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AN ANALYSIS OF THE ROLE OF PRETRAINING, DISPLAY, AND REHEARSAL VARIABLES IN THE ACQUISITION AND RETENTION OF A PERCEPTUAL-MOTOR SKILL

by

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INTRODUCTION

The purpose of this study was two-fold: first, to examine the effects of verbal pretraining and display specificity on the acquisition of a one-dimension tracking task; second, to investigate the influence of these two variables together with the effect of verbal rehearsal on the retention of tracking skill after a one month period of no practice.

Interest in these questions stems from a general hypothesis suggested by several investigators (Bahrick and Shelly, 1958; Fitts, 1951; Fleishman and Rich, 1963; Osgood, 1953). Osgood (1953) was concerned with the changing role of cue-producing or mediating responses in the development of instrumental sequences. He hypothesized that in the initial learning of an instrumental sequence, such as learning how to tie your shoe, the individual responses are initiated one at a time by external conditions. With practice, however, the external conditions appear to become less important, with the cues from the preceding responses functioning as the cue stimuli, and the skill appearing to run itself. Each response is thought of as a cue-producing or mediating response whose response-produced stimulation is one link in a chain of stimulus-response associations.

Fitts (1951) expressed essentially the same idea when he suggested that, "Visual control probably is very important while an individual is learning a new perceptual-motor task. As performance becomes habitual, however, it is likely that proprioceptive feedback or 'feel' becomes important."

The positions taken by both Osgood and Fitts suggests that in acquiring a skill an individual depends on different cues during different stages of the learning process. When presented with a new task an individual must first code the task in some fashion, this code depending largely on the cues which are readily available for use. Accordingly, this code will serve as a mediating step which guides the individual in making the appropriate responses. The development of this code should be of special importance when the task allows for perceptual anticipation (Poulton, 1952a; 1952b; 1957a). In this situation the code, or mediating cues, may serve as a basis for predicting future stimuli and responding in anticipation of these stimuli.

As learning continues and fewer and fewer mistakes are made, further improvement will depend on the ability to make finer motor adjustments. When performance reaches this level it is thought that an individual places less reliance on the cues which he used to code the task initially, turning his attention toward proprioceptive cues as a basis for making these finer adjustive movements.

Two studies present initial support for this general hypothesis. Bahrick and Shelly (1958) attempted to relate the degree of redundancy of a task to the degree of proprioceptive control that can be reached during extended practice. They inferred the presence of this type of control through performance in a time-sharing situation. They found that the interference effects due to time sharing of the two tasks varied inversely with the degree of redundancy of the primary task, thus supporting the hypothesis that redundancy of stimulus sequences permits a change from exteroceptive control of responses to proprioceptive control.

The approach in the second study (Fleishman and Rich, 1963) was first to determine individual differences in terms of spatial-visual abilities and kinesthetic sensitivity and, second, to determine how individuals differing on these dimensions differed in their performance levels on a Two-Hand Coordination apparatus. They found that early in training individuals with high spatial ability were more proficient than those low on spatial ability. By the end of training there was no difference between these two groups. On the other hand they found no difference between subjects with high and low kinesthetic sensitivity early in training but as training progressed those with the greater kinesthetic sensitivity became superior in performance. These results indicated that, as performance reached a level where further improvement depended on the making of finer motor adjustments, individuals who were capable of fine discriminations of proprioceptive cues were able to further increase their proficiency.

Equally significant is the suggestion that early in practice exteroceptive cues provided information which guided subjects in making appropriate responses. These cues assisted subject in learning the spatial relationships between the proper control movements corresponding to the movement of the target. The subjects who were most capable of utilizing this spatial information made more rapid progress at this stage in that they were in the target area more frequently.

It would seem that if performance on a task depends on individual differences in ability to utilize the relevant cues which are available as guides for responses, then it is reasonable to expect that the kind or number of cues available will also influence performance. Thus it is assumed that the probability that a given coding process will be used to encode the task is a function of the type of cues which are available.

It is further assumed that different coding processes will require differential learning times because they will be differentially compatible with the task. Therefore, coding processes will differ in their efficiency, efficiency referring to the time it takes for a coding process to reach its maximum capacity as a guide for behavior. Efficiency becomes of particular significance when perceptual anticipation is an important aspect of the task for in this situation proficiency depends not only on one's ability to make the correct response but also on one's ability to predict the correct responses in advance of the actual presentation of the stimulus. Thus, the number of correct anticipations an individual makes will depend on the degree to which the coding process has been completed. In the present study two techniques are used to influence the initial coding process, display specificity and verbal pretraining.

Three displays were devised which were assumed to give rise to three coding processes. Although these three processes are not clearly unique and independent they can be labeled as verbal, visual-spatial, and proprioceptive. The three displays were thus thought to vary on a dimension of verbal specificity where verbal specificity was defined as the degree to which a display allowed the stimulus sequence to be readily described in specific verbal terms. It was felt that a task which could be encoded in specific and common verbal terms would be the easiest to learn. Under the conditions of high display specificity the stimulus sequence could be described by a number code wherein the numbers referred to definite positions in space. The coding process was primarily that of learning a sequence of numbers. Since the numbers corresponded to the spatial characteristics of the stimulus, it was assumed that such a display would be highly efficient. Under the low display specificity condition the stimulus pattern could be described only in terms of approximate positions in space which were relative one to another. Although the coding involved in this task probably required visual-spatial ability, it was thought that the chief source of discrimination between stimuli would occur through proprioceptive feedback channels. In the intermediate condition of display specificity, definite positions in space could be located visually and used to encode the stimulus pattern. However, cues were not provided for encoding the task by a number code which could be translated readily into distinct positions in space as in the high specificity condition. Rather, stimulus events were described by relative positions. For this reason it was assumed that the coding of stimulus events under this condition was largely dependent on the use of spatial visual cues.

From the discussion to this point two assumptions which are basic to this study can be summarized. 1) Variables which simplify the perceptual task or facilitate central processing of the data will facilitate learning. Since display specificity is thought to be such a variable, the degree of specificity and the efficiency of the related coding process are highly related. 2) By varying specificity of displays one also varies the probability of a given coding process being used--assuming further that the probability and ease with which a given coding process is adaptable to the task are highly correlated.

The second technique employed in an attempt to influence the efficiency of skill learning was verbal pretraining. It was thought that a code would be established through pretraining which could serve as a mediator between the perception of and response to the stimuli in the learning situation.

A number of studies which have argued for such mediation processes have been carried out in the context of verbal pretraining. Verbal pretraining has been shown to have a facilitory effect on learning of a motor task (Baker and Wylie, 1950; Battig, 1954; Gagne and Baker, 1950; Goss, 1953; McAllister, 1953; Rossman and Goss, 1951). With more complex tasks, however, results have been negative (Battig, 1956; Hoffeld, 1957; Laswhe and Cary, 1952). As a result, two of the authors (Battig, 1957 and Hoffeld, 1957) concluded that verbal pretraining may have a facilitory effect on the learning of simple tasks, but that there is no evidence for this facilitation when complex tasks are used. There was, in fact, some evidence that pretraining resulted in a decrement in performance on the more complex tasks.

The relevance of verbal pretraining to the skill task is an important consideration. If a code, which is learned during pretraining, is extremely difficult or impossible to relate to the task, little facilitation would be anticipated as a result of pretraining. If, however, a code learned during pretraining is easily adapted to the task, pretraining could be expected to have a facilitory effect on performance.

Verbal pretraining in this study consisted of learning a list of numbers which related to the stimulus pattern. Therefore it was felt that verbal pretraining was most relevant and consequently, most facilitating, for the high display specificity condition and least relevant and therefore, least facilitating, for the low display specificity condition.

The foregoing rationale led to two hypotheses dealing with the effect of display specificity and verbal pretraining on acquisition of the tracking skill used in this study.

Hypothesis 1: As the specificity of the display increases the probability of a more efficient coding process will increase. Therefore, the initial rate of learning will be greatest for a high display specificity condition (presumably facilitating a verbal mediating process), slowest for a low display specificity condition (presumably requiring a proprioceptive mediating process), and intermediate for the intermediate display specificity condition (presumably facilitating a spatial-visual mediating process).

Hypothesis 2: a) Verbal pretraining on a relevant set of verbal cues will serve to facilitate motor performance. b) The greater the relevance of the verbal pretraining to the display condition, the greater the amount of facilitation; relevance increases with display specificity when both the pretraining and the display specificity are in terms of the same code.

Before discussing the second aspect of this study - retention - it is necessary to consider some evidence which is pertinent to the two hypotheses just stated.

The original general hypothesis suggested that, in the acquisition of skill, individual responses are initially dependent on external conditions. With practice, external conditions become less and less important with internal cues increasing in importance as cues for eliciting correct responses. From this position came the prediction that learning would be influenced by the cues an individual uses to code a task. Variables described in the first two hypotheses affect external conditions and are thus predicted to affect early acquisition performance.

Acceptance of the latter portion of the general hypothesis, that with extended practice performance becomes dependent on internal cues, would seem to require a further qualitification of Hypotheses 1 and 2. There are numerous studies which point to the importance of proprioceptive feedback in the performance of a skilled task. Three of these studies indicate three task conditions under which proprioceptive cues are particularly important in the development of tracking skill: 1) conditions involving periods during which the display is not visible, 2) conditions requiring high accuracy of positioning and uniformity of speed of movements, and 3) conditions involving accurate timing of responses. With respect to invisibility of display, Poulton (1957b) demonstrated that with practice the use of proprioceptive cues enabled subjects to track for 5.0 seconds with eyes closed as accurately as under normal conditions with eyes open. However, Gottsdanker (1952a; 1952b, 1955) found that when prediction of acceleration was required, non-visual conditions tended to be less accurate and consistent than with vision. The second condition was investigated by Bahrick (1957) who showed that by increasing the spring load of an arm control, and thereby increasing the amount and gradient of proprioceptive feedback, subjects could improve the accuracy of positioning the control. In the same study it was shown that an increase of viscous damping of the control resulted in greater uniformity of speed within individual movements, and in greater uniformity of speed in successive reproductions of the same movement.

Data on the third point, timing of responses, was reported by Adams and Creamer (1962). These experimenters proposed a proprioceptive trace hypothesis as an important mediator in tracking tasks when time regularities were present. Using the number of beneficial anticipations as their criterion, they found both signal duration and spring loading of the control to induce significant effects. With increased time between target changes the number of beneficial anticipations went down. With increase in spring load the number of beneficial anticipations increased, thus supporting their hypothesis that the time-persisting proprioceptive after-effects of an overt or mediated response can be the mechanism to account for temporal accuracy for motor performance.

Thus, in dealing with a tracking task it would appear that one must consider the importance of proprioceptive feedback. In accordance with the general hypothesis we have been considering, these proprioceptive cues are internal cues deemed important during the latter stages of training. This leads to a third hypothesis which is a modification of Hypotheses 1 and 2.

Hypothesis 3: All subjects, regardless of pretraining or display specificity conditions, are performing the same task. Therefore, groups should not differ in amount of proprioceptive feedback received. Assuming such feedback to be the primary basis for performance after a considerable amount of training, all groups should reach the same level of performance after an extended amount of training.

The second aspect of this study dealt with the influences of verbal pretraining, display specificity, and verbal rehearsal on the retention of tracking skill. To the writer's knowledge, neither the effect of pretraining nor that of display specificity on the retention of a motor skill have been investigated. However, there have been a few studies which were concerned with the effects of rehearsal during the no-practice period.

Sackell, (1934) and Perry (1939) found retention to be facilitated by imaginary rehearsal of the task during the period of no practice. Bunch (1939, 1946), using a finger maze and a retention interval of 120 days, found that activities performed during the retention interval tended to facilitate retention. This was true even though his subjects used a rehearsal maze in which both the temporal and the spatial patterns of required responses were different from those in the originally learned task.

These latter results are at variance with the findings of Naylor and Briggs (1963). These investigators used a discrete procedural task which had both temporal and spatial characteristics which had to be learned. They found that rehearsal, which took place midway in a 25-day retention interval, on a task with modified spatial characteristics resulted in greater retention of the original task than did rehearsal on a task with modified temporal characteristics. They concluded that timing of responses was the more difficult of the task requirements and most responsive to rehearsal effects. However, in a later study (Brown, Briggs, Naylor, 1963) these results were not supported. In this latter study, in which both a tracking and a procedural task were used, original training time was twice as long as in the first study. The results indicated that retention was unaffected by rehearsal on modified procedural-task characteristics. The authors hypothesized that in the first study subjects were continuing to learn during the rehearsal session what the subjects in the second study learned during the extended training period. They concluded that the beneficial effects of rehearsal will be largely negated when original training is of sufficient duration.

One important implication to come out of these studies is that tasks should be dimensionalized in terms of separate task components. If training time is long enough, any benefits derived from differential rehearsal on separate task components will probably be negated. However, where training time is limited, or when the retention interval is so long as to permit forgetting even though extended original training was given, then rehearsal on the more difficult task components can be expected to lead to superior retention of the skill.

In the present task, if the code by which the pattern of stimuli was encoded were to be forgotten over a period of no practice, a considerable decrement in performance would be anticipated. In this study three modes of facilitating the verbal encoding of the task were employed, all of which could be expected to facilitate retention of the stimulus pattern. They were 1) verbal pretraining, 2) high display specificity, and 3) verbal rehearsal. Considerations of these variables and possible interactions lead to the fourth and final hypothesis.

Hypothesis 4: a) Rehearsal of a relevant verbal code during the retention interval will facilitate the retention of a skilled task.

b) The effect of verbal rehearsal will be maximal when it is highly relevant to the display (high display specificity) and minimal when there is little relevance of rehearsal material for the display condition (low display specificity). For an intermediate display specificity condition the facilitory effect of rehearsal will be less than that for the high specificity display condition, but greater than that for the low specificity condition.

c) For those subjects not given verbal rehearsal, retention will be a function of the pretraining and display conditions present during training. (1) The higher the degree of display specificity, the greater the retention of the skill. (2) Retention will be facilitated by giving subjects verbal pretraining. (3) The greater the relevance of the pretraining for the display condition the greater the amount of skill retention.

METHOD

Subjects

The subjects were 120 undergraduate, right-handed male students enrolled in five sections of an introductory psychology course at Kansas State University. The subjects ranged in age from 17 to 26 years, with a mean of 18.8 years. Each subject was given research participation credit and paid $2.50 for the six one-half hour sessions for which he volunteered to serve.

Apparatus

A one-dimensional pursuit tracking task was employed which required the subject to make discrete movements in response to an irregular step-function input displayed as a narrow 1/2 inch vertical line on the face of an oscilloscope (Tektronix Model 536 with 53/54c plug-in units). The cursor also appeared as a narrow 1/2 inch long vertical line below the target. The target and cursor overlapped by 1/8 of an inch. The position of the target was determined by a programming subsystem which included a six-channel binary tape reader, flip-flop circuits, and a digital-to-analog converter. The position of the cursor was determined by the output of a potentiometer attached to subjects arm control. The arm control consisted of a light weight lateral arm rest, pivoted at the elbow, and an adjustable handle grip. An accelerometer (Schaevits Model HG-2) was attached to the underside of the arm control. The arm control was attached to the right side of an adapted metal dental chair.

The target could appear at any one of eight equidistant positions on the horizontal axis of the 5-inch scope face. The distance between target positions was 5/8 of an inch. There was a maximally possible target excursion of ± 2 3/16 inches from the center. A control movement of ± 22.5 degrees was required to track the maximum amplitude of target movement. The subject sat in the control chair facing the scope. Viewing distance was approximately 32 inches.

The basic scoring unit of this system consisted of an operational amplifier manifold by means of which the momentary error in voltage units was obtained as the absolute difference between the target and the cursor voltages. The absolute error was fed into an integrator circuit to provide absolute error integrated over each trial. A second integrator unit provided absolute acceleration integrated over each trial. Data on input, output, integrated error, and integrated acceleration were immediately and continuously available to experimenter via four Heath Model 1M-10 voltmeter displays.

On selected trials, the input (target) voltage, the arm control output, the absolute momentary error signal, and the momentary acceleration signal were recorded on separate channels of a magnetic tape data recorder (Sanborn-Ampex Model 2007, with FM heads). Each channel of the tape recorder was connected to one channel of an oscillograph (Minneapolis-Honneywell Model 90c Visicorder). This enabled experimenter to visually inspect any portion of the data, either as it was being collected, or at some later time. The program, tape recorder, integrating circuits, intertrial intervals and subjects warning buzzer were all automatically controlled with five Hunter interval timers. A more complete description of the tracking system can be found elsewhere (Trumbo, Eslinger, Noble, and

Cross, 1963).

Knowledge of results was displayed to the subject via a voltmeter (Heath Model 1M-10). During the inter-trial interval subject could look at the voltmeter, which was placed to the right of the scope and out of his line of vision while tracking, and read the total error he had accumulated on the preceding trial.

To reduce the possibility of outside noises distracting the subjects, white noise was piped into the experimental room via a speaker which was placed 12 inches behind the left arm rest of the control chair. A floor fan produced additional constant ambient noise. The ambient noise level was approximately 75 decibels.

Illumination in the experimental room was provided by a 40 watt light bulb with a reflector which was directed toward the ceiling. This was placed above and behind the control chair.

Experimental Variables

Display

The three different display conditions were achieved by placing overlays over the scope face. The three displays were designated as having high, intermediate, and low specificity. In the low specificity condition the display was uncoded, that is, it was a blank scope face. In the intermediate specificity condition there were eight 1-inch vertical hair lines engraved on an overlay and placed over the scope face. These eight lines corresponded to the eight possible target positions. The high specificity condition was like the intermediate condition except the numbers 1 through 8 were engraved from left to right over the vertical lines.

The numbers were 3/16 inches high.

Verbal Pretraining and Rehearsal

Each subject assigned to the verbal pretraining group was seated in a room adjacent to the experimental room. The subject was given a card with a vertical list of 12 numbers printed on it. These numbers ranged from 1 to 8 and, unknown to the subject at that time, corresponded to the fixed sequence of target positions which he was later to track. Each subject was required to memorize the list of numbers by the whole method, that is, he was required to read the entire list aloud on each repetition. At the end of every 5 repetitions a test trial was given to determine whether subject had memorized the list. After the first correct repetition subject was required to give 15 further correct repetitions. When this was completed subject was taken into the experimental room.

The verbal rehearsal conditions were exactly like those of pretraining. Subjects were asked to learn the sequence of numbers to one correct repetition and then to overlearn the list by giving an additional fifteen correct repetitions.

Performance Measures

Integrated Error Score

The primary performance measure was the total absolute error integrated for individuals over the duration of each trial. This score was recorded at the end of each trial from a voltmeter.

Paper and Pencil Test

To obtain an index of the degree to which subjects could reproduce the sequence they had learned during training, a paper and pencil test (PPT) was given to all subjects at the end of the last training session. This consisted of two sheets of paper on which twelve circles representing the scope face were printed. Within each circle eight vertical lines were printed which corresponded to the eight target positions on the scope face. Subjects were instructed to mark the appropriate lines in the order of the sequence they had tracked. They were also given this PPT immediately before the recall trials as a measure of the retention of the sequence.

It was felt that performance on this test would indicate the degree to which individuals had encoded the task by the use of a number code. Few errors would be anticipated if the encoding process was based on number cues for numbers could easily be assigned to the printed lines of the PPT. However, if some other cues were used in coding the task, confusion between these cues and the printed lines of the PPT would be expected, resulting in errors on the PPT.

Analytical Measures

A secondary interest in this study was in indexing the continuous time varying response functions to determine whether or not an increase in integrated error score over a period of no practice could be described in terms of changes in the temporal-spatial patterning of responses.

Several analytical scores were obtained by hand scoring visicorder records of selected trials. Each record was scored on twelve indices in addition to the error and acceleration scores read from voltmeters. Average lead and average lag time were recorded to the nearest 50 milliseconds. The percent of leads and percent of lags was based on the last 46 responses of a trial. If an individual had a zero lead or lag this was not included in either the percent of leads or percent of lags.

Two definitions of beneficial anticipations were used. The first (Type I) included those responses which were initiated within $\pm$ 150 milliseconds of a target displacement. This was assumed to be well under the reaction time for any of the experimental subjects and, therefore, to represent better-than-reaction-time anticipation. The second (Type II) definition stems from the fact that in this tracking task a lead which was in excess of 150 milliseconds resulted in much less error than a lag of comparable time. As an example, Figure 1 shows that the same amount of error is accumulated by a lead of 600 milliseconds as with a 200 millisecond lag, given the same travel times for the two movements. A beneficial anticipation by definition is thus a response which is initiated before a stimulus changes but not begun so soon that the completion of the initial responses reaches the anticipated target position before the target actually arrives at that point. Figure 2 illustrates this distinction.

The magnitude of overshoots and the magnitude of undershoots were both scored to the nearest 25 percent of the area between adjacent target positions which was 5/8 of an inch. The percent of overshoots and percent of undershoots are each based on a total of 47 targets per trial. Incorrect anticipations included all initial responses which were in the direction opposite to that of the target movement. The on target score was defined as the number of responses which kept the cursor within a tolerance limit

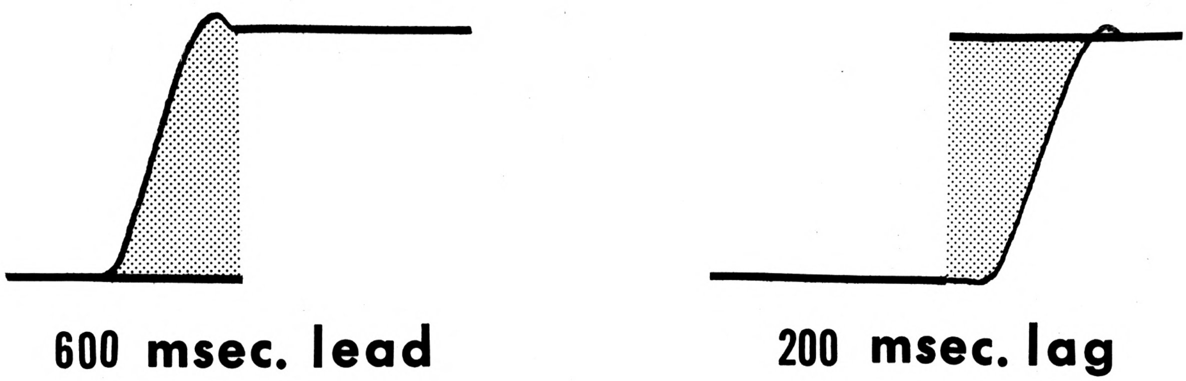

Fig. 1. This figure indicates that the accumulation of error resulting from a 200 msec. lag is equal to the amount of error accumulated with a 600 msec. lead.

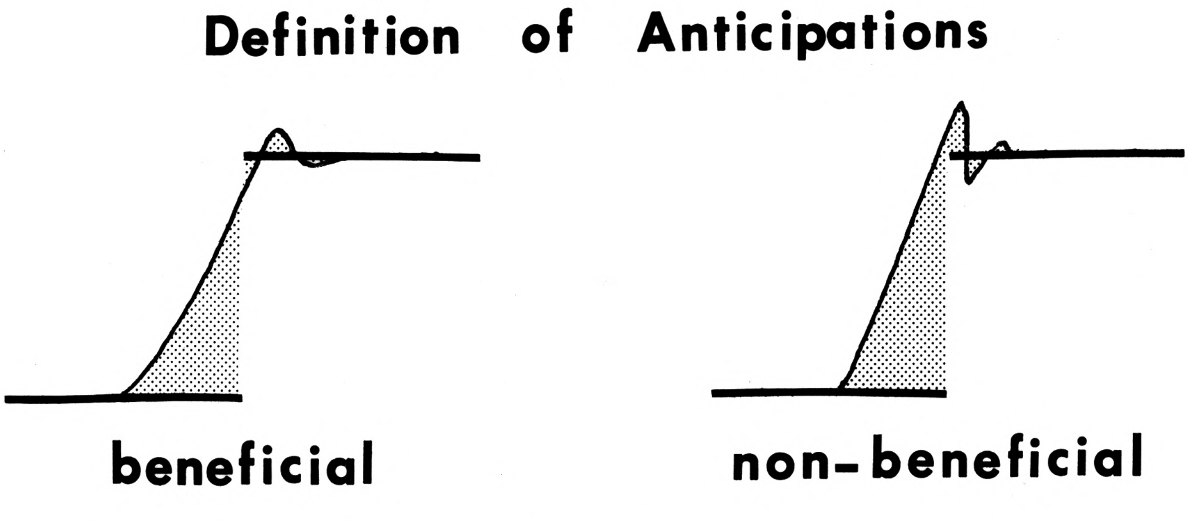

Fig. 2. Illustration of the definition of beneficial and non-beneficial anticipations (Type II) used as one of the analytical measures of tracking performance.

of ± 1/6 of an inch of the target for a minimum of .6 of a second of the possible 1.0 second signal duration.

Design

A 2 x 3 x 2 factorial experiment was used with 10 subjects randomly assigned to each of the 12 groups (Table 1). The first factor was the pretraining condition. One-half of the subjects received verbal pretraining, the other half did not. The three levels of display specificity constituted the second factor. One-third of the subjects tracked in each display condition. The third factor was the verbal rehearsal condition, wherein one-half of the subjects were given rehearsal and one-half were not.

Table 1

Experimental Design

Verbal Pretraining(n=60)	Blank Display(n=20)	Verbal Rehearsal(n=10)
		No Verbal Rehearsal(n=10)
	Lined Display(n=20)	Verbal Rehearsal(n=10)
		No Verbal Rehearsal(n=10)
	Numbered Display(n=20)	Verbal Rehearsal(n=10)
		No Verbal Rehearsal(n=10)
No Verbal Pretraining(n=60)	Blank Display(n=20)	Verbal Rehearsal(n=10)
		No Verbal Rehearsal(n=10)
	Lined Display(n=20)	Verbal Rehearsal(n=10)
		No Verbal Rehearsal(n=10)
	Numbered Display(n=20)	Verbal Rehearsal(n=10)
		No Verbal Rehearsal(n=10)

The task for all 12 groups was the pursuit tracking of a fixed sequence of 12 target positions randomly drawn from the 8 possible positions with the restriction that no one target position could follow itself in the sequence. The fixed sequence repeated four times per trial. Targets appeared at the rate of one per second making each trial 48 seconds long. There was a 12 second inter-trial rest period, the end of which was signaled by a buzzer. Four different fixed sequences were used. These sequences were equated in total distance traveled by the target and in standard deviations of the amplitudes of the individual steps. These four patterns were randomly assigned within the different groups. A total of 115 training and 20 retention trials were given each subject. Fifteen trials were given on the first day and 25 trials on each of the following 4 days. Twenty retention trials were given on one day after a period of no practice which ranged from 28 to 33 days, with an average of 31 days.

Procedure

Subjects assigned to the verbal pre-training condition were first taken to a room adjacent to the experimental room. Once verbal pretraining (as described earlier) had been completed, they were taken to the experimental room.

All subjects upon entering the experimental room were treated exactly alike. Subjects were seated facing a 30 x 30 inch green felt covered panel which had a 5 inch hole cut in the middle of it through which the scope face could be seen. This hole was covered by a piece of cardboard until 12 seconds before the subject actually began to track, except for a very brief period when he was shown the two lines which represented the target and cursor.

After pointing out the target and cursor lines and explaining the nature of the task, experimenter placed the cardboard over the hole. The appropriate overlay was then placed on the scope face and the following instructions were read to the subject:

> The task in which you will be participating today is what is called a tracking task. The upper line on the scope is called the "target." When we begin you will see the line move right and left in discrete jumps. The lower line is called the "follower." The position of this line is determined by the position of your arm control. Try moving the arm control back and forth to see how it works. Your task in this experiment is to keep the follower as nearly superimposed on the target as possible while the target is jumping about the screen and while the target is stationary. It will look like this when you have the follower positioned properly (experimenter superimposed the cursor on the target).
>
> The primary way in which your performance will be evaluated is in terms of your error score. Error in this case is the amount by which the position of the target and the follower differ. For example, if the position of the follower is here with respect to the target (experimenter positioned the follower so that it was not superimposed on the target) this difference (experimenter pointed out difference between the target and the cursor) represents the error and this error accumulates all during the time the follower is not superimposed on the target. If there is a large difference between the target and the follower, the error score will build up very rapidly. If there is only a small difference, the error score will build up more slowly. But remember, any time that the two lines are not perfectly superimposed, there is always some error building up.
>
> There are a number of strategies that can be used to keep your error score as small as possible. One valuable strategy is anticipation. As you have more and more experience with a pattern you will learn enough about the pattern to permit you to anticipate the extent and the direction of the next position as well as the moment at which the target will jump to its next position. Let's look at a typical pattern and see what happens to your error score when you are able to anticipate correctly. (Experimenter showed subjects a pattern from a viscorder-record and explained how error was affected by a correct anticipation.) I think you can see that correct anticipation can <u>greatly</u> <u>improve</u> your score and incorrect anticipation can <u>ruin</u> your score.

A second important factor is the rate with which you move the arm control. You can see on this record (experimenter showed subject a record of slow response) that when your response is slow, much more error is built up than when your response is fast. As was true with anticipation, however, a fast rate of movement can also hurt your score if not used properly. For example if you use such a fast rate of movement that you overshoot the target by a great deal, your score will not be helped. Let's look at some more records which will show you a number of ways in which error is increased. (Experimenter showed subject examples of anticipation too soon, anticipation in the wrong direction, overshoot, slow rate, and lag). These are the types of things which if avoided will greatly improve your score.

Today you will be given 15 trials. Within each trial there will be a repeating sequence of target positions. That is, there will be a pattern which you can learn and it is important that you do so. You can see the aid that you will receive by learning this pattern. We mentioned that two important strategies are anticipation and rapid rate of arm movement. If you know exactly where the target is going to move next,this will enable you to anticipate correctly the direction and extent to move the arm control. It will help you to know that there will be a pattern to the target movements which is twelve units long, that is, after the target has moved through twelve successive positions it will repeat those same twelve positions, in the same order, over and over.

As you track you will find that it is difficult for you to evaluate your own performance. Therefore, to give you an idea as to how well you are doing there is a voltmeter on your right. At the end of each trial you can look at it to compare your performance with previous trials.

The subjects were instructed as to the length of the trials and inter-trial rest periods, and any questions they had were answered. It is to be noted that the instructions and knowledge of results were the same for all subjects with the exception that those who had received pre-training were told that the numbers they had just memorized corresponded to the pattern or sequence of target positions they were to track. These individuals were asked to repeat the sequence aloud once more. At no time during the complete experiment was any mention made regarding the overlay, unless a specific question was asked.

On returning for the retention session, those subjects who were to be given verbal rehearsal were taken to the same room in which the verbal pretraining was conducted. The procedures in verbal rehearsal were identical with those in the pretraining condition. Once rehearsal was completed subject was taken to the experimental room. Again all subjects were treated in exactly the same manner once they entered the experimental room. The scope face was again covered until twelve seconds before the first retention trial began. The instructions read before the retention trials began were:

> Today we are going to give you 20 retention trials. The task today will be exactly the same as it was when you were last here. I want to point out that in a retention session it is actually only the first trial that measures how much you have retained--or forgotten. The rest of the trials will measure rate of relearning. Now, during the short time from when I leave the room to when I ask you to start, try to recall the instructions you were given on the first day you came which dealt with those things you could do to help you become a skilled tracker. Most important is to try and do those things on the first trial. Any questions? Then we shall start.

After completion of the retention trials, subject was engaged in conversation to ascertain any questions or comments he might have had about the task as he experienced it.

RESULTS

Acquisition

The integrated error scores for the six acquisition groups and the twelve retention groups are presented in Figure 3. (Mean group data for all groups during acquisition is presented in Appendix, Table 13.) The mean integrated error scores represented in the acquisition data are based on blocks of five trials. A 24 hour rest occurred between blocks 3 and 4, 8 and 9, 13 and 14, and 18 and 19. Integrated error scores for the retention session are given for the first four retention trials only. The remainder of the retention trials are omitted from Figure 3 since it was clear that no significant differences existed between groups beyond this point. The group mean data for all retention trials is tabled in the Appendix, Table 14. An inspection of Figure 3 indicates that during early acquisition, groups separated in terms of rate of learning as a function of both pretraining and display conditions. To determine whether or not these learning curves reached a point during early training where they were significantly different, an analysis of variance was performed on error scores averaged for individuals across blocks 3, 4, and 5. As Table 2 indicates, at this stage in training the differential effect due to the pretraining condition was highly significant (P .01), and the effect of the different display dimensions was also significant (P .05). However, differences between pairs of display conditions within a pretraining condition were not significant.

A similar analysis was performed on the last three blocks of acquisition trials. The results, which are also presented in Table 2, indicate

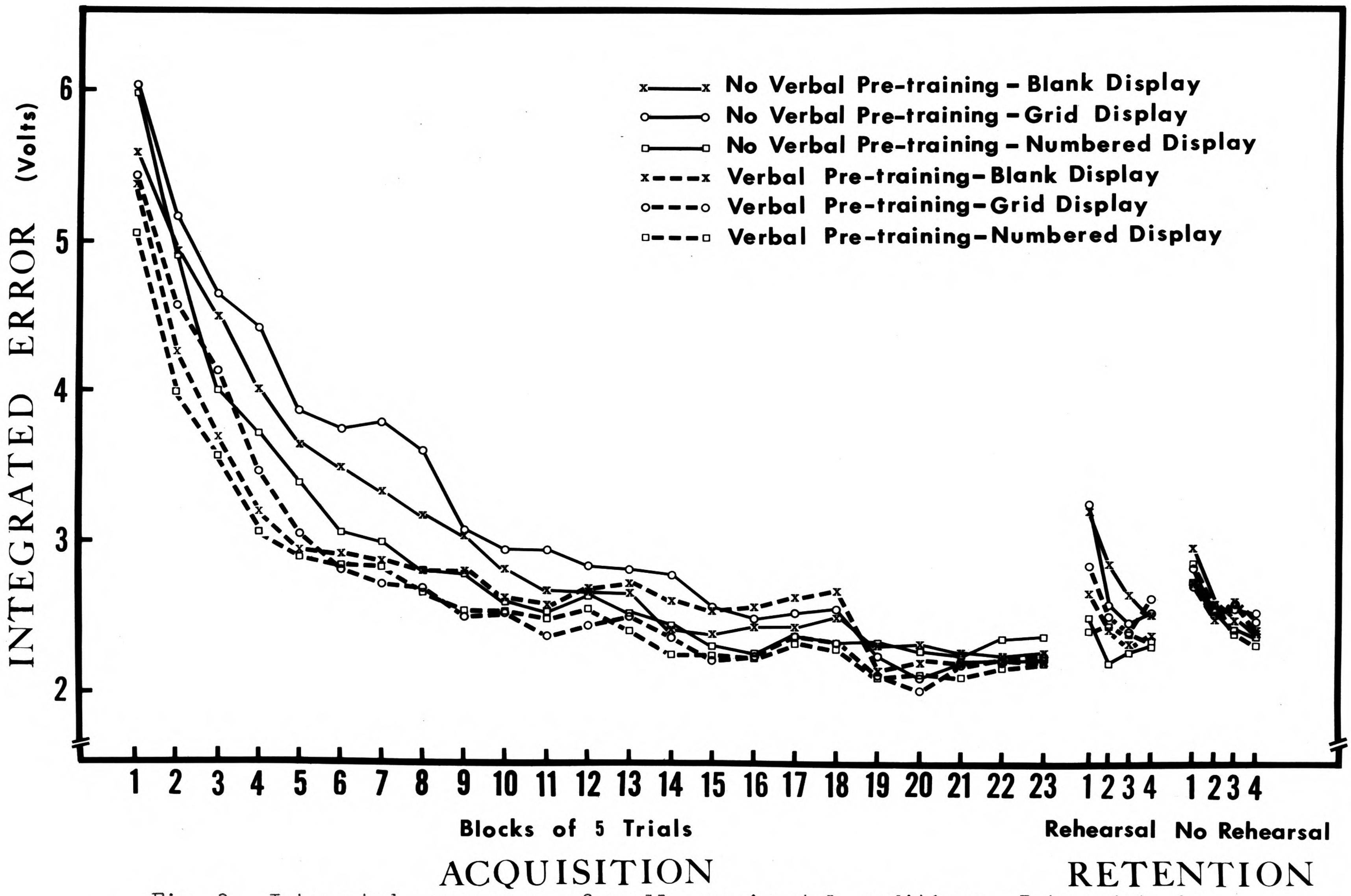

Fig. 3. Integrated error scores for all experimental conditions. Data points in acquisition represent data averaged over 5 trials. Retention data is plotted for single trials.

that by this point in training no differences existed as a function of either the pretraining or display conditions. The group mean scores averaged for trials 11 through 25 and 101 through 115 are presented in Table 3.

Table 2

Summary of Analyses of Variance for Blocks of Trials 11 Through 25 and 101 Through 115

		Trials 11-25			Trials 101-115		
Source of variation	df	SS	MS	F	SS	MS	F
Treatments	5	21.00			.38		
Pretraining (PT)	1	15.29	15.29	17.17**	.19	.19	.85
Display (D)	2	5.48	2.74	3.08*	.02	.01	.03
PT X D	2	.23	.11	.13	.18	.09	.38
Error	114	101.50	.89		25.99	.23	
Total	119	122.50			26.38		

*Significant at .05 level

**Significant at .01 level

Table 3

Group Means for Integrated Error Scores Averaged Across Trials 11-25 and 101-115

	Trials 11-25			Trials 101-115		
	BD	LD	ND	BD	LD	ND
Verbal Pretraining	3.27	3.54	3.11	2.20	2.21	2.15
No Verbal Pretraining	4.24	4.31	3.70	2.26	2.21	2.33

Group mean error scores on the first trial of acquisition are presented in Table 4 as an indication of the beginning level of proficiency of the various experimental groups. An analysis of variance was also performed on these data, a summary of which is presented in Table 5. The main effects of pretraining and display conditions were significant (P .01) as was the interaction between pretraining and display conditions (P .05).

Table 4

Group Means for the Integrated Error Scores
Obtained on the First Trial

	BD	LD	ND
Verbal Pretraining	6.38	6.19	6.50
No Verbal Pretraining	6.36	6.72	6.82

Table 5

Summary of Analysis of Variance Performed on the Integrated
Error Scores Obtained on the First Trial

Source of variance	df	SS	MS	F
Treatments	5	5.55		
Pretraining (PT)	1	2.27	2.27	12.61**
Display (D)	2	1.77	.88	4.89**
PT X D	2	1.51	.75	4.17*
Error	114	20.23	.18	
Total	119	25.78		

*Significant at .05 level
**Significant at .01 level

Retention

Evaluation of the effects of the no practice interval was based on an analysis of scores obtained as the difference between an individual's error score averaged over his last 5 trials of training and the error score he obtained on the first trial of the retention session. A constant of 1.66 was added to all scores for purpose of analysis. (These data are presented in Appendix, Table 13.)

Three separate analyses of variance were performed on these data. First an analysis of variance was computed with the two verbal pretraining conditions, three display specificity conditions, and two verbal rehearsal conditions as the main effects. F-ratios were computed for all main effects and interactions, none of which reached significance at a level of .05. (This analysis is summarized in Table 6.)

Table 6

Summary of Analysis of Variance for all Experimental Groups at Retention

Source of variation	df	SS	MS	F
Treatments	11	6.40		
Pretraining (PT)	1	.90	.90	
Display (D)	2	1.32	.66	
Rehearsal (R)	1	.10	.10	
PT X D	2	.69	.35	
PT X R	1	1.01	1.01	2.44
D X R	2	2.03	1.01	2.44
PT X D X R	2	.25	.13	
Error	108	45.06	.42	
Total	119	51.46		

Data were then analyzed separately for the two rehearsal conditions. In both analyses verbal pretraining and display dimensions were the factors involved. Again F-ratios were computed for main effects and interactions and again, using an of .05, none of the F-ratios reached significance in either analysis. (See Tables 7 and 8 for a summary of these analyses.)

Table 7

Summary of Analysis of Variance for the Verbal Rehearsal Condition at Retention

Source of variation	df	SS	MS	F
Treatments	5	5.35		
Pretraining (PT)	1	1.92	1.92	3.52
Display (D)	2	3.16	1.58	2.90
PT X D	2	.27	.14	.25
Error	54	29.48	.55	
Total	59	34.83		

Table 8

Summary of Analysis of Variance for the No Verbal Rehearsal Condition at Retention

Source of variation	df	SS	MS	F
Treatment	5	.95		
Pretraining (PT)	1	.00	.00	.00
Display (D)	2	.19	.10	.33
PT X D	2	.76	.38	1.31
Error	54	15.58	.29	
Total	59	16.53		

Paper and Pencil Test (PPT)

Tables 9 and 10 present the results from the paper and pencil test. An "O" represents perfect correspondence between the programmed pattern and the subjects reproduction of the pattern on the test. A (12) is indicitive of a subject who was unable to reproduce the pattern in any manner. One error was scored for each omission of a target position in the sequence and two errors were tallied for a reversal of two positions. Often subjects correctly indicated the pattern in terms of direction of movements. One error was scored for each incorrect indication of either direction or extent of movement.

There were a number of subjects whose paper and pencil reproductions of the programmed sequences did not lend themselves to the scoring as outlined above, yet their tests differed qualitatively from those subjects who gave no indication of the pattern (those scored (12)). These individuals gave some recognizable elements of the programed sequence while those in the (12) category did not. For example, an individual might reproduce the 8th, 9th, and 10th target positions of the sequence correctly but would not place these elements correctly within the 12 target sequence. Rather, they would appear at the first of the sequence followed by 3 or 4 target positions which did not appear in the programed sequence. Target positions 4, 5, and 6 would then be reproduced as they appeared in the sequence, followed by additional target positions which did not appear in the programed sequence. There is little doubt that such individuals were confused, yet it appeared meaningful to separate them from those subjects who were placed in the (12) category. To distinguish these individuals, they were arbitrarily given the score (8).

Table 9

Number of Errors Made on the Paper and Pencil Test Administered at the End of Training

	S*	Verbal Pretraining Blank Display	Verbal Pretraining Lined Display	Verbal Pretraining Numbered Display	No Verbal Pretraining Blank Display	No Verbal Pretraining Lined Display	No Verbal Pretraining Numbered Display
Verbal Rehearsal	1	0	2	0	1	2	0
	2	1	0	0	10	1	0
	3	0	0	0	1	2	0
	4	1	0	0	0	5	1
	5	1	1	0	2	3	0
	6	0	1	0	0	1	0
	7	0	0	0	4	7	0
	8	0	0	0	7	0	0
	9	4	1	0	10	0	0
	10	0	0	0	1	10	0
No Verbal Rehearsal	1	6	0	0	0	8	0
	2	0	0	0	1	4	1
	3	0	0	0	7	4	0
	4	0	0	0	1	4	0
	5	0	0	0	4	0	0
	6	0	0	0	2	2	0
	7	0	0	0	8	10	0
	8	0	0	0	1	0	0
	9	0	0	0	10	0	0
	10	0	0	0	0	0	1

*S -- Subject

Table 10

Number of Errors Made on the Paper and Pencil Test
Administered Before Retention

	S*	Verbal Pretraining Blank Display	Verbal Pretraining Lined Display	Verbal Pretraining Numbered Display	No Verbal Pretraining Blank Display	No Verbal Pretraining Lined Display	No Verbal Pretraining Numbered Display
Verbal Rehearsal	1	0	2	0	5	(8)	0
	2	(12)	7	0	9	3	6
	3	2	0	0	8	8	0
	4	0	0	0	6	(12)	(12)
	5	1	(12)	0	6	7	(8)
	6	0	0	0	(8)	2	0
	7	0	0	0	(8)	(8)	0
	8	3	1	0	(8)	2	0
	9	6	10	0	(12)	2	0
	10	0	0	0	6	7	0
No Verbal Rehearsal	1	6	0	0	(12)	(8)	1
	2	2	0	3	4	(12)	(12)
	3	0	0	0	9	1	0
	4	0	0	0	2	(8)	0
	5	0	2	5	(12)	7	1
	6	1	0	0	4	7	1
	7	0	0	2	(8)	(8)	2
	8	0	1	5	0	3	5
	9	0	0	0	(12)	4	1
	10	0	0	0	8	0	3

(12) and (8) arbitrarily assigned as defined in the text.

*S — Subject

Table 9 presents the errors made on the PPT at the end of training. Median tests were computed between all pairs within each pretraining condition. There were no significant differences between display conditions in the pretraining condition. In the no pretraining condition, those with the blank display and lined display were significantly different from those with the numbered display. (Blank vs. lined display: $X_{1df} = 14.44$, P .001; lined vs. numbered display: $X_{1df} = 5.30$, P .025.) However, the blank display and numbered display conditions did not differ significantly from each other. Median tests were also computed between identical display conditions of the two pretraining conditions. The blank display and lined display conditions differed significantly; the numbered display condition did not. (Blank display-pretraining vs. blank display-no pretraining: $X_{1df} = 10.03$, P .005; lined display-pretraining vs. lined display-no pretraining: $X_{1df} = 8.18$, P .005.)

The errors made on the PPT immediately before retention are presented in Table 10. The same comparisons were made (median test) on these data as for the data presented in Table 9, with similar results. No differences were found between groups in the verbal pretraining condition; however, in the verbal rehearsal condition both those with the blank display and lined display differed significantly from those with the numbered display, but not from each other. (Blank vs. numbered display: $X_{1df} = 10.03$, P .005; lined display vs. numbered display: $X_{1df} = 6.40$, P .025.) Comparing display dimensions across pretraining conditions, the blank and lined display conditions again differed significantly whereas the numbered display condition did not. (Blank display-pretraining vs. blank display-no pretraining: $X_{1df} = 19.61$, P .001; lined display-pretraining vs. lined display-no pretraining: $X_{1df} = 12.22$, P .001.)

In summary then, at the end of training and before retention, groups given pretraining did not differ significantly one from another on the PPT. However, in the no pretraining groups, those with the blank and lined display differed significantly from those with the numbered display, but they did not differ significantly from each other. Furthermore, significant differences were found for both the blank display and lined display in comparisons between the verbal pretraining and the no pretraining condition, both at the end of training and before the retention session. In neither case were differences for the number display conditions significant.

To indicate the relationship between performance on the PPT and on the tracking task, Spearman rank correlation coefficients (Seigel, 1954) were computed for each of the six training conditions. Correlations were between the mean error scores on the last block of training trials and the number of errors on the PPT administered at the end of training. No significant relations were found using an level of .05.

Spearman rank correlation coefficients were also computed to determine the relationship between the number of errors made on the PPT administered immediately before retention and the absolute amount of tracking skill lost over the retention interval (the difference scores described earlier). Since any relationship between these measures would be meaningless for the groups which received verbal rehearsal, they were not included in this analysis. Also, those who were given verbal pretraining did not commit a sufficient number of errors on the PPT to make any comparisons meaningful. Therefore, correlation coefficients were computed only for the three experimental groups which were given neither pretraining nor rehearsal. Results indicated that a significant relationship existed only for the group which tracked under the numbered display condition, $r_s = .73$, P .05. (For the lined display and blank display conditions, r_s of .32 and .04, respectively, were found.)

Analytical Measures

The hand scoring of visicorder records on the 12 indices described earlier is a laborious process, therefore both subjects and trials were sampled. Data were obtained for the last trial of training and the first trial of retention for 48 subjects. The sample consists of the two subjects who showed the least retention and the two subjects who showed the greatest amount of retention in each of the 12 retention groups. This sampling permitted comparisons between best and poorest retention subjects as well as between training and retention conditions, on the analytical measures.

Summary data are presented in Table 11 for the 12 indices. Also included in this table are the integrated error and acceleration scores read at the end of each trial from voltmeters. T-tests were computed to test the difference between the "change scores" of the two groups in all cases where the number of subjects scoring greater than zero on each index was at least 23. It was felt that interpretation of changes for the indices on which fewer than 23 subjects scored other than zero would not be meaningful, therefore they were not computed. Results of the

Table II

Summary Data for Analytical Measures of Tracking Performance

		Leads		Lags		Beneficial Anticipations[1]		Overshoots		Undershoots		Incorrect Anticipations	On-target	Error	Acceleration
		%	Mean	%	Mean	Type I	Type II	%	Mean	%	Mean	Frequency	Frequency	Volts	Volts
Good Subjects (N=24)	Last Trial Training	97.63	.225	1.28 (N=7)[2]	.117	16.33	35.17	27.75	.420	14.35 (N=23)	.358	1.00 (N=2)	32.21	2.17	4.10
	First Trial Retention	95.56	.204	3.62 (N=6)	.275	18.21	37.46	37.75	.478	12.39	.432	1.00 (N-4)	32.71	2.16	4.42
	Change	-2.07	-.021	2.34	.158	1.88	2.29	10.00	.058	-1.96	.074	----	.50	-.01	.32
Poor Subjects (N=24)	Last Trial Training	95.57	.198	3.72 (N=7)	.117	21.42	36.79	35.89	.446	11.60	.408	1.50 (N=3)	34.04	1.88	4.44
	First Trial Retention	81.14	.199	12.55 (N=18)	.165	23.16	30.88	46.76	.578	16.04 (N=23)	.508	2.73 (N=15)	24.00	3.29	5.73
	Change	-14.43	.001	8.83	.048	1.74	-5.91	10.87	.132	4.44	.100	1.23	-10.04	1.41	1.29
	t^3	3.06**	n.s.	----	----	n.s.	4.03**	n.s.	n.s.	n.s.	n.s.	----	5.43**	13.34**	2.48*

1. Type I: Movements initiated within ± 150 milliseconds of a target displacement.
   Type II: Movements initiated before -150 milliseconds, but not so soon as to reach predicted target early (Fig. 3).

2. Number of Ss who scored on this index.

3. t-tests are between the change scores for the good and poor subjects.

*significant at .05 level.

**significant at .01 level.

t-tests showed differences between the change scores of the two groups to be significant on 5 measures (P .05). They were percentage of leads, beneficial anticipations (Type II), on-target scores, error, and acceleration.

Table 12 presents the same data as Table 11. However, in Table 12 subjects have been divided on the basis of the verbal rehearsal variable rather than in terms of the amount of skill retention. Thus this table indicates the effects on the analytical measures which can be attributed to the rehearsal conditions.

Table 12

Summary Data for Analytical Measures of Tracking Performance

Group		Leads %	Leads Mean	Lags %	Lags Mean	Beneficial Anticipations[1] Type I	Beneficial Anticipations[1] Type II	Overshoots %	Overshoots Mean	Undershoots %	Undershoots Mean	Incorrect Anticipations Frequency	On-target Frequency	Error Volts	Acceleration Volts
Rehearsal (N=24)	Last Trial Training	98.09	.215	2.90	.150	15.80	34.67	32.45 (N=23)[2]	.446	10.73	.365	1.33 (N=3)	31.88	2.16	4.39
	First Trial Retention	88.49	.222	12.05 (N=11)	.189	17.67	32.51	41.11	.543	14.14 (N=23)	.569	2.42 (N=12)	27.21	2.92	4.50
	Change	-9.40	.007	9.15	.039	1.87	-2.16	8.66	.097	3.41	.204	1.09	-4.67	.76	.11
No Rehearsal (N=24)	Last Trial Training	95.16	.193	3.53 (N=8)	.096	22.09	37.33	31.10	.392	14.61	.391	1.00 (N=1)	33.92	1.90	4.12
	First Trial Retention	88.32	.188	8.85 (N=13)	.157	23.71	35.79	41.28	.520	14.89 (N=23)	.460	2.28 (N=7)	29.50	2.53	5.65
	Change	-6.84	-.005	5.32	.061	1.62	-1.54	10.18	.128	.28	.069	1.28	-4.42	.63	1.53

1. Type I: Movements initiated within ±150 milliseconds of a target displacement.
Type II: Movements initiated before -150 milliseconds, but not so soon as to reach predicted target early (Fig. 3).

2. Number of Ss who scored on this index.

DISCUSSION

Since individuals were randomly assigned to experimental groups it was assumed that differences which were found between groups were due to experimental variables, not to inherent group differences. This assumption could not be tested since experimental groups were treated differentially in pretraining and from the beginning of training. Nevertheless, an analysis of variance was computed on the integrated error scores of the first trial with the expectation that no differences would be found among the experimental groups. The results (Table 5) indicated that even at this early stage of training differences associated with the main effects were significant.

A comparison of Table 3 (Trials 11-25) with Table 4 (first trial) indicated that the relationships among the display groups were somewhat reversed on Trial 1 from what they were by trials 11-25. Subjects in the numbered display condition who received verbal pretraining had the highest error scores on the first trial but they had the lowest error scores on trials 11-25. The relationship between the blank display and lined display conditions for the verbal pretraining group also showed a cross-over between the first trial and trials 11-25. This reversal in relationships of display conditions with training was felt to make the test of significance between display conditions on trials 11-25 a conservative one.

Of greater interest was the finding that on the first trial those subjects who were given pretraining and used either the lined display or numbered display had lower error scores than those who had not been given pretraining (Table 5). Assuming that these groups were drawn from the same population, it was concluded that the effects of pretraining were present during the initial trial. This suggests that the more information an individual has about the task, the better will be his initial performance level.

Hypothesis 1 predicted that the higher the degree of display specificity, the better the performance. This prediction was based on the assumption that as the specificity of the display was increased, the probability of the use of a more efficient coding process would also increase. The significant main effect attributable to display conditions in the analysis of variance on trials 11-25 (Table 2) tended to support this hypothesis. However, inspection of Figure 1 indicates that the differences between groups were not all in the predicted direction. Consistent with the hypothesis, the numbered display condition tended to facilitate learning more than did the other two displays. However, contrary to prediction, the blank display condition tended to be superior to the lined display condition. Furthermore, this non-predicted relationship was replicated in both the pretraining and no pretraining conditions during the early stages of training, and in rehearsal on the first retention trial.

Hypothesis 1 was based on the assumption that the different displays would dictate the use of different cues in the coding of the task. Furthermore, it was felt that number cues (numbered display) would be the most efficient, spatial-visual cues (lined display) less efficient, and finally, the blank display condition (which appeared to place relatively greater demand on the use of proprioceptive cues) the least efficient basis for coding the task.

The best indicator available as to whether or not subjects with different display conditions actually used different cues in coding the task was the PPT.

For the subjects who had pretraining there were no significant differences in scores on the PPT between display condition groups. It appeared these individuals drew on their experience in the verbal pretraining session as a basis for filling out the PPT.

This conclusion was based on the observation that most of the individuals under the low and intermediate display specificity conditions were quite unsure as to how to complete the PPT. Many asked if this test corresponded to the numbers they learned during pretraining. When told that it did, they proceeded to reconstruct the list of numbers as best they could and then filled out the PPT from the list. Even those who did not ask about the relationship between pretraining and the PPT, were frequently observed to either write down or reconstruct verbally the list as learned in pretraining. It appeared that, for these individuals, performance on the PPT test depended primarily on how much they could recall from the pretraining session. For this reason it was felt that these individuals gave little indication of the manner in which they actually coded the tracking task.

For the subjects who did not receive pretraining, performance on the PPT was necessarily based on information obtained during practice on the tracking task. Again individuals who tracked under the low and intermediate display specificity conditions had trouble with this test. These subjects were observed to motion with their arms apparently in an attempt to reproduce the pattern of kinesthetic cues, while those subjects who tracked in the numbered display condition merely counted off the lines and proceeded to fill out the test. It should be recalled that those in the blank display and lined display conditions committed significantly more errors than those in the numbered display condition, however, they did not differ significantly from each other. These observations appear to lend support to the contention that subjects in the numbered display condition used numbers in coding the tracking task, whereas those in the other conditions used different cues in coding the task.

In the early stages of training, tracking involved a good deal of perceptual discrimination; the subject had to discriminate between eight positions on the scope. A consideration of the difficulty that individuals in the different display condition had in discriminating between target positions may suggest an explanation of the unexpected effects of the display conditions. Results indicate that those tracking with a lined display had the most difficult discrimination task whereas those tracking with a numbered display had the easiest discrimination task.

The displays differed in the type of cues present in the task which could be used in making the required discriminations. Regardless of display conditions, the task could be mastered on the basis of proprioceptive cues, plus visual feedback information from the display. Subjects tracking with the lined display had the added line cues, while subjects with the numbered display had numbers as well as lines to facilitate discrimination.

Evidence that subjects in the numbered display condition used the number cues in coding the task has already been discussed. For those in the blank display condition it is difficult to imagine how discrimination between target positions could be based on anything other than proprioceptive cues and visual feedback. It is also quite unlikely that in tracking with the lined display, line cues could be ignored. Therefore, if performance is in part dependent on the ease of discrimination as is being suggested here, then the results indicate that adding numbers to the display aided in this process whereas adding lines interfered with the discrimination process. That is, the task may have been rendered more complex by addition of the lines, without compensatory gains in visual discrimination.

Findings relevant to this interpretation have been reported by Battig, 1956; Battig, et al., 1957; Hoffeld, 1957. These investigators, in attempting to determine the effects of verbal pretraining and stimulus pre-differentiation, found the latter to have an inhibitory effect on performance when complex tasks were used. Battig (1956) suggested that when verbal pretraining adds additional cues to the task which are relevant, the effect will be beneficial, however, if the added cues interfere with other essential elements of the task, a decrement in performance will occur. In the present situation the perceptual discrimination problem encountered early in training has little effect late in training when it was assumed proprioceptive feedback became more important. Quite possibly, then, those in the numbered display group quickly learned the perceptual task and moved rapidly into the stage where proprioceptive feedback became increasingly more important. Those tracking in the blank display condition were, in essence, involved in encoding and refining their responses on the basis of proprioceptive cues from the start of training. However, those who were faced with the lined display may have either coded the task in terms of these lines, perhaps by assigning numbers to the lines, (which, no doubt, was more difficult than coding the task with the numbers present) or, they may have attempted to code the task by giving the lines numbers, then, finding this inefficient, shifted attention to proprioceptive cues. In either case, by the time the coding process had been completed and subjects were ready to refine their responses on the basis of proprioceptive cues, they had fallen behind those subjects who had been relying primarily on proprioceptive cues from the very start of training. The lines, then, may have been attractive distractors, suggesting a means of coding the task, but actually interfering with the early attention to proprioceptive cues, which apparently were essential to the finer discriminations required in this task.

Evaluation of Hypothesis 2 is much more straightforward. Here it was predicted that (a) subjects given pretraining would show a faster initial rate of learning, and (b) the greater the relevance of pretraining to the task, the greater would be its facilitory effects.

The significant F value for the pretraining condition for trial blocks 3, 4, and 5 was interpreted as indicating that verbal pretraining facilitated early performance. Since this effect was in the predicted direction, Hypothesis 2 (a) was supported.

The non-significant interaction between display and pretraining conditions indicated that part (b) of Hypothesis 2 was not supported. This was somewhat of a surprise since it was assumed that a greater facilitory effect might have been realized with the numbered display, because it appeared to be far more compatible than the other display conditions with the verbal pretraining. One explanation of the failure to obtain a significant interaction may be in the assumptions about the data. While the analysis of variance assumes an interval scale, it is doubtful that the difficulty in reducing one's error from 5 to 4 volts is the same as reducing one's error score from 3 to 2 volts. If this is the case, it may well mask some interaction effect between pretraining and display conditions. Failure to find greater facilitation with both verbal pretraining and numbered display conditions present may also indicate that the two modes of presenting cues for a number code were simply too redundant to yield additive effects.

Hypothesis 3 predicted that by the end of training all groups would reach the same level of performance. The summary of the analysis of variance on block of trials 101-115 (Table 2) supports this prediction in that the analysis failed to reject the null hypothesis. However, these results provide only suggestive evidence for the assumption that proprioceptive cues become relatively more important as training progresses. It may be, in fact, that all groups were simply approaching the same asymptotic level of performance.

Considering the evidence for the three hypotheses collectively, it appears that all differences due to pretraining and display specificity conditions were eliminated with practice. That is, whereas the pretraining and display main effects were significant on block of trials 11-25, these main effects were no longer significant on block of trials 101-115. This indicates that both pretraining and display specificity were important during the early, but not the late, stages of training.

The results from the acquisition portion of this study provide tentative support for three conclusions. First, as shown by pretraining, the amount of specific information an individual is given about the task will have a direct bearing on both the initial level of performance and on the initial rate of improvement. Secondly, by varying the display one determines the type of mediating process which is available and easily utilized by an individual. This has an influence on the initial rate of improvement, independent of the influence of pretraining and instruction. Finally, the above factors have their influence only during the early stages of training. As training progresses, behavior may become increasingly dependent on the more direct feedback via proprioceptive channels, regardless of the original cues used in coding the task.

The three parts of Hypothesis 4 dealt with the effect on retention of the three variables under investigation in this study. Part (a), which predicted that verbal rehearsal would facilitate retention, was not supported. One possible explanation for this is simply that the retention interval was not of sufficient length. Verbal rehearsal was employed in an attempt to aid in the retention of the stimulus pattern so that any observed decrease in performance could then be largely attributed to a loss in motor proficiency. However, the results of the analytical scores and the PPT indicated that verbal rehearsal could not have had this effect since little forgetting of the pattern had taken place. If forgetting had taken place, one of two things would have been evident from the analytical data. Either the percentage of lags would have increased substantially, suggesting that subjects were waiting to see where the stimulusmoved to before responding to it, or the number of incorrect anticipations would have increased. The latter would indicate that although subjects were continuing to anticipate movements of the target, they were making errors in the process. While there were changes in these two indices, the magnitude of these changes was not great enough to indicate any marked forgetting of the target sequence. It can be seen in Table 12 that although the percentage of leads dropped from 6 to 9 percent in the two groups over the retention interval, still, on the first retention trial both groups were anticipating on over 88 percent of the targets. This, coupled with the fact that an average of only slightly more than one incorrect anticipation was committed by a maximum of 12 individuals within a rehearsal condition, actually indicates a high degree of retention of the stimulus pattern.

For the PPT data, median tests showed only two of the six groups to have significant increases in the number of errors committed at the retention session over the number committed at the end of training. Those were the blank display and numbered display conditions which did not receive verbal pretraining (blank display: $X_{1df} = 6.40$, $P \; .025$; numbered display: $X_{1df} = 5.38$, $P \; .05$).

Under the conditions in this study, one effect of verbal rehearsal seemed to be to increase the variance among groups. A test for the homogeneity of variance among the groups within the rehearsal and non-rehearsal conditions was performed by dividing the mean square for the treatment effect in the verbal rehearsal group by the mean square for treatment of the no rehearsal group (Snedecor, 1956). This gave a significant $F_{5,5}$ of 5.75 ($P \; .05$). This result indicates that verbal rehearsal interacted with pretraining and display conditions with the result that it tended to have an inhibitory influence in some cases and a facilitory effect in others. It is possible, however, that an extension of the no-practice period would result in all the rehearsal groups showing greater retention of skill than any of the no-rehearsal groups.

Neither part (b) nor part (c) of Hypothesis 4, which dealt with the effects of pretraining and display specificity on retention, were supported. However, the pretraining and display main effects approached significance in the analysis of variance performed on the data for only those subjects with verbal rehearsal. (Table 7) Two points will be discussed briefly with regard to these non-significant trends.

First, there is an indication that variables which may have an effect on early performance, but no effect on final level of proficiency, will have no differential effects on retention of the skill unless there is an interpolated task which reintroduces cues which are pertinent to the coding of the task. In this case the interpolated task was the rehearsal treatment. Under this condition only, was there some evidence of the effects of the other experimental variables. Unfortunately, the loss of skill over the short retention interval was not of sufficient magnitude to evaluate the effects of the experimental variables on rate of relearning.

Second, with verbal rehearsal the numbered display groups, irrespective of the conditions of pretraining, showed the greatest amount of retention as expected. The relationships among the four remaining groups were nearly the same in retention as they were early in training. Indications were that rehearsal tended to interact more with the pretraining conditions than it did with the display conditions. If these trends should be found to be reliable in subsequent studies, they would suggest that, at least for those in the blank and lined display groups, learning to relate pretraining to the task during training is an important determiner of the effectiveness of rehearsal.

One aspect of the PPT has not been discussed, namely, the relationship between performance on the PPT and tracking performance as measured by integrated error scores. Spearman rank correlation coefficients indicated that there was no significant relationship between integrated error scores at the end of training and the number of errors committed on the PPT taken after the last training trial. This was true even though evidence suggests that those tracking in the numbered display group used the number cues both in the initial coding of the tracking task and as a basis for completing the PPT. This gives a further indication that performance in the advanced stages of training is independent of knowledge of the code used to initially encode the task.

Results were somewhat different, however, when individual performance on the PPT administered before the retention session was correlated with the amount of skill lost during the retention interval. In this case a significant relationship was found for the numbered display condition. This indicates that forgetting of a code, which it was assumed was used to originally encode the task, has a significant relationship with the amount of skill lost over a one month period of no practice. On the other hand, forgetting of the code had no significant effect on retention in these conditions where it was assumed that the code was not used to originally encode the task.

This finding is supportive of the suggestion by Brown, et al., (1963) that tasks can and should be dimensionalized in terms of separate task components. Then, when training time is limited, practice during the retention interval on the more difficult components would be expected to lead to superior retention of the original task skill. Under conditions of the present study, practice of the original coding process may facilitate retention after long periods of no practice.

Finally, a word about the results of the analytical measures is in order. It was hoped that by separating individuals on the basis of their retention of skill into good and poor retention groups, insights would be gained as to what changes in the temporal-spatial patterning of responses correlated with skill deterioration during the interval of no practice.

As indicated in Table 11, significant differences were found between the "change score" of the good and poor subjects on four indices: percent leads, beneficial anticipations (Type II), on-target score, and acceleration. Significant difference on a fifth measure, error, was expected since this was the measure on which the grouping of individuals was based.

It has been suggested earlier that the relative large magnitude of leads and the low number of incorrect anticipations, indicates relative little forgetting of the stimulus pattern (Table 12). However, when the grouping of subjects was based on amount of skill retained, the significant difference between good and poor subjects on the percent lead index may have indicated either that the poor subjects had forgotten more of the pattern than the good subjects over the retention interval, or that the poor subjects had lost more in terms of the timing of their movements.

The largest difference between the two groups in Table 12 was on the on-target index (number of targets on which an individual was within a narrow target tolerance band for at least .6 second). A decrease in the on-target score is indicative of one of three things: 1) an individual was laging behind to such an extent that he was not getting to a target in time to stay on it for .6 second, 2) he was reaching a target in time but his movement was inaccurate so that he was not within the "on-target band," and, furthermore, he made no corrective movement to bring himself within the band, or 3) an individual, in correcting for overshoots and undershoots resulting from the primary movement, was inaccurate in his secondary corrective movements which also carried him outside the "on-target band" which, in turn, necessitated his making additional corrective movements.

Inspection of Table 11 indicated that the change in the percentage of and average duration of lag times was probably not sufficient to account for the decrease in on-target scores (a small number of individuals scored on this index). Visual inspection of the records indicated that few individuals would remain off target without making corrective movements. This leaves explanation 3, above, to account for the decrease in the on-target scores for those individuals who showed the greatest loss of skill over the retention interval. A second look at the visicorder records supported this explanation. Characteristic of these subjects was a greater amount of movement of the arm control. That is, it appeared that the number and amplitude of secondary corrective movements increased for these individuals on the first retention trial over what it was on the last training trial. The significant difference in the acceleration scores compliments this interpretation. In the process of making major secondary corrective movements an individual also adds to his total acceleration for that trial. This rationale suggests, then, that one of the primary aspects of skill which was lost over a no-practice interval was the ability to make accurate corrective movements.

Finally, it should be noted that the changes in beneficial anticipations (Type II) were in the opposite direction for the two groups. Whereas there was a decrease on this index for the poor subjects, there was an increase for the good subjects. Although this result is difficult to interpret, it suggests that the good subjects slightly improved the timing of their responses on the retention trial. At the end of training they may have been anticipating too early, arriving at the anticipated target position too soon, while on the retention trial they may not have been anticipating as soon, thus increasing the number of anticipations designated beneficial. The decrease in beneficial anticipations (Type II) for the poor subjects is probably a reflection of the decrease in the percentage of leads and increase in the percentage of lags that these individuals also showed.

The difficulty of pulling out separate measures and interpreting them in terms of skill retention, or loss, in hopes of gaining an overall picture of the changes which occur over a retention interval is obvious. In the future, factor analysis of these response measures may identify factors which will give greater insight into those changes in response patterns which relate to the deterioration of tracking skill.

SUMMARY AND CONCLUSIONS

An investigation was conducted on the effects of verbal pretraining and display specificity on the acquisition of skill in a one-dimensional pursuit tracking task and the influence of these two variables, together with the effect of verbal rehearsal, on the retention of the tracking skill.

An electronic tracking apparatus was used which permitted repeated presentation of a fixed step function sequence of targets on the face of an oscilloscope. The subject responded by moving an arm control which controlled the position of a follower on the oscilloscope.

A 2 x 3 x 2 factorial experiment was employed which permitted comparison between two pretraining conditions (verbal pretraining and no verbal pretraining), three display conditions (high, intermediate, and low specificity displays), and two rehearsal conditions (verbal rehearsal and no verbal rehearsal).

It was assumed that performance on the tracking task depended both on the efficiency of the manner in which the task was coded and on the use of kinesthetic feedback. Consideration of the interaction between these processes and the experimental conditions led to four hypotheses presented here in abbreviated form:

1. As the specificity of the display increases the probability of a more efficient coding process will increase, facilitating early acquisition performance.

2. a) Verbal pretraining will serve to facilitate motor performance when the verbal pretraining provides a set of cues for coding the task. b) The greater the relevance of the verbal pretraining to the display

condition, the greater the amount of facilitation; under the conditions of this study, relevance is assumed to increase with display specificity.

3. All groups, regardless of pretraining or display conditions, will reach the same level of performance after an extended amount of training.

4. a) Rehearsal of a verbal code relevant to the task will have a facilitory effect on retention of the skill. b) Verbal rehearsal will interact with display conditions such that its effects will be maximal under conditions of high display specificity and minimal under conditions of low display specificity. c) For those subjects not given verbal rehearsal, (1) the higher the degree of display specificity, the greater the retention of the skill, (2) retention will be facilitated by giving subjects verbal pretraining, and, (3) the greater the relevance between the pretraining and display condition the greater the amount of skill retention.

Results indicated that:

1. Verbal pretraining significantly facilitated early performance.

2. Performance was affected early in training by the different display conditions; however, these effects were not consistently in the predicted direction. Performance in the high display specificity condition tended to be superior to that in the other two conditions, as predicted. However, performance in the low display specificity condition tended to be better than that in the intermediate display specificity condition, contrary to expectations. There was no significant interaction between pretraining and display conditions.

3. The null hypothesis of no difference in the performance levels

of the experimental groups at the end of training failed to be rejected.

4. Verbal rehearsal did not significantly improve retention of the tracking skill; it did, however, significantly increase the variance among the experimental groups.

5. Pretraining and display conditions did not significantly affect retention. However, within the verbal rehearsal conditions, the high display specificity group tended to be superior to the other four experimental groups. Of the latter four groups, those who had received verbal pretraining tended to retain more than those who had not.

6. Results of the paper and pencil test indicated that subjects in the high display specificity condition had used a number code to encode the task. There was a positive but not significant relationship between amount of skill retained and performance on this test for the low and intermediate display specificity conditions. For those in the high display specificity condition, however, there was a significant positive relationship between number of errors on this test and absolute amount of skill lost over the retention interval.

7. Results of the paper and pencil test and of the 12 indices taken from continuous response records indicated that little or no forgetting of the stimulus sequence took place over the retention period of one month, regardless of the rehearsal condition.

8. Subjects who showed a low retention of the tracking skill had a significantly greater change in the number of leads, beneficial anticipations, on-target score, and acceleration score than those subjects who showed high retention of the tracking skill.

The results clearly indicated that early performance on a tracking task can be facilitated by providing verbal pretraining. There was also evidence that the type of exteroceptive information available affects early performance. It was suggested that the efficiency in coding the task may be closely related to the amount of difficulty an individual has in discriminating between stimuli. The addition of numbers to the display facilitated this discrimination process, whereas the addition of lines interfered with this process. Further evidence on this point could probably be obtained by increasing the number of possible target positions on the scope, thereby increasing the overall difficulty of the discrimination process.

This study provided no definite evidence as to the role of pretraining, display specificity, or verbal rehearsal in facilitating retention. It was concluded that such relationships might have been found had the retention interval been of sufficient duration to produce greater overall forgetting. Rehearsal was designed to facilitate the retention of the code used in the original encoding process. Results of the paper and pencil test and of the analytical scores indicated that very little of this code was forgotten over the retention period.

If in future studies with extended retention intervals, the results support the trends in this study, then it would suggest that motor skills can be analyzed into sub-tasks and that the manner in which these subtasks are handled by an individual can be influenced by pretraining and the kind of exteroceptive cues given to the individual for feedback purposes. Furthermore, rehearsal on the more difficult of these subtasks may facilitate retention of the overall skill task. Factor analysis of the analytical data may suggest factors which differentiate those who show high retention of skill from those who show little retention of skill.

If future research confirms the implications of this study, the possibilities seem good of being able to present perceptual-motor tasks and to devise rehearsal programs in a manner which would enhance the learning and retention of those tasks.

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REFERENCES

Adams, J., and Creamer, L. R. Proprioception variables as determiners of anticipatory timing behavior. Human Factors, August, 1962.

Bahrick, H. P. An analysis of stimulus variables influencing the proprioceptive control of movements. Psychol. Review, 1957, 64, 324-328.

Bahrick, H. P., and Shelly, Carolyn. Time sharing as an index of automatization. J. exp. Psychol., 1958, 56, 288-293.

Baker, K. E., and Wylie, R. C. Transfer of verbal training to a motor task. J. exp. Psychol., 1950, 40, 632-638.

Battig, W. F. The effect of kinesthetic, verbal, and visual cues on the acquisition of a lever-positioning skill. J. exp. Psychol., 1954, 47, 371-380.

Battig, W. F. Transfer from verbal pretraining to motor performance as a function of motor task complexity. J. exp. Psychol., 1956, 51, 371-378.

Battig, W. F., Hoffeld, D. R., Seidenstein, S., and Brogden, W. J. Supplementary report: Effect of verbal pretraining on the acquisition of a complex motor skill. J. exp. Psychol., 1957, 54, 375-376.

Brown, D. R., Briggs, G. E., and Naylor, J. C. The retention of discrete and continuous tasks as a function of interim practice with modified task requirements. AMRL-TDR-63-35, 6578th Aerospace Medical Research Laboratories, Aerospace Medical Division, Wright-Patterson Air Force Base, Ohio, May [illegible], 1963.

Bunch, M. E. Transfer of training in the mastery of an antagonistic habit after varying intervals of time. J. comp. Psychol., 1939, 28, 189-200.

Bunch, M. E. Retroactive inhibition or facilitation from interpolated learning as a function of time. J. comp. Psychol., 1946, 39, 287-291.

Fitts, P. M. Engineering psychology and equipment design. In S. S. Stevens (Ed.), Handbook of experimental psychology. New York: Wiley, 1951.

Fleishman, E. A., and Rich, S. Role of kinesthetic and spatial-visual abilities in perceptual-motor learning. J. exp. Psychol., 1963, 66, 6-12.

Gagne', R. M., and Baker, K. E. Stimulus pre-differentiation as a factor in transfer of training. J. exp. Psychol., 1950, 40, 439-451.

Goss, A. E. Transfer as a function of type and amount of preliminary experience with task stimuli. J. exp. Psychol., 1953, 46, 419-428.

Gottsdanker, R. M. The accuracy of prediction motion. J. exp. Psychol., 1952, 43, 26-36. (a)

Gottsdanker, R. M. Prediction-motion with and without vision. Amer. J. Psychol. 1952, 65, 533-543. (b)

Gottsdanker, R. M. A further study of prediction-motion. Amer. J. Psychol., 1955, 68, 432-437.

Hoffeld, D. R. Transfer from verbal pretraining to motor performance as a function of response similarity and angle of movement. J. exp. Psychol., 1957, 54, 353-357.

Lawshe, C. H., and Cary, W. Verbalization and learning a manipulative task. J. appl. Psychol., 1952, 36, 44-46.

McAllister, D. E. The effects of various kinds of relevant verbal pretraining on subsequent motor performance. J. exp. Psychol., 1953, 46, 329-336.

Naylor, J. C., and Briggs, G. E. Effect of rehearsal of temporal and spatial aspects on the long-term retention of a procedural skill. J. appl. Psychol., 1963, 47, 120-126.

Osgood, C. E. Method and theory in experimental psychology. New York: Oxford University Press, 1953.

Perry, H. M. The relative efficiency of actual and imaginary practice in five selected tasks. Archives of Psychology, New York, 34(243), 1939.

Poulton, E. C. The basis of perceptual anticipation in tracking. Brit. J. Psychol., 1952, 43, 295-302. (a)

Poulton, E. C. Perceptual anticipation in tracking with two-pointer and one-pointer displays. Brit. J. Psychol., 1952, 43, 222-229. (b)

Poulton, E. C. On prediction in skilled movements. Psychol. Bull., 1957, 54, 467-478. (a)

Poulton, E. C. On the stimulus and response in pursuit tracking. J. exp. Psychol., 1957, 3, 189-194. (b)

Rossman, I. L., and Goss, A. E. The role of discriminative verbal responses in facilitating the acquisition of discriminative motor responses. J. exp. Psychol., 1951, 42, 173-182.

Sackett, R. S. The influence of symbolic rehearsal upon the retention of a maze habit. J. gen. Psychol., 1934, 10, 376-398.

Siegel, S. Nonparametric statistics for the behavioral sciences. New York: McGraw-Hill, 1956.

Snedecor, G. W. Statistical methods. Ames, Iowa: Iowa State University Press, 1956.

APPENDIX

Table 13

The Difference in Error Scores Between Last Block of Training Trials and First Retention Trial. A Constant of 1.66 Has Been Added to Each Score

	Verbal Pretraining			No Verbal Pretraining		
	Blank Display	Lined Display	Numbered Display	Blank Display	Lined Display	Numbered Display
Verbal Rehearsal	2.10	3.22	1.68	1.90	3.38	1.54
	3.54	3.16	1.96	1.60	2.20	3.10
	.84	2.16	1.66	2.82	2.86	1.44
	1.44	0.00	1.80	2.84	4.18	2.52
	1.34	4.32	2.02	1.80	2.16	1.74
	1.18	1.66	1.06	2.62	2.32	1.71
	2.34	2.10	2.40	2.80	2.70	1.62
	2.50	1.96	1.40	2.08	2.72	1.98
	2.28	1.76	2.28	3.10	1.58	2.06
	2.20	2.42	1.70	3.44	2.18	2.22
$\bar{x}$=	1.97	2.28	1.79	2.50	2.63	1.99
No Verbal Rehearsal	2.82	2.10	2.88	2.20	2.30	1.56
	2.74	1.53	2.26	3.44	2.82	3.12
	2.30	2.00	2.32	2.44	1.54	1.80
	1.84	2.46	1.50	1.54	2.72	1.26
	1.56	2.24	2.36	2.56	1.92	1.44
	2.56	2.12	3.54	1.82	2.32	2.40
	1.24	2.16	2.28	2.06	2.20	1.56
	2.84	1.46	1.82	2.28	2.78	3.34
	2.52	2.00	2.38	1.94	2.18	2.12
	2.92	2.36	2.62	2.72	2.40	2.62
$\bar{x}$=	2.33	2.04	2.39	2.30	2.32	2.12

Table 14

Mean Error Scores of 5 Trial Blocks For All Experimental Groups During Acquisition (N = 20)

Trial Block		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Verbal Pretraining	Numbered Display	5.02	3.99	3.56	3.06	2.89	2.85	2.84	2.67	2.54	2.53	2.48	2.55	2.42	2.25	2.25	2.23	2.33	2.27	2.09	2.11	2.10	2.17	2.20
	Lined Display	5.44	4.57	4.13	3.47	3.05	2.82	2.72	2.70	2.50	2.52	2.37	2.44	2.50	2.36	2.23	2.25	2.37	2.33	2.11	2.02	2.18	2.21	2.25
	Blank Display	5.38	4.26	3.69	3.20	2.94	2.92	2.88	2.81	2.81	2.62	2.59	2.69	2.73	2.61	2.56	2.58	2.63	2.66	2.13	2.19	2.19	2.21	2.20
No Verbal Pretraining	Numbered Display	5.97	4.90	4.00	3.72	3.38	3.05	3.00	2.81	2.78	2.60	2.53	2.63	2.52	2.45	2.31	2.26	2.37	2.33	2.34	2.28	2.26	2.36	2.37
	Lined Display	6.03	5.16	4.65	4.41	3.87	3.67	3.72	3.60	3.08	2.94	2.94	2.84	2.82	2.77	2.58	2.48	2.52	2.56	2.24	2.09	2.20	2.20	2.22
	Blank Display	5.59	4.92	4.50	4.01	3.64	3.49	3.33	3.17	3.04	2.81	2.68	2.67	2.67	2.41	2.39	2.44	2.44	2.50	2.32	2.34	2.27	2.25	2.27

Table 15

Mean Error Scores For All Groups During Retention

		Trials	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rehearsal	Pretraining	Numbered Display	2.41	2.44	2.39	2.34	2.36	2.27	2.28	2.47	2.58	2.33	2.21	2.23	2.25	2.32	2.25	2.36	2.36	2.29	2.32	2.36
		Lined Display	2.84	2.50	2.41	2.64	2.43	2.53	2.42	2.57	2.74	2.56	2.52	2.42	2.46	2.45	2.36	2.52	2.45	2.59	2.52	2.70
		Blank Display	2.66	2.41	2.32	2.39	2.53	2.42	2.43	2.32	2.35	2.35	2.34	2.35	2.51	2.51	2.50	2.64	2.69	2.45	2.44	2.52
	No Pretraining	Numbered Display	2.51	2.19	2.27	2.29	2.28	2.27	2.12	2.17	2.05	2.24	2.23	2.22	2.21	2.35	2.23	2.23	2.19	2.20	2.20	2.27
		Lined Display	3.25	2.58	2.46	2.53	2.46	2.57	2.61	2.45	2.53	2.44	2.63	2.65	2.51	2.43	2.53	2.59	2.57	2.72	2.63	2.69
		Blank Display	3.20	2.85	2.66	2.52	2.74	2.47	2.53	2.60	2.61	2.57	2.55	2.58	2.54	2.65	2.59	2.70	2.59	2.87	2.71	2.59
No Rehearsal	Pretraining	Numbered Display	2.86	2.58	2.39	2.31	2.43	2.36	2.32	2.35	2.35	2.27	2.14	2.28	2.22	2.25	2.20	2.18	2.30	2.29	2.27	2.28
		Lined Display	2.71	2.52	2.60	2.48	2.40	2.24	2.43	2.55	2.39	2.33	2.34	2.42	2.34	2.26	2.36	2.49	2.46	2.50	2.53	2.60
		Blank Display	2.72	2.50	2.61	2.41	2.49	2.32	2.30	2.30	2.22	2.26	2.25	2.14	2.25	2.29	2.31	2.34	2.13	2.21	2.30	2.35
	No Pretraining	Numbered Display	2.73	2.54	2.42	2.39	2.32	2.38	2.46	2.35	2.50	2.58	2.32	2.56	2.33	2.35	2.44	2.36	2.32	2.45	2.45	2.47
		Lined Display	2.82	2.56	2.57	2.53	2.51	2.46	2.40	2.46	2.34	2.49	2.46	2.62	2.79	2.67	2.56	2.50	2.56	2.41	2.46	2.43
		Blank Display	2.96	2.58	2.49	2.42	2.48	2.39	2.58	2.43	2.48	2.48	2.50	2.53	2.30	2.46	2.52	2.55	2.41	2.39	2.40	2.46

AN ANALYSIS OF THE ROLE OF PRETRAINING, DISPLAY, AND REHEARSAL VARIABLES IN THE ACQUISITION AND RETENTION OF A PERCEPTUAL-MOTOR SKILL

by

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This study was conducted to determine the effects of verbal pretraining and display specificity (three conditions differing as to degree of specificity) on the acquisition of skill in a one-dimensional pursuit tracking task, and of the influence of these two variables, together with the effect of verbal rehearsal, on the retention of the tracking skill.

It was assumed that performance on the tracking task depended both on the efficiency of the manner in which the task was coded and on the use of kinesthetic feedback. Consideration of the interaction between these processes and the experimental conditions led to the predictions that 1) there would be a positive relationship between display specificity and level of performance, 2) verbal pretraining would facilitate performance; effect being greater for the high than the low display specificity condition, 3) after extended practice all groups would reach the same level of performance, and 4) verbal rehearsal would facilitate retention of the skill; effect being positively related with levels of display specificity. For those not given verbal rehearsal the amount of retention would be greatest for those who had received pretraining and would be positively related to display specificity conditions.

Results indicated that: 1) Pretraining significantly facilitated performance. 2) Performance was facilitated most for those in the high display specificity condition, as predicted, however, performance was poorest for those in the intermediate display specificity condition and intermediate for those in the low display specificity condition, contrary to prediction. 3) The null hypothesis of no difference between performance levels of groups at the end of training failed to be rejected. 4) Verbal rehearsal did not significantly increase the variance among experimental groups. 5) Pretraining and display conditions did not significantly affect retention. 6) Results of a paper and pencil test indicated that for those individuals who had coded the task by use of numbers, retention of the task was significantly correlated with ability to recall this code. 7) Results of the paper and pencil test and of analytical scores, derived by handscoring selected trials, indicated little or no forgetting of the stimulus sequence over the retention interval. 8) Subjects who showed a low retention of the tracking skill had a significantly greater change in the number of leads, beneficial anticipations, on-target score, and acceleration score than those subjects who showed high retention of the skill.

The results clearly indicate that early performance on a tracking task can be facilitated both by providing verbal pretraining and by the type of exteroceptive information made available. It was suggested that the efficiency in coding the task may be closely related to the amount of difficulty an individual has in discriminating between stimuli.

This study provided no definite evidence as to the role of pretraining, display specificity, or verbal rehearsal in facilitating retention. It was concluded that such relationships might have been found had the retention interval been of sufficient duration to produce greater overall forgetting.