TASK ANALYSIS: A CONSIDERATION FOR TEACHERS OF SKILLS

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is evident that the study of how man acquires skill has progressed con- lerably in the past fifteen to twenty years. Knowledge about sensory and rceptual mechanisms and effector action — revealed to us through the c of the computer — has broadened the horizons of those engaged in c study of the acquisition of skill. We have come to accept the fact that begin to understand how man executes a complicated movement pat- rn it is necessary to understand the intricate operations of the sensory id perceptual mechanisms as well as the action potential of the effectors.

Recently, there has been increased focus on task analysis, including nsideration of how the analysis of a task influences the structuring of c learning environment. If man is viewed as an information processing stem, it must be recognized that the kind and/or amount of information esented to the learner is critical to the learning process. Each task must analyzed to determine its unique characteristics and the consequent nsory, perceptual, and effector demands on the performer. The chal- nge to the skills teacher, then, is not only to understand the learner/ rformer's processings capacities and limitations, but also to be able to ialyze critically specific tasks.

The Process of Task Analysis

The concept of task analysis is based on the premise that man performs sks successfully when he has selected and processed necessary or rele- nt information. Before specifying what responses are needed to achieve ccess, it is first essential to determine the stimuli to which the learner ust attend. Each task must be examined in order to ascertain critical urces of information.

One source of information available to the performer is the actual se- ential output of his ongoing performance, that it, feedback information garding immediate output. Another source of information deals with ex- nal factors in the environment. Both these sources of information are rectly related to the specific task to be performed. Fox and Levy (1969),

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Bourne (1966), and Armstrong (1970) found that feedback is largely task specific. Armstrong reviewed more than fifty studies dealing with feed- back and motor learning and concluded that the discrepancies in the vari- ous findings of these several studies probably were due to variation in the components of the task.

Different tasks demand the processing of different types of feedback. For example, in driving a car a great deal of visual feedback is necessary for good performance. Accurate feedback is also critical in aiming tasks. Sport skills that call for gross movements of the body demand adequate internal, or proprioceptor, feedback information.

It is well recognized that feedback is one of the more important vari- ables controlling human performance and learning (Bilodeau and Bilo- deau, 1961). According to Holding (1965), the manipulation of feedback is one of the most effective ways of influencing the course of learning. If feedback is task specific, then it is obvious that task analysis is required in order to determine the critical sources of feedback information. The term "critical components" is used, also, to denote a critical source of feedback. A component is critical if its absence or malfunction prevents correct or efficient performance.

Various approaches have been suggested to aid in the identification of the critical components of tasks. Figure 1 presents a summary of several of the approaches developed by human performance theorists such as Poulton (1957), Fitts (1965), and Knapp (1963).

Four different approaches are displayed. Each suggests that a different factor be considered in task analysis. Spatial or spatial/temporal control of a task is regarded as environmental regulation. Pacing of movement is

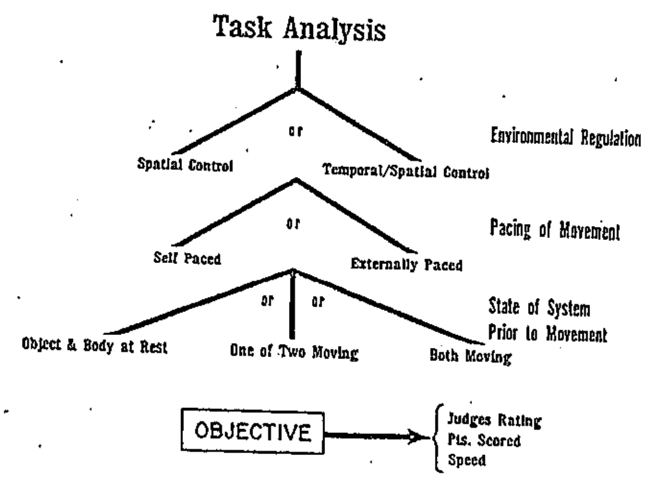

Figure 1. Task classification approaches.

based on the rate at which the performer must process information. Objective and state of the system prior to movement refer to another approach to task analysis. In order better to understand each concept presented, the reader is encouraged to select a sport task and proceed to analyze sources and types of information inherent in the tasks critically as each of the approaches is discussed.

Environmental regulation. Environmental regulation is concerned with the type of movement control needed to accomplish the task. First it is necessary to determine the state of the environment: is the environment relatively permanent or stable, or is the environment unpredictable and in a state of flux? The environmental regulation approach is based on Knapp's (1963) adaptation of Poulton's (1957) open and closed skill classification system.

"Closed" skills are those performed in a predictable environment, that is, the critical information in the environment is not constantly changing. A gymnastic vault is a task which calls for the execution of a closed skill. The vaulting apparatus, i.e., buck or horse, is not moving in space, but is a stable, fixed object. Thus a closed skill utilizes a stereotyped movement pattern or demands a habitual type of response, i.e., spatially controlled movements.

"Open" skills are those in which the critical source of information is constantly changing as the result of the movement of external factors. A task which involves unpredictable events occurring in time and space is categorized as open. When a performer must adjust to an environment in which objects are moving in space and are unpredictable, he needs a different movement pattern than when he can predict with a fair amount of certainty that an object will be in a particular space the majority of the time.

Our physical activity environment is more likely than not to contain objects in space to which the performer must be constantly adjusting; that is, external elements such as the location of other players and/or game objects determine the movement patterns.

An open skill demands anticipation. According to Poulton (1952, 1957), there are two types of anticipation: (a) receptor anticipation and (b) perceptual anticipation. These two terms imply the source or origin of the information which will aid the performer in completing the task successfully. Receptor anticipation is information which is received from the immediate environment and is external to the performer. Perceptual anticipation involves information from internal sources and relies heavily on stored data.

Pacing of movements. The concept of pacing involves an understanding of the rate of incoming information as well as of the location of the information. Tasks can be classified as either self-paced or externally paced. If critical information arrives too quickly, the individual must either ignore it or filter it out, because man is limited in the rate at which he can process information.

A self-paced task is one that allows the performer to regulate incoming information and thus determine the initiation and rate of his movement sequence. Golf is an example of a self-paced sport task. The golfer determines when to initiate his movement sequence.

An externally paced movement is one in which the operator or performer has no direct control over the rate of incoming information. The player must process information at a rate determined by something or somebody else. Many sport tasks are externally paced, in that the movements of the opponent or the game object determine the amount of information to be processed, the rate at which it must be received, and the subsequent movement pattern. Tennis is externally paced because the tennis player must time and adjust his movements to the game object.

Some skills may encompass the processing of information from both external and internal sources. Driving a car, for example, can be a self-paced task in that the driver controls the rate of oncoming information by setting his own acceleration speed. If, however, the traffic around him is heavy, the task becomes externally paced.

The state of the system. Fitts (1965) proposed that information prior to the execution is as important as ongoing information during the performance. That is, the information to be processed in order to accomplish a task is dependent on the state of the system prior to the initiation of the movement sequence. He proposed a classification system based on the features of the task as well as the degree of body involvement prior to the initiation of the sequence. Is the performer's body at rest or in motion? Is the object to be acted upon at rest or in motion? Are both the object and body in motion?

Fitts identified three levels of difficulty for his classification of tasks, labeled I, II, and III. Difficulty was arranged in hierarchical order. Level I is considered to be the least difficult and Level III the most difficult. The difficulty is inherent in the task and does not imply a skill level (ability) of the person. The Level III task is more difficult because of the amount and source of critical information to be processed by the learner.

Level I tasks are those in which the performer and the object are at rest prior to initiation of action. Croquet players execute Level I tasks. Golf is a Level I activity. The object and the body are at rest prior to the initiation of the swing. The performer must process information about his own stable body position as well as the location of a fixed object (the golf ball). One can imagine how much more difficult it would be to hit a moving golf ball.

Level II tasks are those in which either the performer or the object is moving. Baseball batters perform Level II tasks.

Level III tasks involve movements of both the performer and the object prior to initiation of the movement pattern. A tennis player moving to return a forehand drive is performing a Level III task. A quarterback in football rolling out to throw a pass to a moving player is also engaged in a Level III task. The critical element is the release of the ball. Since both the object (receiver) and body (passer) are moving prior to the release of the ball, the performer must process information about the object's (receiver) movement as well as the changing state of his own body position.

According to Fitts, tasks in which both object and body are moving are more difficult than those in which the body and object are both at rest prior to the initiation of the sequence.

Objective. Figure 1 also identifies the objective of the task as another element which must be considered in the entire process of task analysis. Objectives are listed in reference to sports tasks. Thus, a sport objective may be goals scored, judge's ratings, or measures of speed and distance. Obviously, the type of information to be processed must be related to the game objective. The objective is viewed as an overall guiding force which determines the final movement pattern selected by the performer. It also serves as a standard or reference with which to compare output. Since the critical element in the selection of feedback information is a comparison of output to a reference pattern, the objective established is one of the more important elements in this selection.

Still another approach to task analysis, one which is not shown on the diagram presented in Figure 1, is to examine the relationship between the task to be performed and expectations held for the information processed. Posner (1964) proposed such a classification scheme from data gathered through experimentation. He cited three types of expectations for processing: information conservation, information reduction, and information creation.

Information conservation tasks. A task which requires conservation of information is one in which a person must select from all possible sets of outputs and execute the one corresponding exactly to the specific input signal. The subject's output, to be correct, must have utilized all the critical information from the input, i.e., the output must be equal to the input.

Typing is one example of a task which demands the conservation of information input. The key selected must correspond to the input signal. Accuracy in performing conservation type tasks depends upon the relationship between the input and output as well as the subject's ability to discriminate important input signals.

Information reduction tasks. A second class of information processing tasks requires a condensation and/or filtering of the input information. In a filtering task man acts as a monitor. He is required to examine the state of a situation, and to respond only when a certain event occurs. Refereeing a ball game is an information filtering task. Spectators object vociferously when a referee filters out too much of the information the crowd observed. Both the rate of information and the complexity of the information affect man's ability to perform filtering tasks.

A second form of reduction task involves the condensation of information. Writing an abstract or condensing a book involves the task of collapsing or condensing the input information. An individual's output is less

than that contained in the input whenever he executes a condensing or filtering task.

Information creation tasks. In many cases the task confronting man calls for an elaboration or rearrangement of the input information. Choreographing a dance or creating a swimming routine are examples of tasks in which man is asked to utilize all the input information and then either elaborate, extend, or rearrange it. Thus, original thinking, i.e., generating "new" information, is involved in this type of task, whereas rote memory or imitation are thinking processes involved in the other two types of tasks.

Utilizing Information

Whenever a skilled act is performed, the performer has successfully integrated the sequence of action and is engaged in utilizing and translating information from his sensory system to his effectors. The sequential/temporal organization of the movement pattern is efficient and effective.

Man is limited in his ability to process information. He cannot handle all the available information in the environment and must learn to sort out noise or irrelevant information. Experiments concerned with multiplexing have supported the idea that man cannot process information from more than one stimulus simultaneously (Bahrick, Noble, and Fitts, 1954). He operates as a single channel system (Welford, 1967, Annett and Kay, 1956).

If man is a single channel operator and multiple signals arrive, some signals must be held up, and be transmitted to the central processing system in serial order. Tasks, then, may be viewed as the receiving of incoming signals which have been processed in some kind of serial order. Annett and Kay pointed out that the skilled player knows some events will follow certain responses. Since some events frequently follow others, the skilled player is more capable of recognition of redundancy in any task. He knows which information is necessary to process and which to ignore. The unskilled player does not know what information is coming next or which to process. In order to aid the learner to process information serially, tasks must be examined according to the location and probability of serial order information.

The quarterback who has completed a forward pass in football is successful; that is, he has processed the necessary information. While it may be easy to differentiate a skilled movement as opposed to an unskilled movement, it is more difficult to explain the actual processing of information which occurred. The quarterback must have processed the visual input about the location of his teammates; he has processed information regarding the weaving moves of his receivers, the movements of defensive backs, and the charge of potential tacklers. Data from his memory storage system, collected during hours of practice, produced a plan of action. The quarterback had to calculate the force and trajectory of the pass and decide the moment of release. He made a decision when he saw a 250-pound linesman evade a blocker and come charging at him. The alternatives of passing, running out of the pocket, using his safety receivers, or scrambling and falling on the ball were considered. At some point in his decision-making he remembered the score, the down, and the time. The quarterback processed much information and made a decision in a few thousandths of a second. It is no wonder crowds cheer when he succeeds and groan when he fails. No wonder we marvel at the skill he possesses.

Models have been suggested which attempt to explain how a skilled player utilizes information coming from the environment, how he draws on past data, and translates incoming information into effective action. A model is a theoretical explanation of how something occurs. Figure 2 presents a theoretical explanation of the basic mechanisms involved in processing information.

The model shown in Figure 2 presents a diagram of the input-central processing system, output, and feedback mechanisms. According to Fitts (1964, p. 244), a skilled response is "one in which the receptor-effector-feedback processes are highly organized, both spatially and temporally." The central processing system plays the role in the organization of the information from the receptor-effector-feedback process.

While Figure 2 depicts the mechanisms involved in executing a skilled response, it is limited in that it relates little about the actual occurrence of events within each mechanism. The objective of the movement pattern, the task itself, the motivational factors, and the capacities and limitations involved in the serial order of information processing are not accounted for by the model.

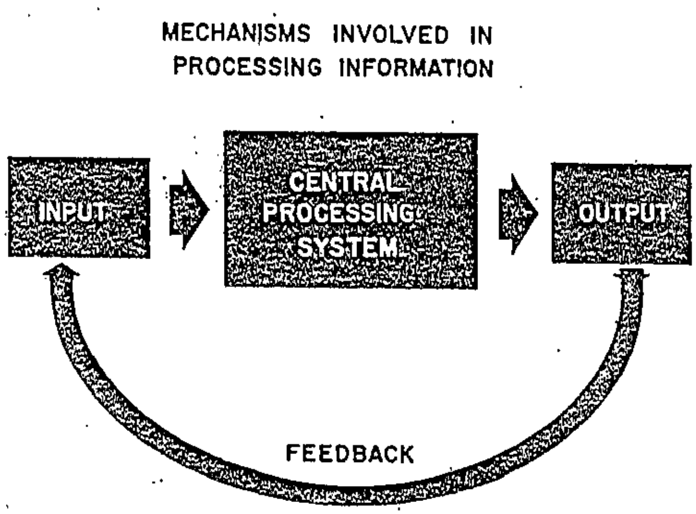

Figure 2. An elementary model of man as an information processing system.

The model shown in Figure 3 is more inclusive. It presents this author's attempt to adapt and expand models developed by other human performance theorists, including Whiting (1969), Broadbent (1969), Welford (1960). The intent of Figure 3 is to explain the complex systems involved in the utilization of information better.

As previously mentioned, an objective or overall plan guides the entire information processing action and task execution. Miller, Galenter, and Pribram (1960) used the term *Plan* to imply the hierarchical nature of behavioural organization as well as the existence of a mechanism which directs and guides action. Behavior is goal directed and cannot be simplistically explained as the chaining of stimulus-response units.

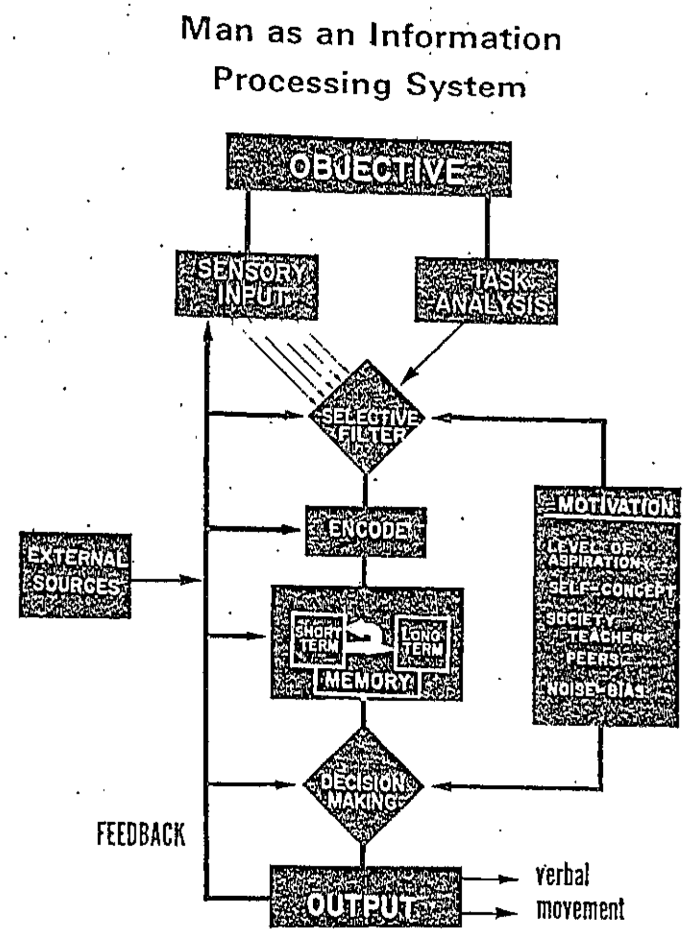

Figure 3. A "working" model of information processing and skill acquisition.

Figure 3 attempts to show the interrelationship between the objective and task analysis. The task (see box labeled task analysis) influences information which must be processed in order to accomplish the overall plan or objective. Thus, in this model, task analysis is not synonymous with objective. The objective may be to "hit a golf ball." Task analysis, however, helps identify critical components which enable the performer to process the necessary information in order to hit the ball.

Man receives sensory input information from both external and internal sources. Since he does not process all the information available, he must somehow select the relevant information. The selection of information (selective filtering) is influenced by motivational factors and feedback from the previous response. Motivational factors also affect the decision-making process.

Some information may be encoded or transformed into symbols and sent to the memory storage system. Memory is believed, by some human performance theorists, to consist of two types: long- and short-term memory. According to Broadbent (1958), all incoming data proceed through the short-term memory system into the long-term memory or go directly to output (either verbal or nonverbal). Long-term memory reflects permanent storage which is the result of learning. Short-term storage may aid in the moment-to-moment performance of skills.

This approach to the study of skilled performance clearly acknowledges that the human organism possesses some type of decision-making mechanism. How man makes a decision may, indeed, be the key to the understanding of the total information processing system. Welford (1961) pointed out that limitations on the rate of information processing may be due to the decision-making mechanism.

Man is continuously sampling output. A form of monitoring occurs which allows him to evaluate the state of the system with respect to the objective. Thus the feedback information produced by the monitoring system becomes new input to the information processing system.

Phases of Learning

Tasks must not be viewed apart from the capacities and limitations of the learner. On the contrary, the critical information in any task must be related directly to the state of the learner. Students bring to the learning situation a variety of abilities, past experiences, and desires, as well as certain capabilities and limitations which either hinder or aid in the accomplishment of a specific task.

The amount and rate of information a learner can handle is directly related to the stage of learning. The beginner cannot possibly use or process the same type of information that the more advanced player is able to handle. Furthermore, additional or augmented feedback may not be helpful to the beginning student.

Robb (1972) proposed a hierarchical organization of skill which included the concepts of executive programs, subroutines, and serial organization. An executive program is the overall purpose or plan of the skilled act, while subroutines are units of movement which are largely automatic. Executive plans are flexible and adaptable. Subroutines are fixed and run off automatically once a sequence is established.

Most individuals have several subroutines available for accomplishing an executive plan. A skill that an individual repeats is never performed identically; rather, the same effect or executive plan can be achieved in several ways. The skilled person, however, has narrowed the range of variation within the subroutines he uses to accomplish a task. The unskilled movement pattern may include incorrect subroutines, too many or too few subroutines, or subroutines that are executed in the wrong serial order. To make a skilled response, the proper subroutine must be performed in a specific, consecutive manner. In a golf swing, for example, the actions of the feet, hip, shoulders, arms, and wrists must follow one another. If this ordering of sequential movements is changed, the act generally appears awkward and the movements are uncoordinated.

Temporal patterning is another important characteristic of a skilled act. This means that the performer must not only know the sequence of the movement pattern but, also, that he must integrate and connect the various subroutines temporally. The more expert or skilled the performer, the smoother the transition from one subroutine to another. The unskilled performer often moves in a jerky or mechanical way because he has not mastered the correct timing between each subroutine, nor has he smoothed the transitions from one subroutine to another.

It is a responsibility of the teacher of skills to engage in task analysis prior to contacting students for the first time. If the learner is a beginner he needs information regarding the formulation of the executive program. The information should be limited and directly related to the sequential order of the various subroutines.

Once the learner has an idea of the executive plan, it is necessary to "fix" the performance sequence. This is accomplished by practice — meaningful practice, with emphasis on the temporal patterning. Appropriate feedback information must be supplied to the learner to aid him in interpreting internal feedback arising from output. In order to supply the correct feedback information regarding errors, the teacher or coach must be able to identify whether the error occurred in the sequential organization or in the temporal patterning.

If the learner does not have an effective subroutine, he must either isolate and practice that particular subroutine, substitute another for it, or compensate for it. How long and how hard he practices will depend on his level of aspiration or his motivational set. Traditional concerns of motor learning specialists with respect to structuring the learning environment, e.g., whole or part practice, length of practice sessions, etc., should be determined in reference to the type of task information the learner must process.

Once the movement pattern is learned it becomes, in a sense, "automatic." This implies that the central processing system is free to deal with other types of input information. Walking, for example, is an automatic act for adults. The central processing system is free to deal with other thoughts and input which may occur during a walk or hike.

Summary

This article has stressed the importance of viewing the skill learning or performing individual as an information processing system. Information may be obtained from several sources: results of output, external factors, or task specific factors. In order to help the individual process information, it is suggested that the teacher or coach be aware of the critical components in the task. It is not enough to know the rules, techniques, and strategies of a sport task. One must also understand the critical components as they relate to the task specific information.

To enhance readers' understanding of the various task specific feedback sources, several classification systems have been presented, and models describing how information is used have been identified. It has also been pointed out that man's information capacities and limitations, as well as the stage of his learning, must be considered in order to structure the learning environment for maximum performance.

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