very practical problem--that of comprehending instructional material. Hyman, Reicher, Schaeffer and Wickelgren have joined together to study this problem. We expect help from the other investigators in the project who are also anxious to see how our findings can be extended to the worlds of reading, education, and related matters.

We have seen other possible applications of our work being developed. A doctoral dissertation by Karen Boise used our apparatus and matching procedures to compare brain-damaged patients with normals. The results are promising in enabling us to pinpoint the nature of the deficit in terms of isolable subsystems that we have been studying.

7.0. ARPA Articles Cross Referenced by Key Words (prepared by Jacelyn Heddel).

The following Key Word List is intended only as a guide, not as a complete listing of all relevant terms. Contents of articles, as well as titles, were studied to complete the list. A number of terms which would be common to a great number of articles in the bibliography have been deleted. Most efficient use of the list can be accomplished by noting the articles under a number of related terms and referring to those which are listed more than once.

ABSOLUTE JUDGMENT

Stewart, 1969

ABSOLUTE PRODUCTION

Stewart, 1969

ABSTRACT REPRESENTATIONS

Posner, 1972 (c)

ABSTRACTION

Buggie, 1970
 Posner, 1970(a)
 Posner & Keele, 1970
 Schaeffer & Wallace, 1968

ACCURACY

Ells, 1969
 Keele, 1968
 Well, 1969, 1971

ACOUSTIC CODING

Posner, 1972(c)
 Posner & Taylor, 1969
 Reicher, Ligon, & Conrad, 1969

ADDITIVE SCALING AXIOMS

Adams, Fagot, & Robinson, 1970
 Fagot & Stewart, 1969(a)

ALERTNESS

Posner, 1971(b)
 Posner & Boies, 1971
 Posner & Keele, in press

AMBIGUITY

Attneave, 1971
 Conrad, 1972(b)

ANALOG OPERATIONS

Buggie, 1970
 Posner, 1970(a)

ANGLE

Attneave & Frost, 1969

ANTICIPATION

Adams, Submitted
 Eichelman, 1970(c)
 Hyman & Umilta, 1969
 Posner & Keele, in press
 Umilta, Snyder & Snyder, 1972

APPARATUS

Attneave, 1969
 Attneave & Frost, 1969
 Lewis, Boies, & Osgood, 1971

APPARENT PLANE OF REVERSAL (A.P.R.)

Olson, 1970(a)

ARCHIMEDIAN ASSUMPTIONS

Adams, Submitted
 Adams, Fagot, & Robinson, 1970

ARTICULATORY FEATURES

Wickelgren, in press(b)

ASSIMILATION

Stewart, 1969

ASSOCIATIONS

Attneave, 1969
 Hintzman, 1972
 Hintzman, Block & Summers, Submitted
 Posner, 1972(c)
 Schaeffer & Wallace, 1968, 1969

ATTENTION

Posner, 1971(b)
Posner & Boies, 1971

ATTENTION DEMANDS

Ellis, 1969
Keele, 1968,1970,1972

Posner, 1972(c)
Posner, Boies, Eichelman,
& Taylor, 1969

Posner & Keele, 1969, In Press
Posner & Warren, 1972

ATTENTION, DIVIDED

Atwood, 1969, 1971
Keele, 1968
Lewis, 1970(b)
Schaeffer & Wallace, 1970(b)

ATTENTION, MANIPULATION OF

Posner, 1970(a)

ATTENTION, REDUCED

Posner, 1969(b)
Posner, Boies, Eichelman,
& Taylor, 1969

ATTENTION, SELECTIVE

Beck & Ambler, 1972
Hintzman, Carre et.al, in press
Lewis, 1970 (a),(b)
Posner, 1971(b)
Posner & Boies, 1971

ATTENTIVE, PRE-V.S. FOCAL

Beck & Ambler, 1972
Beller, 1970(a)
Eichelman, 1970(a)
Snyder, 1972(b)

ATTENUATION

Lewis, 1970(a),1970(b)

ATTRIBUTE LEARNING

Schaeffer & Wallace, 1968

AUDITORY CODES

Posner, 1970(a),1972(c)
Posner, Lewis, & Conrad, 1972
Warren, 1970

AUDITORY FEATURES

Wickelgren, In press(b)

AUDITORY PERCEPTION

Atwood, 1969,1971
Lewis, 1970(a)

AUTOMATION

Posner, 1969(b)
Posner, Boies, Eichelman
& Taylor, 1969
Posner & Keele, In press

BIAS

Fagot & Stewart, 1970(b)

BINOCULAR VISION

Attneave & Frost, 1969

BISECTION

Adams, Fagot & Robinson, 1970
Fagot & Stewart, 1970(b)

BISENSORY TASK

Lewis, In press

BRIGHTNESS

Fagot, & Stewart, 1969(a),1969(b)
1970(a)

Fagot, Stewart & Kleinknecht,
Submitted
Johnson, 1968
Kleinknecht, 1971
Murdoff, 1971

BUFFER

Attneave & Frost, 1969
Beck & Ambler 1972
Posner, 1970(a)
Posner & Boies, 1971
Posner & Klein, 1972
Posner & Warren, 1972

CAPACITY, LIMITED

Posner, 1969(b), 1972(b)
Posner, & Boies, 1971
Posner, Lewis & Conrad, 1972
Posner & Warren, 1972
Schaeffer & Wallace, 1970(b)

CAPACITY, PROCESSING

Boies, 1971
Posner & Boies, 1971
Posner, Lewis & Conrad, 1972
Schaeffer & Wallace, 1970(b)

CARTESIAN COORDINATE SYSTEM

Attneave & Frost, 1969
Frost, R. 1971
Olson, 1970(a), 1970(b)

CATEGORY

Conrad, 1971, 1972(a), 1972(b)
Posner, 1970(b)
Warren, 1970, 1972
Well, 1969, 1971

CATEGORY FORMATION

Posner, 1969(a)
Schaeffer & Wallace, 1968, 1969

CENTRAL PROCESSOR

Posner & Boies, 1971
Posner & Keele, In press 1972

CHANNELS

Lewis, 1970(a)
Warren, 1968

CHESS MASTERS' CODES

Reicher, Haller & Aitken, Submitted

CHOICE REACTION TIME

Umiltà, Frost & Hyman, 1972

CLASSIFICATION

Boies, 1971
Well, 1969, 1971

CLOSED LOOP

Posner & Keele, In press

CLUSTERING

Frost, N. 1970, 1971(a), 1971(b)
In press
Hintzman, Block & Inskip, In press

CODES ACOUSTIC

Posner, 1972(c)
Posner & Taylor, 1969
Reicher, Ligon, & Conrad, 1969

CODES, AUDITORY

Posner, 1970(a), 1972(c)
Posner, Lewis & Conrad, 1972
Warren, 1968

CODES, CHESS MASTERS'

Reicher, Haller & Aitken, Submitted

CODES, COLOR

Beller, 1970(b)
Conrad, 1972(b)
Warren, 1970, 1972

CODES, COORDINATION OF

Posner, 1972(c)

Posner, 1970(a),1972(c)
Posner, & Boies, 1971
Posner & Taylor, 1969
Posner & Warren, 1972CODES, KINESTHETICKeele, 1968
Posner, 1972(c)
Posner & Keele, 1969, In pressCODES, RESPONSE

Wallace, 1971

CODES, MULTIPLEConrad, 1972(b)
Posner, 1972(c)
Posner & Taylor, 1969
Warren, 1970, 1972CODES, SEMANTICConrad, 1971,1972(a),1972(b)
Frost, N.,1971(b),In press
Schaeffer & Wallace, 1969,1970CODES, NAMEBeller, 1970(b),1971
Boies, 1969,1971
Buggie, 1970
Frost, N. 1970,1971(a),1971(b)
In press
Posner, 1970(a),1970(b)
Posner & Boies, 1971
Posner, Boies, Eichelman,
& Taylor, 1969
Posner, Lewis & Conrad, 1972
Posner & Taylor, 1969
Posner & Warren, 1972
Snyder, 1972(b)
Turnbull, 1971
Warren, 1970,1972CODES, SHAPE

Attneave & Frost, 1969

CODES, SINGLE vs MULTIPLE

Posner, 1972(c)

CODES, SPATIALAttneave, 1969
Attneave & Frost, 1969
Frost, N., 1971(b),In press
Laabs, 1971
Posner & Keele, In press
Posner & Warren, 1972
Snyder, 1972(a)
Wallace, 1970, 1971CODES, PARTIAL

Beller, 1971

CODES, SYMBOLICBeller, 1970(b)
Schaeffer & Wallace, 1968CODES, PERCEPTUALAttneave & Frost, 1969
Hintzman,Block & Inskip, In press
Johnson, 1968CODES, TRANSLATION OFPosner, 1972(c)
Posner, Lewis & Conrad, 1972
Rogers, 1972CODES, PHONETIC

Wickelgren, In press (b)

CODES, VISUALAttneave, 1969
Beck & Ambler, 1972
Boies, 1969,1971
Buggie, 1970
Conrad, 1972(b)
Frost, N., 1970,1971(a),1971(b),
In pressCODES, PHYSICALBeller, 1971
Boies, 1969,1971

Posner, 1970(a),1970(b),1972(c) COMPATIBILITY, S-R

Posner, Boies, Eichelman
& Taylor, 1969

Posner & Keele, 1969

Posner, Lewis & Conrad, 1972

Posner & Taylor, 1969

Posner & Warren, 1972

Rogers, 1972

Snyder, 1970

Turnbull, 1971

Warren, 1968

Posner & Keele, 1972

Umilta, Snyder & Snyder, 1972

Wallace, 1970, 1971

Well, 1969,1971

COMPETITION, S-R

Umilta, Snyder & Snyder, 1972

COMPLEXITY

Johnson, 1968

COMPREHENSION

Conrad, 1972(b)

Posner, 1969(a)

CODING, CONTEXT SENSITIVE

Wickelgren, In press (a)

CODING, EFFICIENT

Conrad, 1972(a)

Reicher, Haller & Aitken, Submitted

COMPUTER EQUIPMENT

Lewis, Boies & Osgood, 1971

CODING PROCESSES

Atwood, 1969,1971

CONCEPT IDENTIFICATION

Posner, 1969(a)

Schaeffer & Wallace, 1968

CODING SYSTEMS

Conrad, 1972(b)

Schaeffer & Wallace, 1968

CONCEPTS

Posner, & Warren, 1972

Reicher, Haller & Aitken, submitted

Schaeffer & Wallace, 1968, 1970(a)

Wickelgren, In Press (a),(b)

COGNITION

Conrad, 1972(a)

Posner, 1971(a),1972(b),1972(c)

CONDENSATION

Keele, 1970

COLOR CODES

Beller, 1970(b)

Conrad, 1972(b)

Warren, 1970,1972

CONFIDENCE RATING

Hintzman, In press

COMPARISON

Posner, 1970(a)

Posner & Keele, 1972

Schaeffer & Wallace, 1970(a)

CONFUSIBILITY

Rogers, 1972

Snyder, 1972(a)

COMPATIBILITY, SPATIAL

Attneave & Frost, 1969

Posner & Keele, In press

CONJOINT MEASUREMENT

Adams, Fagot & Robinson, 1972

CONJUNCTION

Schaeffer & Wallace, 1968

CONSOLIDATIONAdams, Submitted
Wickelgren & Berian, 1971CONSTANCYAttneave, 1971
Frost, R., 1971
Olson, 1970(b)CONSTANT BRIGHTNESS

Fagot & Stewart, 1969(a), 1970(a)

CONTEXTConrad, 1972(b)
Hintzman, Block & Summers, SubmittedCONTEXT-SENSITIVE CODING

Wickelgren, In press (a)

CONTEXTUAL CUES

Hintzman, Block & Summers, Submitted

CONTROLLABILITY

Snyder, 1972(a)

CONVERGENCE

Frost, R., Submitted

CREATIVITY

Silveira, 1971

CROSS-MODALITY

Attneave, 1969

CUES, CONTEXTUAL

Hintzman, Block & Summers, Submitted

CUES, MOTORLaabs, 1971
Posner, 1969(b)CUES, MULTIPLE

Laabs, 1971

CUES, SENSORY

Snyder, 1972(b)

CUES TO FORGET

Block, 1970

DATA EQUIVALENCEAdams, Submitted
Adams, Fagot & Robinson, 1970DECAYPosner, 1970(a)
Warren, 1968
Wickelgren & Berian, 1971DECISION UNIT

Schaeffer & Wallace, 1970(a)

DECISIONS, SKILLED PERFORMANCE

Posner & Keele, 1969

DECISIONS, TIME

Keele, 1970

DELAYBeck & Ambler, 1972
Boies, 1969
Posner, 1970(a)
Posner & Keele, 1970
Wickelgren & Norman, 1971

DEPTH PERCEPTION

Attneave, 1971
Olson, 1970(a)

DICHOTIC LISTENING

Lewis, 1970(a),1970(b)

DIFFERENCE

Beck & Ambler, 1972
Eichelman, 1970(a)
Schaeffer & Wallace, 1968

DIFFERENCE JUDGMENTS

Fagot & Stewart, 1969(b)

DIFFERENTIATION

Block, 1970,1971

DIMENSIONS

Schaeffer & Wallace, 1968,1969
Snyder, 1972(b)
Warren, 1970,1972
Well, 1969,1971

DIRECTIONAL UNCERTAINTY

Ells, 1969

DISCRIMINABILITY

Beck & Ambler, 1972
Eichelman, 1970(a)
Schaeffer & Wallace, 1968
Well, 1969,1971

DISCRIMINATION,LIST

Hintzman, Block & Summers,
Submitted
Hintzman & Waters, 1969,1970

DISTANCE

Laabs, 1971

DISTRACTION

Schwank, In preparation

DUAL TRACE THEORY

Wickelgren & Berian, 1971

DURATION JUDGMENTS

Hintzman, 1970

EEG

Posner & Keele, In press

EFFICIENT CODING

Conrad, 1972(a)
Reicher, Haller & Aitken,
Submitted

ELECTION BALLOTS

Schwank, 1971

ELEMENT

Schaeffer & Wallace, 1970(a)

ENCODING

Frost, N., 1971(b),In press
Posner & Boies, 1971
Posner & Klein, 1972
Posner & Warren, 1972
Warren, 1970,1972

ENCODING, LIMITS OF

Beller, 1970(b)

EQUIVALENCE

Schaeffer & Wallace, 1968

ERASURE

Block, 1970,1971

EXHAUSTIVE COMPUTATION HYPOTHESIS

Conrad, 1972(b)

EXPOSURE DURATION, EFFECTS OFHintzman, 1970
Posner & Klein, 1972EXTENSIVE MEASUREMENT

Adams, Fagot & Robinson, 1970

FACILITATION

Wallace, 1970,1971

FAMILIARITYAttneave, 1971
Eichelman, 1970(b)
Posner, 1970(a)
Posner, Lewis & Conrad, 1972
Snyder, 1970FEATURE ANALYSIS

Eichelman, 1970(a)

FEATURE EXTRACTION

Buggie, 1970

FEEDBACKElls, 1969
Keele, 1968
Posner & Keele, 1969, In press
Stewart, 1969FIGURE-GROUND REVERSAL

Attneave, 1971

FIGURAL UNITY

Atwood, 1969,1971

FILTERBeller, 1970(b)
Lewis, 1970(a),1970(b)Posner, 1970(a)
Well, 1969,1971FITTS' LAWKeele, 1968
Posner & Keele, 1969, In pressFOREPERIOD

Posner & Keele, In press

FORGETTINGBlock, 1970,1971
Hughes, 1970
Posner & Keele, 1969, In press
Wickelgren & Norman, 1971FRACTIONATION

Kleinknecht, 1971

FREE RECALLFrost, N., 1970,1971(a),1971(b),
In press
Hintzman, In press
Hintzman & Block, Submitted
Hintzman, Block & Inskip,
In press
Hintzman, Block & Summers,
Submitted
Hintzman, Carre, et.al., In press
Hughes, 1970FREQUENCY, JUDGMENT OFAttneave, In press
Hintzman, 1970
Hintzman & Block, 1970,1971FUNCTIONS, HALF-JUDGMENT

Fagot & Stewart, 1969(a)

FUNDAMENTAL MEASUREMENTAdams, Submitted
Adams, Fagot & Robinson, 1970

GATING

Posner, 1970(a)
Well, 1969,1971

GENERALIZATION

Buggie, 1970

GENERATION

Boies, 1969,1971
Posner, 1970(a),1972(c)
Posner, Lewis & Conrad, 1972
Rogers, 1972

GIBSON FIGURES

Posner, 1970(a)

GRAMMAR

Hughes, 1970

GROUPING

Beck & Ambler, 1972
Frost, N., 1971(b).In press
Olson, 1970(b)

HALF-JUDGMENT FUNCTIONS

Fagot & Stewart, 1969(a)

HEMISPHERIC EFFECTS

Posner, Lewis & Conrad, 1972
Umiltà, Frost & Hyman, 1972

HICK-HYMAN LAW

Hyman & Umiltà, 1969
Posner & Keele, 1969

HIERARCHY

Conrad, 1971,1972(a)
Posner & Warren, 1972
Schaeffer & Wallace, 1970(a)

ICONIC BUFFER

Attneave & Frost, 1969
Beck & Ambler, 1972
Posner, 1970(a)
Posner & Boies, 1971
Posner & Klein, 1972
Posner & Warren, 1972

IMAGERY

Attneave, 1969
Atwood, 1969,1971
Buggie, 1970
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Silveira, 1971

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Snyder, 1972(a)

INFERENCE

Reicher, Haller & Aitken,
Submitted

INFORMATION HYPOTHESIS

Hyman & Umiltà, 1969

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Silveira, 1971

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Block, 1971
Buggie, 1970
Frost, N., 1971(b), In press

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Fagot & Stewart, 1969(a)
Kleinknecht, 1971

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Atwood, 1969, 1971
Conrad, 1972(b)
Hintzman, Carre et.al., In press
Hughes, 1970
Keele, 1972
Laabs, 1971
Lewis, 1970(a), 1970(b)
Posner, 1972(c)
Posner & Boies, 1971
Posner, Boies, Eichelman &
Taylor, 1969
Posner & Keele, 1969, In press
Posner & Klein, 1972
Posner, Lewis & Conrad, 1972
Reicher, Ligon & Conrad, 1969
Schaeffer & Hallace, 1970(b)
Wallace, 1970, 1971
Warren, 1970, 1972
Well, 1969, 1971

INTERFERENCE, INTERLIST

Hintzman, Block & Summers,
Submitted
Reicher, Ligon & Conrad, 1969

INTERHEMISPHERIC EFFECTS

Posner, Lewis & Conrad, 1972
Umiltà, Frost & Hyman, 1972

INTERRUPTION

Silveira, 1971

INTERSTIMULUS INTERVAL (ISI)

Johnson, 1968

INTERVAL JUDGMENTS

Fagot & Stewart, 1969(b)
Fagot, Stewart & Kleinknecht,
Submitted

INTERVAL MEASUREMENTS

Adams, Fagot & Robinson, 1970

INTERVAL SCALING

Fagot, Stewart & Kleinknecht,
Submitted

INVARIANCE

Attneave, 1969
Attneave & Olson, 1971
Frost, R., 1971

IRRELEVANT INFORMATION

Atwood, 1969, 1971
Beller, 1970(b)
Keele, 1972
Well, 1969, 1971

ISOLABLE SUBSYSTEMS

Conrad, 1972(h)
Posner, 1972(c)
Posner, Lewis & Conrad, 1972

JUDGMENTS, ABSOLUTE

Stewart, 1969

JUDGMENTS, BRIGHTNESS

Fagot & Stewart, 1969(a), 1969(b),
1970(a)
Fagot, Stewart & Kleinknecht,
Submitted
Kleinknecht, 1971
Murdoff, 1971

JUDGMENTS, DIFFERENCE

Fagot & Stewart, 1970(a)

JUDGMENTS, DURATION

Hintzman, 1970

JUDGMENTS, FREQUENCY

Hintzman, 1970, In press
Hintzman & Block, 1970, 1971

JUDGMENTS, INTERVAL

Fagot & Stewart, 1969(b)
Fagot, Stewart & Kleinknecht,
Submitted

JUDGMENTS, LIST MEMBERSHIP

Hintzman & Block, Submitted
Hintzman, Block & Summers,
Submitted

JUDGMENTS, MAGNITUDE

Fagot, & Stewart 1969(a), 1969(b)
1970(a)
Fagot, Stewart & Kleinknecht,
Submitted

JUDGMENTS, PATTERN

Posner, 1970(a)

JUDGMENTS, POSITION

Hintzman, Block & Summers,
Submitted

JUDGMENTS, RATIO

Fagot & Stewart, 1969(b)
Fagot, Stewart & Kleinknecht,
Submitted
Kleinknecht, 1971

JUDGMENTS, RECENCY

Hintzman & Block, Submitted

JUDGMENTS, SAME-DIFFERENT

Boies, 1969, 1971
Eichelman, 1968, 1970(a)
Johnson, 1968
Posner, 1970(a), 1970(b)
Posner, Lewis & Conrad, 1972
Rogers, 1972
Schaeffer & Wallace, 1968, 1970(a),
1970(b)

Taylor, 1968, 1969(a), 1969(b)

JUDGMENTS, SIMILARITY

Schaeffer & Wallace, 1969

JUDGMENTS, SLANT

Attneave & Frost, 1969

KINESTHETIC CODES

Keele, 1968
Posner, 1972(c)
Posner & Keele, 1969, In press

KINESTHETIC CONTROL

Keele, 1968
Posner, 1969(b)

KINESTHETIC INFORMATION

Attneave, 1969
Keele, 1968
Laabs, 1971
Posner & Keele, In press

KINESTHETIC MEMORY

Keele, 1968
Keele & Ellis, In press
Laabs, 1971
Posner & Keele, 1969

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Conrad, 1972(b)
Posner, 1972(h)
Posner, Lewis & Conrad, 1972

LEARNING, ATTRIBUTE

Schaeffer & Wallace, 1968

LEARNING, INCIDENTAL

Hintzman & Block, Submitted

LEARNING, RULE

Schaeffer & Wallace, 1968

LEARNING, TRANSFER OF

Schaeffer & Wallace, 1968

LETTER MATCHING

Boies, 1969, 1971
 Buggie, 1970
 Eichelman, 1968, 1970(b), 1970(c)
 Posner, 1970(a), 1970(b)
 Posner & Boies, 1971
 Posner & Klein, 1972
 Posner & Warren, 1972
 Turnbull, 1971

LEXICON

Conrad, 1972(b)
 Wickelgren, In press (a)

LIMITATIONS

Posner & Keele, In press
 Posner & Klein, 1972

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Conrad, 1971, 1972(a), 1972(b)
 Hughes, 1970
 Schaeffer & Wallace, 1968, 1969,
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LIST DISCRIMINATION

Hintzman, Block & Summers
 Submitted
 Hintzman & Waters, 1969, 1970

LIST MEMBERSHIP, JUDGMENTS OF

Hintzman & Block, Submitted
 Hintzman, Block & Summers,
 Submitted

LISTENING, DICHOTIC

Lewis, 1970(a), 1970(b)

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Atwood, 1969, 1971

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Attneave, 1969
 Attneave & Olson, 1971
 Laabs, 1971
 Posner & Keele, In press

LOGOGEN MODEL

Schaeffer & Wallace, 1970(a)

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Lewis, 1970(a)
 Posner, 1972(c)
 Posner & Warren, 1972
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LONG TERM MEMORY (LTM)

Belder, 1971
 Boies, 1971
 Conrad, 1971, 1972(a), 1972(b)
 Hintzman, 1970, 1972
 Hintzman & Block, 1970, 1971,
 Submitted
 Hintzman, Block & Inskip, In
 press
 Hintzman, Block & Summers,
 Submitted
 Hintzman & Waters, 1969, 1970
 Keele, 1969, 1972
 Posner, 1970(a)
 Posner, Boies, Eichelman,
 & Taylor, 1969
 Posner & Keele, 1970
 Posner & Warren, 1972
 Schaeffer & Wallace, 1968, 1969, 1970(a)
 Wickelgren & Derian, 1971

LUMINANCE

Fagot & Stewart, 1969(a), 1970(a)

MAGNITUDE, JUDGMENTS OF

Fagot & Stewart, 1969 (b)
1970(a), 1970(b)
Fagot, Stewart & Kleinknecht,
Submitted

MAP SEARCH INDEX (MSI)

Beller, 1970(b)

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Beck & Ambler, 1972

MASTER

Reicher, Haller & Aitken,
Submitted

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Beller, 1970(a), 1970(b), 1971
Boies, 1969, 1971
Buggie, 1970
Eichelman, 1968, 1970(b), 1970(c)
Murdoff, 1971
Posner, 1970(a), 1970(b), 1972(c)
Posner & Boies, 1971
Posner & Klein, 1972
Posner & Taylor, 1969
Posner & Warren, 1972
Snyder, 1972(a)
Taylor, 1969(b)
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MEANING

Conrad, 1972(b)
Posner, Lewis & Conrad, 1972
Schaeffer & Wallace, 1969, 1970(a)
1970(b)

MEANINGFULNESS

Reicher, 1969

MEASUREMENT

Adams, Fagot & Robinson, 1970
Fagot & Stewart, 1969(a), 1969(b),
1970(a), 1970(b)

Fagot, Stewart & Kleinknecht, Submitted

MEDIA

Attneave & Olson, 1971

MEMORY CODES

Conrad, 1971, 1972(a)
Frost, N., 1971(b), In press
Hintzman, Block & Summers, Submitted
Posner, 1972(c)
Posner & Keele, 1969
Schaeffer & Wallace, 1970(a), 1970(b)

MEMORY, KINESTHETIC

Keele, 1968
Keele & Ellis, In press
Laabs, 1971
Posner & Keele, 1969, In press

MEMORY, LONG TERM (LTM)

Beller, 1971
Boies, 1971
Conrad, 1971, 1972(a), 1972(b)
Hintzman, 1970, 1972
Hintzman & Block, 1970, 1971,
Submitted
Hintzman, Block & Inskip
In press
Hintzman, Block & Summers, Submitted
Hintzman & Waters, 1969, 1970
Keele, 1969, 1972
Posner, 1970(a)
Posner, Boies, Eichelman, & Taylor,
1969
Posner & Keele, 1970
Posner & Warren, 1972
Schaeffer & Wallace, 1968, 1969, 1970(a)
Wickelmaier & Berian, 1971

MEMORY, LONG TERM VISUAL

Frost, N., 1971(b), In press

MEMORY ORGANIZATION

Conrad, 1971, 1972(a), 1972(b)
Frost, N., 1971(b), in press
Schaeffer & Wallace, 1969, 1970(a)

MEMORY RETRIEVAL

Atwood, 1969, 1971
 Conrad, 1971, 1972(a), 1972(b)
 Frost, N., 1971(b), In press
 Hintzman & Block, Submitted
 Hintzman, Block & Summers, Submitted
 Keele, 1969, 1970, 1972
 Posner, 1970(a), 1972(c)
 Posner & Taylor, 1969
 Posner & Warren, 1972
 Schaeffer & Wallace, 1969,
 1970(a), 1970(b)
 Wickelgren & Berian, 1971

MEMORY, SEMANTIC

Conrad, 1971, 1972(a), 1972(b)
 Frost, N., 1971(b), In press
 Hughes, 1970
 Lewis, 1970(a), 1970(b)
 Schaeffer & Wallace, 1970(a)

MEMORY, SHORT TERM (STM)

Beller, 1971
 Block, 1970, 1971
 Hughes, 1970
 Johnson, 1968
 Laabs, 1971
 Reicher, Ligon & Conrad,
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 Stewart, 1969
 Taylor, 1968, 1969(a)
 Warren, 1968
 Wickelgren & Berian, 1971
 Wickelgren & Norman, 1971

MEMORY TRACES

Posner & Warren, 1972
 Wickelgren & Berian, 1972

MEMORY, VISUAL

Atwood, 1969, 1971
 Beck & Ambler, 1972
 Boies, 1969
 Frost, N., 1970, 1971(a), 1971(b),
 In press
 Lewis, 1970(a)
 Rogers, 1972
 Wickelgren & Norman, 1971

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Schwank, In preparation

MINIMUM PRINCIPLE

Attneave, 1971
 Attneave & Frost, 1969

*MEMONIC SYSTEM

Atwood, 1969, 1971

MODALITY EFFECTS

Attneave, 1969
 Hintzman, Block & Inskien,
 In press
 Keele, 1970
 Lewis, 1970(a)
 Warren, 1968

MONOCULAR VISION

Attneave & Frost, 1969
 Olson, 1970(a)

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Schwank, In preparation

MORPHORIC PROPERTIES

Attneave & Olson, 1971

MOTOR CUES

Laabs, 1971
 Posner, 1969(b)

MOTOR PERFORMANCE

Keele, 1968
 Laabs, 1971
 Posner & Keele, 1969, In press

MOTOR PROGRAM

Posner & Keele, 1969, In press

MOTOR SET

Posner & Keele, In press

MOTOR SKILLS

Ells, 1969
 Posner, 1969(b)
 Posner & Keele, 1969, In press

MOVEMENTS, ACCURACY OF

Ells, 1969
 Keele, 1968
 Posner & Keele, 1969, In press

MOVEMENTS, ATTENTION DEMANDS OF

Ells, 1969
 Posner, 1969(b)
 Posner, Boies, Eichelman, &
 Taylor, 1969
 Posner & Keele, 1969, In press

MOVEMENTS, CONTROL OF

Ells, 1969
 Keele, 1968
 Posner & Keele, In press

MOVEMENTS, EXECUTION OF

Ells, 1969
 Posner & Keele, In press

MOVEMENTS, MEMORY FOR

Laabs, 1971
 Posner, 1969(b)
 Posner, Boies, Eichelman &
 Taylor, 1969
 Posner & Keele, 1969

MOVEMENTS, SKILLED

Posner, 1969(b)
 Posner & Keele, 1969, In press

MOVEMENTS, SPEED

Keele, 1968
 Posner & Keele, In press

MULTIPLE CODES

Conrad, 1972(b)
 Posner, 1972(c)
 Posner & Taylor, 1969
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MULTIPLE CUES

Laabs, 1971

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Keele, 1970
 Posner, 1970(a), 1972(c)
 Posner & Taylor, 1969
 Umiltà, Frost & Hyman, 1972

MULTISTABILITY

Attneave, 1971

MULTITRACE THEORY

Hintzman, & Block, 1971
 Wickelgren & Berian, 1971

MUSIC

Attneave & Olson, 1971
 Reicher, Haider & Aitken,
 Submitted

NAME CODE

Beller, 1970(b), 1971
 Boies, 1969, 1971
 Buggie, 1970
 Frost, N., 1970, 1971(a), 1971(b)
 In press
 Posner, 1970(a), 1970(b)
 Posner & Boies, 1971
 Posner, Boies, Eichelman &
 Taylor, 1969
 Posner, Lewis & Conrad, 1972
 Posner & Taylor, 1969
 Posner & Warren, 1972
 Snyder, 1972(b)
 Turnbull, 1971
 Warren, 1970, 1972

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Buggie, 1970

NONPARAMETRIC SCALABILITY

Fagot & Stewart, 1970(b)

NUMERICAL RESPONSE METHODS

Fagot & Stewart, 1969(b)
 Fagot, Stewart & Kleinknecht,
 Submitted

OPEN LOOP

Posner & Keele, in press

ORGANIZATION

Conrad, 1971, 1972(a)
 Frost, N., 1970, 1971(a)
 Schaeffer & Wallace, 1969, 1970(a),
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Buggie, 1970
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PARALLEL PROCESSES

Beller, 1970(a)
 Frost, N., 1971(b), In press
 Hintzman, Carre, et. al., In press
 Johnson, 1968
 Posner, 1970(a), 1972(c)
 Posner & Boies 1971
 Posner, Lewis & Conrad, 1972
 Posner & Taylor, 1969
 Posner & Warren, 1972
 Reicher, 1969
 Wickelgren, In press (a)

PARTIAL CODES

Beller, 1971

PARTIAL REPORT

Snyder, 1972(b)

PATTERN JUDGMENTS

Posner, 1970(a)

PATTERN RECOGNITION

Buggie, 1970
 Posner, 1970(a), 1972(b)
 Posner & Keele, 1970

PERCEPTION

Attneave, 1969, 1971, In press
 Attneave & Frost, 1969
 Attneave & Olson, 1971
 Beck & Ambler, 1972
 Eichelman, 1970(a)
 Fagot & Stewart, 1969(a), 1969(b),
 1970(a)
 Fagot, Stewart & Kleinknecht,
 Submitted
 Frost, R., 1971, Submitted
 Johnson, 1968
 Kleinknecht, 1971
 Murdoff, 1971
 Olson, 1970(a), 1970(b)
 Posner, 1971(b), 1972(b)
 Posner & Warren, 1972

PERCEPTION AND IMAGERY

Posner 1972(c)

PERCEPTION, DEPTH

Attneave, 1971
 Olson, 1970(b)

PERCEPTION, SPACE

Attneave, 1971
 Attneave & Frost, 1969
 Frost, R., 1971
 Olson, 1970(b)

PERCEPTUAL CODES

Attneave & Frost, 1969
 Hintzman, Block & Inskip, In press
 Johnson, 1968

PERCEPTUAL UNITS

Johnson, 1968

PFANZALGEL'S MEASUREMENT MODELAdams, Fagot & Robinson, 1970
Fagot & Stewart, 1970(b)PHI-LAWFagot & Stewart, 1969(a), 1970(a)
Kleinknecht, 1971PHONETIC CODE

Wickelgren, In press (b)

PHOTOPIC VISION

Fagot & Stewart, 1969(a)

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Posner, 1970(a), 1972(c)
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Posner & Taylor, 1969
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Attneave & Olson, 1971

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SubmittedPOWER FUNCTIONFagot & Stewart, 1969(a), 1969(b)
1970(a)
Kleinknecht, 1971PRACTICEBoies, 1971
Posner & Keele, In pressPRAGMANZAttneave, 1971
Attneave & Frost, 1969PREPARATIONPosner & Boies, 1971
Posner & Keele, In press
Silveira, 1971PREPROCESSINGBuggie, 1970
Schaeffer & Wallace, 1968PRIMACY EFFECTHintzman, Block & Summers,
SubmittedPRIMINGBeller, 1971
Posner & Klein, 1972
Wickelgren, In press(a)PROACTIVE INTERFERENCEBlock, 1970, 1971
Hintzman & Waters, 1969PROBLEM SOLVING

Silveira, 1971

PROCESSING, AUTOMATIC

Posner & Warren, 1972

PROCESSING CAPACITYBoies, 1971
Posner & Boies, 1971
Posner, Lewis & Conrad, 1972
Schaeffer & Wallace, 1970(b)PROCESSING, HIERARCHICALConrad, 1971, 1972(a)
Posner, Lewis & Conrad, 1972
Schaeffer & Wallace, 1969

PROCESSING, LEVELS OF

Posner, 1970(a)

PROCESSING, PARALLEL

Beller, 1970a
 Frost, N., 1971(b), In press
 Hintzman, Carre, et. al., In Press
 Johnson, 1968
 Posner, 1970(a), 1972(c)
 Posner & Boies, 1971
 Posner, Lewis & Conrad, 1972
 Posner & Taylor, 1969
 Posner & Warren, 1972
 Reicher, 1969
 Wickelgren, In press(a)

PROCESSING, SEMANTIC

Lewis, 1970(b)

PROCESSING, UNITS OF

Eichelman, 1968
 Posner, 1970(a)
 Posner, Lewis & Conrad, 1972

PRODUCT SCALING AXIOM

Fagot & Stewart, 1969(b)

PROGRAM CONTROL

Posner & Keele, In press

PROTOTYPE

Posner, 1970(a)
 Posner & Keele, 1970

PSI-LAW

Fagot & Stewart, 1969(a), 1970(a)
 Kleinknecht, 1971

PSYCHOLOGICAL REFRACTORY PERIOD (PRP)

Posner & Keele, IN press

PSYCHOPHYSICAL SCALING

Attneave & Olson, 1971
 Fagot & Stewart, 1969(a), 1969(b)
 1970(a), 1970(b)

Fagot, Stewart & Kleinknecht,
 Submitted
 Kleinknecht, 1971
 Stewart, 1969

RATIO JUDGMENTS

Fagot & Stewart, 1969(b)
 Fagot, Stewart & Kleinknecht,
 Submitted
 Kleinknecht, 1971

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Beller, 1970(a)
 Boies, 1969
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 Eichelman, 1968, 1970(b), 1970(c)
 Ellis, 1969
 Hyman & Umilta, 1969
 Johnson, 1968
 Keele, 1969, 1970
 Lewis, 1970(b)
 Posner, 1969(b), 1970(a), 1972(c)
 Posner & Boies, 1971
 Posner, Boies, Eichelman &
 Taylor, 1969
 Posner & Keele, 1970
 Posner & Klein, 1972
 Posner, Lewis & Conrad, 1972
 Posner & Taylor, 1969
 Posner & Warren, 1972
 Rogers, 1972
 Schaeffer & Wallace, 1968, 1969,
 1970(a)
 Taylor, 1968, 1969(a), 1969(b)
 Umilta, Frost & Hyman, 1972
 Umilta, Snyder & Snyder, 1972
 Warren, 1970, 1972

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Posner, Lewis & Conrad, 1972

RECALL, FREE

Frost, N., 1970,1971(a),1971(b)
 In press
 Hintzman, In press
 Hintzman & Block, Submitted
 Hintzman, Block & Inskip, In
 Press
 Hintzman, Block & Summers,
 Submitted
 Hintzman, Carre, et.al., In
 Press
 Hughes, 1970

REGENCY EFFECT

Hintzman, Block & Summers,
 Submitted
 Hintzman & Waters, 1969,1970
 Umilta, Snyder & Snyder, 1972

REGENCY JUDGMENTS

Hintzman & Block, Submitted

RECEPTORS

Attneave, 1969

RECOGNITION MEMORY

Beller, 1970(a)
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 Buggie, 1970
 Conrad, 1972(b)
 Frost, N., 1971(b), In press
 Hintzman, 1970
 Hintzman, Block & Inskip,
 In press
 Hintzman, Block & Summers,
 Submitted
 Posner, 1970(a)
 Posner & Keele, 1970
 Reicher, 1969
 Reicher, Ligon & Conrad, 1969
 Rogers, 1972
 Snyder, 1972(a)
 Taylor, 1969(b)
 Wickelgren & Berian, 1971
 Wickelgren & Norman, 1971

RECOGNITION, SPEECH

Wickelgren, In press(a), In press (b)

REDUNDANT INFORMATION

Schaeffer & Wallace, 1968

REHEARSAL

Block, 1970, 1971
 Laabs, 1971
 Posner, 1970(a), 1972(c)
 Posner & Boies, 1971
 Warren, 1968

REMINISCENCE

Silveira, 1971

REPETITION

Eichelman, 1970(c)
 Fagot & Stewart, 1970(b)
 Hintzman, 1970
 Hintzman, & Block, 1970,1971
 Submitted
 Hintzman & Waters, 1970
 Posner, & Warren, 1972
 Umilta, Snyder & Snyder, 1972

REPETITION EFFECT

Hyman & Umilta, 1969
 Keele, 1969
 Posner, 1969(b)

REPRESENTATION

Boies, 1971
 Hintzman, Block & Inskip, In press
 Posner, 1970(a)
 Posner & Boies, 1971
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REPRESENTATIONS, ABSTRACT

Posner, 1972(c)

REPRODUCTION

Keele, 1968
 Laabs, 1971
 Posner & Keele, In press

Reicher, Haller & Aitken,
Submitted

REPRODUCTION CODE

Wallace, 1971

RESPONSE BIAS MODEL

Fagot & Stewart, 1970(b)

RESPONSE COMPETITION

Hintzman, Block & Summers,
Submitted
Keele, 1970,1972
Lewis, 1970(a)
Posner & Boies, 1971
Posner & Keele, 1969

RESPONSE PRIMING

Posner & Klein, 1972

RESPONSE SELECTION

Ells, 1969
Keele, 1970
Lewis, 1970(a)
Posner & Boies, 1971
Posner & Keele, 1969

RESPONSE-STIMULUS INTERVAL (RSI)

Eichelman, 1970(c)
Umilta, Snyder & Snyder, 1972

RETENTION

Boies, 1969
Hintzman, Block & Summers,
Submitted
Posner, Boies, Eichelman &
Taylor, 1969
Posner & Keele, 1970, In press

RETRIEVAL

Atwood, 1969, 1971
Conrad, 1971,1972(a),1972(b)

Frost, N., 1971(b), In press
Hintzman & Block, Submitted
Hintzman, Block & Summers,
Submitted
Keele, 1969,1970,1972
Posner, 1970(a),1972(c)
Posner & Taylor, 1969
Posner & Warren, 1972
Schaeffer & Wallace, 1969,1970(a),
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Wickelgren & Berian,1971

RETROACTIVE INTERFERENCE

Block, 1970,1971

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Posner, 1972(c)

RULE LEARNING

Schaeffer & Wallace, 1968

SALIENCE

Schaeffer & Wallace, 1968

SAME-DIFFERENT JUDGMENTS

Boies, 1969,1971
Eichelman, 1968,1970(a)
Johnson, 1968
Posner, 1970(a),1970(b)
Posner, Lewis & Conrad, 1972
Roders, 1972
Schaeffer & Wallace, 1968,1970(a),
1970(b)
Taylor, 1968,1969(a),1969(b)

SCALING

Adams, Fagot & Robinson, 1970
Attneave & Olson, 1971
Fagot & Stewart, 1969(b)
Fagot, Stewart & Kleinknecht,
Submitted
Kleinknecht, 1971

SCHEMA

Atwood, 1969,1971
 Buggie, 1970
 Posner, 1970(a)
 Posner & Keele, 1970
 Posner & Warren, 1972
 Schaeffer, & Wallace, 1968
 Silveira, 1971

SCOTOPIC VISION

Fagot & Stewart, 1969(a)

SEARCH, INTERFERENCE

Posner, 1972(c)

SEARCH, LONG TERM MEMORY

Posner, 1970(a)

SEARCH, VISUAL

Beller, 1970(b)
 Boies, 1971
 Snyder, 1970,1972(b)
 Turnbull, 1971

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Posner, 1971(b)
 Snyder, 1972(b)

SELECTIVE ATTENTION

Beck & Ambler, 1972
 Hintzman, Carre, et.al.,
 In press
 Lewis, 1970(a),1970(b)
 Posner, 1971(b)
 Posner & Boies, 1971

SELECTIVE INTERFERENCE

Atwood, 1969,1971

SEMANTIC CODES

Conrad, 1971,1972(a),1972(b)

Frost, N., 1971(b), In press

SEMANTIC, MEMORY

Conrad, 1971,1972(a),1972(b)
 Frost, N., 1971(b), In press
 Hughes, 1970
 Lewis, 1970(a),1970(b)
 Schaeffer & Wallace, 1970(a)

SEMANTIC SIMILARITY

Lewis, 1970(a)
 Schaeffer & Wallace, 1968,1969,
 1970(b)

SEMANTIC UNITS

Wickelgren, In press (b)

SENSORY BUFFER

Attneave, 1969
 Lewis, 1970(a),1970(b)

SENSORY CUES

Snyder, 1972(b)

SENSORY SET

Posner & Keele, In press

SEPARABILITY

Posner & Boies, 1971

SEQUENTIAL INFORMATION

Posner & Keele, In press

SERIAL POSITION

Hintzman, Block & Summers,
 Submitted

SERIAL PROCESSES

Beller, 1970(a)
 Reicher, 1969
 Wickelaren, In press (a)

SHAPE

Attneave & Frost, 1969
 Frost, N., 1970, 1971(a), 1971(b)
 In press
 Frost, R., Submitted
 Laabs, 1971
 Olson, 1970(a)

SHORT TERM MEMORY (STM)

Beller, 1971
 Block, 1970, 1971
 Highes, 1970
 Johnson, 1968
 Laabs, 1971
 Reicher, Ligon & Conrad, 1969
 Stewart, 1969
 Taylor, 1968, 1969(a)
 Warren, 1968
 Wickelgren & Berian, 1971
 Wickelgren & Norman, 1971

SIGHT READING

Reicher, Haller & Aitken,
 Submitted

SIGNAL DETECTION

Reicher, Ligon, & Conrad, 1969

SIMILARITY

Beck & Ambler, 1972
 Frost, N., 1971(a), In press
 Lewis, 1970(a)
 Olson, 1970(b)
 Posner & Taylor, 1969
 Reicher, Ligon & Conrad, 1969
 Schaeffer & Wallace, 1968
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SIMILARITY JUDGMENTS

Schaeffer & Wallace, 1969

SIMULATION

Posner, 1972(b)

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Beller, 1970(b)

SKILL LEARNING

Posner & Klein, 1972

SLANT

Attneave & Frost, 1969
 Eichelman, 1970(a)
 Frost, R., 1971
 Laabs, 1971

SLOPE

Attneave & Frost, 1969
 Beck & Ambler, 1972
 Olson, 1970(b)

SPACE PERCEPTION

Attneave, In press
 Attneave & Frost, 1969
 Olson, 1970(b)

SPACING, EFFECTS OF

Hintzman & Block, 1970, Submitted

SPATIAL CODING

Attneave, 1969
 Attneave & Frost, 1969
 Frost, N., 1971(b), In press
 Laabs, 1971
 Posner & Keele, In press
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 Snyder, 1972(a)
 Wallace, 1970, 1971

SPATIAL COMPATIBILITY

Attneave & Frost, 1969
 Posner & Keele, In press

SPATIAL OPERATIONS

Buggie, 1970
 Frost, R., 1971
 Laabs, 1971
 Posner, Lewis & Conrad, 1972

SPATIAL REPRESENTATION

Atwood, 1969, 1971
 Posner & Keele, In press

Snyder, 1972(a)

SPEECH PRODUCTION

Wickelgren, In press(a)
Wickelgren, In press (b)

SPEECH RECOGNITION

Wickelgren, In press (a)
Wickelgren, In press (b)

STIMULI, DISTAL

Attneave, 1969

STIMULI, PROXIMAL

Attneave, 1969

STIMULI, UNIDIMENSIONAL

Stewart, 1969

STIMULUS, COMPLEXITY

Johnson, 1968

STIMULUS DISCRIMINATION

Ells, 1969

STIMULUS PREPROCESSING

Buggie, 1970
Schaeffer & Wallace, 1968

STIMULUS, RECALLED VS PERCEIVED

Taylor, 1968,1969(a)

STIMULUS RESPONSE COMPATIBILITY

Posner & Keele, 1972
Umilta, Snyder & Snyder, 1972
Wallace, 1970,1971
Well, 1969,1971

STIMULUS RESPONSE COMPETITION

Umilta, Snyder & Snyder, 1972

STRENGTH

Hintzman & Block, 1971
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Wickelgren & Norman, 1971

STROOP EFFECT

Conrad, 1972(b)
Hintzman, Carre, et.al., In press
Keele, 1972
Posner & Warren, 1972
Warren, 1970,1972

STRUCTURE, DEEP VS SURFACE

Conrad, 1972(b)

STRUCTURE, SPATIAL VS HIERARCHICAL

Conrad, 1971,1972(a)
Posner & Warren, 1972

SUBJECTIVE LEXICON

Conrad, 1972(b)

SUBJECTIVE PROBABILITY MEASURES

Adams, Submitted

SUBTRACTIVE METHOD

Posner & Taylor, 1969

SUPERORDINATE

Posner, 1970(b)

SUPRAORDINATE

Conrad, 1971,1972(a)

SYMBOLIC CODES

Beller, 1970(b)
Schaeffer & Wallace, 1968

SYNTAX

Conrad, 1972(b)

TASK DECISION CRITERION

Schaeffer & Wallace, 1970(a)

TEMPORAL ORDER

Warren, 1968

THRESHOLD PARAMETER

Fagot & Stewart, 1969(a), 1969(b),
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Fagot, Stewart & Kleinknecht,
Submitted
Kleinknecht, 1971

TIME

Snyder, 1972(a)

TIME ENCODING

Hintzman & Block, 1970, 1971,
Submitted

TIME SHARING SYSTEM

Ells, 1969
Lewis, Boies & Osgood, 1971,

TIME TAG

Hintzman & Block, 1971, Submitted

TRACE

Beck & Ambler, 1972
Boies, 1969
Hintzman & Block, 1971
Posner & Warren, 1972

Wickelgren & Berian, 1971

TRACE COLUMN

Hintzman & Block, 1970
Hintzman, Block & Summers,
Submitted

TRACKING

Keele, 1968

TRANSFER

Attneave & Frost, 1969
Schaeffer & Wallace, 1968

TRANSFORMATIONS

Bungie, 1970
Hughes, 1970
Snyder, 1972(a)

TRANSLATION, CODE

Posner, 1972(c)
Posner, Lewis & Conrad, 1972
Rogers, 1972

TRANSPOSITIONS

Attneave & Olson, 1971
Beller, 1970(b)

TRAPEZOIDAL WINDOW ILLUSION

Olson, 1970(a)

TRI-DIMENSIONAL ORIENTATION

Attneave & Frost, 1969
Frost, R., 1971
Olson, 1970(a), 1970(b)

UNCERTAINTY

Ells, 1969
Umiltà, Snyder & Snyder, 1972

UNCONSCIOUS THOUGHT

Silveira, 1971

UNIDIMENSIONAL STIMULI

Stewart, 1961

UNITARY PERCEPTION HYPOTHESIS

Conrad, 1972(b)

UNITS OF PROCESSING

Eichelman, 1968
 Posner, 1970(a)
 Posner, Lewis & Conrad, 1972

VALIDITYFagot, Stewart & Kleinknecht,
SubmittedVARIABILITY

Posner, 1970(a)

VERBAL MEMORY

Conrad, 1971, 1972(a), 1972(b)
 Hintzman, 1970, 1972
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 Hughes, 1970

VIVIDNESS

Snyder, 1972

VISION, SCOTOPIC AND PHOTOPIC

Fagot & Stewart, 1969(a)

VISUAL CODE

Attneave, 1969
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VISUAL IMAGINATION

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VISUAL INFORMATION STORAGE (VIS)

Reicher, 1969
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VISUAL MATCHES

Eichelman, 1968
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VISUAL MEMORY

Atwood, 1969, 1971
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VISUAL SENSORY ANALYSIS

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VISUALIZATION

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WARNING SIGNAL

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8.0 ARPA Bibliography

This bibliography is complete as of December, 1972. Changes are continuously being made in that articles in preparation are being published, submitted articles are accepted, etc. Also, at the time of this writing, many articles are in preparation and some articles may or may not be written depending upon the completion of data analyses and experiments.

The bibliography contains a small proportion of articles that were not directly credited as being sponsored by the present ARPA contracts. Because our investigators sometimes had other contracts or grants which overlapped with the present project, it was sometimes quite arbitrary how the credit for sponsorship was assigned. It was felt that articles published by investigators which were intimately related to the purposes of the project even though at the time they were assigned to other contracts should be included here for completeness.

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