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ABSTRACT

This paper conjectures about motivational, behavioral, and contextual factors in the transferability of vocational skills--factors which will influence performance when and if movement into or across jobs occurs. It is assumed that skill transfer depends upon similarity within and among motivational, contextual, and behavioral factors, referred to as domains. The basic points of view presented about each domain are (1) the motivational domain concerns interests, attitudes, goals, and reinforcers which guide the individual's actions, (2) the behavioral domain concerns the sequence and array of processes through which an individual arrives at measureable end performance having practical utility, and (3) the contextual domain concerns the performance requirements imposed by the environment as well as the organizational, information, and physical support provided. The structure and functioning of each domain is discussed in separate sections. A final section considers the implications for education of current knowledge about skill transfer. Characteristics of educational outcomes which would lend confidence in transferability of skills are defined. Educational implications of conjectures made in the paper are examined through a series of recommended steps for educational development: (1) Define and analyze criterion contexts; (2) develop educational tasks; (3) optimize educational sequences; and (4) optimize conditions of skill acquisition. (LAS)

Information Series No. 103

TRANSFERABILITY OF VOCATIONAL SKILLS:

Review of Literature and Research

James W. Altman

Synectics Corporation
Allison Park, Pennsylvania

The Center for Vocational Education
The Ohio State University
1960 Kenny Road
Columbus, Ohio

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An Interim Report
On a Project Conducted Under
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U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

National Institute
of Education

THE CENTER MISSION STATEMENT

The Center for Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOREWORD

Because many people change jobs, and some do so frequently, future education and work programs have to be concerned with and improve the ability of individuals to make career changes. Under sponsorship by the National Institute of Education, The Center is conducting research and development on questions of what schools should be teaching to all students to improve their chances of adapting to new jobs when a job change is desirable or necessary.

One interim product of this effort is this review of literature and research on the transferability of vocational skills. This summary and discussion serves as one component of a multifaceted R&D effort aimed at identifying the types of personal and job characteristics that previous research has identified as common and potentially transferable from one work situation to another. The review is intended to form the basis for a synthesis of what is presently known about the factors which influence the transferability of vocational skills and the implications of those factors for education.

Published separately but augmenting this review of the transferability of skills, are two other review papers. Though prepared independently, the three papers relate to the common concern for identifying the factors which can facilitate occupational adaptability. One is a review of what is known about the range of occupation-related skills and characteristics that could be considered transferable from one occupation to another. It focuses on describing those transferable skills which are teachable in secondary and post-secondary career preparation programs. The other is a review of what is known about the characteristics of jobs that are considered common. It focuses on various approaches to job classification exploring how they may contribute to a better understanding of occupational adaptability and skill transfer. These and other planned project reports are listed inside the back cover of this report.

The Center expresses its deep appreciation to Dr. Altman for his scholarship in the preparation of the report. Recognition is also due Dr. Douglas Bray, American Telephone and Telegraph; Dr. Keith Goldhammer, Michigan State University; Dr. R. B. Miller, Poughkeepsie, New York; Dr. Edward Morrison, The Center; Dr. Anne Roe, Tuscon, Arizona; Dr. Arthur DeW. Smith, Department of Manpower and Immigration, Ottawa; and Dr. Douglas Sjogren, Colorado State University for their critical review of the manuscript prior to final revision and publication. Special gratitude and appreciation is extended to the project's Panel of Consultants: Dr. Marcia Freedman, Conservation of Human Resources; Dr. Jerome Moss, University of Minnesota; Dr. Calvin Taylor, University of Utah; and to Mr. Robert Stump, National Institute of Education for their help and contributions to the project and throughout the development of this report.

The report was prepared under the general oversight of Dr. Frank C. Pratzner, Director of The Center's study of occupationally transferable skills.

Robert E. Taylor
Director
The Center for Vocational Education

PREFACE

I began preparation of this paper with a number of basic convictions which have been reinforced by review, discussion, and analysis. Somehow, it seems, education for life must derive its objectives and substance from real-world activities. Systems and task analysis methods have appeared to be the best available to date for linking real-world and educational practice. Yet, such methods have seemed inadequate to the purpose in several important ways:

- ✓ Methods for task identification, enumeration, and description are relatively straightforward and adequate—but they require enormous investment of resources for any but the most specific and limited of real-world contexts. The return on investment for non-specific education tends to be very poor.
- ✓ Truly analytic aspects of so-called task analysis have not shown unique utility to drive the definition of significant educational objectives. There is little evidence that results would differ whether or not educational developers went through the motions of applying analytic models.
- ✓ Efforts to derive general taxonomies of tasks have no proven ability to enhance cost/efficiency of task analysis for education.

Despite these deficiencies in our techniques for dealing with task data, two additional considerations underscored the importance of coping with real-world tasks:

- ✓ Task performance is the only generally acceptable basis for inferring skill.
- ✓ Knowledge of task similarity is essential for accurate prediction of skill transfer.

All of the above considerations led to the following emphases:

- ✓ Consistency with the spirit of systems and task analysis while avoiding many of its common mechanics—specifically trying to avoid a requirement for exhaustive identification, enumeration, description, or analysis of tasks.
- ✓ Delineation of a general, though admittedly tentative and gross, framework for:
  - Sampling and characterizing real-world tasks.
  - Organizing educational tasks.

Hopefully, such a framework will:

- Encourage and support serious analysis of real-world requirements without diverting major resources from the creation of responsive educational experience.
- Define educational task similarity in ways that will facilitate positive skill transfer within school, from school to real-world performance, and across real-world contexts.

James W. Altman

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SUMMARY

This paper conjectures about motivational, behavioral, and contextual factors in the transferability of vocational skills. The state of organized reliable knowledge in each domain is found to be rudimentary, at best. Enough hints of the underlying dynamics are garnered to suggest a general approach to educational programming for maximum positive transfer of skills. This approach includes:

- ✓ Explicit definition of the real-world contexts toward which the educational program is oriented.
- ✓ Analysis of relevant contexts in terms of the classes of behavioral elements involved in task performance.
- ✓ Development of educational tasks which reconstruct behavioral elements identified in the real world, but with cost/effective educational programming rather than direct simulation as the central criterion.
- ✓ Sequencing of educational opportunities such that an individual at each stage of his or her educational experience will have demonstrated competency on significant tasks.
- ✓ Arranging the conditions of skill acquisition so that the unique transfer characteristics of perception, intellectual processing, memory, response, and integration of informational/motivational feedback will be realized. Emphasis is given to conditions in all facets and phases of education which include:
  - *Challenge*—opportunity to succeed or fail against known standards.
  - *Fair feedback*—scaled realistically, and contingent upon performance.
  - *Growth*—an increasing individual responsibility for task selection, standards, and self-evaluation.

INTRODUCTION

The purpose of this paper is to conjecture about the factors which influence the transferability of vocational skills and the implications of these factors for education. We mean by vocational skill any capability of a worker to perform a job task. We infer skill transfer from observation of consistent relationships among task performances. We consider transfer to be *positive* when a high level of performance in one instance is associated with enhanced performance on a subsequent instance and to be *negative* when superior performance in a prior instance is associated with subsequent degraded performance.

We are not concerned in this paper with factors that facilitate movement into or across jobs. Rather, our concern is limited to a consideration of factors that will influence performance when and if such movement occurs.

Figure 1 presents a simple model of our general assumptions about the sources of influence on performance, skill, and skill transfer. At the most general level, we assume that skill transfer depends upon similarity within and among motivational, contextual, and behavioral domains. Each domain represents a different point of view from which a given body of skill transfer may be considered:

- ✓ The MOTIVATIONAL domain is concerned with the interests, attitudes, goals, and reinforcers which guide the individual's actions.
- ✓ The BEHAVIORAL domain is concerned with the sequence and array of processes through which an individual arrives at measurable end performance having practical utility.
- ✓ The CONTEXTUAL domain is concerned with the performance requirements imposed by the environment as well as the organizational, information, and physical support provided.

It is part of our fundamental argument that effective analysis of skill transfer requires simultaneous consideration from all three points of view.

We discuss the structure and functioning of each domain in the following three sections, even though acceptable taxonomies and dynamic models do not exist for any. Notwithstanding this thoroughly unsatisfactory state of affairs, we consider in a fourth section the implications for education of our current modest knowledge about skill transfer.

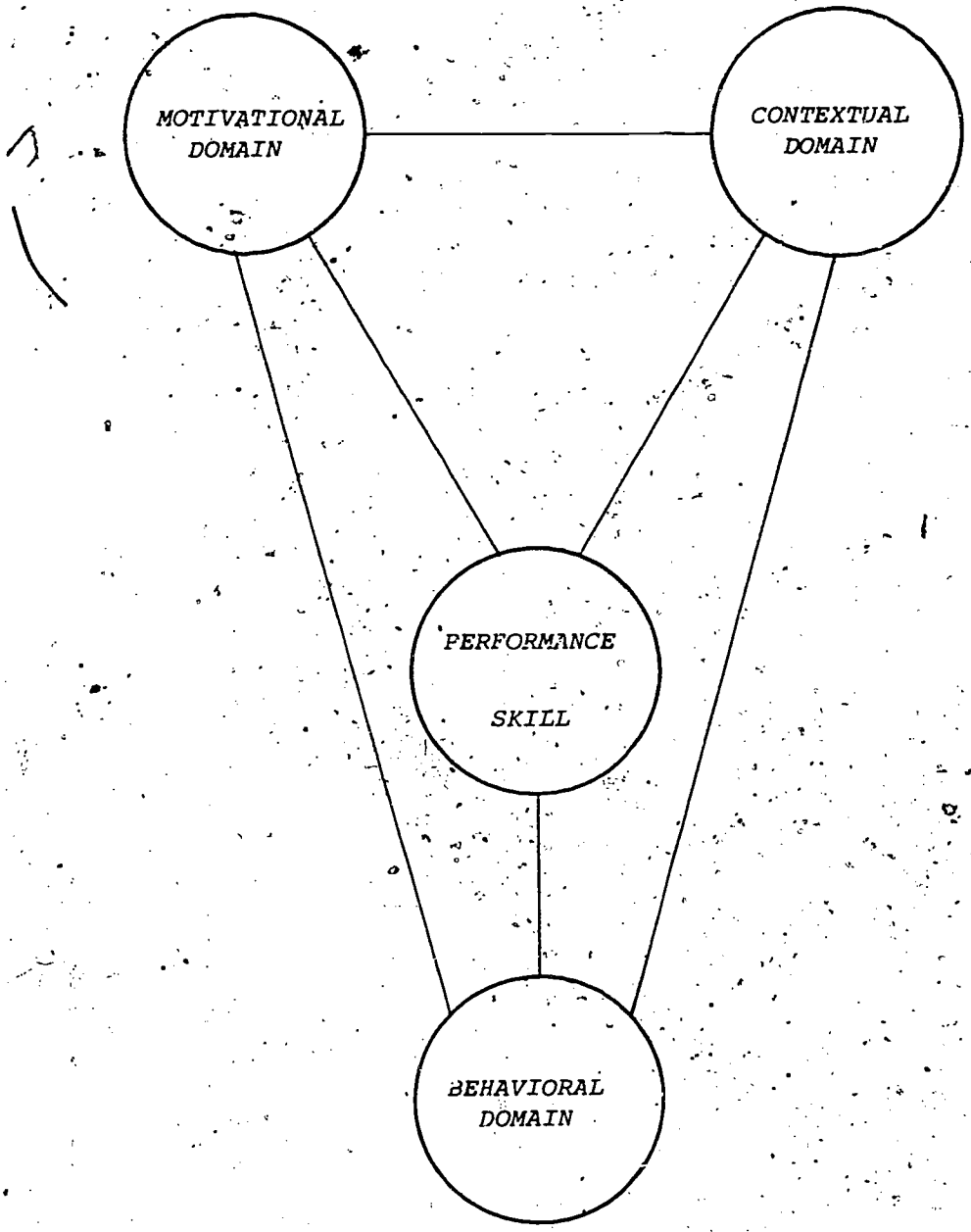

Figure 1. Principal sources of influence on skill transfer.

MOTIVATIONAL DOMAIN

We include in this domain of considerations interests, goals, attitudes, values, and reinforcers of behavior. This is an enormous and sprawling field with limited integration of alternative conceptions. Even a cursory review across the full span of argument and empirical data would be far outside the scope of this paper. Our objective here is much more modest—to suggest what currently appear to be the major motivational factors impacting on skill transfer.

Figure 2 summarizes the principal elements relating to work motivation. Three elements are external to the motivational domain, but interact strongly with it:

- Task PERFORMANCE (through which skill can be inferred) depends upon the motivation of the individual worker. Feedback about performance is, in turn, a major source of motivation for the future.
- CONTEXT defines:
  - Performance requirements and criteria of success, which have a prime impact on motivation.
  - Informational and other resources which influence the probability of successful performance, with its resulting impact on motivation.
  - Outputs from the environment in the form of rewards, punishments, and penalties which guide the course of motivational development.
- BEHAVIOR includes covert processes which may be essential in achieving required performance, but may not be obvious from observation of overt performance. Analysis of such "background" behavioral processes may contribute to an understanding of motivational structures and dynamics by both individual task performers and by outside observers. Conversely, an understanding of relevant motivation may greatly facilitate an understanding of the total set of behavioral processes involved in any given task performance.

We are concerned with four principal influences within the motivational domain:

- MEDIATION which is concerned with the human and other media by which performance-related data are fed to the performer.
- SALIENCY which is concerned with the significance of goals and motivational feedback to the performer.
- CONTINGENCY which is concerned with the linkages the performer makes between performance and subsequent motivational feedback.
- PROBABILITY which is concerned with the likelihood of successful accomplishment of a task, at whatever level may be defined as a standard for success.

Each of these sources of effect on motivation is discussed, in turn, in the following four sections

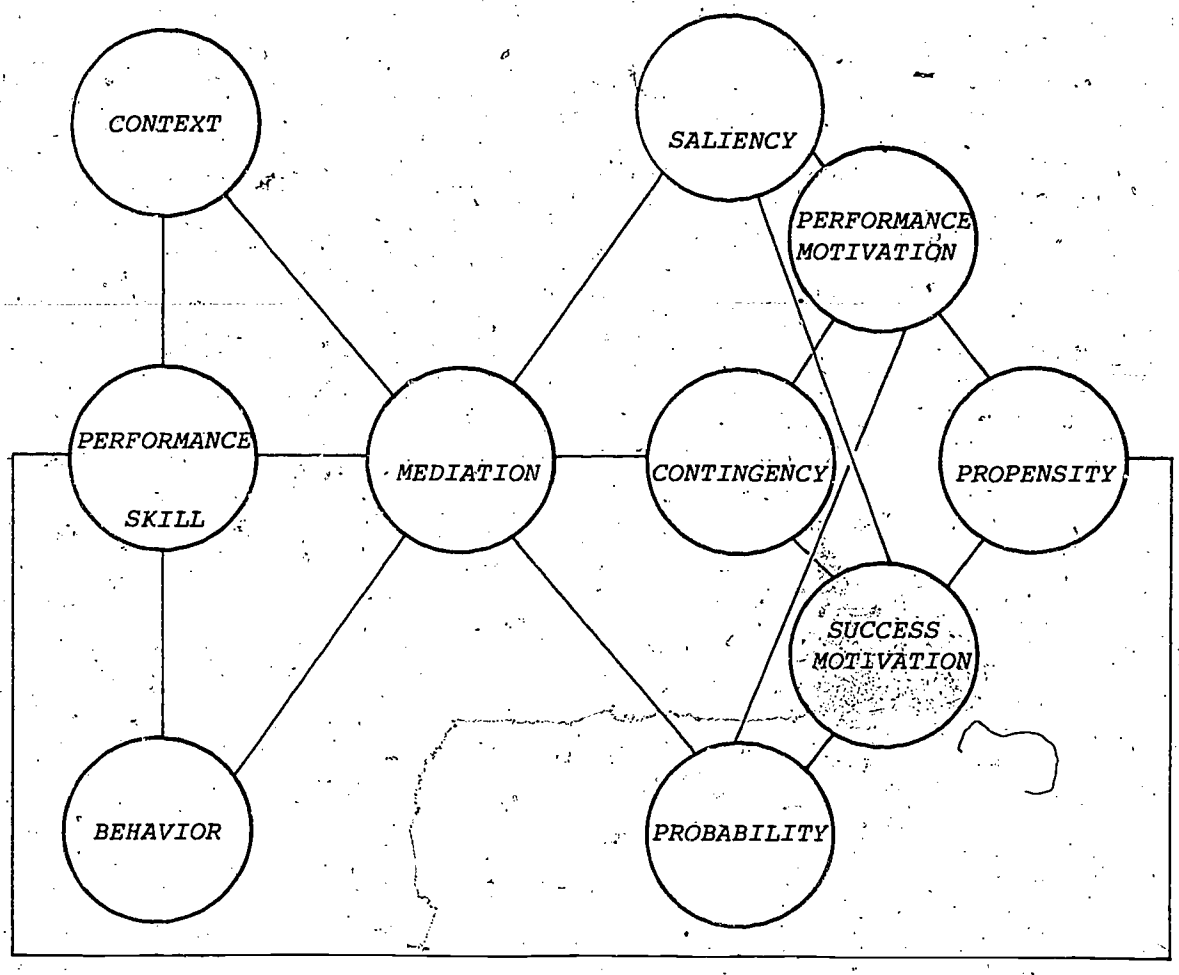

Figure 2. Principal elements of work motivation.

Saliency, contingency, and probability combine to generate two principal kinds of motivation—PERFORMANCE MOTIVATION and SUCCESS MOTIVATION. These two types of motivation then resolve into a PROPENSITY for particular kinds of behavior and performance. Performance motivation, success motivation, and behavioral propensity are each discussed below.

Throughout these discussions we will consider any tendency to perform a task or striving for its successful completion as an indication of motivation. Verbal and other expressions of intent or feelings will also be considered to have potential relevance to an individual's motives. As extensively noted (Vroom, 1964), there is not necessarily a high correlation among presumed effects of motivation such as expressed job satisfaction, absences, turnover, and task performance.

Mediation

Mediation of motivational feedback has long been a major issue in human affairs. Long and intensive debates on topics such as the parental role in child raising, the role of teachers and tests in education, and traditional versus "job-enriched" industrial settings have focused on responsibility for mediating informative and motivational feedback. Control systems and human factors engineers expend a great deal of effort on designing electromechanical mechanisms for enhancing performance feedback to the worker.

Albert Bandura (1969, n.d.) has emphasized the pervasive human tendency to set one's own standards and evaluate one's own behavior in accordance with such standards. He has presented a reinforcement theory model and a great deal of experimental data relating to self-mediated feedback. Behavioral researchers who have experienced working with human subjects in "controlled" laboratory situations can attest to their active role in interpreting behavior, frequently in ways quite different from those intended by the experimenter. Indeed, a rather elaborate methodology (Swets, 1973) is required to isolate such factors from other behavioral processes of interest in the laboratory. On the other hand, James Altman and others (1969) have emphasized the unique role self-mediated informational and motivational feedback can play in going beyond the results from an already mature and effective industrial safety program.

The mediation of motivational feedback is an important factor in determining performance and the individual is an important agent in this mediation. This self-mediation, however, interacts with the role of other humans and nonhuman media of feedback. The particular mix of roles has an important impact on skill transfer. In general, the more similar the feedback mediation from one situation to another the greater the potential for positive skill transfer.

We can observe outstanding examples of positive transfer whenever highly effective executives move from one company to another, no matter how dissimilar the companies are with respect to technology or organizational arrangement. The effective manager quickly moves to define his or her goals, set priorities, identify reliable information sources and self-evaluate performance *before* influential others in the situation take such initiatives. Positive transfer can be observed at the other end of the continuum when workers who have become conditioned to closely supervised routine work adapt better to new jobs which are also closely supervised and routine than fellow workers with more relevant and superior technical skills (Turner & Lawrence, 1965).

Examples of negative skill transfer can also be observed. Personnel with rigorous advanced graduate training are frequently less effective when they enter employment than less well trained colleagues. Individuals who have long been conditioned by the educational environment sometimes

seem to require a considerable adaptation to the realization that there is no professor with right and wrong answers. The essence of high-level work in business is frequently learning from the unique problems themselves, not from some pre-ordained expert who modulates and evaluates progress toward an already known solution.

Another kind of negative transfer from a change in feedback mediation occurs when workers go from personal to externalized responsibility. For example, G. P. Latham and G. A. Yukl (1976) report a negative effect on job satisfaction when quality evaluation (which has been self-evaluated only) was added to an external measure of production.

Saliency

Saliency is concerned with the nature and extent of utility or disutility goals and their achievement or nonachievement have for individuals. Feedback is important both because it may have qualities which are intrinsically pleasant or unpleasant as well as providing information about progress toward more remote goals. For present purposes, we will consider interests, attitudes, and opinions to be verbal or other expressions by the individual relating to the saliency of different work contexts or features.

Saliency is a complex issue which has been discussed under a great many rubrics and with a considerable divergence in conception. It is a considerable distance from a generally accepted resolution. It would be unreasonable to aspire to or pretend such resolution here. However, we can identify:

- ✓ Five important attributes of the context which the individual perceives from mediated feedback, namely:
  - LEVEL of individual welfare to which the phenomena of interest relate.
  - PARTICULARITY with which feedback is tied to the specific context.
  - LATENCY between individual action and feedback.
  - MAGNITUDE of the feedback.
  - EQUITY of the outcome as perceived through mediated feedback.
- ✓ Two kinds of outcomes for the individual, namely:
  - UTILITIES or favorable outcomes for the individual.
  - DISUTILITIES or unfavorable outcomes for the individual.
- ✓ Two kinds of saliency, namely:
  - PERFORMANCE SALIENCY which is concerned with the importance to the individual of participating or not participating in a given context.
  - SUCCESS SALIENCY which is concerned with the importance to the individual of achieving or not achieving goals in a given context.

Attributes, outcomes, and types of saliency are discussed, in turn, below. Their general relationships are suggested in Figure 3.

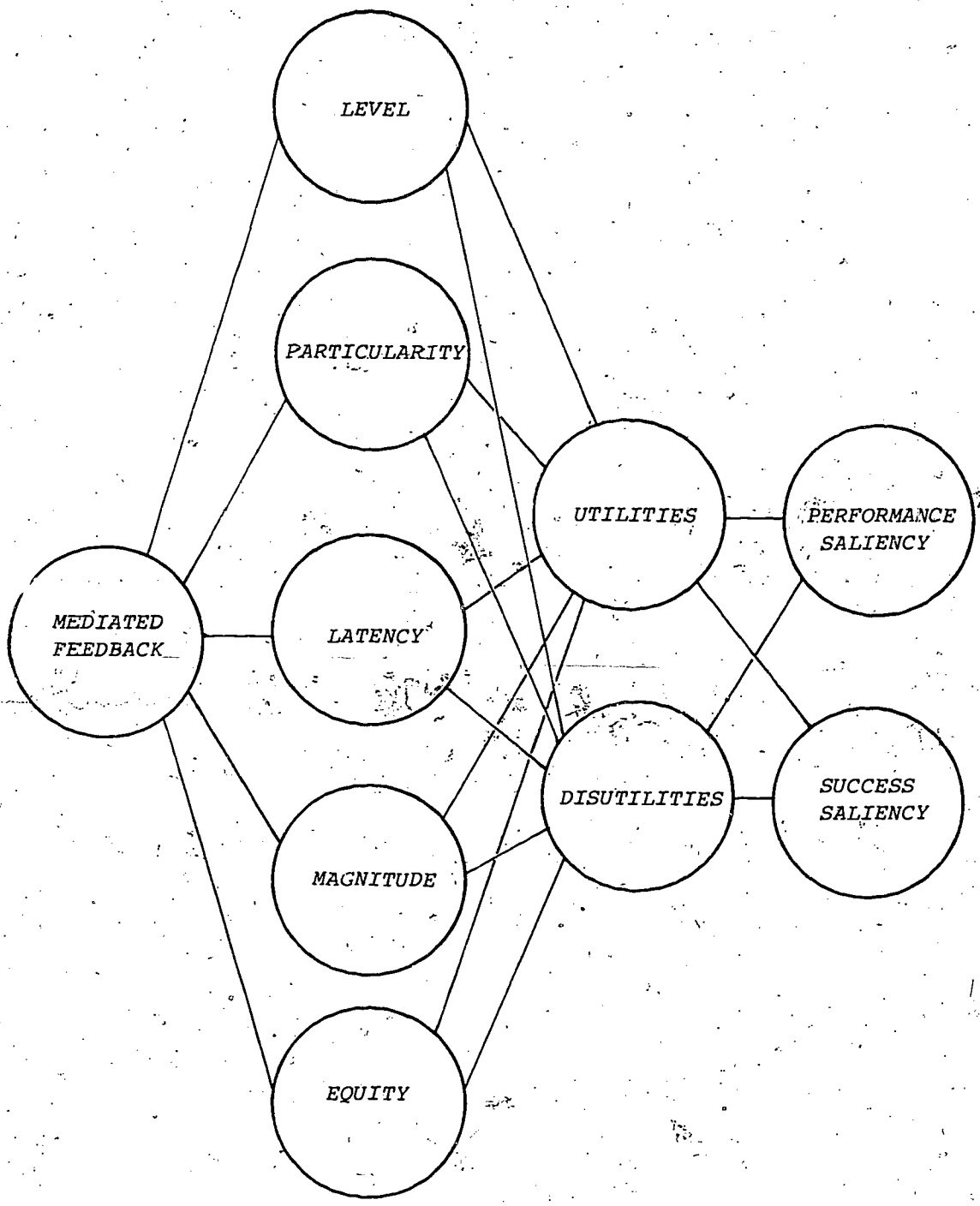

Figure 3. Principal elements of saliency.

Attributes

Mediated feedback from work contexts and performance has many different attributes which can be organized in a great many different ways. No generally accepted scheme exists for their delineation and analysis. In general, we can expect greatest positive transfer of skills across contexts that provide the individual with similar kinds of feedback and less or negative transfer across contexts which provide the individual with dissimilar feedback—recognizing as we must that each individual will probably mediate and interpret feedback in an active and somewhat idiosyncratic way.

We can identify five general attributes which the individual derives from mediated feedback — and something of the special implications of each general attribute for skill transfer. These general attributes are LEVEL, PARTICULARITY, LATENCY, MAGNITUDE, and EQUITY. Each is discussed briefly below.

LEVEL: This attribute is concerned with the points of intersection between motivational feedback and the hierarchy of an individual's needs. Sample levels in such a hierarchy might be:

- *Physiological* needs for food, water, oxygen, etc. are the most imperative. Their direct gratification dominates those hunting-gathering societies which face a resource-scarce environment. As pointed out by Uriel G. Foa (1971), population density and increased insitutional specialization have been associated with the creation of less direct, but more efficient and universal, media of resources exchange. Good air, comfort breaks, quiet and other environmental factors are closely tied to physiological needs and can be important factors in turnover, morale, absence, and may even be so out of tolerance that they directly interfere with task performance. However, direct gratification or withholding of resources to meet physiological needs is not generally efficacious in an advanced technological society. A picture of workers being fed food pellets when they meet a production quota may have its place in science fiction, but not in modern western business and industry.

- *Emotional* needs relate to a reduction of disequilibria in the autonomic nervous system and associated endocrine systems—disequilibria associated with subjective feelings of startle, anger, and fear (Hackman & Dysinger, 1961). Feedback which warns of imminent danger to health and safety may appropriately tap such states, and consistency of such warnings across contexts is important (as with the use of flashing red lights to indicate danger). However, direct appeal to strong emotion seems to have extremely limited utility across any segments of the world of work. Even in the military, where the tremendous short-term energy potentials mobilized by strong emotion were once useful for personal combat, strong emotion is usually just disruptive to efficient operations in modern war.

- *Social* needs derive naturally from the lifelong dependence each human has on others. Approval, affiliation, affection, love, responsibility, and power needs are pervasive in the lives of most of us. This is a level or, more accurately, a complex of levels which is almost universally involved in human affairs, including the world of work. There are many regularities in the feedback codes. But, the media of communication are many and the languages subtle. Facial movements and sets, voice tones, pauses, attenuated gestures, body postures, spatial positioning, and specialized language styles are all used in addition to straight informative feedback. Novices who are unfamiliar with the local norms for qualitative or quantitative features can be misled to the point of understanding exactly the opposite of what was intended by the source. There are probably still jobs where misfits in the immediate social contexts can perform effectively, but this is rare. In general, severe maladaption to the social milieu of the job seriously disrupts perform

- ✓ *Achievement* needs are concerned with doing a good job for the intrinsic rewards of success. We touch on the sources of and deterrents to such motives in the later discussion of CONTINGENCY. Regardless of source, an individual with achievement needs will tend to transfer skills fully to any work context in which there is reasonable challenge, but not necessarily apply them fully to contexts in which standards are perceived to be excessively low, tasks too easy, or opportunity for success too limited (Atkinson, 1965).

Feedback can influence multiple levels of need simultaneously. For example, failure to receive an anticipated salary increase may simultaneously signify to the individual that he or she has failed to achieve, is rejected by the employing organization, is in danger of losing a valued position, and may suffer physical privation.

PARTICULARITY: This attribute is concerned with the extent to which feedback has universal significance versus meaning only within a particular context. As Foa (1971) has pointed out, the trend in western society definitely has been away from highly particular and personal feedback such as signs of affection, status, and services to more universal and impersonal feedback such as money, information, and goods. She also presents theory and data which suggest that ease of exchange among types of feedback is a joint function of particularity (which she calls particularism) and concreteness. In Figure 4 we have added "enablement" (or providing an opportunity for desired behavior) to Foa's six resource classes and conjectured about its position within her bivariate space. In general, we would expect disruption to skill transfer to be proportional to the straight-line distance between circles, namely:

- ✓ Minimal disruption to skill transfer will occur when feedback remains of the same type.
- ✓ If an exchange between types must be made, interference of transfer will be least for exchanges between enablement and any other type, love-status, status-information, information-money, money-goods, goods-services, or services-love.
- ✓ Exchanges expected to result in intermediate, but near-maximal, disruption to transfer are love-information, status-money, information-goods, money-services, goods-love, or services-status.
- ✓ Exchanges expected to result in maximum disruption to transfer are love-money, status-goods, or information-services.

LATENCY: This attribute is concerned with the period between behavior and feedback. Latency has different scales and significance for at least three different types of goals:

- ✓ *Process* goals involve maintenance of a near-null difference between controlled input and a subjective reference signal of the individual during task performance (Powers, 1973). Critical periods of latency and effects on input tend to be quite short.
- ✓ *Completion* goals involve termination of an identifiable task. Latency requirements for signal of completion may be substantially different from requirements for quality assessment. For example, the signal that a required report is finished must be relatively immediate but feedback concerning its judged quality may be delayed.
- ✓ *Extrinsic* goals may be derivations of many successful task completions and may involve latencies of months or years, as may happen in a long-delayed promotion.

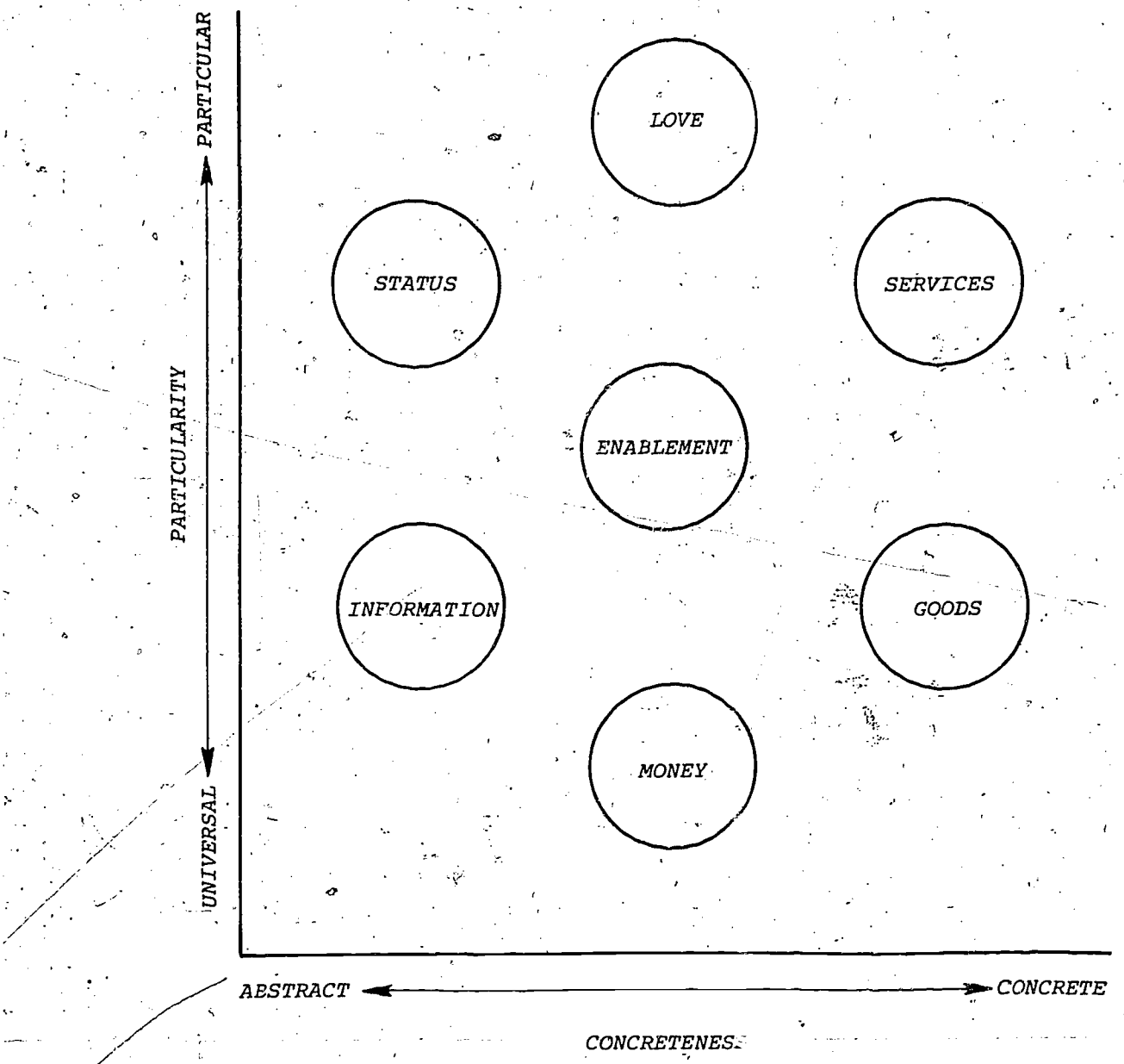

Figure 4. Relative exchangeability of feedback (as indicated by straight-line distance between circles).

An important general feature of latency across all levels of goals is that skill transfer is not much impeded by shortening, but lengthening latency may require extensive adaptation.

MAGNITUDE: This attribute is concerned with the amount or strength of any given kind of feedback perceived by the individual—how strong the criticism or praise, how close to the desired product, how much money, etc. Differences in magnitude of feedback can impact heavily on skill transfer. Amounts of feedback that might be intended as strong encouragement in one context might be intended to exhibit relative indifference or even disapproval in another. For example, a normally reticent supervisor may exhibit strong praise by a few words of encouragement. A more ebullient supervisor may use a similar cautious statement to indicate serious concern.

EQUITY: This attribute is concerned with fairness of the outcomes indicated by mediated feedback. In general, equity will be perceived by the individual when benefits and costs are similar to those for others judged to be making an equivalent contribution to the enterprise. Perceived equity has emerged as an important organizing concept in social psychology (Berkowitz & Walster, 1976). Elucidation of the formal models of equity theory and analysis of their full implications for skill transfer are beyond the scope of this paper. However, we should note that any substantial deviation from perceived equity (whether on the long or short end) will tend to distress the individual and have a potential for interfering with performance. Individuals in a new work context are especially likely to suffer difficulty in skill transfer when feedback is perceived to be inequitable.

Outcomes

Mediated feedback, with its various attributes, resolves into two principal kinds of outcome for the individual:

- UTILITIES are favorable outcomes which in some way serve needs.
- DISUTILITIES are unfavorable outcomes which in some way prevent or threaten satisfaction of needs. The individual may derive disutilities from direct feedback (punishment) or the withholding of utilitarian feedback (penalty).

In general, the more similar the utilities and disutilities an individual perceives in two different contexts, the greater the potential for transfer of skill.

Types of Saliency

The individual is typically concerned with two main kinds of saliency:

- PERFORMANCE SALIENCY is concerned with the perceived utilities and disutilities associated with commitment to or avoidance of a particular task. Obviously, there will be no opportunity for transfer of skills to an avoided task.
- SUCCESS SALIENCY is concerned with the perceived utilities and disutilities associated with success or failure once commitment has been made to performance of a task. The potential for skill transfer is greatest where the saliency of success, avoiding failure, and failure are most similar from one context to another.

Contingency

There is a growing body of theory and data demonstrating that an individual who perceives feedback to be contingent upon his or her performance will have a high motivational potential. This contrasts sharply with an individual who perceives feedback to be independent of his or her performance. In this latter case, the individual's goal-oriented motivation is likely to be near zero (Grant, 1974; Woods, 1974; Seligman, 1975; Tryon, 1976). Thus, we would see the opportunity for skill transfer to a new context to be restricted to the extent that the new context leads to a perception of feedback as being independent of performance. None of us, for example, is likely to work as effectively for a supervisory whose feedback is always biased against us and independent of performance as we are for one whose feedback is based on a fair judgement of our work.

Probability

Probability is concerned with the likelihood a task will be successfully performed, for whatever reasons. More precisely, it is the perceived likelihood that a given utility or disutility will be experienced by the individual as a function of success. The other side of this, of course, is the likelihood of failure. Both kinds of probability are important to motivation for work. In general, individuals avoid tasks with low success probabilities and, therefore, would not have much opportunity to transfer skill to such contexts. The principal exception to such a generalization appears to be with research scientists, inventors, creative artists, and sports record-setters who, somehow, perceive a pattern of failures as a path to success.

Performance and Success Motivation

Performance motivation is concerned with whether an individual will perform or avoid performance of a task. Success motivation is concerned with whether the individual will fully employ relevant skills. Performance may be divided into two antagonistic types—commitment and avoidance. Success motivation may also be divided into two antagonistic types—win and fail. We may get a better sense of these different types from the following formulations:

$$M_c = U_p + D_a + P \cdot U_w + Q \cdot U_f \quad (1)$$

$$M_a = U_a + D_p + Q \cdot D_f + P \cdot D_w \quad (2)$$

$$M_w = C \cdot P \cdot U_w + C \cdot Q \cdot D_f \quad (3)$$

$$M_f = C \cdot P \cdot D_w + C \cdot Q \cdot U_f \quad (4)$$

where:

M_c is motivation to commit to performance,
M_a is motivation to avoid performance,
M_w is motivation to win success in performance of a task,
M_f is motivation to fail in performance of a task
U_p is utility of performing a task regardless of outcome (for example, gaining approval for trying),

D_a is disutility from avoiding a task (for example, anger from a colleague who must fill in),

P is probability of success if the task were to be performed,

U_w is utility associated with winning success,

Q is 1-P,

U_f is utility associated with failing on a task (for example, when success would lead to an unwanted assignment),

U_a is utility associated with avoiding a task (for example, when peers approve of such avoidance),

D_p is disutility associated with performing a task (for example, that task is thought to be beneath one's dignity),

D_f is disutility associated with failing in performance of a task,

D_w is disutility associated with winning success on a task (for example, gaining praise from a hated supervisor), and

C is the extent to which feedback is perceived to be contingent on performance.

Motivation to perform and to win success are, obviously, essential to prospects for successful performance.

Propensity

It would be convenient to assume that behavioral propensity is a simple and direct function of the motivations relevant to any given context. Unfortunately, this is decidedly not the case. Commitment and avoidance motivation do not simply cancel each other out but jointly are involved in choosing to perform or avoid a task. Similarly, motivation to win success and to fail jointly operate in defining a propensity for behavior leading to success or failure.

If the total of the two relevant motivations is low, neither choice nor success can be expected to have a particularly pervasive impact on the individual no matter how closely balanced the conflicting motives. But if total motivation is high and conflicting motives are close, effects are likely to be long-lasting and pervasive.

When strong balanced conflicting motives are involved, behavioral shifts tend not to be smooth but characterized by sudden shifts from one mode to another, shifts of the sort currently best predicted by the mathematical theory of elementary catastrophes (Woodstock & Paston, 1974; Thom, 1975; Zeeman, 1976).

BEHAVIORAL DOMAIN

Any nontrivial work activity is likely to involve multiple stages of behavior. It may be useful to delineate the following five stages for purposes of our present discussion:

- ✓ Perception
- ✓ Memorization
- ✓ Intellectual processing
- ✓ Response
- ✓ Integration

Figure 5 suggests some of the major interfaces among these stages, the contextual domain, and the motivational domain. The structure suggested in Figure 5 is generally in accord with control system (Powers, 1973), information-processing (Gagné, 1974a), and social learning (Bandura, 1969) models. Each of the five behavioral stages is discussed briefly below.

Perception

We will assume that the important potential for acquisition of significant vocational skills is after sensory input has been processed through end receptors.[1] Thus, our focus will be on the formation of perceptions from raw sensory data rather than modulating the activity of end receptors to acquire or not acquire such input.

Perceptual skills support the discrimination of stimulus input. More specific and precise the discrimination of stimulus input means greater the skill. According to Eleanor J. Gibson (1968) the guiding principle in learning perception is filtering or extracting signals from a noisy and irrelevant input—a form of dissociation rather than the association of elements which characterizes much other learning.

Gibson also contends that the basic motivating and reinforcement principle in the learning of perceptual skills is reduction of uncertainty. Frank Restle (1961) and Wendell R. Garner (1962) provide considerable theoretical and empirical support for there being a pervasive relationship between uncertainty and structuring of perceptions. Evidence on sensory restriction and its effects on behavior (Schultz, 1965) points to there being some subjective optimum of sensory stimulation which, given the opportunity, the individual will actively seek. This suggests that the basic motivational process is seeking out and then reducing uncertainty. We would postulate that the acquisition of perceptual skills is an intrinsic human process which occurs unless:

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[1] Experimental psychology traditionally has separated sensation from perception (Woodworth, 1938; Boring, 1950; Osgood, 1953). The question of whether sensory experience is subject to significant learning effects has engendered much argument and is probably still moot, at least in a theoretical sense if not a practical one.

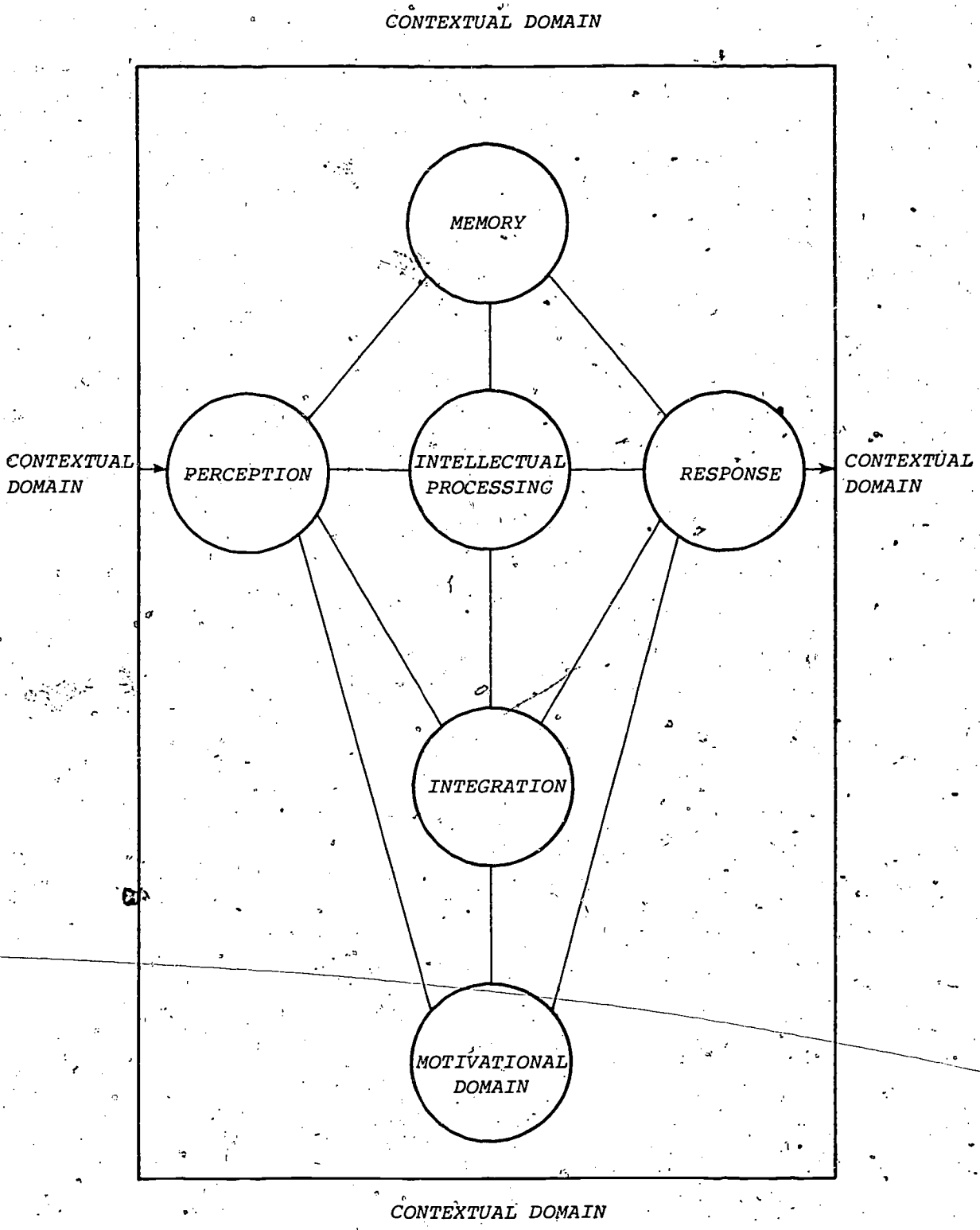

Figure 5. Major behavioral stages.

- ✓ The stimulus environment is so capricious as to defy reduction of uncertainty.

- ✓ The environment is so chronically benevolent, malevolent, or indifferent as to condition uncertainty to boredom, anxiety, helplessness, or depression.

Nickolass Tinbergen (1974) has dealt with these issues in an ethology analysis of stress diseases. Martin E. P. Seligman (1975) has dealt with them extensively from an operant and classical conditioning point of view. The important point is that most individuals have a strong motivation for the learning of perceptual skills unless it has been extinguished by serious mismanagement of prior learning.

In Figure 6 we show one way of arranging some of the principal elements in perception. Gibson has suggested that sensory data early come to be perceived as objects, space, and events. Somewhat later representations such as pictures have meaning to the child. Spoken words begin to have meaning in infancy and written letters and words usually begin to have distinctive meaning to the child by the time of entry into public school.

Gibson also has suggested that active perceptual strategies on the part of the individual observer can play an important role in the acquisition and application of perceptual skills. Although the notion of perceptual strategies has not been very formally or fully delineated, we can identify at least three distinct strategies:

- ✓ *Attention* involves selective focus on points of high information and the shutting out of irrelevant stimuli.

- ✓ *Scanning* involves active search across the stimulus field. Systematic and regular scanning has been found, for example, to be an important factor in early detection and diagnosis of aircraft emergencies (Craig, Purifoy, & Miller, 1956; Craig & Purifoy, 1957).

- ✓ *Observational control* involves orderly movement of elements of the stimulus field or the observer to facilitate perception—such as might be involved in gaining improved perception of motion parameters.

Gibson has delineated three general classes of perceptual attributes that are essential to learn for effective acquisition of perceptual skill:

- ✓ *Distinctive features* are contrasting differences on a dimension or property of the members of a set. An example is the set of 12 contrasts (such as grave-acute, lax-diffuse, and vocalic-nonvocalic) which suffices to differentiate all the phonemes of all languages (Jacobson & Halle, 1956). Another example is the increasing number and precision of distincitve features such as eyes, nose, and mouth which infants learn to use in recognizing faces. It has been found that teaching only distinctive features is more effective in training aircraft recognition than teaching entire configurations (Gagné & Gibson, 1947).

- ✓ *Invariance* over time best characterizes perceptual learning for events. Constancies of space, shape, size, loudness, mass, and proximal causality are learned from invariances in events even though sensory properties change—such as a motor vehicle maintaining continuity even though its retinal image changes in size as it approaches and retreats.

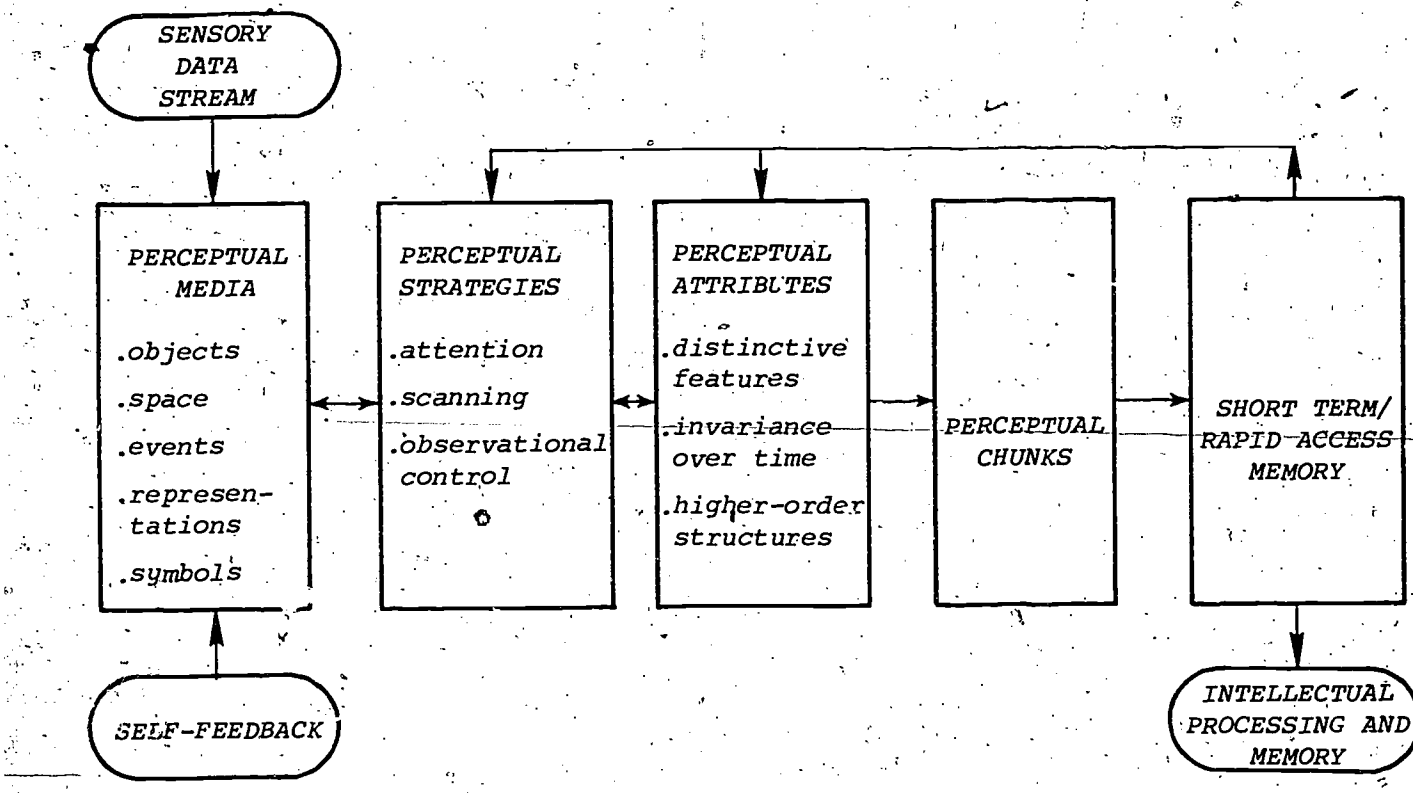

Figure 6. Major elements in perception.

- *Higher-order structures* involve the perception of regularities and redundancies among elements of a stimulus field. Especially important for efficient skill transfer is the learning of regularities and redundancies which lead to the perception of lower-order and higher-order units which form hierarchies. An important example is the move from letter to word recognition in reading.

D. O. Hebb (1961) has emphasized the intimate relationship between perception and memory. Because of its "front-end" role in behavior and learning, we would expect perception to be associated with early emergence of the "engram"—"the set of physical processes and changes in the brain that forms the basis of learning" (Thompson, 1976, p. 209). Despite the fact that the brain appears to operate essentially as a parallel processor, Thompson suggests the possibility of there being one set of places or systems in the normally functioning mammalian brain where the engram first makes its appearance. Further, he reports a large and reliable learning-dependent hippocampal response which develops very early in training. He conjectures that forward and backward tracking from this response might localize the site of formation of the initial learning-dependent brain response.

Psycho-neurophysiology is not yet to the point where one can point to a specific part of the brain and associate it with a particular perceptual learning or skill function. Yet, even if we defer neurophysiological considerations until some indefinite later date, there are three important memory-oriented issues to be resolved before our delineation of perception can be complete:

- *Chunks versus bits.* Humans do not input information in units such as bits which reduce uncertainty by some standard amount. Rather, they organize or group input into familiar units or chunks which are themselves formed out of a great deal of learning (Miller, G. A., 1956). The bits of information per chunk are available in number, depending upon the complexity of the chunk. For example, chunks can be letters, syllables, words, or well-known phrases. Each successive type is likely to carry progressively more bits of information on the average.

- *Short-term versus long-term memory.* Chunks appear to be formulated in a very short-term sensory register and temporarily stored in a short-term memory buffer. Short-term memory has a capacity of about five to seven chunks and transfer of information to long-term memory has been shown to take about five to ten seconds per chunk (Simon, 1974). Interpolated information processing which delays a start of fixation in long-term memory is increasingly detrimental up to about nine seconds, beyond which it is unlikely that the chunk will be available (Kulp, 1967).

- *Perceptual versus associative memory.* Although the latency for recognition of complex perceptions is longer than for simple and intense signals, it is characteristic that perceptions are derived out of the sensory data stream in a very short time—usually in a fraction of a second and seldom more than a few seconds unless the target is highly ambiguous. This suggests that such memory information as is retrieved in support of common perceptions tends to be highly accessible, in contrast to certain of the infrequently used associative data which may be retrievable in support of intellectual processing but which may involve relatively time consuming search strategies—including a series of successive approximation retrievals and evaluation of tentative output. The point here is that memory support to perception tends to emphasize rapid retrieval of remembered information, even if this speed is achieved at the expense of flexibility.

It is difficult to imagine negative transfer of perceptual skills *per se* within the vocational arena. Possibly some of the higher-order structures will be excessively general for the lower perceptions required on a job, but properly developed perception should support relative easy reversion to use of more specific levels of subsumed perceptions. Many of the available perceptions may be irrelevant to a given job and result in zero transfer with an attendant waste of human resources, but not to negative transfer. Perceptions can be associated with inappropriate responses but this type of association is not a function of the perceptual skills themselves but rather of linkages between stimuli and responses.

Memory

Memory is concerned with receiving, encoding, and storing perceptual and conceptual data; with maintaining these data over time; and with the retrieval of such data as demanded by external or internal processes. It is very difficult, and within the current state of knowledge may be impossible, to separate the memory processes from the data themselves. The weight of evidence to date, however, would appear to suggest that it is the encoding and retrieval processes rather than storage capacity which limit useful memory (Kumar, 1971; Natkin & Moore, 1972; Buschke, 1974). In Figure 7 we suggest some possible relationships among major elements of memory.

There is an enormous body of literature on verbal learning (e.g. Miller, G. A., 1951; McGeoch & Irion, 1952; Kausler, 1966; Dixon & Horton, 1968). Unfortunately, a very large proportion of the work on verbal learning has developed principles having limited relevance to vocational skill transfer because it has been oriented toward nonsense syllables, word association, and digit span rather than the connected units of language and mathematics. Even more, nonsymbolic inputs have been generally ignored, at least since the time of great interest in Gestalt psychology. This relative dearth of information about the management of nonsymbolic data is unfortunate in two ways. First, it has been found that there are many vocational opportunities which lack significant symbolic demands but which are rich in the processing of nonsymbolic data (Munger, Seiler, & Altman, 1975). Such vocation opportunities are naturals for properly skilled persons who lack a high degree of symbol-handling potential. Second, it is unfortunate that there has been such a relative lack of research on nonsymbolic data skills because this seriously limits our insight into the role such data can play in the formation of concepts. This impoverishes our understanding of conceptual data handling and restricts our vision of what use might be made of such skills for vocational purposes.

We have already alluded to the encoding of perceptual information in some kind of sensory register and buffering of chunks of information in short-term memory until they can be rehearsed and incorporated into long-term memory. Another facet of the encoding process which should be touched upon is the re-coding of information already in long-term memory (Gagne & Fleming, 1962). Although the principal inter-element interference appears to be among highly similar new information being added to other related information already in the repertory, there also seems to be a requirement for rehearsal of previously acquired information in order to meet performance specifications for application of the total data set.

This re-coding requirement touches on a general characteristic of data management skills, they involve active maintenance of the data base. Reaction time experiments have been used to infer the structure of long-term memory, at least for verbal symbols (Meyer & Schvaneveldt, 1976). Results suggest that data are stored as quasi-hierarchical nets in long-term memory. In order to maintain currency of relationships among elements of the net it is necessary to insert new information at appropriate nodes and to rearrange existing proximal elements accordingly. Whether there are also substrates

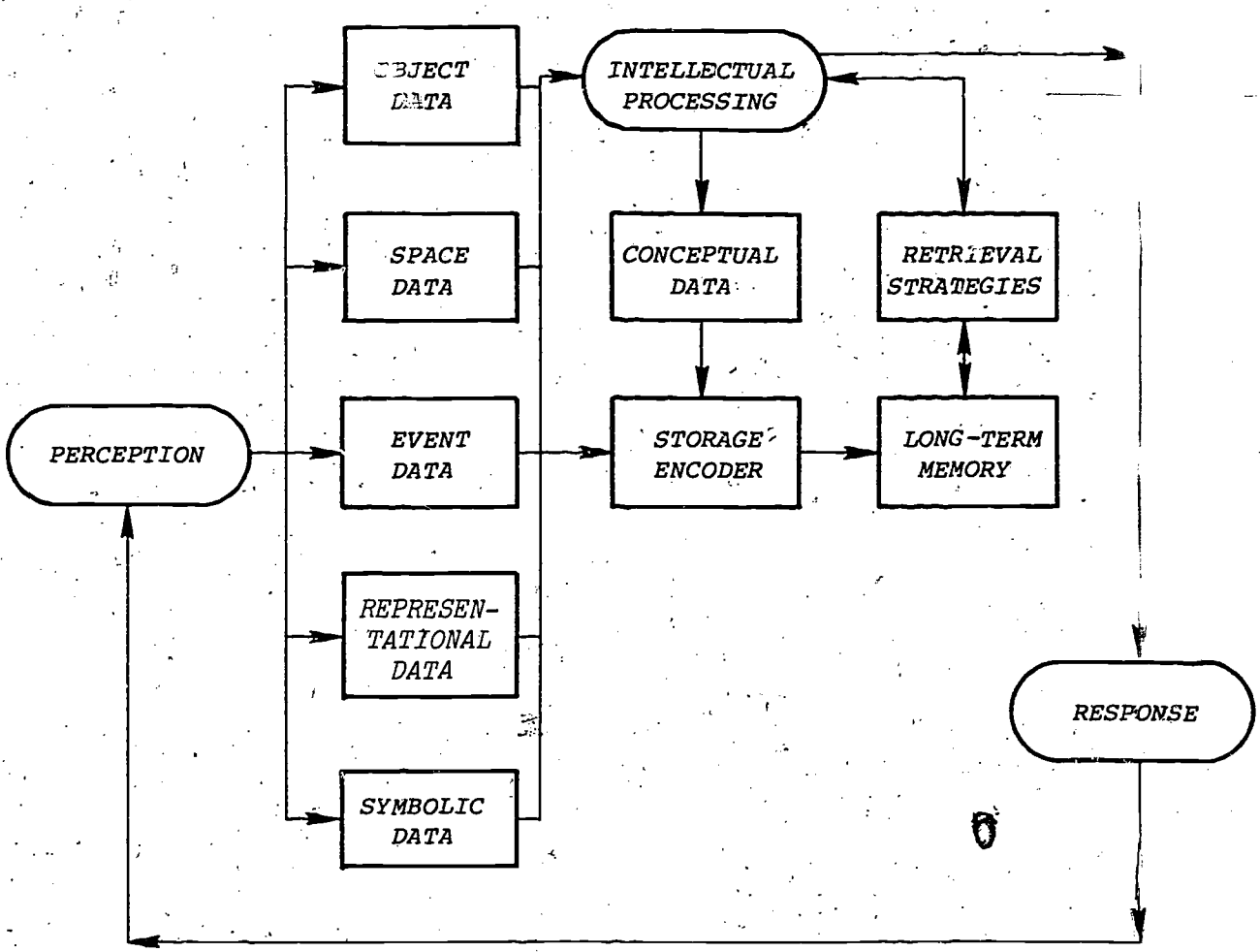

Figure 7. Some important elements of memory.

of inviolable magnetic tape-like memory records of the sort some neurosurgical experiences suggest, we cannot say at this point. For present purposes, however, it is the quasi-hierarchical network model which has greatest salience for us.

Our allusion to relationships among memory elements identifies the site of principal potential for negative vocational skill transfer. This is in the bonding of stimulus material to responses (Osgood, 1956; Houston, 1964; Wimer, 1964; Dallett, 1965; Martin, E., 1965; Altman, 1966a, 1968, 1970; Schulman, 1967, 1968). We postulate that neither perceptions nor responses *per se* result in negative transfer. However, whenever stimulus and response elements are present in both prior and subsequent tasks, but are associated by different stimulus-response bondings, there is indeed a strong potential for negative transfer.

There is much to be done in education which will, fortunately, simultaneously facilitate the development of transferable encoding and retrieval skills while minimizing the probability of negative transfer. This regimen revolves around a concept of meaningfulness (Altman, 1971). We attempt to illustrate the role of meaningfulness in memory in Figure 8. We cannot hope fully to explore the dimensions of meaningfulness in this brief paper. However, the following appear to be among the most important considerations in facilitating encoding and retrieval skills, with additional benefits from minimized likelihood of negative transfer due to stimulus-response bonds:

- *Associative value* (Underwood & Schulz, 1960; Johnson, 1973, 1974) is concerned with the denotative and connotative richness the learner can ascribe to input and stored items. This richness assures multiple pathways to retrieval and minimizes the likelihood that single-thread stimulus bonding will occur.

- *Multiple modes* of encoding, storing, and retrieving data can provide alternative routes to learning and retrieval (Drumheller, 1970). B. R. Bugelski (1970) has stressed the role of imagery. The more concrete and vivid the internalized images associated with external stimulus configurations, the greater the tendency to consider the experience meaningful and to remember it even if one's deliberate intent is not to remember.

- *Conation* has also been emphasized by Bugelski. Stimulus configurations will tend to be meaningful to the extent they induce a willful striving or effort. Thus, there is a close linkage between meaningfulness and the motivational domain.

- *Affect* lends meaning to an experience. In general, the stronger the feelings engendered by an experience, the more it will tend to be considered meaningful. Whether these feelings are favorable or otherwise will, of course, determine whether the meaning is positive or negative. Excessively strong affect, especially of a negative sort, can have disruptive influences on an experience with frequently unpredictable and undesirable side effects. Purposeful and controlled affect (Krathwohl, Bloom, & Masia, 1964) can contribute to the meaning of input and retrieved data as well as contributing to the development and application of integrative skills. This is another facet of the linkage between the motivational domain and memory.

- *Structure* is a central feature of most, if not all, significant bodies of knowledge (Phenix, 1964). David P. Ausubel (1963, 1964) has led in the analysis of ways in which educational materials might be organized to facilitate the psychological structuring of knowledge. Ernest Z. Rothkopf (1966, 1970) has been a leader in the analysis of learner behaviors that facilitate encoding, rehearsal, and structuring—although recent work has tended to emphasize the difficulties of obtaining clear-cut principles concerning the effects of organizing information (Ladas, 1973; Barns & Clawson, 1975). M. C. Wittrock (1974) has reported results

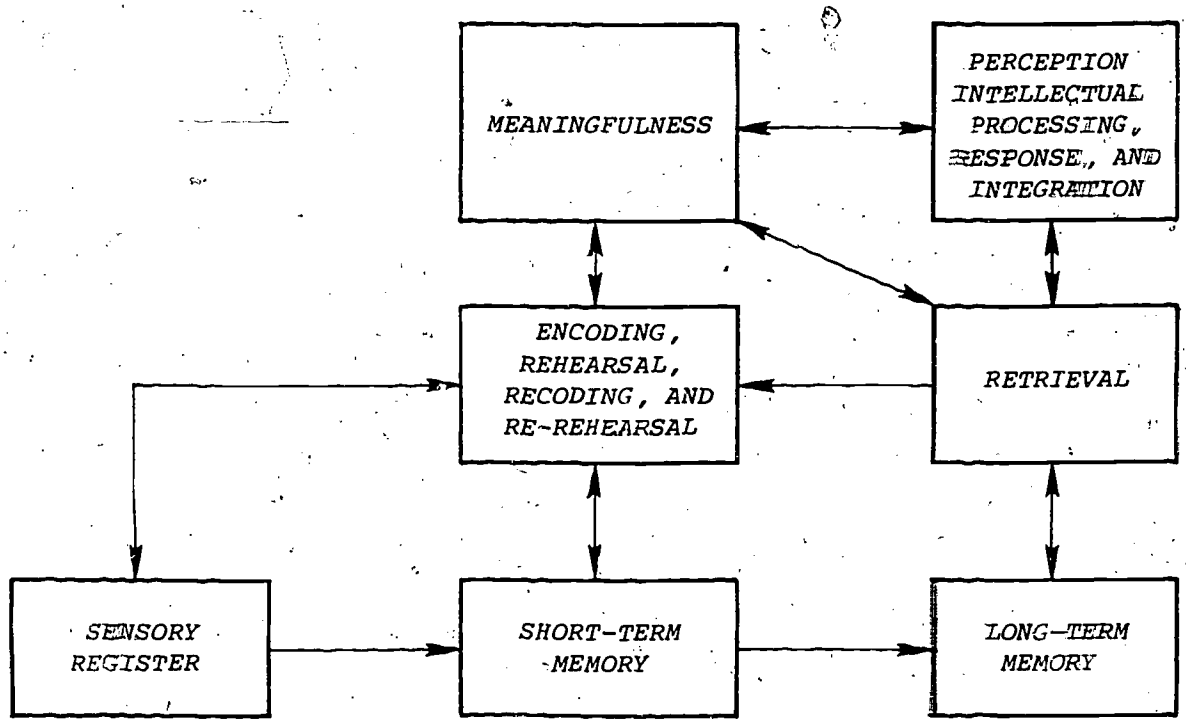

Figure 8. Meaningfulness in memory.

which support the view that people tend to generate meanings in new situations by generating idiosyncratic associations between information in long-term storage and new stimuli. Even though the validation of learning hierarchies is complex (White, 1975), the available evidence seems to support the view that memory is not inherently hierarchical in the same sense as intellectual processing (White, 1974). The structure of knowledge is primarily a function of the structure of the input material, the tools available for analysis and representation of the material (Geeslin & Shavelson, 1975), existing memory networks, and the anticipated needs for the information.

- *Dissonance reducers* (Brehm & Cohen, 1962) lend meaning by bringing into consonance, through some larger frame of reference, cognitive elements which would otherwise be psychologically incompatible with each other.

The above considerations of meaning have direct relevance to information input to and retrieval from human long-term memory. Additional leverage on information retrieval can, of course, be gained by acquiring skills in the use of documentary, computer-based, and other knowledgeable humans as sources.

We should note at least one serious constraint on the transfer of memory. If vocational performance requires high-speed reactions to perceptions (e.g., rapid production typing, high-speed vehicle operation, fast competitive sports), school tasks will have to be extremely close to vocational tasks or specific vocational training will be needed to insure against perceptual-response bonding errors.

Intellectual Processing

Intellectual processing takes input from a near-real-time perceptual data stream, combines it with data from memory and translates the data into instructions and datasets for response. In Figure 9 we have suggested illustrative relationships among intellectual processes. We have borrowed from a number of taxonomic sources (Bloom, 1956; Gagné & Paradise, 1961; Gagné, Mayor, Garstens, & Paradise, 1962; Gagné, 1965, 1966; Altman, 1966b; Cole, 1969; Haymes, 1970; Burns & Brooks, 1970; Teichner & Olson, 1971; Merrill, 1971; Tennyson & Merrill, 1971; Thelen, Woods, & Nuttall, 1973; Peill, 1975). In general, however, there has been a confounding of intellectual with other processes. We have tried to limit our delineation to intellectual processing of data.

Our suggested major types of intellectual processes are:

- Perceptual Transfer
- Conceptual
- Principle
- Discovery
- Invention
- Formulation
- Evaluation

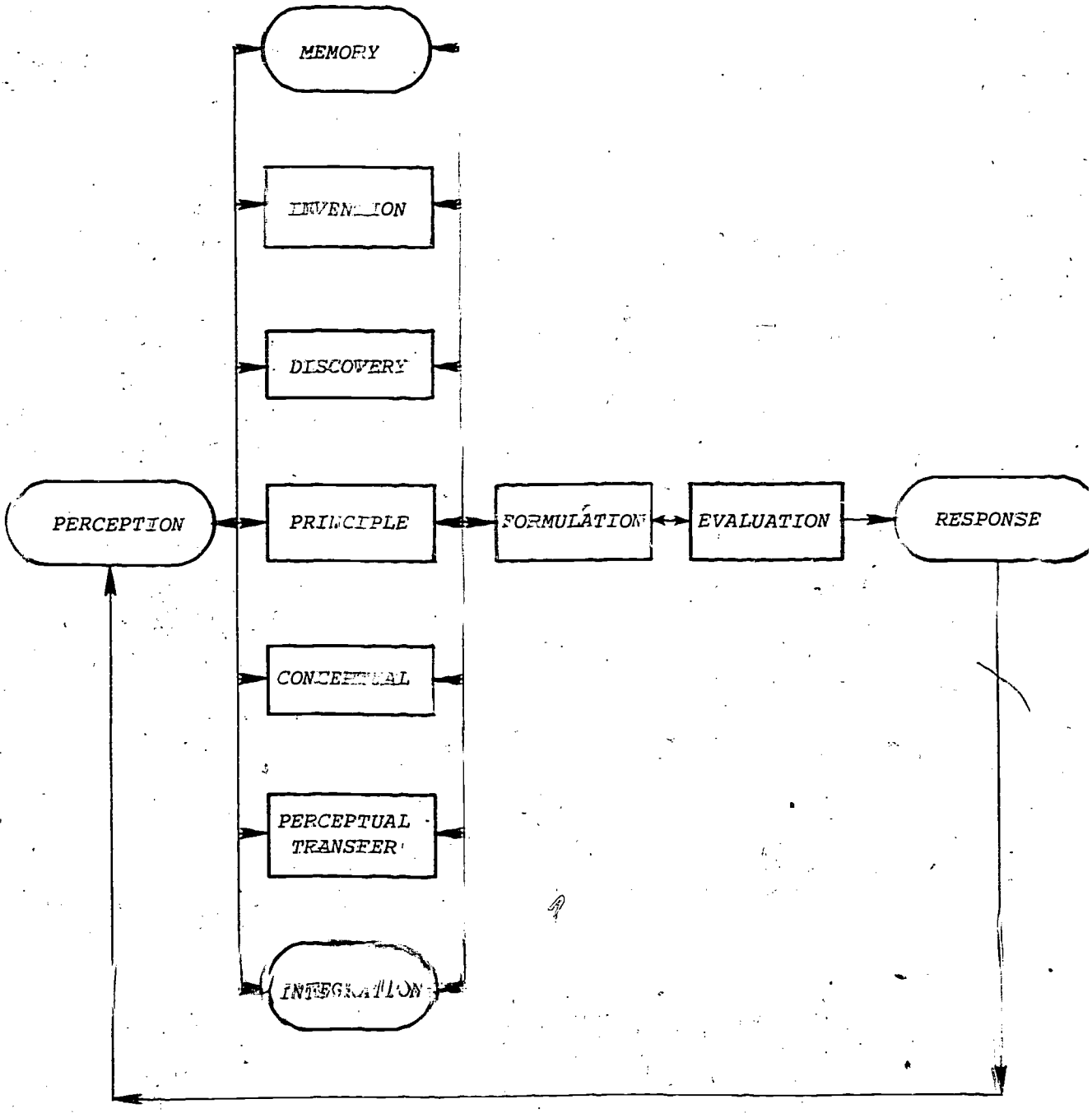

Figure 9. Illustrative relationships among intellectual processes.

An obvious feature of all these categories is that they are quite general and needful of much more detailed analysis. For our present purposes, however, we will limit our discussion to a brief delineation.

Perceptual Transfer

Perceptual transfer involves the application of relatively fixed routines for translating perceptual input into response instructions. Handling of contingencies might be included here if the contingency rules are fixed and inferences are not required about the underlying dynamics of the system being dealt with. The comparison of perceptual input with an internal reference standard in most tracking tasks would be one example. Another would be the translation of a perceived word into response instructions for speaking it in another language. A third would be to connect the activities of a routine procedural task in a proper sequence.

Conceptual

Conceptual processes involve the classification of perceptions as belonging within a particular category where objective characteristics of perceptions within a class may be widely dissimilar. Susan M. Markle and Philip W. Tiemann (1970) have stated a criterion-of-mastery for a conceptual skill as:

> . . . correctly classify previously unmet bits of reality into two piles: either it is or it isn't an x. . . . Given a new example of "force," for instance, a student who recognizes that this example is a force is *generalizing.* Given a bit of reality which a physicist would not classify as a force, the student who rejects it is discriminating. To really understand a concept is to be able to discriminate all possible noninstances, including those that bear a strong resemblance to the members of the class. (p. 43)

Markle has more recently (1975) emphasized the joint roles of definition, multiple examples, and multiple nonexamples in the acquisition of conceptual skill. F. Ross Wooley and Robert D. Tennyson (1972) have attempted to state formally the characteristics of examples and nonexamples that will result in correct classification, over-generalization, under-generalization, and misconceptions (accepting and rejecting examples and nonexamples on irrelevant attributes). Richard C. Anderson and Raymond W. Kulhany (1972) have presented evidence for the role of semantic encoding in the acquisition of conceptual skill, as well as in verbal associative learning. Gary R. McKenzie (1972) has presented evidence to suggest that inference quizzes facilitated mental processing involving logical manipulation of concepts. Moss, Pucel, Smith, and Pratzner (1970) have suggested verbal free association methodology as a way of mapping the cognitive structures of workers.

Dorothy A. Frayer, Elizabeth Schwenn Ghatela, and Herbert J. Klausmeir (1972) have presented a hierarchy of 12 tasks to assess levels of concept mastery. The first 11 levels range from providing an example given a concept name to providing subordinate concept names given the name of a reference concept. Their twelfth level involves the student's selecting/supplying the principle which relates two given concepts—an example of principle processes to which we now turn.

Principle

Principle processes involve the delineation and application of relationships among classes of elements (concepts). This can range from simple pair-wise comparison to an elaboration of elegant

taxonomies. Application of principles can range from the application of contingency rules to decision making in a probabilistic situation with formal logic rules and optimization criteria. It does not, however, involve the discovery or invention of new principles—merely the incorporation and use of accepted principles, relations, and rules.

Discovery

Discovery involves the generation of new concepts and/or principles which can, at least retrospectively, be derived directly from available perceptions and remembered data. Discovery is an important form of problem solving which Carl P. Duncan (1959) has related to a variety of other learning models and behavior analyses. Robert M. Gagné (1959) has included under "problem solving" application of decision strategies which we would consider here to be the application of principle skills. Indeed, at the time of his early review of problem solving, he included little which would qualify as demonstrating discovery skills. However, Gagné and Smith (1962) report results which:

> . . . appear to indicate that requiring [experimental subjects] to verbalize during practice has the effect of making them think of new reasons for their moves, and thus facilitates both the discovery of general principles and their employment in solving successive problems. (p. 18)

This result confirms earlier results (Gagné & Brown, 1961) that suggest that requiring an individual to reinstate (i.e., actively produce) concepts in problem solving helps in the discovery of problem solutions. Francis J. DiVesta and Richard T. Walls (1967) have presented evidence that prior experience with only a narrow functioning of devices required to solve a problem in a unique way on a criterion task can result in a "functional-fixedness" and negative transfer.

Invention

Invention involves the development of hypothetical constructs concerning concepts and/or their relationships which cannot be directly observed and which cannot be directly derived using established rules. This is not too different from Marshall Hahn's (1968) definition of creativity:

> Creativity is the ability and initiative to create new ideas and/or things by the restructuring or redefining of past experiences into new forms. (p. 5)

There can, of course, be an enormous range of inventions along many dimensions—e.g., trivial-profound, useful-useless, ugly-aesthetic, seminal-dead end. The conditions for effective acquisition and transfer of invention skills are not yet well understood—but we do know two important essentials:

- ✓ Intellectual skills of the sort delineated above.
- ✓ Nonpunitive opportunities to practice.

Formulation

Formulation involves taking the results of any of the intellectual skills delineated above and structuring them in a form suitable for:

- ✓ Pre-response evaluation.
- ✓ Post-evaluation instruction to the response mechanism.

Formulation can be oriented around:

- ✓ Delineating internal message units.
- ✓ Forming messages.
- ✓ Queueing messages for transmission to effectors.
- ✓ Editing messages against evaluative criteria.

Evaluation

Evaluation involves the application of pre-response criteria to formulated output of intellectual processing. Effective evaluation frequently means the difference between a writer who comes close to a final draft for the first time versus one who goes through many drafts to achieve equivalent quality, a painter who wastes little or much paint, and an automobile driver who makes many or few gross steering adjustments.

Perhaps it will suffice here to make three general points about intellectual processing and skill transfer:

- ✓ As Robert Gagné has reiterated often and well, there are strong possibilities for hierarchical relations among intellectual processes. Given compatible stimulus-response associations and similar stimulus and response sets, there should be high positive transfer as one moves to increasingly complex tasks from perceptual transfer, to conceptual analysis, to principle delineation and application, to discovery, and to invention—subject, of course, to inherent individual limitations and to compatible motivations.
- ✓ The level at which we have described intellectual skill is, of course, much too gross to support effective analysis of probable transfer. Far more rigorous and detailed delineations of processes are required as general guides to analysis.
- ✓ Intellectual processing can result in negative skill transfer when inappropriate models are applied—as, for example, when we reach for a knob where it was on the dashboard of our old, not our new car.

Response

We use a very restrictive definition of response here—limiting it to the carrying out of a clearly commanded overt act. This is decidedly not the same as traditional definitions of perceptual-motor, psychomotor, or similar discussions of the same topic under shortened titles such as "motor skills" or just "skills." Indeed, Paul M. Fitts in his chapter on perceptual-motor skill learning (1964) contends that the strictly response aspects tend to be trivial relative to the perceptual and feedback aspects. The book edited by Edward A. Bilodeau on acquisition of skill (1966) similarly seems to give minimum attention to delineation of the response *per se* or to conditions of its acquisition.

Such narrow delineation of response as we seek here also runs counter to prevailing current practice in educational psychology. For example, Gagné (1975) emphasizes five categories of response organization which involve various combinations of the skill categories described in this paper, but none of which is limited to or primarily emphasizes the terminal or overt acts of performance.

We are inclined to agree that response skills are probably the most simple to acquire for persons not having physical disabilities. However, we believe that response should receive independent delineation for at least two main reasons:

- ✓ Most responses can be combined in a wonderful variety with other skill areas. By separating out the response set from other behavioral aspects we achieve analytic simplicity without assuming or implying inappropriate constraints on combinatoric possibilities.
- ✓ Response skills tend to transfer widely, fully, and positively. It is true that responses closely associated with a particular stimulus will involve some negative effects in transfer until associations with the appropriate stimuli are established, but this is a problem of the learning of associations—not negative transfer of response skills as such.

Even though responses may be simple relative to some other aspects of behavior, they still cover an impressive variety—including:

- ✓ Vocalizations (speaking, singing, etc.)
- ✓ Writing
- ✓ Drawing
- ✓ Making facial signals
- ✓ Signaling with body postures
- ✓ Locomotion
- ✓ Manipulating tools
- ✓ Manipulating objects
- ✓ Operating controls
- ✓ Reaching and grasping
- ✓ Positioning and moving the limbs
- ✓ Positioning the body as in standing, sitting, kneeling, etc.

Each of these seemingly simple response categories has a number of dimensions and levels of refinement.

Integration

Integration processes are concerned with modulating behavior in accordance with evolving experience. This involves relating motivational/behavioral dynamics to contextual dynamics, and represents the principal point of intersection between motivational and behavioral domains. It encompasses human learning, motivation, decision theory, closed-loop system theory, information theory, communications theory, and probably numerous arcane areas which we have not yet identified. It would be fatuous to imagine that we could rigorously define the dynamics of these integrative processes.

Even at a superficial level, however, we can identify three kinds of integrative processes having implications for skill transfer:

- ✓ Perception of feedback
- ✓ Analysis of contextual/response relations
- ✓ Formulation and evaluation of goals

In Figure 10 we illustrate some of the major interfaces among these processes as well as between these processes and other significant elements.

Feedback Perception

We are here concerned with a restricted class or subset of perception—perception of the individual's prior responses and association of these responses with contextual events. As mentioned in the discussion of the motivational domain, contiguity of response and contextual event (short latency) is a dominant factor in perception of an association. However, perception of response-context associations can be modified by prior beliefs about the dynamics of relevant parts of the context and about the nature of linkages between performance and the environment. For example, an individual may ignore a contiguity between performance on a machine and its malfunctioning on the basis of knowledge about design of the machine.

At least three different kinds of dissimilarity between contexts can degrade feedback perception and, thereby, interfere with positive skill transfer:

- ✓ The latency and/or probability response/event linkage may change. For example, a sales person used to working under close supervision may sorely miss supportive remarks upon assignment to a remote location.
- ✓ The "noise" surrounding relevant contextual events may increase. For example, an incisive supervisor may be replaced by a wordy one.
- ✓ The signals and messages reflecting performance effects may change. For example, new switches may not yield the auditory click associated with activation of old ones.

Relational Analysis

Analysis of relations between performance and contextual response is a limited and special form of intellectual processing. It is limited in two ways:

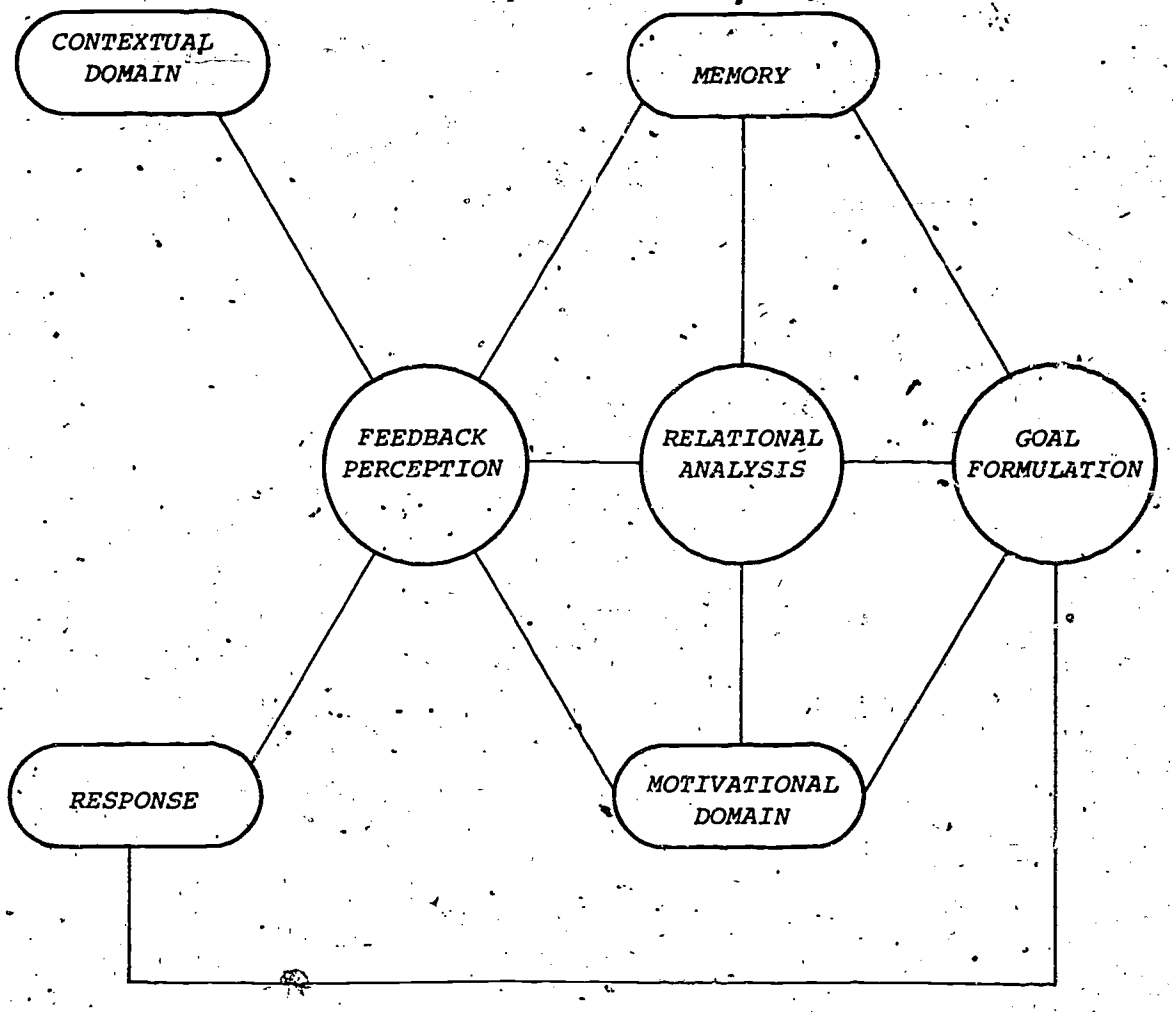

Figure 10. Illustrative interfaces for integrative processes.

- ✓ We arbitrarily defer formulation and evaluation processes to the later discussion of goals.

- ✓ As we conceive of it here, relational analysis is restricted to a limited class of phenomena—namely, prior individual performance and associated contextual events.

Relational analysis is not restricted as to level of intellectual processing since perceptual transfer, conceptual processing, application of principles, discovery, and invention may all be involved.

At least two kinds of differences between contexts in relational analysis may impede skill transfer:

- ✓ The level of intellectual processing required to maintain an accurate model of perf[illegible]ce/context dynamics may change. For example, introduction of power assist to an exp[illegible]d operator's work context may impede performance until some concept of "variable [illegible] is introduced to mediate between control responses and machine performance.

- ✓ The dynamics of performance/context relationships may demand new models. For example, a worker who is promoted to team leader may cope with the same objective context, but with new rules governing productivity. Whereas previous individual effort led directly to increased productivity, optimum productivity in the new role may be achieved with limited direct technical effort.

Goal Formulation

Goals are explicit or implicit future states toward which the individual is motivated. As such, we have considered goal formulation and evaluation at some length in our discussion of the motivational domain. Indeed, now that we have delineated both behavioral process and motivational points of view, we might subsume the motivational domain as a subset of considerations under mediation.

Once an individual has formulated current goals, it can lead to three principal kinds of response options:

- ✓ Withdraw from the context, thus precluding further opportunity to transfer skills to that particular context.

- ✓ Change one's own behavior to accord with new goals. This can have a positive impact on skill transfer if the new goals are more stringent, and reduce potential for transfer if the new goals and standards are more lax. An imp[illegible]tant variant here is a commitment to a schedule of changed behavior over time which derives from a self-directed program of acquiring increased proficiency. Such commitment gives maximum opportunity for positive skill transfer.

- ✓ Change the context. This is usually a risky proposition unless responsibility is a legitimated and protected part of one's job. Job enrichment, participant management, and other humanistic philosophies would argue, however, that context-changing skills are (or should be) among the most important and transferable.

CONTEXTUAL DOMAIN

Having touched broadly, albeit lightly, on behavioral/motivational factors in skill transfer, have we missed any important considerations? Indeed we have, for we have touched only coincidentally on substance—the content or stuff with which an individual must cope in performing a work task.

In his companion paper to this one, Bruce McKinlay (1976) has extensively reviewed research on characteristics of jobs that are considered common. We will not parallel, duplicate, or attempt to summarize the results of that review. We interpret those results to suggest that:

- ✓ There is no dearth of alternative bases for characterizing jobs, but no basis or set of articulated bases have proven to be uniquely useful for skill analysis.
- ✓ Multivariate characterization of jobs has substantial promise, but this promise is not to be fulfilled without substantial applied research. The implications are methodological rather than substantive to date.
- ✓ One of the most extensively used and promising approaches to job characterization is task analysis.

When Robert B. Miller (1962) called for the development of a task taxonomy almost a decade and a half ago, he was stating formally and publicly matters which had been discussed informally for more than a decade. To the best of our knowledge, no one has argued successfully against any of the many and serious constraints under which Miller contends task description and analysis must be carried out when a task taxonomy is not available. By now, there has been a long, varied, and extensive search for more effective ways of characterizing skill-oriented relationships among tasks. Edwin A. Fleishman has recently (1975) described probably the most extensive and, quite possibly, the most successful. Despite interesting and sometimes promising results, it seems fair to characterize the current state of the art as follows:

- ✓ Neither the approaches nor results relating to vocational task analysis have led to strong inferences (Platt, 1964) about a skill-oriented task structure.
- ✓ Results from different approaches and methods have not been clearly characterized in terms of either commonalities or differences of outcomes.
- ✓ Construct validity has not been established for any approach to analysis or model of the vocational task domain. That is, there is no coherent set of relationships established between general behavioral theory and task taxonomic approaches and results.
- ✓ Predictive validity has not been established for any approach to analysis or model of the vocational task domain. That is, no coherent set of empirical relationships between task characteristics and performance has been established.

- There is little in the way of precepts or results which an analyst undertaking a new domain mapping effort would be forced to accept *a priori*. That is, there is little in the way of a generally accepted vocational task technology. Indeed, our behavioral/motivational analysis in this paper has been essentially just an extension of general categories for analysis suggested by Robert Miller some 25 years ago.

We still believe "task" to be a key concept. We have used it extensively throughout this paper, and shown that the behavioral/motivational domains relate to each task. How, though, should we best proceed to extract from the contextual domain a framework of the alternative content that might be involved in any particular task?

In a sense, this is asking to structure the universe of phenomena with which working humans interact—a chore wildly beyond the scope of this paper. However, an exploratory study reported by Altman (1966c) a decade ago suggests that useful structuring of vocational content across a wide variety of jobs is not particularly difficult. Further, that preliminary study showed that American youth tend to organize knowledge in ways which parallel clusterings of job content. In many respects the Altman study was naive and simplistic, confounding many of the behavioral/motivational distinctions which we have endeavored to maintain here. Much more direct progress should be possible with the increment in behavioral theory and data which has taken place in the past decade.

Perhaps the most immediate promising results derive from studies of perception (discussed on pages 15 to 20). There are, of course, many difficulties to overcome in delineating and organizing object, space, event, representational, and symbolic domains. Characterizing the principal entities within each of these domains according to distinctive features, invariance over time, and relation to higher-order structures will also be fraught with difficulty. However, a taxonomy of percepts must be orders of magnitude easier to develop than a comparable taxonomy of total tasks.

A phenomenological mapping of vocational perceptions would not necessarily be structured the same as content when it is being remembered, intellectually processed, acted upon, or integrated into informative feedback and motivation. But such perceptual mapping would go a very large first step toward organizing vocational content in ways tht will predict transferability of skills.

Some of the kinds of factors that must be involved in perceptual mapping of a given context are summarized in Figure 11.

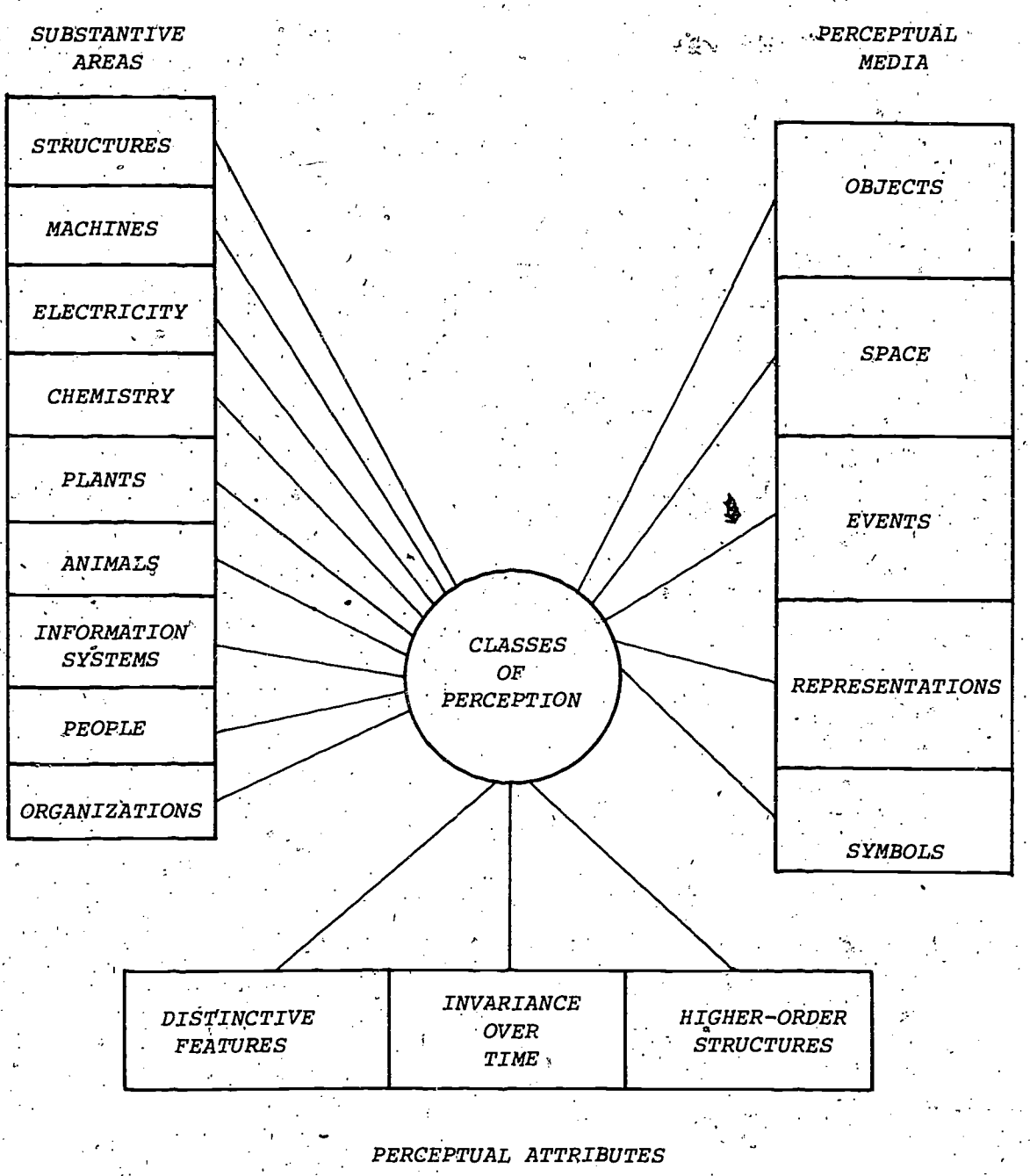

Figure 11. Illustrative bases for defining classes of perception.

EDUCATIONAL IMPLICATIONS

We have conjectured at some length about the relationships of motivation, behavioral processes, and work contexts to skill transfer. To derive implications from conjecture has obvious dangers. Nevertheless, there seem to be hints for educational practice that will tend to generate transferable skills.

First, we define what characteristics of educational outcomes would lend confidence in transferability of skills. Then, we examine the educational implications of our previous conjectures through a series of five recommended steps for educational development:

- ✓ Define criterion contexts
- ✓ Analyze criterion contexts
- ✓ Develop educational tasks
- ✓ Optimize educational sequences
- ✓ Optimize conditions of skill acquisition

This series of steps is not intended as a comprehensive procedure, but rather as a vehicle to highlight differences between current approaches and one directed more explicitly toward the development of transferable skills.

Confidence in Transferability

What would give us confidence that graduates of our educational program will be able to perform a given real-world vocational task successfully? One situation that should give us a great deal of confidence is if a large number and variety of people have tried and have, without exception, succeeded in their first try. Unfortunately, this may also suggest that education is not very relevant or necessary to the task at hand.

More cogent confidence might be gained by inclusion of in-school task performance requirements such that all those who succeed in the school tasks perform successfully on the job and those who fail in school also fail on the job. But, committed as we might be to empirical validation, such specific validation seems to have substantial promise only for very specific job training—not for broad educational programs. The practical problems would be enormous.

Even if we had to forego empirical validation, we might have reasonable confidence in positive skill transfer if the job task were brought intact into the school and performed under apparently similar conditions. But it is difficult to imagine a coherent educational program growing out of a direct sampling of job tasks unless the range of jobs sampled is extremely limited.

If we reject the triple traditional tools of blind faith, broad subjective impressions, and occasional anecdote, confidence must come from the way in which the educational program is derived from the work content—supported by highly selective empirical validation. The issues in such validation are significant, varied, and complex, but not central to the central purposes of this paper.

Our concern for the remainder of this paper will be on feasible methods for deriving an educational program from real-world contexts. We believe these preliminary notions uniquely derive, in turn, from the kinds of considerations examined previously in this paper from the contextual, behavioral, and motivational points of view.

Define Criterion Contexts

Any orientation of an educational program toward out-of-school behavior is based on assumptions about the contexts in which the intended behavior will be useful. But, such assumptions are usually tacit and imprecise. "Education for life," without further rationale to link purpose to curriculum, does not reveal serious commitment. If we are committed to educational derivation with maximum potential for skill transfer, we must be serious about delineating the contexts to which we are and are not accountable.

It is easy to confuse exhaustiveness and rigor here. Indeed, excessive detail is a great danger to clarity of purpose. For example, one can delineate inclusion and exclusion of multitudes of tasks with a single simple statement such as:

> "All tasks in machine setup, operation, and malfunction reporting will be included but all corrective maintenance tasks are excluded."

The definition of criterion contexts should explicate:

- ✓ The population of organizations, institutions, and systems to be included.
- ✓ The functions and activities which relevant human performance is to support.
- ✓ The population of individuals and roles for which the skills will have relevance.
- ✓ The span of time for which skills are expected to have full relevance and the probable schedule by which an update of requirements will be needed.
- ✓ The sources and types of data that will be accepted as authoritative with respect to performance requirements for given contexts.

The selection and general delineation of contexts is one of the places where community representation can be most helpful.

Analyze Criterion Contexts

This is the step on which most attempts at rigorous educational development flounder, primarily for one or more of the following reasons:

- ✓ Excessive resources go into extraneous detailing.

- ✓ The favored units of "tasks" or "skills and knowledges" tend to come in quite large numbers. Even their brief enumeration can be a formidable chore for contexts of any breadth.

- ✓ Multiple sets of tasks or skill/knowledge turn out to be a relatively awkward and intractable basis for educational development. Even "simple" tasks tend to include a surprising number of component actions, each with its own series of behavioral stages.

Our review of contextual, behavioral, and motivational domains lends confidence to the view that we might decompose the relevant contexts into relatively simple and nonredundant sets of elements without excessive fear that subsequent recomposition for educational purposes will lose the essence of skill requirements. Such an approach has the important practical advantage that, like traditional textbook writing, inclusion of specifics from real-world source materials can be deferred until actual preparation of curriculum and instructional aids. Extensive documentation for preliminary phases is not required.

The suggested approach to analysis of the selected criterion contexts includes three steps:

- ✓ Decompose the relevant contexts

- ✓ Organize and delineate elements

- ✓ Estimate significance of elements

Decompose the Context

The foregoing discussion of contextual, behavioral, and motivational domains has suggested a number of dimensions which might be used (one at a time or in small sets) to extract analytic information from the context. Our initial suggestion for order would be:

- ✓ Perceptions and the principal contextual factors that control their advent

- ✓ Responses

- ✓ Intellectual processes

- ✓ Memory elements

- ✓ Integrations and their principal motivational implications

The essential requirement for this step is to decide into what slices contexts are to be cut for purposes of analysis.

Organize and Delineate Elements

The purpose here is to achieve a notion of the contextual content in terms of:

- ✓ Kinds of entities (perceptions, responses, etc.)

- ✓ Attributes (characteristics which distinguish each class of entity)

- ✓ Relations (linkages between classes of entities on different dimensions, such as between perceptions and responses)

It is not exhaustive detail which is important, since this can be picked up subsequently if needed. Rather, the crucial need is for well-structured and comprehensive sets of element categories.

Estimate

In line with our sincere desire to avoid unnecessary work in this analytic step we will not want excessive description of contextual/behavioral/motivational elements. However, estimates of the frequency of use, performance difficulty, and importance of each element may facilitate later steps. This is another place where community leaders can be helpful since social value judgments will be involved in defining importance and technical judgments are likely to be involved in estimating frequency and difficulty.

Develop Educational Tasks

The prior analysis should result in a specification of the kinds and relationships of behavioral elements involved in the contexts of interest. The next step is to create, in accordance with such specifications, cost/effective learning or education tasks to cover the same elements.

Development should begin with the most complex tasks and work to the most simple, stopping when the next developed task would be so simple that all persons qualified to enter the program could perform it without practice. But, the different behavioral dimensions have different difficulty levels and interrelate differentially at the various levels. For example, the classes of perception that interact with the highest levels of intellectual processing are likely to be different from the classes of perception having greatest use in simpler processing. This means that "difficulty" is not a unitary factor. It is a composite characteristic for each learning task which derives from the different kinds of behavioral elements involved.

A great deal of empirical experience is required before solid development guidelines can be prepared. Preliminarily, we might suggest the following general sequence:

- ✓ Determine the class of intellectual processing having greatest complexity/difficulty.
- ✓ Determine the perceptual classes normally associated with this most difficult intellectual processing. Determine whether all of these perceptual classes can be included in a convenient learning task or whether multiple tasks are required. For each prospective task, determine whether there are additional intellectual processes and/or perceptual classes whose inclusion would enhance the task as an educational tool.
- ✓ Given intellectual processes and perceptions for the most complex set of tasks; follow a similar procedure to the above for response, memory, and integration processes in turn.
- ✓ When all of the tasks have been prescribed for the most difficult/complex level, take the next most complex/difficult class of intellectual process and follow a procedure similar to the above—taking into account articulation of new tasks at the next higher level of complexity.
- ✓ Continue the process until the desired minimum level of difficulty has been reached.

Optimize Educational Sequences

We do not have well-defined general rules for sequencing students through a set of tasks such as would result from the previous step. Such rules await greater depth of analysis and more relevant data than we have available at the present time. In addition, optimum is almost always subject to local definition—influenced by purpose, administrative constraints, and student characteristics. Nevertheless, we can make five general observations about sequence:

- ✓ The general order of mastery should be from simple/easy to complex/difficult. This is probably not terribly critical except where more complex tasks demand specific skills or knowledge acquired in a previous task.
- ✓ Mastery of a given task should be prerequisite to moving to a new task. At each level students should have achieved useable proficiency. Performance on a given task should improve as a function of practice on that task. But the general progress through the program should be from competent performance on increasingly complex tasks, not from incompetent to competent performance.
- ✓ The organizing framework for lateral moves (from one educational task to another at the same level) should usually be contiguity on a perceptual dimension. This will tend to yield structure to the content acquired at each level. For example, it may help to clarify functional relationships among the widely varied objects encountered.
- ✓ Administrative constraints on sequence due to equipment, instructor skills, and time limits will probably not have serious effects unless they result in extended periods of nonproductivity for students.
- ✓ The set of educational tasks will constitute a performance context of its own. All of the considerations of skill transferability reviewed in this paper should be relevant. Maximum positive transfer is required for optimum sequencing of student experience.

Optimize Conditions of Skill Acquisition

Obviously, skills not acquired cannot be transferred—so optimization of acquisition has clear importance for educational design and practice. It is beyond the scope of this paper to review the particulars of the instructional technology which should lead to optimization of skill acquisition. We limit our discussion here to a few informal observations about each of the five main stages of behavior.

Perception

New perceptions are usually interesting and can even be exciting. Old perceptions can be a bore, unless they:

- ✓ Are associated with salient feedback.
- ✓ Occur in new and varied surroundings.
- ✓ Are used in new combinations with other stages of behavior (as, for example, in new uses for a tool).

Intellectual Processing

Acquisition of skill in any given type of intellectual processing is especially demanding of variety. This includes varied perceptual input, varied memory sets, and varied responses. Intellectual processes are also especially likely to involve hierarchical learning sets, with more complex processes including combinations of simpler processes that can be independently acquired. For example, Gagne' and others (1962) have found a great deal of hierarchical relationship among mathematical concepts. Intellectual processes represent an especially good basis for defining a core task with a wide variety of alternative exposures to what is essentially the same task. For example, deciding what to do with a vehicle in a skid might involve a wide variety of programs for getting into skid trouble.

Memory

We would anticipate that few contextual analyses will find requirements for overstuffed memories. In contrast, we would expect to find an emphasis on efficient storage and retrieval—and readiness to reorganize the most relevant material. Growth of memory will, of course, be involved in the educational program. But the emphasis should be on flexible use for given task requirements.

Response

Response oriented skills seem to be especially sensitive to the individual's self-awareness and self-criticism. It is desirable to achieve a high quality of response capability early because of the utility responses have for carrying out and demonstrating competency on tasks. For example, knowing how to say and write words is basic to competency in symbol systems—and locating controls in machine operations is also basic.

Integration/Motivation

The biggest leverage education has on skill acquisition and transfer is on a student's motivation. This is not separate from, but intrinsic to, performance on educational tasks. A generalized orientation toward competency is essential not only for adequate development of an individual's potential, but also for full positive transfer to and across jobs.

This is not the place for an extensive review of existing literature on the conditions for generating competency versus helplessness. But, we are not talking about an occult process or even a very complicated issue in its essentials. Two concurrent factors are required:

- *Challenge*. Within the normal attention span of the age group, opportunity must be provided for success or failure. Guaranteed success will result in boredom and inattention to future opportunities. Guaranteed, or highly probable, failure will result in helpless response to future opportunities.

- *Fair feedback*. Excessive reward will be disruptive and create unnecessary potential for feelings of inequity. Excessive punishment or penalty will be even more disruptive and may divert behavior toward means of escaping the situation. Most important, feedback must be contingent on performance. Rules must be consistent and the individual must be able to understand them.

In addition, generalized competency will develop greater open-ended potential insofar as opportunity is afforded the individual to set goals, performance standards, and feedback rules.

A realistic sense of competency is probably as valuable a commodity as an educational enterprise can offer—to an individual, to the general society, and to the institutions into which skills will ultimately be transferred.

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PLANNED PROJECT REPORTS

The following is a list of approximate titles and estimated dates for currently planned project reports. The reader is cautioned that many of the reports are not yet available, and that both titles and dates of availability are tentative and can change in the future. Announcements of availability and information for ordering copies of reports will be published in future issues of The Center's monthly newsletter, *Centergram.*

Characteristics of Jobs Considered Common—Review of Literature and Research. Bruce McKinlay (available Winter 1977).

A review of various approaches for classifying or clustering jobs, and their use for describing the elements of commonality involved when people make career changes; intended for better understanding occupational adaptability and skill transfer.

Developing Transferable Skills: Review of Current Practices in Training and Selection Programs (available Fall 1977).

A review of selected training programs, with clues, suggestions, and recommendations for practice which appear to have been successful for recognizing skill transfer and taking advantage of student's prior skills and experience.

The Nature of Transferable Skills—Review of Literature and Research. Douglas Sjogren (available Summer 1977).

A review of what is known about the range of occupation-related skills and characteristics that could be considered transferable from one occupation to another. Expected to focus on describing those transferable skills which are teachable in secondary and post-secondary career preparation programs.

Occupational Classifications and Mobility Data: A Catalog of Classification Schemes and Data Bases (available Summer 1977).

Expected to be a quick and concise reference to the content of numerous existing occupational data bases and job classification schemes. Abstracts of each data base and classification scheme will include such information as: identification, investigator, location, documentation, access, design information, subject variables, occupation variables, and organizational variables.

Report of Employer's Reactions to the Notion of Transferable Skills (available Spring 1977).

A report of the views expressed in nine meetings across the country by groups of local community and business representatives concerning the types of transferable skills required and useful in their work settings and how a better understanding of transferable skills could improve training and occupational adaptability.

A Study of Occupationally-Transferable Skills: Final Project Summary Report (available Fall 1977).

An executive summary final report of the project, expected to summarize recommendations for subsequent research and development growing out of each project activity and report.

Transferability of Vocational Skills—Review of Literature and Research. James Altman (available Winter 1977).

A review of what is known about the transferability of occupational skills. Expected to focus on describing the process or the facilitators of skill transfer.

INFORMATION CURRENT AS OF DECEMBER 1976