EFFECTS OF INTERMITTENCY AND SPECIFICITY OF KNOWLEDGE OF RESULTS ON PERFORMANCE OF A PERCEPTUAL TASK

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CHAPTER I

INTRODUCTION

Knowledge of results (KR) can be defined as knowledge of various kinds which the trainee or performer receives about his performance (cf. Ammons, 1956). KR has been further defined as including the subject's (S's) perception of KR. The definition and roles or properties of KR will be discussed further in a Literature Review section. Bilodeau (1966) has compiled a list of terms various authors have used for "much the same experimental procedures" as are used for KR: feedback (achievement information feedback, information or informative feedback, reinforcing feedback, psychological feedback, etc.), reinforcement, and reward. Bilodeau also lists modifiers such as supplementary, intermittent, augmented, terminal, intrinsic, extrinsic, action, and learning (i.e., learning feedback) that have been used in association with KR. Much research interest has centered on the effects of KR on performance. Bilodeau and Bilodeau (1961) state that no other independent variable offers such a wide range of possibilities for getting man to repeat or change his responses so immediately and by such large amounts.

KR Specificity

KR Specificity (KR Spec), a parameter of knowledge of results, "may be defined as the degree to which information given the learner describes the manner in which his performance deviates from criterion performance (Cotterman, 1960). It may be regarded as analogous to quality of reinforcement. Though not specifically stated, Underwood (1966, pp. 336-337) seemed to use the term precision for specificity though Cotterman (1960, p. 12) apparently would use "precision" or "accuracy" to refer to another aspect of information. [This particular author does not at present feel that there is a clear need for the three terms therefore, specificity will be the only term necessary for this paper.] For a particular task, if the difference in KR Specificity is great enough (and enough trials are given), an increase in KR specificity may result in an improvement in performance.

Intermittent KR Schedules

An intermittent KR schedule refers to the presentation to an S of KR on some trials (or after some responses) and not on others. KR intermittency may be thought of as referring to the placement of KR following responses in a series in which other responses are not followed by KR. It is noted that random ratio (or random-interval) KR schedules may interpose two or more consecutive KR trials between or among non-KR trials.

There are two possible types of intermittency schedules, a KR schedule and a KR percentage.

KR Schedule

KR schedule will refer to the manner in which KR is presented: fixed-ratio, fixed-interval, random-ratio, or random-interval KR. Concerning KR schedules, very little research has been done comparing fixed-ratio (or fixed-interval) with random-ratio (or random-interval) schedules of KR presentation.

Fixed-Ratio KR. When every nth response receives KR, and when n is constant, the KR may be said to be given according to a fixed-ratio schedule.

Fixed-Interval KR. If KR is given according to fixed time intervals, then KR is given on a fixed-interval schedule. This would also be the case if KR was given on a fixed-ratio schedule having a constant inter-trial interval.

Random-Ratio KR. On the other hand, in a random-ratio (RR) or variable-ratio (VR) schedule of KR, the KR occurs after a varying number of responses, the number varying unpredictably from KR to KR (cf. Ferster and Skinner, 1957, p. 391). Thus, random-ratio KR conditions result in KR occurring on randomly picked trials. However, for a given ratio the *average* number of responses preceding a response followed by KR is usually equated with the number of such responses in a fixed-ratio schedule.

Random-Interval KR. Random- or variable-interval KR may occur where the time between KRs is randomly varied. As with random-ratio KR one particular average interval may be used.

KR Percentage Schedules

KR percentage or ratio refers to a method of presenting KR in which KR is given on a certain percentage of the total trials or according to a certain ratio of KR trials to total trials.

Little intermittent-KR research has been done using a procedure which, over different KR percentages, holds the number of KRs constant and varies the number of total trials (including the non-KR trials). It is obvious that the opposite could be done; that is, the total number of trials could be held constant and the KR ratio varied. But this might only demonstrate the behavioral effects of increasing the number of KRs. Since reward, or reinforcement, and KR are not synonymous terms, methodological and theoretical comparisons between the two areas of research interest are difficult; however, holding the number of KRs constant is analogous to holding the number of reinforcements constant.

KR Spec x KR Intermittency

Much research has been done concerning the separate effects of the intermittency and the quality of reinforcement on the behavior of animal Ss. However, there is a lack of research concerned with the interactive effects of these two variables. Lewis (1960, 1963) found few parametric laws after reviewing the partial-reinforcement literature of the 1950's. He mentions further that not many researchers seem to be interested in how one variable relates to another along the major range of both. An earlier review by Jenkins and Stanley (1950) supports his statement. Much the same can be said concerning the KR area, but to an even greater extent, since far less research has been devoted to the effects of KR on learning than to the effects of reinforcement.

Using, for example, a perceptual-learning task, the effects on performance on this task of the interaction or relationship between various levels of specificity of KR (or feedback) and different KR intermittencies (different percentages and the two schedules) could be studied using a factorial arrangement of experimental treatments.

This study is designed to discover the effects of the interaction of different KR specificities and different KR schedules and percentages holding number of KRs constant.

CHAPTER II

STATEMENT OF THE PROBLEM

With relatively few exceptions, knowledge of results (KR) has been shown to be an important variable in learning. Whenever a training method or device must be designed to aid learning of a task involving perceptual judgements, it is important not only to consider whether KR must be provided but, also, how and to what degree it can be provided in order to help the learner most. It is thus desirable to know the effects of various types of feedback on learning. Both qualitative and quantitative aspects of feedback are important. This would include studying the specificity of the feedback, the rate, the periodicity, and the effects of withdrawing KR on performance. The latter can be studied through the use of intermittent KR schedules, thus providing not only an estimate of KR rate effects, but the amount of learning which occurs without KR or during non-KR practice trials as well. There has been a lack of research dealing with these variables.

It was therefore thought desirable to use a factorial experiment to investigate the main and interactive effects of the specificity of KR, the ratio of KR, and the schedule of KR presentation (fixed ratio and variable ratio) on the rate and level of learning of a simple perceptual judgement. Thus, the three variables used were KR specificity, KR percentage, and KR schedules.

Only one response was allowed per trial. Since the intervals between and within trials were the same from trial to trial, the fixed-ratio KR group is also a fixed-interval KR group, and the variable-ratio KR group a variable-interval KR group. However, fixed- or random-ratio will be the terms usually used in this paper.

The perceptual task used consisted of estimating to the nearest degree the extent of angular separation between a small arrow-headed line and a larger one running completely across a $3\frac{1}{2}$ inch circle. Some normative data are available for judgments of this sort as a function of the physical characteristics of the stimulus (Baker and Grether, 1954; Reese, 1953). Cotterman (1960), using the same stimuli as those used in this study and six types of KR specificity, found that the "rate and level of learning to estimate angular separation are increased when knowledge of results is given." Cotterman (1960) stated that the "no-knowledge group was generally the worst" in performance. However, one might question whether any learning (or a sample deviation) occurred for this group from stimulus set I to II before increasing approximately halfway to what resembles a plateau for the three additional stimulus sets. However, the difference between the first and last "no information" stimulus sets in absolute error was found to be non-significant. Cotterman (1960) did feel that the no information group learned nothing but then states that "while practice with or without knowledge permitted a reduction in absolute error on the hardest stimuli, practice with knowledge was necessary for the maintenance and improvement of performance on the easiest items." Thus, one can compare the responding for this study's groups with that of Cotterman's no KR groups to obtain some idea of the influence of non-KR responding although the effects of non-KR responding after one or more KRs have been given and then discontinued for large numbers of trials are not completely known.

In addition to looking for such as possible interactions, this study investigates the addition of differing numbers of non-KR trials and such factors as differing KR rates and inter-KR intervals.

Cotterman found that "learning, as measured by absolute error, was generally greater the more specific the knowledge of results given." The KR specificity groups were generally ordered from lowest to highest in specificity and performance and with no exception for the KR Specificities used in this study.

However, Cotterman states that: "In general, adjacent treatment groups did not differ significantly, although more extreme ones did." This is apparently considering _t_-tests of paired comparisons of group means on each stimulus set. Of the KR Specificities used for this study, KR Specificities II and III (Cotterman's KR specificities IV and VI, respectively) never differed significantly in Cotterman's (1960) study on a stimulus set; Cotterman's KR specificity VI was significantly superior to II on the second, third, and fourth stimulus sets in Cotterman's (1960) study. Twenty-four different stimuli were given per set, each set containing the same stimuli but given in a different random order. Cotterman further states though that: "The failure to find reliable differences among adjacent treatment groups is readily understandable in the light of the considerable variability shown by even the best group." However, suffice to say that since adjacent treatment groups did not always significantly differ on a stimulus set as to mean absolute error, the specificity or precision of information may have to be increased beyond a certain level in order for S to achieve a statistically significant improvement in performance from the level one begins with. Thus this writer feels that in view of the foregoing material in this chapter regarding Cotterman's (1960) study the above statement regarding the operation of increased KR Specificity on learning may perhaps need some qualification. This qualification may even include the following statement, regarded by Cotterman as confirmed, "(2) the rate and level of learning to estimate angular separation were directly related to the specificity of the KR given." The present study used three of Cotterman's KR specificity types (type II, "right" if S was either correct to the nearest degree or no more than one degree in error or "wrong"; type IV, "over", "under", or — if to nearest degree — "correct"; and V, the correct answer), thus providing a test of certain of Cotterman's findings under conditions involving variation of the numbers of non-KR trials and the rate and periodicity of KR presentation.

Bilodeau and Bilodeau (1958) and others have studied the effects of KR rates and Bilodeau, Bilodeau, and Schumsky (1959) and others the effects of introducing and withdrawing KR, but both studies involved a lever-pulling task. Thus, this study also served to extend the findings of Bilodeau and Bilodeau (1958) and others by employing a visual judgment task without S's having to acquire a motor skill or, at least, with less emphasis on either acquiring a motor skill or on the motor skill (functioning) itself.

This study was designed to determine if:

(1) the rate and level of learning are related to the specificity of the KR given,

(2) fixed-ratio (interval) and random-ratio (interval) and variable ratio KR schedules differ in their effects on the rate and final level of learning to estimate angular separation,

(3) higher KR percentages (rates) result in higher rates and/or final levels of learning, and

(4) the three variables interact in the effect(s) on learning.

Predictions concerning the dependence of learning on KR and KR rate were not made. However, it should be pointed out that if learning were largely dependent on KR _per se_, then a decrease in error would occur primarily after a KR trial and, in addition, fixed-ratio performance curves should follow a step-function. This would support Thorndike (1927) who emphasized the importance of feedback in acquiring a perceptual skill and Bilodeau and Bilodeau (1958) who found such a step-function and concluded that learning is dependent on the absolute frequency of KR, i.e., the _number_ of KRs, and independent of the relative KR frequency. Stated another way, Bilodeau and Bilodeau (1958) found that learning _rate_ was indeed a function of the KR rate or percentage, but that the final learning _level_ was only a function of the total number of KRs.

CHAPTER III

REVIEW OF THE LITERATURE

An attempt has been made primarily to survey selected studies closely relating to the present study in regard to method, task, and variables studied, thus placing a limit on the KR studies reviewed.

There are studies mentioned which are outside these limiting aspects but which demonstrate a particular procedure, finding, or conclusion which is relevant to procedural or discussion aspects in this study and/or which give some indication of the status and perhaps flavor of KR research. Thus, though there are studies included which may be pertinent in regard to other specific aspects of KR or perhaps KR in general, the primary concern of this literature review is with verbal KR or feedback, perceptual tasks, KR specificities, and KR intermittencies. The study is not concerned primarily with motor skills. To review all pertinent literature might be to review all or almost all of psychology since all or almost all of behavior involves some kind of feedback. Certain investigations are of some interest, however, if they for example, involve some aspect of the above-mentioned procedure, if the conclusion from the study can perhaps apply in some way to this study's findings, or if the study is instructive in view of presenting possible procedural aspects and problems which should be dealt with or perhaps avoided. In some of these latter, less fully related cases, several studies may be briefly mentioned and one discussed more fully so as to provide an example.

Selected Earlier Research

Cotterman wrote in 1960 that "Perceptual skills are among those kinds of behaviors for which the effects of knowledge of results are less well determined." He feels that "enough has been done to warrant the conclusion by Gibson in 1953 that if knowledge of results is not absolutely necessary to the improvement of a perceptual jusgement, it is at least of great value." Cotterman (1960) states that evidence for this is found in research on the tasks of judging whether one or two points are contacting the skin (Solomons, 1897); grading handwriting (Gilliland, 1925); estimating length (Thorndike, 1927); estimating auditory number (Taubman, 1944); estimating visual number (Minturn and Reese, 1951); and judging visual stimuli differing in size, brightness and hue (Eriksen, 1957). However, these studies did not go beyond the validation of the general principle and explore the effects of systematic variations in the knowledge (Cotterman, 1960). Thus, one may inquire about the influence on learning due to changes in KR specificity, intermittency rate, frequency (cf. Bilodeau, 1966, and Bilodeau and Bilodeau, 1958), interval and/or ratio, and schedule (including periodicity).

Knowledge of Results (KR)

There has been some disagreement in defining knowledge of results (KR). Bilodeau and Bilodeau (1961) present a number of statements by various authors concerning KR, some or all of which might be taken as or construed to be definitions of KR. These include information to S as to how accurate his reactions are (Brown, 1949), knowledge of various kinds which the performer receives about his performance (Ammons, 1956), S's perception of KR (Annett and Kay, 1957) and a restriction of feedback to observable, quantifiable events (Bilodeau, 1955; Fitts, Noble, Bahrick, and Briggs, 1959; Taylor, 1957; and Norbert Wiener). Bilodeau and Bilodeau (1961) state that Bilodeau (1955), Fitts et al., and Taylor use response error as feedback and feel that S's overt responses to feedback are the objects of the inquiry and that the word "knowledge" in the phrase "knowledge of results" should not have the implication of a response to feedback by S. In an earlier era, Seashore and Bavelas (1941) argued that correct and incorrect conceptions of one's performance were included in KR (Bilodeau and Bilodeau, 1961). Bilodeau and Bilodeau (1961) state that Brown (1949), Ammons (1957), Annett and Kay (1957), and Fitts et al. (1959) "take somewhat different positions on knowledge of results. All would include external events that depend upon what S has done and that are directed back towards S. They disagree on whether S's knowledge or habits enter the definition."

Bilodeau et al. (1961) also point out that many of the preceding do not precisely state what types of external stimulus feedback are admissible for consideration as "feedback". Apparently there is no present limit on what may be considered legitimately as feedback (Bilodeau and Bilodeau, 1961). Cotterman (1960) appears to define feedback or KR in general as information given to a trainee about his performance beyond what is naturally available as a result of performing the task.

For a discussion of some types of KR or KR labels see, e.g., Miller (1953) [referred to by Annett and Kay (1957)], Annett and Kay (1957), Bilodeau and Bilodeau (1961), and Bilodeau (1966).

> The outstanding thinking on KR in the 1940s was done by Brown [1949] who discussed the three now famous roles of KR: reward, information, and motivation. That is, like primary reward, KR might serve to reinforce or strengthen habits, evoke already established habits (cue properties), and provide the motivation (incentive) for learning or performing. These ideas are generalizations from the issues of reward research, and even today there is no methodology to differentiate between the alleged effects. It must be said, however, that KR research is not yet overly concerned with theory, since it is more or less acknowledged that suitable probes are wanting. Identifying relevant variables and finding functional relationships are much more militantly pursued (Bilodeau and Bilodeau, 1961).

Knowledge of results may lead to improvement in performance (1) by causing a tendency to repeat actions which have been successful; (2) by what may be called a "directive effect," i.e., by causing a tendency to correct any unsuccessful action; and (3) by setting up a conscious attitude or mood which is conducive to accurate performance. Removal of KR may produce, on the other hand, an attitude or mood which is not conducive to accurate performance (cf. Elwell and Grindley, 1938).

Bilodeau (1966) provides additional discussion of this problem.

> Probably most psychologists would allow that IF [informative feedback] has at least the following three empirical properties, regardless of hypothesized theoretical properties: (a) R strengthening, (b) sustaining performance, and (c) eliminating previously established Rs. As for its theoretical properties, logically, IF, as any stimulus, can have all or any of three: (a) directive, (b) motivating, and (c) reinforcing.

Bilodeau (1966), continues:

> Among [certain other] investigators, the directive property seems generally accepted, though not with equal stress by all. E. A. Bilodeau, who emphasizes the directive property, maintains one extreme position. Others (Adams, 1964; C. E. Noble & Broussard, 1955) are more moderate, either allowing all three properties as reasonable or not committing themselves as to how IF operates. Withholding commitment until more low-order laws are gathered is doubtless the sensible position; few manipulations have yet been offered that would vary the potential properties separately...

Comparisons and Contrasts Between KR and Reward. In some cases, KR has effects similar to those of reward. According to Bilodeau and Bilodeau (1958), there is an obvious likeness between KR and reward (or punishment); each is the terminal effect of S's behavior, dependent on S' response, but also controlled by E. For example, according to Bilodeau and Bilodeau (1958) improvement increases as the number of trials followed by KR increases (Bilodeau, 1953), deterioration occurs with its removal (Elwell and Grindley, 1938), and response shifts occur with arbitrary shifts in KR (Bilodeau, 1953). Bilodeau et. al. (1958) state that rates and levels of learning have proved sensitive to the adequacy of KR, variously defined. Manipulations of time (Lorge and Thorndike, 1935), consistency (Bilodeau, 1953; Bilodeau, 1955), frequency (Bilodeau and Bilodeau, 1958), and specificity (Cotterman, 1960) of KR have been shown to affect learning (cf. Bilodeau and Bilodeau, 1958, and Cotterman, 1960).

However, according to Bilodeau and Bilodeau (1958) the two are not necessarily equivalent. Reward is typically provided after one of a dichotomy of responses, while KR more often varies with the degree of response error. Actually, some of the confusion arising out of comparisons of data from the two areas arise from the different types of tasks and procedures which have been used to date. In the human skills context, the task is usually one of learning to make graded responses by means of a graded error signal, KR being a quantitative index of how and by how much subsequent behavior should be modified. In KR studies, verbal instructions to S generally define the general problem, limit the response types, and establish the range within which the correct response lies. Absence of KR does not usually signify anything at all. On the other hand, in studies of reward gradations of response are commonly irrelevant, a common reward being administered for any one of many responses meeting a broadly defined criterion such as "turning right" (Bilodeau and Bilodeau, 1958).

Many of the KR studies involve a correlation between the KR received and the corresponding response, i.e., especially with higher KR Specificity the level of response accuracy determines what KR S receives. However, correlated reinforcement studies using reward rather than KR have also been done. In addition, the factual or empirical meaning of reinforcement refers to any of a wide variety of conditions which may be introduced into the learning situation to increase the probability that a given response will reappear in the same situation (Kimble, 1961, p. 137). It would seem that KR would fit the empirical definition of reinforcement although the theoretical definitions of KR appear to vary somewhat among authors as do those for reinforcement. If KR is considered in empirical terms as a condition which, when used appropriately, promotes learning, then it may be considered a form of reinforcement —

providing, of course, that reinforcement is empirically defined as by Kimble (1961, p. 239).

Bilodeau (1966, p. 259) seems to agree "despite previously expressed objections (E. A. Bilodeau and Bilodeau, 1958..., 1961)" that IF (information feedback) could be included "in the general class of reinforcing events, without commitment on its theoretical action—i.e., IFs are certainly stimuli that are consequences of behavior and that serve to modify R probability." As Bilodeau et al. (1958) state, once we have a number of studies undertaken with comparable operations, there will be better opportunity to compare the operation of reward and KR at a theoretical level.

Studies Concerned with the Effects of the Specificity of Knowledge of Results. The effects of variations in the specificity of knowledge about a perceptual response have been investigated by Hamilton (1929) and by Waters (1933).

> Hamilton studied the effect of five different incentive conditions on judgements of length. Sixty undergraduate women individually made fifty attempts on each of two days to set a flexible rod, controlling the length of a horizontal bar of light, in such a a way as to make the variable bar twice as long as as a standard (120 mm.) one. Beginning with the sixth attempt on the second day an equal number (10) of subjects (Ss) were given the following treatments: (1) punishment — a bell sounded after each wrong response; (2) reward — a bell sounded after each correct response; (3) guess-with-punishment — a bell sounded after each wrong response and Ss then guessed whether their adjustment was long or short; (4) told-with-punishment — a bell sounded after each wrong response and the experimenter (E) said "long" or "short;" (5) knowledge — E said "long," "short," or "correct" after each response; and (6) a control — no bell or knowledge. Analysis of error, expressed as a percentage of average error, showed all incentive conditions superior to the control condition. Told- and guess-with-punishment groups did not

> differ significantly, but were superior to reward and punishment groups which also did not differ significantly. The knowledge group was inferior to all other incentive groups (significantly so for guess- and cold-with-punishment groups). In general, the time required for settings was uncorrelated with error and decreased with practice. At least superficially, the results of the experiment are at variance with the common sense hypothesis that performance is directly related to the specificity of knowledge of results. But, there are several possible explanations for the knowledge group's inferior performance. First, variations in specificity were confounded with variations in the time relations because the bell was sounded immediately after the response and E's remarks followed after some delay. Second, it is possible that once the Ss were sure they had made an error, they already had sufficient information to guide future responses. Finally, the bell may have been intrinsically more reinforcing and motivating and so enhanced performance relatively more than simple knowledge (cf. Brown, 1949) (Cotterman, 1960).

An additional variable to consider is "correct" in the "long," "short," or "correct" KR, but it is assumed that few or none would consider "correct" a detriment.

Waters (1933) found in one study that improvement in judging the length of cardboard strips was seemingly unrelated to degree of information given. In a second study, estimations of a twelve-second interval improved in proportion to degree of information. Thus, the effect of specificity may depend on the nature of the task being learned (Cotterman, 1960).

In a classic experiment, Trowbridge and Cason (1932) studied improvement in drawing three-inch horizontal lines while blindfolded. As indicated by mean percent correct lines (if within one-eighth inch of three inches) and average error, those S's receiving information on amount and direction of error were far superior to the others. Those receiving right-wrong information were better than those receiving no information from E, and those given nonsense syllables were worst of all. In the second series of one-hundred trials, when Ss in each group were divided equally among the three conditions not encountered in the first series of trials, the same relative performances were noted for the various conditions (cf. Cotterman, 1960).

Hirsch (1952) used six multiple-choice type film-tests of material learned from six training films, and six KR methods (five KR Specs and no KR) in a Latin Square design. Hirsch (1962) states that the Ss were "highly motivated," "in a realistic training situation," and that the "learning material" was "highly meaningful and relevant." Hirsch implies that "meaningfulness" and a gradient of such can be applied to KR (though his designations of this in his study may be somewhat arbitrary). The six methods or treatments relating to the KR presentations were: (A) no KR; (B) KR, light from a neon lamp, when S chose the correct answer on a multiple-choice question; (C) neon light as in (B) plus information as to the number of the correct choice; (D) neon light method again — as in (B) — with the addition that the question was repeated on the screen with only the correct answer (i.e., all alternatives were removed except the correct one); (E) method (D) with the addition of a second showing of the film after the immediate test; and (F) a second showing of the film after the immediate film-test, no other KR apparently being given. Hirsch does not seem to label the showing of the film as KR, though it is asked if Cotterman (1960) apparently might do so in that he states "To the extent that recall of test questions and responses is stimulated by it, the film affords . . .

knowledge of results."

Hirsch (1952) states that

> Learning in this study was measured as retention. That is, it was measured as a difference obtained between two tests, the first test accompanied by knowledge of results and the second three weeks later without specific awareness of results. It is recognized that there are other definitions of learning; however, in this study learning was considered operationally, namely, as the retention of specific material (Hirsch, 1952, p. 2).

Measured in terms of the delayed post-test minus the immediate test retention, the descending order of differences between the two tests were: methods E and D were not significantly different (largest differences); D and F were similar; F, C, and B were similar; and A was lowest in retention.

Method E was felt by Hirsch to be the most effective in holding retention losses to a minimum; a gain in mean score was actually brought about for some film tests, though the overall mean did not reach the .10 level of significance. Method D showed some loss, but this was held to a minimum (i.e., the loss was not significantly greater than that which might be expected to occur by chance — at least for certain test films and groups and in relation to the overall mean). The other methods had overall means which showed a loss in retention, though this did not always occur or did not occur beyond an .05 level of significance for all individual groups and films for certain of the KR methods.

Besides the overlapping of the "clusters," certain specific results were a little more complicated. The differences in the effects of the different KR methods from one film-test or group to another do not appear always to have been the same on the immediate test, the delayed post-test, and for retention, though t tests are available only for the retention data. For example, overall immediate test performance under method A was higher than the other methods but only higher than methods C or B on the delayed post-test. Hirsch states that the obtained difference attributable to methods on the immediate test was due to one test and group, but he does not give the significance level, and it seems that perhaps the differences for both the immediate tests and retention could have been due to more than one test or group. However, the overall mean loss under Method A was greater than that for any of the other methods with regard to retention between the immediate and post tests. Whether some of the differences are due to the methods themselves or to some other variable, for example, to one or more groups having more upper classmen, was apparently not always known.

Ross (1927) had Ss (perhaps not completely naive) under presumably motivating conditions make as many tallies (four vertical lines crossed with a fifth) as they could in a one-minute trial within certain limits of accuracy. It is interesting that although increased specificity of "knowledge of progress" seemed to cause better performance, no change in relative order of the three different KR Spec sections was noted in the last two periods. It appears that all sections may even have continued to improve during the last two periods.

Testing and feedback were apparently given in groups of Ss rather than individually, which might or might not have had an influence in this type of study. Apparently, there was the existence of knowledge by at least certain or all of the particular KR sections of what, respectively, all or certain of the other sections were doing, one section even hearing a different KR condition being given to another section.

However, relatively disparate numbers of practice periods were allowed before and after KR was changed for the sections, i.e., only two practice periods after KR conditions were changed were given compared to ten before the change. (It might be noted that most Ss had learned to a certain degree already.) Other factors seemed to exist such as the possibility that: (1) there was the apparent presence of additional KR (knowledge to Ss of their performance "standing with reference to the other sections") for all sections during the last two periods; and it is asked if (2) KR procedures or KR may not have been quite the same for respective before and after KR change sections. In addition, it appears that (3) KR changes were not all made for certain groups during the same period, and (4), though this is not clear, it is asked if the periods before the KR changes involved more delay of KR, i.e., if at least two of the periods—the last two, where KR changes were begun—may have been closer together in regard to their temporal intervals. In addition, it is felt that though certain control of KR procedures was used for at least certain sections, it is felt that perhaps additional procedures such as using a device or apparatus to conceal the S's prior tallies could also have been used to control the S's ability to obtain extraneous, additional sources of KR and to receive knowledge of his own progress.

It could be asked, however, if the effects of certain of these procedures just mentioned might have been greater or less — facilitative or detrimental — for, e.g., the less specific KR groups and, if these procedures might have served to decrease the differences among groups (cf. Ross, 1927, p. 345, p. 346). It seems that it is not known if these or certain procedures might have affected the responding after, and for certain procedures, as well as before, a change in KR conditions was made for the sections.

Ross (1927) mentions other tasks that he has utilized in conducting other experiments in a manner similar to the one reported in his article, finding that "there was no tendency for the groups motivated during the first part of the experiment by a knowledge of their progress to show a reversal of form when the information was withheld during five successive practice periods."

In several experiments performed in classroom situations (Ross, 1933), different degrees of knowledge of performance for weekly objective tests did not produce differential learning. The procedure included:

> The distribution of scores of the entire class was placed on the board and the items on the test missed by any considerable number of students were discussed after each test. However, [1] one group was given no knowledge whatsoever as to its progress, either individually or as a group. [2] A second group was given vague information, each student being told simply that his score was "good," "fair," or "poor." [3] A third group was given partial information as to progress, each student being told his point score on each test, but not shown his test paper. [4] The fourth group, however, was given full information, being retained at the close of the class hour so that the papers could be distributed to them and opportunity given for discovering and discussing individual errors. The papers were then collected — the whole process usually taking five or ten minutes.

Also included in the procedure was some interchanging of KR Spec among the KR Spec groups. The difficulty level (such as mean percentages of questions answered correctly) which, it would seem, might determine differences among different KR Spec groups, and the amount, if any, of relative discreteness, similarity, or the extent of differences among the tests and questions between tests and within a test do not appear to be extensively treated. Whether certain questions were similar or required similar answers and to what extent a certain type of knowledge of one question's response would be expected to aid or interfere with responses on other questions is also not clear. Thus involved may be a task to task transfer of learning or training situation involving somewhat different tasks. Ross felt that Ss, as well as having a subjective estimate of their own score, were all operating at a higher motivation level, and mentions that motivation for Ss in the classroom is probably higher than in the laboratory. (It might also be noted that perhaps the "effort" of the decreased KR groups may have increased to compensate for their lack of information; anxiety might have increased and additional increases in effort may have occurred due to higher anxiety levels as well as to feelings of "annoyance" which might have become associated with the course subject, classroom learning, etc.). Further analysis by Ross in a subsequent experiment revealed that Ss were able to estimate what their scores were to a certain extent (median correlation of .71 between student's estimates and actual scores). Perhaps it should also be noted that Ss in the "full information" group received only five to ten minutes at the close of the class hour as a group to discover and discuss individual errors and allow E to collect the papers. If there were individual questions within each test it would seem that there would be a certain KR delay, even if S had time — and this may be questioned — to look at and understand all the questions and answers. Testing once a week also appears to involve relatively larger inter-test intervals than those in Ross' 1927 study. It might be mentioned that KR for a particular test might produce learning for the questions missed as well as more greatly "impress" on S an answer even if correctly given originally by S. Thus, assuming that Ss were not achieving very close to one-hundred per cent correct scores, giving the same test again might produce different results for different KRs if outside sources of KR could be controlled and, by giving the same test again, the possibility of differences in effects in retention could also have been tested. Somewhat related to this matter, it is of interest to compare, for example, certain discussion and references mentioned by Ammons, 1956, e.g., Pressey, 1950, who according to Ammons, 1956, reported that "students who repeated quizzes with an immediate self-scoring arrangement showed much greater learning than did those to whom the test was merely given again without any knowledge of results" (Ammons, 1956). Ross (1933) reports that additional experiments by himself and another E did not reveal any significant differences favoring the group with full knowledge of progress. He mentions another author who apparently found differences using arithmetic tasks but Ross (1933) mentions that the experimental and control groups were not equated on the basis of attainment in arithmetic.

In general, many of these studies do not offer critical evidence of how the specificity of KR is related to effectiveness of learning. It is apparent that precise control of specificity has often been lacking (Cotterman, 1960). For example, in Ross' (1933) classroom experiments Ss may have had some knowledge of results through classroom discussion of test items missed by any considerable number of students as well as a distribution of scores of the entire class placed on the board. Other experiments confound guidance (KR) conditions (Ross, 1927), time of giving the knowledge (Hamilton, 1929, Hirsch, 1952) or different levels of specificity (Hirsch, 1952) with specificity per se in a way as to make inferences from them hazardous (Cotterman, 1960).

Hirsch (1952) combined certain KR conditions, and apparently did not compare the KR combination conditions with all the possible separate KR conditions. In addition, the times for at least certain of the "trials", treatments, or KR conditions do not appear to have been the same. In addition, among the points made by Cotterman in his (1960) review of Hamilton's (1929) study, it appears that Hamilton combined certain KR conditions in one treatment condition; one of the KRs may have been given after the other, and, according to Cotterman, "after some delay". It would seem, then, that there might have been the introduction of delay of KR in the Hamilton (1929) study. The effects of delaying various KRs may not be readily determined and an allowance for the delay made if the KRs have been combined and given at different times for an S and have not also been studied for other delays and, perhaps in addition, given separately each, to a different group of Ss. It might sometimes be possible for the separate effects of certain KR specificities which have been combined to be determined from certain of the designs used, but this might prove to be less exact. This is not to say necessarily that in at least every case the purposes of the authors of these studies have not been fulfilled. However, the experiments by Trowbridge and Cason (1932) and Cotterman (1960) clearly suggest that performance is directly related to the degree of specificity of the information given the trainee about his performance.

Studies Concerning Intermittent Knowledge of Results. Bilodeau and Bilodeau (1958) using fixed ratio conditions somewhat similar to those used in this study, were also interested in comparing the effects of various ratios or frequencies of KR. Using the simple task of requiring S to learn to move a lever a certain distance (the apparatus is described by Bilodeau and Ferguson, 1953), three groups of seventy-eight Ss and a fourth group of thirty-nine Ss were given the magnitude and direction of the error on each trial (the one-hundred per cent KR group) or on a set of proportion of trials (.10, .25, and .33 groups). The number of KRs per group was held constant at ten, and KR was administered under fixed ratio conditions. KR for the .10 group was given on every tenth trial starting with the first trial; for the .25 group, every fourth trial; and for the .33 group, every third trial. The numbers of total trials for the above four groups were one-hundred, forty, thirty, and ten, respectively, the one-hundred per cent group receiving only ten trials.

For all groups the optimal lever travel was 33.57° of arc, but S was not informed of this — only that he was to find out how far to pull the lever to get a "hit". On trials when KR was given, E gave S a verbal report of the magnitude of the error, rounded to the nearest whole number and transformed according to a scale graduated into one-hundred units rather than degrees. In addition, positive errors were read as "too high," negative as "too low." The task set S was thus one of minimizing the reported error.

Bilodeau and Bilodeau's "hypothesis tested was that in a relatively simple, discrete motor-learning task the effect of a KR upon the response tendency is immediate and without additional beneficial effect upon later non-KR responses." In other words, KR will cause an immediate change in the performance level at the KR + 1 trial but changes beyond the KR + 1 trial due to KR will be negligible. So far, a step function is implied (though apparently not specifically predicted or stated by Bilodeau and Bilodeau, 1958, in their introduction before their experiment) as well as the importance of the mere occurrence of KR rather than its ratio (frequency) in that, it is implied, KR whether occurring with a high or low frequency (or low or high spacing) yields equal KR + 1 performance. On the other hand, there is a list of possible considerations to the contrary. With the growth of inhibitory or extinction effects, performance might be related to the relative frequency of KR (Bilodeau *et al.*, 1958). Further, interference from non-KR trials might reduce the effectiveness of the occasional KR, or the wider spacing of KR trials might reduce motivation (Bilodeau *et al.*, 1958).

Results showed that there was little difference between groups, although Group .10 generally had the smallest error on a given KR + 1 trial and had the smallest grand mean error over the ten KR + 1 trials. Group .10 reversed, if anything, the slight trend in the main experiment (the other percentage groups), apparently meaning that some increase in mean absolute error occurred as percentage was decreased.

In addition, there was no evidence that performance improves in the absence of KR for the preceding response. A step-like function was generally found for the partial KR groups with a gradual slope for the one-hundred per cent group.

The major findings was that "learning" is "independent of relative frequency of KR and positively related to absolute frequency. The former finding means that the learning effect of a KR is the same whatever the dispersion of KR, provided number of previous KRs is held constant."

The amount and level of learning or performance was a function of the number of KRs and the learning rate was a function of KR rate or percentage. Higher KR percentages and rates produced greater rates of error decrease; an increase in KR percentage thus also resulted in a decrease in the total amount of error responding but the error level eventually reached was the same for all groups.

The number of non-KR trials appeared neither to hinder nor facilitate the learning level produced by the KR trials although larger numbers of non-KR trials did produce a greater amount of error responding and slower error reduction (learning and performance) rates. In addition, performance tended to deteriorate after KR + 1 trials though the greater deterioration was seen in the early stage of practice.

It does not appear that Bilodeau and Bilodeau provided in 1958 an explanation for the performance deterioration in mean absolute error at least after earlier KR + 1 trials. Bilodeau and Bilodeau (1958; p. 383) stated that "Inasmuch as the non-KR trials had no effect upon the responses of succeeding KR trials" (it is felt by this author that Bilodeau and Bilodeau, 1958, could perhaps use, and perhaps mean, KR + 1 trials) "it was not necessary to raise the issue of secondary KR during non-KR trials, interference from non-KR trials, nor differential motivation and inhibitory processes." However, it appears to this author that the suggestion could be made that some of these or other variables including forgetting or lack of retention may be needed if explanations are to be provided for all of the phenomena, such as for non-KR responding, found in, e.g., Bilodeau and Bilodeau's 1958 study or for results found when KR presentation conditions are further varied. [Bilodeau, Bilodeau, and Schumsky (1959) using greater numbers of continuous, successive non-KR trials than in the Bilodeau and Bilodeau (1958) study, do speculate the presence of I_R to cause increasing "overshooting" of the correct response on non-KR trials.]

Bilodeau and Bilodeau (1958), referring to Jenkins and Stanley's 1950 review of partial reinforcement, pointed out that many writers have dealt with block means which have included rewarded (or, e.g., UCS) and unrewarded trials although it is apparent that this may obscure the results of any of the individual rewarded and unrewarded trials. In the case of KR, using block means may obscure the responding at the KR, KR + 1 and any following trials and make comparisons among these trials difficult or impossible. Bilodeau and Bilodeau (1958) report that Denny's (1946) study was comparable and gave results similar to Bilodeau and Bilodeau's (1958). In Denny's (1946) study, using a "T maze, he reported that learning is equally good for schedules of 50% and 100% reward provided performance is plotted against rewarded trials (and provided there is no bias attributable to secondary reinforcement)" (Bilodeau and Bilodeau, 1958).

Bilodeau (1966, p. 273) seems to admit of either "no trend, or a negative trend," on non-KR trials, i.e., for responses not followed by IF (information feedback). Bilodeau (1966) further discusses KR percentage including "relative frequency of IR" and mentions other studies concerning the KR percentage topic including Larré (1961) [of which Bilodeau (1966) states that the Larré study (1961) "allowed IF for every R, every third R, or every seventh R" and provided verification of Bilodeau and Bilodeau's (1958) findings]; Bourne and Pendleton (1958) in concept identification; and A. Taylor and Noble (1962) in selective learning. Bilodeau (1966) states that Bourne et al. (1958) and A. Taylor et. al. (1962) found that "R error over a block or series of Rs was greater the fewer the IFs within a block."

Responding With and Without KR Considerations. It is suggested that the KR and how S uses the KR may determine how he performs without KR and what he learns about the task and his performance on it (cf., e.g., Goldstein and Rittenhouse, 1954)[1]. (Perhaps E's control of

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[1]Annett and Kay (1956 and 1957) have discussed the problem of Ss attending cues intrinsic and not intrinsic to the task and performance without the extrinsic cues. In this regard, Annett's (1959) hypotheses include sensory interaction and facilitatory or inhibitory intermodal effects as replacement for a pure attention hypothesis in discussing findings from studies utilizing functions probably involving somasthetic response produced cues, e.g., in the appendages, and visual cues. The possibility of, e.g., sensory interaction, may also be offered as a reason in the present literature review for limiting somewhat the inclusion of sensory-motor skills literature and findings since the present study involves what might be regarded primarily as visual-cognitive functions, memory probably included, and, thus, probably somewhat different situations.

KR conditions and S's knowledge of certain scoring factors, whether due to the KR or to lack of control of experimental conditions, might also be added as a factor affecting non-KR performance.) E may vary the conditions of giving KR in an attempt to cause higher maintenance or retention of performance when KR is withdrawn. A random intermittent presentation of KR (e.g., Goldstein and Rittenhouse, 1954, and Stockbridge and Chambers, 1958) has been used by Es in such an attempt. This particular method did not appear to be successful, or highly successful as the case may be for all of the types of KR used.

Bilodeau and Bilodeau (1958) using a lever-pulling task state that "it is obvious that between KR trials S made responses at least qualitatively similar to those associated with KR trials." However, in connection with implications from his own study, Lavery (1964) mentions that there is

> an impressive area of investigation in which numerous KR variables have been reported to have null effects on retention of motor skills. Since we now know that Ss do not necessarily produce the same response on NK trials as they do on K trials, it is not surprising that variables introduced on K trials do not affect performance on NK trials. Another group of these studies which merits consideration investigated the effect of interpolated activity on the learning of a simple skill (Bilodeau and Bilodeau, 1958; Larre, 1961; Blick and Bilodeau, 1963). In these studies the interpolated activity always consists of a variable number of NK responses which are more or less similar to the response which is acquired with KR.

Another viewpoint might hold that situations with KR and those without KR are two different types of situations and when KR is withdrawn, S is required to perform in and transfer what he has learned to a somewhat different situation. Under conditions involving the introduction and withdrawal of KR (often only KR as defined by E; other types of KR or feedback may or may not be available) including those involved in intermittent KR schedules, S may be said to be responding in two different situations. Thus, transfer of training may be a consideration not only when a change from one training device to another occurs but also when KR-occurrence to KR non-occurrence trials are given on the same training device or in the same general situation.

Periodic Versus Aperiodic KR and Reinforcement. It appears that there is a scarcity of research which compares fixed-ratio or fixed-interval with random-ratio or random-interval KR.

Results from certain studies indicate that differences may exist in acquisition responding due to periodic or nonperiodic (random) reinforcement patterns or schedules, although other studies have not found them (see, e.g., Grant, Riopelle, and Hake, 1950; Longnecker, Krauskopf, and Bitterman, 1952; and Tyler, Wortz, and Bitterman, 1953; these studies are discussed by Lewis, 1960, 1963).

SUMMARY AND CONCLUSIONS

Selected literature concerning KR specificity and intermittency has been discussed. The review, after discussing certain general findings, and general, empirical and theoretical aspects, and problems, covered primarily selected studies concerned with the effects of one particular variable, e.g., specificity, and levels thereof. As mentioned in an earlier chapter, studies of the interaction of KR specificity, schedule type, and percentage appear to be relatively scarce.

Certain authors have pointed out the major importance of KR in acquiring a skill. However, universal agreement or definite commitment as to the definition of KR as well as its properties has not been achieved. Perhaps the particular definition of KR and roles that a researcher will assign to KR may, at least in part, be related to the type of KR research, i.e., the type of task, KR, mode of KR presentation, etc., that the particular researcher emphasizes. It is even seen that not all Es have used the same term for KR.

An increase in KR specificity often increased learning or, at least, improved performance though exceptions were noted. Apparently, for some tasks, the specificity or precision of the information must sometimes be increased beyond a certain level in order for S to achieve a statistically significant (e.g., beyond the .05 level of significance) improvement in performance. Some of the exceptions may have been the result of an experimental condition or condition which would have to be controlled if only a consideration of the effects of an increase in KR specificity are desired. An interesting problem might be the comparison of a method which would give KR of right responses with a method which would present KR after wrong responses (e.g., cf. Hamilton, 1929).

Intermittency work concerning KR percentage has included the addition of different numbers of non-KR trials for different groups using a simple lever-pulling task and the response goal held constant for all individual trials. This method demonstrated the dependence of S on KR for performance improvement, and the lack of improvement, even some performance deterioration, without KR. The effect, or at least the main effect, of KR seemed to be at the KR + 1 trial. For at least the preceding task, the rate of performance change did seem to be related to the KR rate (or percentage). However if the number of trials were held constant, the level of performance obtained seemed to be related to the absolute occurrence of KR.

It seems that generalizing much beyond the task situation, KR, and KR method of presentation, etc., used to find or demonstrate the particular KR principle should still be cautiously done.

This author would like to see more research concerning KR schedules and percentages as well as more research using tasks requiring a large amount of perceptual (such as estimating angular displacement) and cognitive (such as in concept formation) skill.

CHAPTER IV

METHOD

Subjects

One hundred and eight subjects (Ss) were in the experiment, thirty-six male and seventy-two female college students. Each S was randomly assigned to one of the eighteen cells of the design and run individually and successively by one and the same E. Table I shows the experimental layout. Six Ss were used for each cell. (Two males and four females were assigned to each cell; though Ss were balanced in number within a cell for sex, the data was not analyzed for differences in responding due to sex).

Data from several (5) Ss containing a procedural error or variation was omitted and replaced with that from five additional Ss.

Stimuli

The stimuli consisted of twenty-four 5- x 6-inch white non-glossy photos all of which resembled those used by Cotterman (1960). Figure 1 shows a sample stimulus pattern (full-size) used by Cotterman (1960) and in this study.

Centered on each of the photos was a $3\frac{1}{2}$-inch circle in bold outline with an arrowheaded line running completely across it though not always through the center and a small $\frac{1}{4}$-inch arrow adjacent, but

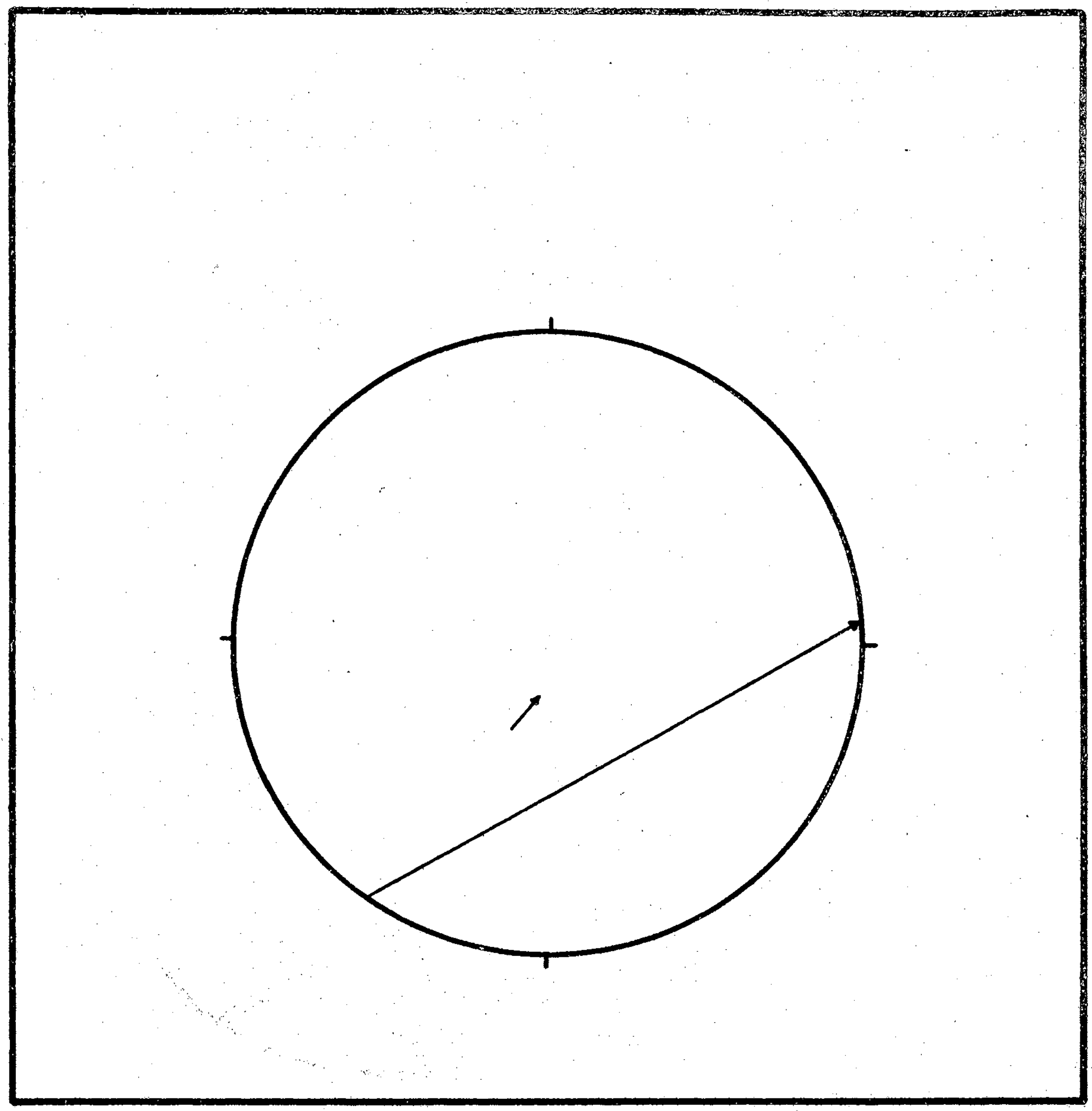


Figure 1. Sample Stimulus (20°)

not parallel, to the line (cf. Cotterman, 1960). Four fine lines radiating 1/16 inch outward from the periphery of the $3\frac{1}{2}$-inch circle indicated the main directions. The stimuli differed as to direction and position of the arrow and the line and there were twenty-four different arrangements or stimulus patterns. Each group of three longer arrows pointed to a different point of the eight main compass points (Cotterman, 1960). The preceding statement does not refer to the stimulus circle itself in relation to the larger lines but the larger lines appear to have been taken with the "beginning" as the center of a compass disregarding or independent of the circle used for the stimulus. Since there were eight main compass points and three arrows originating from each, a total of twenty-four patterns could be generated. For each group of three long arrows one passed through the circle's center and the other two seemingly passing through a perpendicular distance of 3/4 inch on either side of the center. The small arrow was randomly positioned anywhere along the line (except near the circle perimeter) with a minimal separation between the two of 3 to 12 mm. Cotterman (1960) stated that "Although it was oriented in the same general direction as the line, the arrow deviated by 11 to 44 degrees from being parallel to the line and the amount of deviation was never duplicated."

The sample stimulus was used in instructing Ss. Cotterman stated that it differed from the experimental stimuli in that the arrowheaded line did not point towards a major compass point and the small arrow deviated in a direction and by an angular amount (20°) not used in the experimental series.

For convenience in handling, the stimulus-photos were dry-glued to thin 5- x 7-inch tin squares so that the side and bottom edges coincided. A one-inch margin of tin was present at the top of the stimulus and was unseen by S. A 5- x 7-inch posterboard paper square was glued on the back of each stimulus to protect the stimulus photos from scratches from the tin when the stimuli were piled in stacks. It was felt that cues such as scratches on the photos were minimal and did not contribute significantly to the results of the experiment.

For each S the twenty-four stimuli within a set were presented in a different random order. As with Cotterman (1960), for the present study

> Five copies of each of the 24 different arrangements, or 120 stimuli in all, were used in the experimental series. These were grouped into five sets of 24 each so that each set contained copies of all the arrangements but in a different random order (Cotterman, 1960).

Thus E did not have to present the exact same stimulus photo over to an S though the same stimulus pattern would or might, depending on the number of trials received, reoccur for an S.

One important aspect of the stimuli and the task is that with practice (with or without knowledge) projection distance appears to emerge as a stimulus aspect to become a very important determiner of the responses in that it appears to be or eventually become positively correlated with mean algebraic error. Cotterman seems to at least imply that this process occurs more quickly for at least certain higher KR Specs. The "projection distance" may be defined as the shortest distance from one or the other end of the small arrow along its axis to the command heading or longer line (large arrow) using only a two-dimensional or plane system. There also is the suggestion that knowledge speeds this process (Cotterman, 1960).

There is at least one problem associated with the stimuli. Cotterman mentions that the stimuli used in his experiment differed considerably in difficulty. He states that this lack of consistency in stimulus difficulty reduced the power of his experiment in that it contributed to greater within-group variability.

Cotterman's (1960) twenty-four stimuli, each being different, may thus involve S in a situation involving twenty-four different separate tasks requiring or involving the possibility of transfer of learning or training from task to task. Though problems such as the existence of stimuli differing in difficulty were mentioned somewhat by Cotterman, task differences are not analyzed in this study.

Apparatus

The presentation apparatus consisted of a vertical board (3 x 2½ feet) mounted on wooden feet and placed on a table in front of the seated S. A small aperture or slot (7/8 inch in height and 5 2/8 inches in width) was cut in the board 16½ inches from its top so that the stimulus pattern could be slid through onto a slightly tilted stimulus holder directly in S's line of sight. Measuring at eye-level, S's head was about seventeen inches from the opening in the screen. The distance from S's eyes to the stimulus varied somewhat, however, dut to S's size and the movements of his head. An attempt was made to keep the seating arrangement constant with proper estimated allowances made for S's size by varying the chair-to-stimulus distance. This distance could be estimated through the use of several marks on the floor. Over the stimulus holder was a 40-watt shielded bulb, located eleven inches below the top of the screen, which provided illumination of the stimulus pattern. The board obstructed S's view of the exposed upper portion of the metal squares in such a way that only the 5- x 6-inch stimulus-photos mounted on the metal squares were visible. The experimenter (E) sat to one side of the aperture.

The whole apparatus was painted dull black. E used a desk lamp behind the apparatus which, with the stimulus light, constituted the main source of light in the small sound-protected cubicle in which the experiment was done.

The lamp was arranged so that to S the top and side edges of the board appeared evenly-surrounded by light of moderate intensity, thus alleviating any possible unpleasantness due to contrast between the brightly-lighted white stimuli and the black board.

Experimental Design

A 2 x 3 x 3 factorial arrangement of treatments was employed (see Tables I and II).

A "trial" consisted of the presentation by E of one stimulus, the oral report by S as to the amount of the angular displacement in degrees, and, afterwards, when required by the percentage-frequency schedule, the oral report by E of the appropriate KR or feedback.

The data for each subject were divided into three blocks and three block means were obtained. For ten per cent KR groups means were obtained for the first forty, second forty, and third forty trials; for the twenty per cent KR groups one for each twenty of the sixty total trials was obtained; and, likewise, for the thirty-three per cent KR groups one mean for each twelve trials was obtained.

An analysis involving responding from individual KR to KR + 1 trials was also done and is presented in the Discussion chapter.

Procedure

Each S was seated before the apparatus and read the same general instructions. In addition each S received instructions that were relevant to the KR Spec he received. The instructions are presented in Appendix A. Each S was shown successively each stimulus pattern of his respective set. Using a stopwatch, E presented a stimulus for approximately five seconds, allowed ten seconds to elapse during which he noted S's response, gave the appropriate knowledge of results if such was required by the schedule, and then presented the next stimulus. Each S was permitted a one-minute rest between the third and fourth sets in the ten per cent KR group.

All trials were of the same time length in so far as E's timing was accurate and certain procedural irregularities (such as questions from S) could be eliminated or kept to a minimum though a small amount of variance in the timing may have occurred at least for certain Ss.

It can be seen from Table I that there were three types of specificity in KR. Type I KR involved telling S that he was "right" if he was either correct to the nearest degree or no more than one degree in error; otherwise, he was told that he was "wrong". Type II KR involved telling him "over", "under", or (if to nearest degree)

TABLE I

EXPERIMENTAL PROCEDURAL LAYOUT

KR Schedule (A)	KR Specificity (B)	KR Percentage (C)*		
		10% (C_1) (120 trials per S)	20% (C_2) (60 trials per S)	33% (C_3) (36 trials per S)
Fixed Ratio (A_1)	KR Spec I (B_1)			
	KR Spec II (B_2)			
	KR Spec III (B_3)			
Random Ratio (A_2)	KR Spec I (B_1)			
	KR Spec II (B_2)			
	KR Spec III (B_3)			

* Each S Received 12 Reinforced Trials (12 trials with KR)

"correct". Type III KR involved telling him the correct answer (to the nearest degree).

For the ten per cent fixed ratio (intermittent KR) group, KR was given every tenth trial beginning with the first trial and this continued until twelve KR trials and one-hundred and twenty total trials were given. For the twenty per cent fixed ratio group, KR was given every fifth trial beginning with the first trial; E again gave twelve reinforcements but this time S received only sixty trials. The .33 fixed ratio group received KR only on every third trial beginning with the first trial yielding a total of thirty-six trials.

For the variable, or random ratio groups (random intermittent KR), the twelve KR trials for each S were selected randomly from the thirty-six, sixty, or one-hundred and twenty trials that S received, depending on what KR percentage group he was in, except that KR was not given on the last trial, i.e., the 36th, 60th, or 120th trial depending on the KR percentage.

It is seen that in regard to the occurrence of KR the fixed-ratio KR group is also a fixed-interval KR group and the variable-ratio KR group a variable-interval KR group due to the constant inter- and intra-trial intervals. Thus, both the number of the trials and the time interval between successive KRs was constant for the fixed-ratio (fixed-interval) group while the number of the trials and the time interval between successive KRs was random (i.e., may have been variable) for the random-ratio (random-interval) groups. However, fixed-ratio and random-ratio will be chosen as the terms used to represent the presentation of KR in this experiment.

Each S received only one type of KR Specificity, one type of KR Percentage, and one type of KR Schedule. Each group of six S's received only one unique type of KR Specificity x Percentage x Schedule interaction.

Scoring

For each stimulus presentation, subtraction of the correct answer from the corresponding judgment yielded a score indicating amount of error. The absolute error, sign disregarded, was recorded. Amount of error was used as a measure of performance or learning ("performance" and "learning" are used interchangeably and distinctions between the two terms will not be made). In this experiment, as in Cotterman's, the .05 probability level was used in all tests for statistical significance.

CHAPTER V

RESULTS

Block Data: Averages Over Trials

All data reported are in terms of mean absolute errors or mean absolute deviations of the subjects' responses from the correct values of the angles. Only block data are reported in this section. Block means were obtained for each S by dividing the total number of trials into three equal parts and computing an average. Block means for the .10 group are based on forty trials, for the .20 group on twenty trials, and for the .33 group on twelve trials.

All data discussed in this section are summarized in Table III (and in the Appendix). The summary of the analysis of variance is presented in Table II.

Periodicity: Fixed-Ratio Versus Random-Ratio Schedules. A significant difference between the two periodicities, fixed and random ratio was not found, although there tended to be consistent differences between the fixed-ratio and variable-ratio groups from block to block with the random-ratio treatment groups receiving greater mean absolute errors than the fixed-ratio (see Figure 2). The Periodicity x Blocks interaction was also not significant.

It should perhaps be noted that further statistical tests would be necessary to place a higher confirmation on statements in regard to differences between groups, blocks, etc. Nevertheless, some

TABLE II

SUMMARY OF THE ANALYSIS OF VARIANCE: BLOCK MEANS

Source of Variation	Error Term	df	Mean Square	F
KR Periodicity	90	1	42.45200	1.12910
KR Specificity	90	2	159.05600	4.23043*
KR Percentage	90	2	22.62900	0.60187
Blocks	180	2	173.47650	30.96130**
Periodicity x Specificity	90	2	6.19350	0.16473
Periodicity x Percentage	90	2	50.58300	1.34536
Periodicity x Blocks	180	2	6.49000	1.15831
Specificity x Percentage	90	4	34.90275	0.92831
Specificity x Blocks	180	4	15.72825	2.80711*
Percentage x Blocks	180	4	12.45250	2.22247
Periodicity x Specificity x Percentage	90	4	49.77975	1.32399
Periodicity x Specificity x Blocks	180	4	6.00875	1.07242
Periodicity x Percentage x Blocks	180	4	15.13025	2.70038*
Specificity x Percentage x Blocks	180	8	6.49250	1.15875
Periodicity x Specificity x Percentage x Blocks	180	8	4.53000	0.80849
Error: Subjects (Periodicity x Specificity x Percentage)		90	37.59852	
Error: Periodicity (Specificity x Percentage x Subjects) Blocks		180	5.60290	
Total: Periodicity x Specificity x Percentage x Subjects x Blocks		323		

* .05 Significance Level
** .01 Significance Level

TABLE III

TREATMENT MEANS

KR SCHEDULE	KR SPECIFICITY	KR PERCENTAGE .10 BLOCKS 1	.10 BLOCKS 2	.10 BLOCKS 3	.20 BLOCKS 1	.20 BLOCKS 2	.20 BLOCKS 3	.33 BLOCKS 1	.33 BLOCKS 2	.33 BLOCKS 3
FIXED RATIO	I	11.16	9.12	8.05	9.12	9.83	8.72	8.12	10.15	10.10
	II	10.09	8.04	9.48	6.88	6.41	5.96	10.51	7.11	7.38
	III	11.76	6.66	4.63	8.25	7.71	6.09	8.66	6.76	5.95
RANDOM RATIO	I	10.06	9.24	8.03	11.78	6.88	7.58	13.75	13.94	14.22
	II	10.18	7.31	6.19	12.24	9.02	7.81	8.36	6.29	6.93
	III	8.96	6.10	5.38	11.00	7.73	7.05	9.82	8.87	7.62

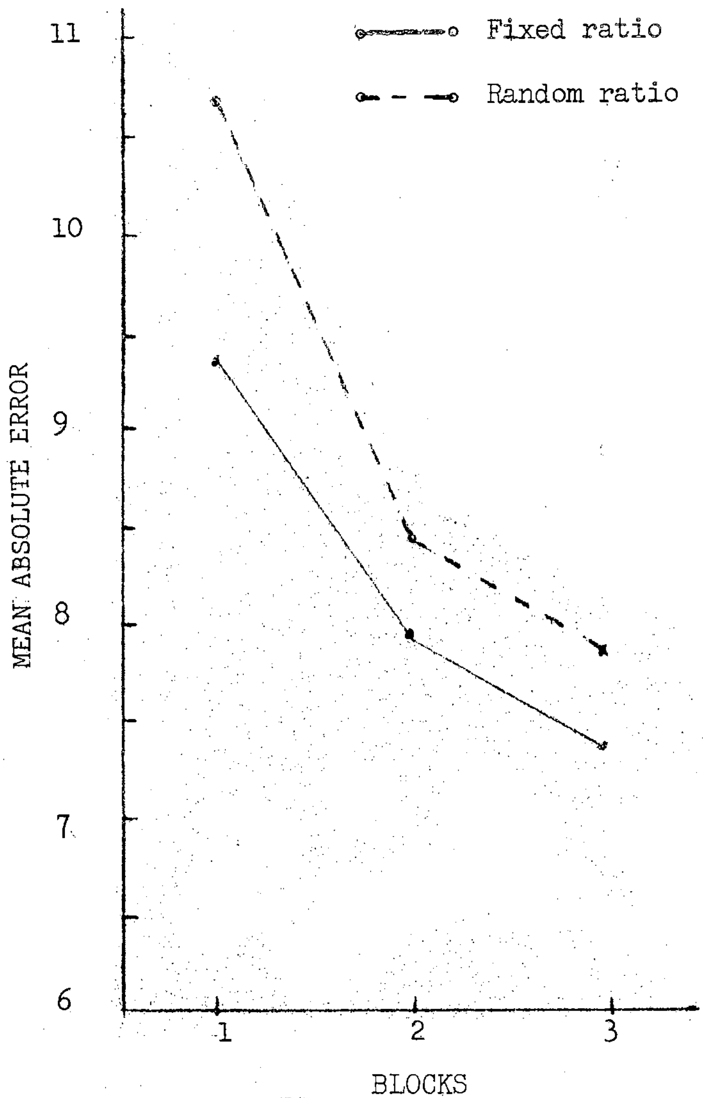


Fig. 2. Mean absolute errors of the fixed-and random-ratio groups as a function of blocks of trials.

statements in this regard, i.e., beyond merely pointing out where significant F scores occurred, will be made.

KR Specificity, Blocks, and the KR Specificity By Blocks Interaction. The significant main effects of KR Specificity and Blocks can best be understood by examining the significant KR Specificity x Blocks interaction, for the presence of a significant KR Specificity x Blocks interaction. This significant component shows that the effects of the three KR specificities differed across certain or all of the three blocks.

It can be seen in Figure 3 that errors for KR Specificity I (right-wrong KR) were always higher than those for KR Specificity II or KR Specificity III. The decline in errors for Ss in the KR Spec I groups from block to block appeared to be almost linear while the curve for the KR Specificity II groups (over, under, or correct) appeared to be curvilinear. The decline in errors for the KR Specificity III groups (correct answer) was less clear though it possibly tended to be non-linear. Responding under the two higher KR Specificity conditions improved more rapidly from block one to block two than responding for "right or wrong" information. In addition, the improvement of the KR Spec III groups from block two to block three appeared to be greater than that for the KR Spec II groups.

Periodicity x Percentage x Blocks Interaction. The other significant interaction was the KR Periodicity x KR Percentage x Blocks interaction. Figures 4a and 4b show the mean absolute errors for the three KR Percentages at each block for the fixed-ratio and random-ratio conditions, respectively. Differing trends as a function of both KR Periodicity and Percentage are obvious across the three

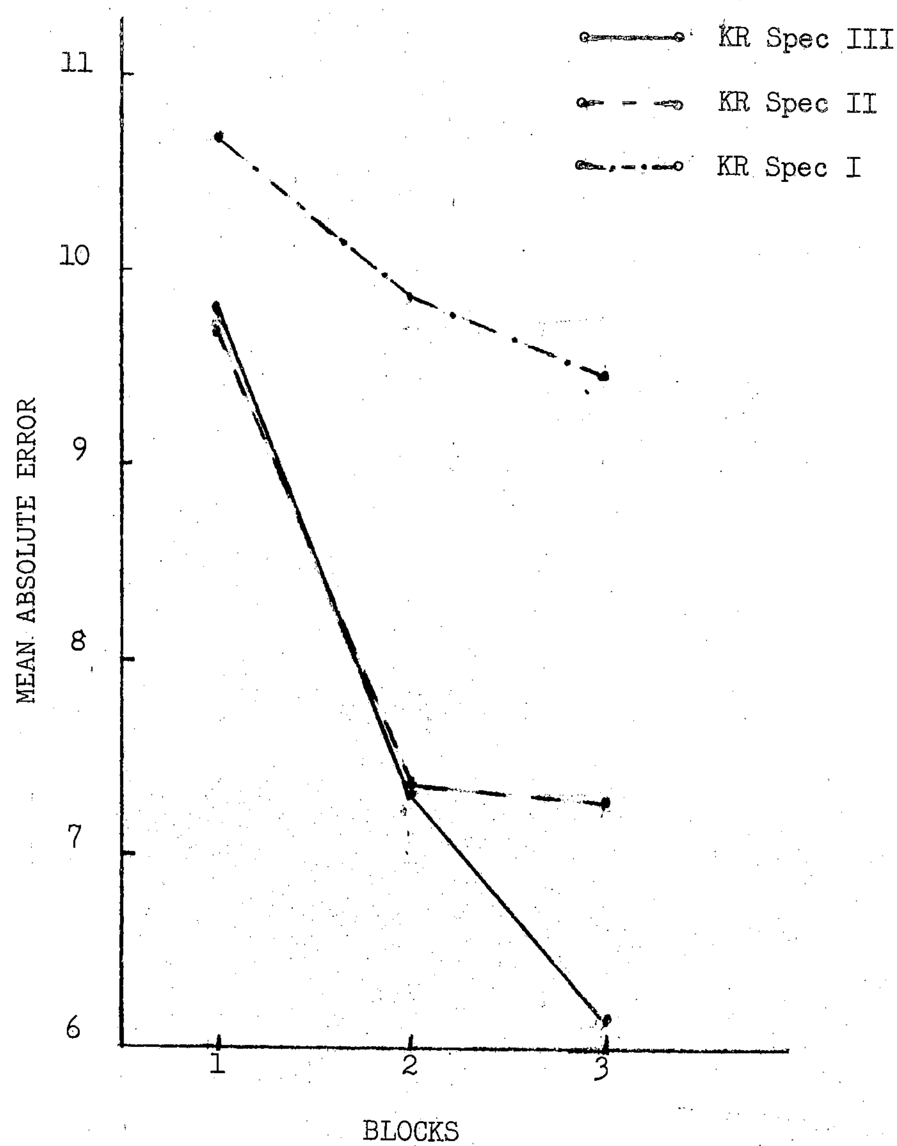


Fig. 3. Mean absolute errors across blocks as a function of KR specificity.

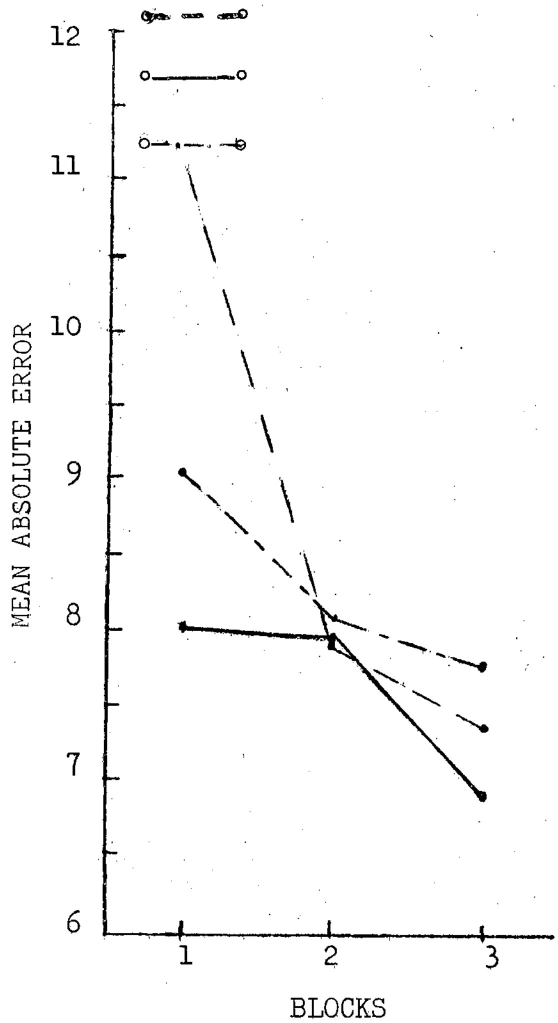


Figure 4a. Mean absolute errors of the three KR percentage conditions under the fixed-ratio schedule.

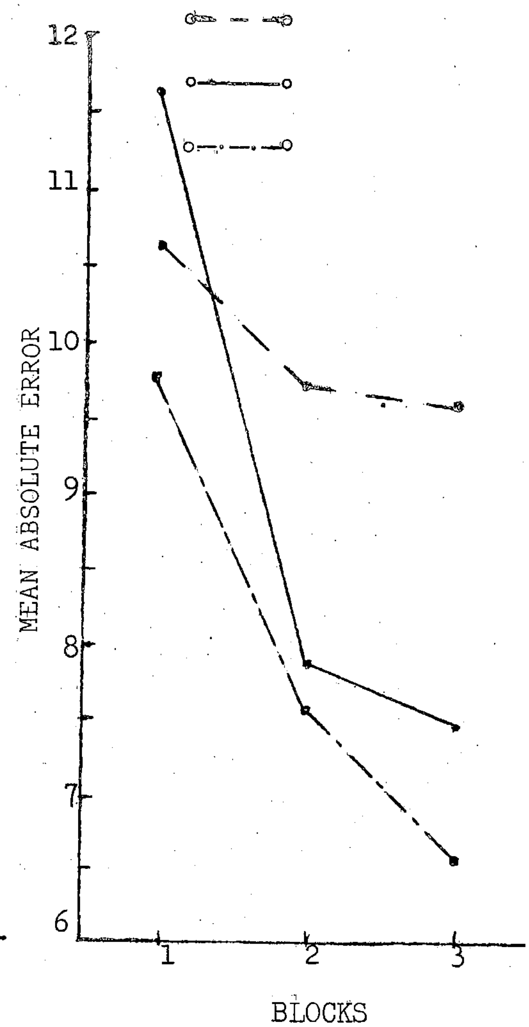


Figure 4b. Mean absolute errors of the three KR percentage conditions under the random-ratio schedule.

blocks, but are at this time unexplainable. It appears that random KR presentation may have had a greater overall inhibiting effect at block one; however, if present, this effect was soon lost over further trials. Examination of Table III reveals a mean error of 9.40 for fixed-ratio, block one responding and an error of 10.68 for random-ratio, block one responding, so that the overall number of errors did not differ greatly between fixed-ratio and random-ratio schedules at block one. The .20 and .33 random-ratio and .10 fixed-ratio groups appear to be highest in error at block one and the .20 fixed-ratio group the lowest. In addition, it can be clearly seen that the mean error for random-ratio, .33 responding at block three and perhaps block two was greater than the other means. Therefore, if random-ratio scheduling had an effect on perceptual performance different from that on performance manifested under fixed-ratio conditions, it may have been when feedback occurred more rapidly, i.e., .33, or was more closely packed and the total number of practice trials was less. It can be seen, too, that the fixed .33 group appears to be the next highest in error at block three though it is not nearly as high as the random .33 group.

The fixed-ratio, .20 groups and random-ratio, .10 groups were lowest in terms of mean errors both at block three (6.922 and 6.532, respectively) and for all three blocks combined (7.664 and 7.939, respectively) (see Table III).

Individual Trials and KR to KR + 1 Data

Individual trials and KR to KR + 1 data are presented in the Discussion chapter.

CHAPTER VI

DISCUSSION

The Influence of KR and Non-KR Trials

Though the results of this study may seem to point out certain aspects of the effects of intermittent KR, it is recognized that a more precise determination of effects should receive further consideration. For example, this might include a study of the amount and duration of influence on performance of a given number of continuous KR trials followed by a given number of non-KR trials and vice versa. [With regard to responding under no KR and continuous KR conditions, Cotterman's (1960) study, from which stimuli used in this study were taken, was mentioned earlier.]

The KR Specificity Times Blocks Interaction

With regard to the KR Specificity x Blocks interaction, it was found that:

1. For the Specificities employed, rate and level of learning to estimate angular separation are increased when more specific knowledge of results is given. This is in agreement with Cotterman (1960) and Ammons (1956, Generalization 3). However, learning may not immediately increase when specificity of KR is increased. Different KR specificities during early trials may not produce

differential learning effects—for example, in the levels of learning among the three KR Specificity groups at block one in Figure 3. Thus, the beneficial effects of an increase in KR Specificity may not be noticeable until later in learning. A difference between means for KR Specificities II (over, under, or correct) and III (correct answer) was not noticeable at blocks one or two but some difference appeared at block three. However, in general, greater specificity of KR results in faster learning or a faster decrease in error rate and, eventually, lower levels of error responding.

The following are additional conclusions which might be drawn from this experiment and which merit further testing. It should be pointed out that all conclusions based on the KR Specificity x Blocks interaction are always to be considered in the light of the significant KR schedule x KR Percentage x Blocks interaction.

2. Performance curves for the KR Specificities tend to be concave upward with a negative slope (sloping downward to the right) across blocks (for the size of blocks used). The rate of mean absolute error reduction appeared to be negatively accelerated. For a given KR specificity, the level of learning to estimate angular separation increased and the rate appeared to decrease largely in quadratic fashion. One exception might be the overall curve for the KR Specificity I group (right-wrong information). Here there is also a slight trend in a curvilinear direction though the curve is nearly linear. Curves for Cotterman's data do not always appear to be consistently linear or curvilinear in form.

3. Assuming that performance follows a negatively accelerated curve which approaches some limit, it may be postulated that:

(a) Over trials, a certain point or plateau will be reached where additional practice trials, including trials with KR, will cause only very small or no increments in performance. However, it is possible that a certain amount of feedback may be needed in order to maintain responding at a lower error and, hence, higher performance level (cf. Bilodeau, Bilodeau, and Schumsky, 1959).

(b) Different KR specificities cause performance to reach an asymptote or plateau at different levels or points, higher levels being reached as KR Specificity increases. Cotterman (1960, p. 12) notes the difference between actually changing the specificity, and only changing the precision or accuracy of the specific information. He does not consider the latter case to properly be an increase in specificity. For example, Cotterman (1960, p. 12) feels that changing the KR Specificity from "no information" to information including "'right' if correct to nearest degree <u>or</u> if no more than one degree in error, otherwise 'wrong'," actually yields two different kinds of specificities. However, changing the latter information to "'right' if correct to nearest degree, otherwise 'wrong'" results only in a change (an increase) in the accuracy of the information and not in the kind of specificity. All of the three KR specificities used in the present study may be considered to be three distinct types of KR specificity. As mentioned, the problem remains one of closely defining "specificity of knowledge of results," and even "knowledge of results," and obtaining agreement among KR researchers.

4. Feedback specificity must be somewhat restricted before overall performance is severely hampered in a perceptual skill situation such as the one used in this experiment. Apparently, the

performance of the KR Specificity I group was somewhat worse at all three blocks than that of the KR Specificity II and KR Specificity III groups, but curves for KR Specificity II and KR Specificity III are hardly separate except at block three. Cotterman's (1960) curves for the same KR specificities as the latter two are always separate and do not cross; however, the two types were not significantly different from each other in their effects at each block. Giving more trials might show whether, as KR Specificity is increased, learning continues for a longer period and/or reaches a final higher level. In addition, several plateaus or asymptotes might be found for any one performance curve.

5. Cotterman states that when considering absolute mean errors, his treatment "groups differed from each other at each successive stage of practice" (Cotterman, 1960, p. 9). Except for one group at one stage or block in Cotterman's study, curves for all groups retain their respective rank orders. Stated more specifically, it was found that the effects of increased numbers of KR given according to a continuous KR schedule were such that KR Specificity groups involved in the particular type of perceptual learning task described in his study generally differed from each other at each successive stage of practice though not always significantly and maintained the same rank order from block to block. However, the effects of decreased numbers of KR given according to an intermittent KR schedule in this study were such that the respective KR Specificity groups did not necessarily differ from each other at each successive block until the later blocks of learning were reached and a greater number of KRs had been given. Cotterman's Ss responded with much less error

for their first block of twenty-four trials. The Ss in this study received an average of twenty-four trials for their first block (twelve, twenty, or forty trials, making an average of twenty-four trials per block); however, Ss in this study had four KRs (usually but not always for the random ratio group) while Cotterman's Ss had twenty-four KRs for the first block of trials.

6. Giving additional KR in the particular task used in this study might decrease errors further to at least a level of about 4.5 degrees absolute error (such as that found in Cotterman's 1960 study). Further comparisons with Cotterman's and with Bilodeau and Bilodeau's data will be presented later in the discussion.

7. Various possible "emotional" aftereffects associated with verbal reinforcement may be present. Probably there is a greater emotional component associated with "right," "wrong," and "correct" than with feedback consisting of a difference answer (number of degrees missed by) or the correct answer itself (number of degrees). Feedback such as "wrong" might actually be considered to approximate punishment and possibly be detrimental to performance, although, while less probable, facilitative effects cannot be ruled out either. Thus, not only was feedback reduced at KR Specificity I but an emotional component was quite possibly present. KR I performance would thus be expected to be inferior to that of either KR II or KR III if the emotional component were detrimental. Further research might attempt to describe both the interaction and the specific separate influences of the informational and emotional variables more fully.

Further, similar but possibly less intense emotional components were perhaps present for the other two Specificity groups. Coming closer to the correct answer might have resulted in a "good feeling," with the opposite result expected when S's answer was farther from the correct answer. It should be pointed out that any emotional components of KR would probably have occurred intermittently—just as the non-emotional components.

Schedule and Percentage and the Schedule Times Schedule Percentage Times Blocks Interaction

Some pre-experimental speculation could have considered the fact that the .20 condition might result in a compromise between (a) greater rapidity of KR occurrence which would involve less forgetting of the KR or information on non-KR trials and greater overall tension and alterness and (b) a larger amount of practice or a greater number of non-KR trials and a greater contrast between KR and non-KR trials when KR occurred, and, hence, might result in the most efficient performance. However, the ANOVA results did not show a significant F for the percentage variable, but they did show a significant Schedule x Schedule Percentage x Blocks interaction.

Concerning the schedule x schedule percentage x blocks interaction, several trends do appear. These are listed below:

1. Performance convergence for all schedule-percentage combinations except the random .33 group appears to be greatest at block two (during the intermediate stage of learning) rather than at block three (during a later stage of learning).

2. Schedule percentage appears to be more of a critical factor in learning earlier in training for Fixed Ratio responding and later in training for Random KR responding.

3. Comparing fixed-ratio to random-ratio schedules for a given percentage only, there is a general trend, <u>though not consistent for all blocks</u>, for a particular higher percentage group (.20 or .33) to perform at lower error levels for fixed-ratio conditions rather than when it is under random-ratio conditions (though, e.g., the .20 RR group may be equal or better than the .33 FR group for later blocks). It was noted that the errors were usually higher for the .33 fixed-ratio group than for the .20 fixed-ratio group. However, under .10 percentage conditions, the random-ratio groups performed better than the fixed-ratio .10 groups (though .10 random-ratio error responding appeared to be—at least somewhat—lower than that for the other schedule x percentage groups except at block one where .20 and .33 fixed-ratio responding is better).

(a) At the .33 schedule percentage only the decreased KR spacing and increased rapidity of KR occurrence may favor fixed-ratio KR conditions in that the .33 schedule appears to be detrimental to responding under random KR conditions at blocks two and three.

(b) Performance for the .10 random-ratio KR condition, involving an increased KR spacing and a decreased KR rate, appears to have been slightly but consistently better for all blocks than performance under the .10 fixed-ratio KR schedule and the other random-ratio percentage conditions. In other words, for percentages used in this study the highest spaced (.10) random-ratio KR group performed slightly better than the highest spaced (.10) fixed-ratio KR and the other random-ratio percentage groups.

It appears that as feedback rapidity is increased and practice without KR is shortened, a certain amount of response decrement under random aperiodic KR is noticed. For a low KR rate but large amount of practice aperiodic KR responding appears to improve and become slightly but consistently better for blocks two and three than responding under periodic or fixed-ratio KR conditions. Again, this result or trend is tentative and whether or not further response decrement or increment would occur when percentage is further increased or decreased, respectively, is at present unknown.

Perhaps inefficient use of KR would be operative for the .33 RR group where KR might sometimes occur quite close together. At least, KRs being distributed quite close together followed by Ss receiving none for a while might result in less efficient use of KR.

The Effects of KR Percentage

From the preceding results it may generally be concluded that differing percentages of KR (feedback) are unequal as to their effects on rate of learning and on the total amount of error responding, higher percentages resulting in faster learning and fewer total errors, but equal in their eventual total effect on the level of learning to estimate angular separation. Larger KR percentages therefore result in more efficient learning conditions, since the same amount or level of learning is evidenced by all percentage groups yet the larger percentage Ss require fewer trials.

It seems that the three percentage means were obtained using three divisors—total numbers of trials—of unequal value; these three percentage means were "equal" insofar as one considers only their insignificant F score in the ANOVA, and thus the three total absolute error scores corresponding to the three divisors would also be assumed to have been of unequal value. Thus, it might be tentatively inferred that an increase (or decrease) in non-KR trials resulted in an increase (decrease), in total error.

Considering the inverse relationship between the number of non-KR trials and the rate of KR, i.e., as the number of non-KR trials increased, the rate decreased, and vice versa, it would then follow that the total error was inversely dependent upon the rate of KR, or that as the KR rate increased, the total error decreased.

Such inference emphasizes the importance of KR in determining error responding and performance and is related to the increase in efficiency which occurred with larger KR percentages. In addition, such inference would tend to go against speculation that learning occurred on non-KR trials (and thus against specualtion that KR rate *per se* also affected learning through some type of KR after-effect phenomena such as the overlap and summation of KR aftereffect or an increase in tension or arousal or through other mechanisms. Such inference would perhaps also be compatible with speculation that learning was not occurring at a high rate on non-KR trials.

It is still unresolved as to whether the final equality of different percentage effects on learning levels is due to increases (facilitative) or decreases (detrimental) in KR rates (rapidity of KR occurrence) corresponding with approximately equal balancing effects from respective decreases (detrimental) or increases (facilitative) in non-KR trials (total number of practice trials), or due only to the frequency of occurrence of KR. "Approximately equal" is used since the exact effects, whether equal or unequal, over a large number of percentages between and beyond the percentages used in this study are not known. Whether increases or decreases of KR rates and non-KR trials would even be facilitative or detrimental to learning levels is unknown. It is possible that if a balancing of KR rate and non-KR practice does occur, it might break down when more extreme increase and decrease in KR percentage, holding other conditions, including the quantity of KR, constant.

Small percentages such as .05 appraoch zero reinforcement and involve larger numbers of non-KR trials. In the direction toward zero KR total overall responding should eventually begin to increase significantly in error. A percentage such as .05 for twelve KR trials requires a total of 240 trials, 228 of the total number of trials being non-KR trials. A zero percentage can only be considered a limit toward which percentages only approach but never reach if conditions involving KR are being compared. However, zero percentage conditions should probably be studied for comparison purposes.

The actual percentage value(s) at which a transition to better or worse is not known—if it exists at all. A transition point, if such exists, from equal performance effects among percentages to detrimental effects would more probably lie in the direction of smaller percentages of KR. However, for a .05 rate and twelve total KRs, for example, effects of variables such as fatigue, boredom or reactive inhibition might serve to decrease performance and would confound results if only the KR rate and non-KR trials were the objects of inquiry. A facilitative transition point may not exist, but if it does, it will probably be found to lie in the direction of one-hundred per cent or continuous KR. As mentioned, Bilodeau and Bilodeau (1958) found no differences among the final learning levels of Ss due to KR rate under ten, twenty, thirty, and one-hundred per cent KR conditions using a lever-pulling task and equal numbers of KR for each percentage.

Due to the variability of responding, it is often difficult to obtain by inspection of the individual graphs even a rough picture of non-KR responding when compared to the impression one may obtain from inspecting Bilodeau and Bilodeau's (1958) curves (where a non-varying task, i.e., the same correct response, was attempted on every trial).

To further complicate the problem, an increase in the inter-KR interval could hypothetically be facilitative due to enhanced contrast effects, or detrimental due to decreasing amounts of retention over non-KR trials of the supposed beneficial KR aftereffects. For these smaller percentages still additional factors such as "boredom" and loss of motivation could be postulated to have occurred.

In addition, the assumption that increased KR rates are associated with facilitative effects (due to such phenomena as less forgetting between KR trials) might be counterbalanced (at least somewhat) if an opposite "detrimental" effect(s) can be postulated, at least for earlier trials. For example, earlier .33 KR might be postulated to have occurred too soon for efficient use of KR, i.e., a few non-KR trials might have been useful in allowing S a chance to consolidate, integrate, or think about the KR and its relation to responding without interference from immediately recurring KR.

Further explanatory factors with regard to responding under different schedules and percentages will be presented in a following section.

Figure 5 compares responding under ten and one-hundred per cent KR conditions. Two curves from this study are presented, one based on three blocks of forty trials each with four KRs being given at each block, and the other containing five blocks of twenty trials each with two KRs given at each block. The curves are for the .10 fixed-ratio group which had KR Specificity III. Each of Cotterman's points for KR group VI is composed of a block of twnety-four trials and twenty-four KRs. Two curves are presented for Bilodeau and Bilodeau (1958), one curve with two blocks of forty trials with four KRs and a third block composed of twenty trials and two KRs and the other curve drawn from points each representing a block of twenty trials and two KRs. Both curves are for the same .10 KR condition or group. Note how the location and shape of the curves are somewhat changed when smaller blocks of trials are used in drawing the curve (sigmoid) for this study and the second Bilodeau and Bilodeau (1958) curve.

Surprisingly, responding under the .10 KR condition of this study almost reaches the level of responding obtained under the one-hundred per cent - KR conditions of Cotterman's study, although total overall performance is still better for the one-hundred per cent continuous KR condition. The reader should note that although one-hundred and twenty trials were received by Ss in both groups, only twelve KRs were given to the .10 group in this study and one-hundred and twenty KRs, one-hundred and eight more than the group in this study, to Cotterman's group. (It is noted that other--at least certain other--KR Spec x Blocks, KR Schedule x KR Percentage x KR Blocks groups, or other groups in this study, may not reach levels

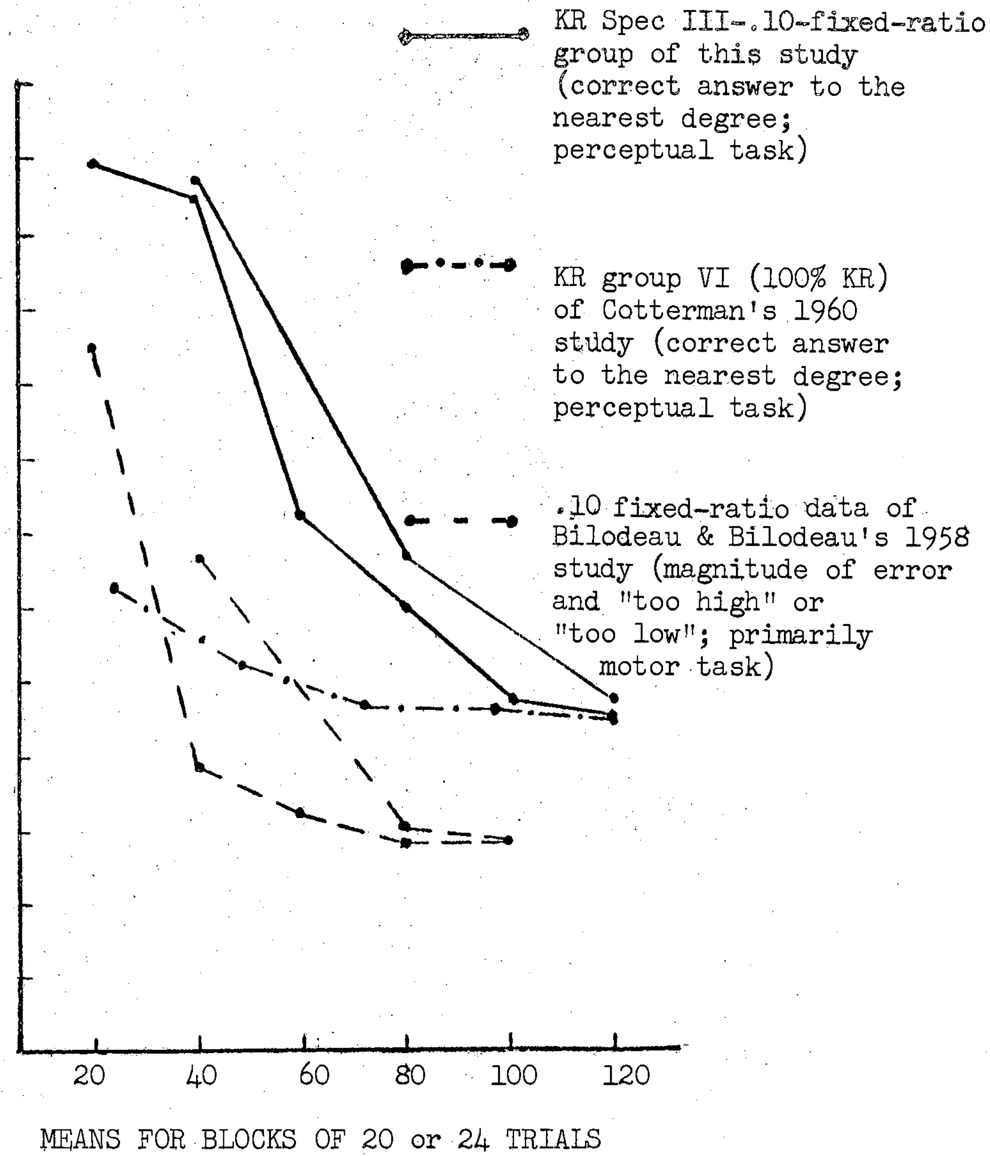


Fig. 5. Curves for selected block means from this study, Cotterman's 1960 study, and from the author's calculated block means from estimated individual trial scores from Fig. 1 of Bilodeau and Bilodeau's 1958 study.

as low as that of the .10 fixed-ratio KR Spec III group). Additional study of the graph reveals that at twenty-four trials and 24 KRs Cotterman's Ss equal this study's .10 Ss at approximately eighty trials and 8 KRs and that at one-hundred and twenty trials and 120 KRs, Cotterman Ss do not appear to differ greatly from this study's .10 Ss after receiving one-hundred and twenty trials and 12 KRs. This is significant in that it may point to factors other than KR as operative on this task. The approximate convergence of the two curves could be due to the following factors:

(1) The task used by both Cotterman and this author is such that S may operate on or approach an initial plateau after forty-eight to seventy-two KRs, though some additional learning might occur later. Thus Cotterman's Ss might have approached asymptotic performance during the second block (they received forty-eight KRs in these two blocks), while the .10 group showed a faster learning rate, but still at a higher error level, since they received only eight KRs during the first two blocks of forty trials each, or during the first four blocks of twenty trials each. However, this study's .10 curve would then be expected to cross Cotterman's curve unless for unknown reasons the performance of the Ss in this experiment reached an asymptote at twelve KRs. It would be interesting to compare the slopes and final levels of this study's KR Spec curves with the slopes and final levels of Cotterman's curves for the first twelve KRs.

(2) Non-KR practice contributes significantly, and in a facilitatory way, to performance. (An additional factor such as KR rate may then be needed to explain the equality of the percentage groups, especially the two extreme ones, .10 and .33, in the present study.

That is, if support is found for non-KR practice effects, then this may also support indirectly the hypothesized KR rate effect, since _something_ would be needed to balance the .10 group's advantage in having more non-KR trials; all percentage groups still were equal in absolute mean errors.)

(3) Although less likely, KR might have a facilitative influence on responding under .10 conditions due to greater KR-non-KR contrast or to some unknown factor(s) unique to intermittent conditions and/or their interaction(s) with other variables such as KR specificity or schedule. For example, during the earlier phases of intermittent KR _S_ may somehow be able to utilize KR to reduce errors more rapidly and efficiently than during either the later phases of intermittent KR or during continuous (massed?) KR responding.

(4) A factor related to fatigue or reactive inhibition might more rapidly influence responding under continuous KR presentation. It might be assumed that inhibition is also produced by nonreinforced trials, although this assumption may be more difficult to make using KR rather than reward. If the motivation established by KR is self-sustaining, at least for several trials (cf. Ross', 1933, speculations), then inhibitions due to the absence of information might not be immediately operative.

The question might be asked as to whether the use of ten per cent KR with 120 KR trials (involving a total of 1,200 trials — 1,080 more trials per _S_ than in the Cotterman study), would result in responding below the plateau (assuming, in other words, that the upper limits of performance hadn't been reached). If so, this would seem to show the presence of learning during non-KR trials.

Concerning the effects of the temporal spacing of trials and possible difficulties which might be encountered, Helson (1964) and Bevan (1963) have mentioned that since each application of a fixed value of reinforcement is assumed to bring its effective value nearer to an indifference level, rapid repetition should be accompanied by relatively rapid neutralization of stimulation with a consequent decrement in performance. In accordance with an assumption of a curvilinear relationship between tension level and performance, not only could too high a rate and level of tension be detrimental to performance but a spacing of reinforcements which is too wide would also result in poorer performance due possibly to the relatively large decrease in tension. According to Helson and Bevan, extended periods of zero reinforcement cannot support optimal tension levels for performance. Bevan (1963) gives experimental evidence for these deductions. However, if nonreinforced trials can be viewed as having zero intensity (see, e.g., Helson, 1964), then such trials should have the effect of reducing a postulated internal sensory norm and thus enhancing the perceived magnitude of any subsequent stimulus change.

In this study, the addition of KR into the situation might be taken to have been the main stimulus change, although it should be noted that a lesser stimulus change occurred from trial to trial when the stimulus photos were changed. In addition, the stimulus was present and responding still occurred on non-KR trials. Thus, in a following section non-reinforced trials will not be considered by this author to be of "zero intensity", especially when related to expectancies of KR occurrence (expectancies of a percentage or schedule—pattern—of KR occurrence), though non-KR trials will be thought of as tending to be associated with a lower arousal level and a lower internal sensory norm (unless some counteracting influence such as the expectancy of RR KR — see following section — is present).

If KR rate follows the same U-function that tension level does (this could be the case, e.g., where tension is dependent on KR rate), it would seem, then, that whether increasing or decreasing KR rate would result in an increase or decrease in performance would depend on where one begins choosing values on the U-function. Unless one started in the middle of this function, changing the KR rate toward a middle value would yield a consistent increasingly facilitative effect on performance until one passed the mid-point, at which time the effect would become detrimental.

It might thus be possible to increase KR rate so that S could not use the feedback as efficiently, although for the inter-stimuli intervals used in this study efficiency of KR use might continue to increase (or at least level off and show no decrease) for KR rate values up to a continuous (100%) KR level.

Nevertheless, aside from some increased error in the .33 random-schedule groups, variables such as rate, tension, stimulus change and non-KR practice effects were either unoperative, or, if operating for this task, were apparently counterbalanced in effect by each other; that is, the increased KR rate may still have produced a facilitative overall level of arousal but was balanced by a facilitative enhanced stimulus change (contrast) and additional non-KR practice in the .10 groups.

Actually, there are several possible hypotheses regarding the apparently equal effects of the three percentages. Explanations involving either the absolute amount of KR as the only factor influencing responding, or as additional factors the balancing out of non-KR practice with the effects of rate of KR presentation have been presented previously. A third explanation which could work separately or in conjunction with the preceding two would involve "tension", "contrast", and possibly other motivation considerations and, again, involve the hypothesis that these variables facilitated performance in that they were within facilitative limits but were distributed differentially among the percentage conditions. It is possible, of course, that with regard to the findings relating tension level to performance and Helson's assumptions concerning the repetition of reinforcement, the percentages used in this study did not represent a range sufficiently large to be relevant. For example, the percentages may have been intermediate in value and, hence, have lain in the middle of the U-function describing the relationship between tension level and performance.

The Nature of the Task

Cotterman's and this study's curves are from the same "judging-angular-displacement" task, while that of Bilodeau and Bilodeau's (1958) is for a lever-pulling task. The KR effect appears to be dependent in some measure on the type of task used since the curves based on Bilodeau and Bilodeau's 1958 data (see Figure 5) appear to be different, reaching lower levels of errors than the other curves, and, if correct in shape, possessing a greater overall rate of error reduction (for the block sizes shown) than Cotterman's curve.

In addition, whether learning is due mainly to the absolute frequency of KR or to the relative frequency of KR (and the influence of KR rates, non-KR practice, tension level and alertness, competing responses, contrast and other variables) may depend on the nature of the task.

KR Schedule, KR Percentage, and Blocks: Expectancy, Tension Level and Arousal, Contrast, and Competing and Emotional Responses. The nonsignificant Schedule main effect and the nonsignificant Schedule x Blocks interaction for means provides support for the hypothesis that a fixed-ratio presentation of KR results in learning equal to that found when treatment conditions involve a random-ratio presentation of KR (although fixed-ratio performance was consistently better than random-ratio from block to block). In addition, the *F* scores for the Percentage means as well as the Percentage x Blocks interaction were nonsignificant. However, the Schedule x Percentage x Blocks interaction (see previous section) suggested some differences between the schedules for different levels of percentage and blocks. If this is a reliable result, then additional explanation may be needed other than the conclusion that *S*'s eventual performance level (after several KRs have been given) is due only to the absolute occurrence of KR and not to the KR rate or schedule.

Selected Constructs Defined. The following constructs and related discussion are offered in the hope that some further explanation might be made in regard to Percentage and Schedule as well as Percentage x Schedule interactive effects, at least for responding at later stages of training (e.g., Block three in the present experiment). Large case letters will be used as symbols in order to abbreviate a particular hypothetical intervening construct or phenomenon. Subscripts generally will be used to refer to the source of a variable. After presenting the constructs, their possible interaction and their place in a model used to explain selected cases from the above-mentioned responding will be presented.

Arousal. Tension or arousal (*a*) were mentioned previously in connection with tension (*t*) as mentioned by Helson (1964) and Bevan (1963). However, the term arousal will be preferred in this section.

Arousal (*a*) is a form of tension, drive, or alertness, and, perhaps with the exception of tension or arousal due to frustration, arises when *S* feels that he can predict somewhat in regard to stimulation other than KR but cannot predict as well the effects of responding or response outcome, including the feedback (such as the KR pattern or rate of occurrence), until higher levels of learning are attained. For example, *S* knows what is going to happen (will happen) but not how he "will come out", such as might be expected sometimes on an exam in school. However, for only arousal to exist without anxiety he must not be overly aroused by KR inconsistencies.

Unless otherwise mentioned, *a* is usually considered in a facilitative sense, at least in direct action, though an *a* which is facilitative directly might also be considered indirectly detrimental if speculation has a particular level of *a* subtracting from another construct. This will be discussed later.

When a stimulus, response, KR, and arousal at a "facilitative" level occur temporally and spatially close together, then it is assumed that there is optimal use of a KR and, thus, optimal learning and performance.

KR Rate. Rate will be abbreviated by *r* and rate of KR will be written *r(KR)*. More specific *r(KR)s* will be designated by a decimal, e.g., .10 KR. The close relationship of *r(KR)* to such aspects as the number of non-KR trials and inter-KR intervals has been discussed.

Contrast. Contrast (*C*) refers to the "contrast" between KR and non-KR trials or the novelty or change of KR compared to non-KR trials. Contrast, as mentioned earlier, would occur at a higher level when the internal sensory norm in reference to KR is greatly reduced by the occurrence of non-KR trials.

Contrast also will be said to yield arousal and this arousal with its contrast source is designated a_C. The occurrence of KR increases the KR sensory norm; thus, higher rates of KR might reduce contrast since more frequent receipt of KR would reduce its novelty. However, this may only occur during early trials before Exps are formed. Once *S* begins to form Exps, the role of r(KR) might be expected to decline in importance. Exps might be formed earlier and perhaps at higher levels for higher r(KR)'s and formed later and at lower levels for the lower r(KR)'s. The Exps, ExpFR and ExpRR would also reduce *C*. If *S* has learned to expect fixed-ratio

KR on the trial on which it occurs, or to expect random-ratio KR on any trials or on most trials, then KR will be less "novel" and afford less C when it occurs.

Expectancy. Expectancy (Exp) will be considered to be synonymous with set or anticipation. S may consciously or unconsciously anticipate or expect a future KR trial according to his own "guess" as to a given percentage or schedule. This may be clearly held uppermost in mind by S or exist only as a more vague "feeling" that "information should occur 'soon'" or "information will probably not occur 'for a while.'" This brings up another concept, namely, the certainty that S has concerning his Exps, but this will not be further discussed at this time.

Support for a hypothesis that Ss were able to "estimate" the approximate percentage of KR occurrence in this study is the direct relationship found in certain light-prediction studies between percentage of reinforcement and response rate or percentage of guesses in acquisition: increase in the response rate occurs with an increase in the reinforcement percentage (cf. Edwards, 1959; Estes and Straughan, 1954; Grant, Hake, and Hornseth, 1951; Grant, Hornseth, and Hake, 1950; Humphreys, 1939; Lewis and Duncan, 1958; Rogers, Webb, and Gallagher, 1959; and Kimble, 1961, pp. 194-196). Lewis (1960; 1963, p. 164) states that 'Expectancy "theory" was brought into partial reinforcement by Humphreys (1939)'; Lewis mentions that Humphreys' (1939) expectancy theory considered that "partial reinforcement resulted in an expectancy of irregular reinforcement and that continuous reinforcement resulted in an expectancy of regular reinforcement." (Lewis; 1963, p. 164).

Lewis (1960, 1963, pp. 164-166) discusses some studies concerning expectancies. However, expectancy concepts have been in psychology since before 1939 (see, for example, Kimble, 1961). Skinner (e.g., Ferster and Skinner, 1957) has also reported the unique patterns of responding associated with various types of schedules, such as decreases in response rate between reinforcements under fixed-interval schedules.

It may therefore not be an unreasonable step to assume that Ss may consciously or unconsciously form estimations (assumptions, guesses, expectations, sets, etc.) of periodic or aperiodic KR and even of KR percentages after a certain number of trials with KRs. Consequently, in the case, for example, of widely spaced, fixed-ratio KRs, Ss might become less aroused $[a_{ExpFR(non\text{-}KR)}]$ and perform with less accuracy between KRs. Exp of fixed-ratio KR will be written ExpFR and Exp of random-ratio KR will be written ExpRR. ExpFR(non-KR) is a term for convenience in designating the low level of Exp existing between FR KRs.

Other Constructs. Other terms and their abbreviations are: Adaptation (Adpt), Competing Response (Cmptg R), Frustration (Frust), and Anxiety (Anx).

Frust is similar to Arousal; however, Frust differs from arousal in that S is more unable to predict KR, S is more greatly aware of a perceived inability to meaningfully structure or interpret incoming stimulation such as the pattern or rate of KR presentation or both. Whether S's structuring or interpretation is compatible or incompatible with "reality" is not necessary to consider in this case but, rather, whether S feels "content" with his interpretations.

By *Cmptg R's* are meant those responses made by an *S* attempting to "figure out" the meaning of the experiment or predict the occurrence of KR. Any event distracting from an *S*'s trial-by trial-performance and his concentration upon the stimuli, his responses, and the KR as it occurs would be classified as a *Cmptg R*. (This might even include *S*'s attempting to remember the last KR, stimuli, and his performance at a KR trial, though memory for KR was generally considered earlier in the context of the r(KR) variable). If *Cmptg Rs* and other variables interfere with the overtly *E*-defined perceptual responding by *S*, i.e., with *S*'s actual perceptual task performance, then additional *Frust* might develop.

Anx will be said to occur under the same conditions as *Frust* but under the additional condition that *S* is "ego-involved" in the task and views any kind of perceived failure as a threat to his ego.

Adpt refers to lessened ability of a stimulus or an event to yield arousal.

Arousal, Its Source and Location of Occurrence. The following *a*'s, their sources, and the location of their particular occurrence will be considered:

(1) $\underline{a}_C$ occurs at a KR trial. It may be considered as the arousal due to contrast.

(2) $\underline{a}_{r(KR)}$ occurs at KR and non-KR trials. The faster an individual receives stimulation, in this case KR, the higher his *a* level might be.

(3) (a) $\underline{a}_{ExpFR}$ occurs mainly at and/or just before a KR trial.

(b) $\underline{a}_{ExpFR(non-KR)}$ occurs over non-KR trials. Since it is a occurring between KR trials, when S expects no KR, it is usually assumed to constitute a lower level of a.

(4) $\underline{a}_{ExpRR}$ occurs over KR and non-KR trials. It may be thought of as a due to S's uncertainty regarding the temporal presentation of KR.

Total Arousal As a Function of the Constructs. Total arousal effects ($\underline{a}_T$) for fixed-ratio conditions will be considered to be some function of C, $\underline{a}_{ExpFR}$, $\underline{a}_{r(KR)}$, and Adpt. This can be written as:

$$a_T = (f)\ C,\ a_{ExpFR},\ a_{r(KR)},\ \text{and Adpt.}$$

For a random-ratio situation,

$$a_T = (f)\ C,\ a_{ExpRR},\ a_{r(KR)},\ \text{and Adpt,}$$

except for high percentage random-ratio conditions for which

$a_T = (f)\ C,\ a_{ExpRR},\ a_{r(KR)}$, Anx, Cmptg Rs, Adpt, (and perhaps certain additional Frust-derived variables which tend to make for detrimentally high a).

The existence of the variables in the preceding equations and their operation in this study is unknown, though in many cases they have been borrowed from findings from other research or from hypotheses and concepts discussed by other researchers. The actual degree of contribution of the variables in each equation is also not presently known, nor is the form of the interaction of such variables, e.g., whether additive, subtractive, multiplicative, etc.

A General Consideration of the Location of the Occurrence of Various Constructs. Exp and higher r(KR) may be thought of as conditions which lower the C effect and thus the $\underline{a}_C$. For a KR trial only, $\underline{a}_T$ may have as its possible components one or more of the following: $\underline{a}_C$ and $\underline{a}_{ExpFR}$; values of ExpFR, ExpRR, and r(KR), all of which might serve to subtract from C (and, hence, $\underline{a}_C$); and values of ExpFR(non-KR) which may enhance C (and, hence, $\underline{a}_C$).

On both KR and non-KR trials, $\underline{a}_T$ may have as its possible components one or more of the following: $\underline{a}_{r(KR)}$ and $\underline{a}_{ExpRR}$.

For a fixed-ratio, non-KR trial, $\underline{a}_T$ will include only $\underline{a}_{ExpFR(non\text{-}KR)}$.

Examples of the Constructs and their Interaction as Applied to the Results of this Study. A few selected examples involving the constructs and their possible explanatory usefulness with regard to the results of this study will be presented below.

Schedule. An hypothesis to explain the absence of a significant schedule main effect might consist of a postulated eventual formation of (a) a set or expectancy of periodic KR and an increase in arousal ($\underline{a}_{ExpFR}$) at the KR trial for the fixed-ratio groups, and (b) an expectancy of variably occurring KR and an overall increase (over all trials, KR and non-KR) of arousal ($\underline{a}_{ExpRR}$) in the random-ratio groups. The fixed-ratio groups might eventually have become "set" to receive a particular KR approximately at the time it occurred and, thus, received maximum benefit from the KR. The tension or alertness in the random KR group might be attributed to the Ss' inability to predict the occurrence of the next KR and, thus, they might have been more "tense" and "alert", looking for KR at each trial. The increased tension, a_{ExpRR}, may thus have operated in a facilitative fashion for many of the random-KR groups and equalled the facilitative effects operating for the fixed-ratio KR groups' arousal system ($\underline{a}_{ExpFR}$).

However, the random KR situation might have excited other processes such as competing responses, frustration, and anxiety reactions, since, for example, S, in an effort to obtain or structure a "reasonable" picture of environmental-organism interaction (perhaps compatible with former experiences), may have tried to "figure out" what aspect of his behavior pattern the KR was dependent upon for presentation. Actually, however, there was none and, therefore, S presented himself with an unsolvable problem. If continued attempts were made to arrive at a solution, there might have resulted an increase in competing responses (including irrelevant hypotheses or conclusions as to the experiment's purpose), anxiety, frustration and other processes, some of which could have increased arousal levels beyond facilitative limits. (This might be tested with the use of attitude scales given after the judgement task). Though the overall FR mean was superior to the overall RR mean, the means were not significantly different; therefore, the role of emotional and competing responses will be considered in the discussion of the Schedule x Percentage x Blocks interaction below.

Percentage. Higher KR percentages, e.g., .33, might be assumed to yield high over-all arousal levels (assuming an optimum or maximum facilitative percentage value of .33 for this study). Lower percentage values might be assumed to yield low $\underline{a}_{r(KR)}$ and, thus, be less facilitative than the $\underline{a}_{r(KR)}$ of the higher percentage value--however, proportionately higher arousal at the KR trial due to a KR-non-KR contrast effect ($\underline{a}_C$) might also be predicted. Groups who received lower KR percentages (e.g., .10) and thus wider KR spacing may therefore have eventually benefited from a greater contrast between KR and non-KR trials and relatively greater amounts of $\underline{a}_C$ at the KR trial.

Percentage x Schedule x Blocks. If any of these hypotheses is correct, additional assumptions may be required since, among other possible differences among means of this second-order interaction, the performance of the .33 random-ratio group was lower at blocks two and three, and the mean performance of the .10 random-ratio group tended to be higher than that for a large majority of other Schedule x Percentage treatment groups at block three (although the differences may have been due to sampling).

Concerning the .33 random-ratio group, perhaps both a strong expectation for irregular KR with its associated arousal ($\underline{a}_{ExpRR}$) and a high arousal level due to the high KR rate [$\underline{a}_{r(KR)}$] eventually combine to yield a high degree of overall arousal. This, along with competing and emotional (frustration) responses similar to those mentioned earlier, might eventually have resulted in a highly detrimental arousal level.

The high KR-non-KR contrast under the .10 random-ratio condition, coupled with a weaker set for random KR and thus weaker $\underline{a}_{ExpRR}$, might perhaps have yielded a level of arousal which was particularly facilitatory. There is also the possibility that the small amount of $\underline{a}_{ExpRR}$ would not be formed very quickly. That is, a .10 ExpRR might be more "difficult" to develop than a .10 ExpFR, i.e., the .10 ExpRR formed at lower levels and perhaps had a shorter existence. As mentioned earlier, a lower amount of ExpRR might be less facilitative in its own right but might be hypothesized to interfere much less with $\underline{a}_C$.

However, it would seem that a set for periodic KR under the .10 fixed-ratio condition (which should also involve high contrast) would also be facilitatory unless performance worsened between KRs. This might be due to a decrease of $\underline{a}_{ExpFR}$ between KRs [designated $\underline{a}_{ExpFR(non\text{-}KR)}$ for convenience] due to the expectancy of not receiving a KR for relatively long lengths of time. A performance decrement between KRs, at least with highly-spaced KRs with large numbers of intervening non-KR trials, seems possible if motivation (i.e., arousal) was much abated over non-KR trials. If $\underline{a}$ and ExpFR did decrease between KR trials, however, a compensatory increase in $\underline{a}_C$ might also have occurred on a KR trial.

Attempts to pursue this problem further and explain various results utilizing the C, Exp, the several a's, Adpt and other theoretical concepts have been attempted elsewhere by the author, but the problems involved have proven to be complex and involved. For example, for a given experimental operation, the time at which one of the particular theoretical phenomena occurs, the level it reaches, and its duration are unknown and can only be guessed at. In addition, it seems that there can always be hypothesized compensatory increases or decreases in one construct to account for a loss or gain in another construct.

Error by Individual Trials Analysis
Aftereffects, Continued:

Figures 11-15 show absolute mean error versus individual trials rather than blocks for selected groups from this experiment. Effects of individual KR trials, i.e., trials with KR, on KR + 1 trials, i.e., the first trial following a KR trial, and thus, the more immediate effects of a given KR, can be studied. Figures 6-10 also show several other KR effects not shown by the earlier graphs drawn from block data.

Of current interest, then, are the scores obtained on KR and KR + 1 trials, and, then, the absolute mean error scoring from a KR to a KR + 1 trial. It is seen that the possibilities could involve a majority (or minority) or no majority of KR to KR + 1 error increases or decreases as well as equal KR to KR + 1 responding for a given KR trial to its first following KR + 1 trial. From Tables IVab and Figures 6-10, it is seen that for the fixed-ratio groups, those who received the lowest KR frequency and greatest inter-KR spacing, (.10, one-hundred and twenty trials), appear to have along with one other group (.33 FR KR Spec I) which received the highest KR frequency but least KR specificity a majority of decreases in absolute error after the KR at the KR + 1 trial (Figures 6, 9, and 10). For the fixed-ratio groups, immediate facilitative KR effects appear to occur more often as KR trials are more interspersed, the effect moving toward .10 scheduling rather than toward .33. Groups receiving conditions .20 and .33 involving an increased KR frequency and decreased KR spacing are

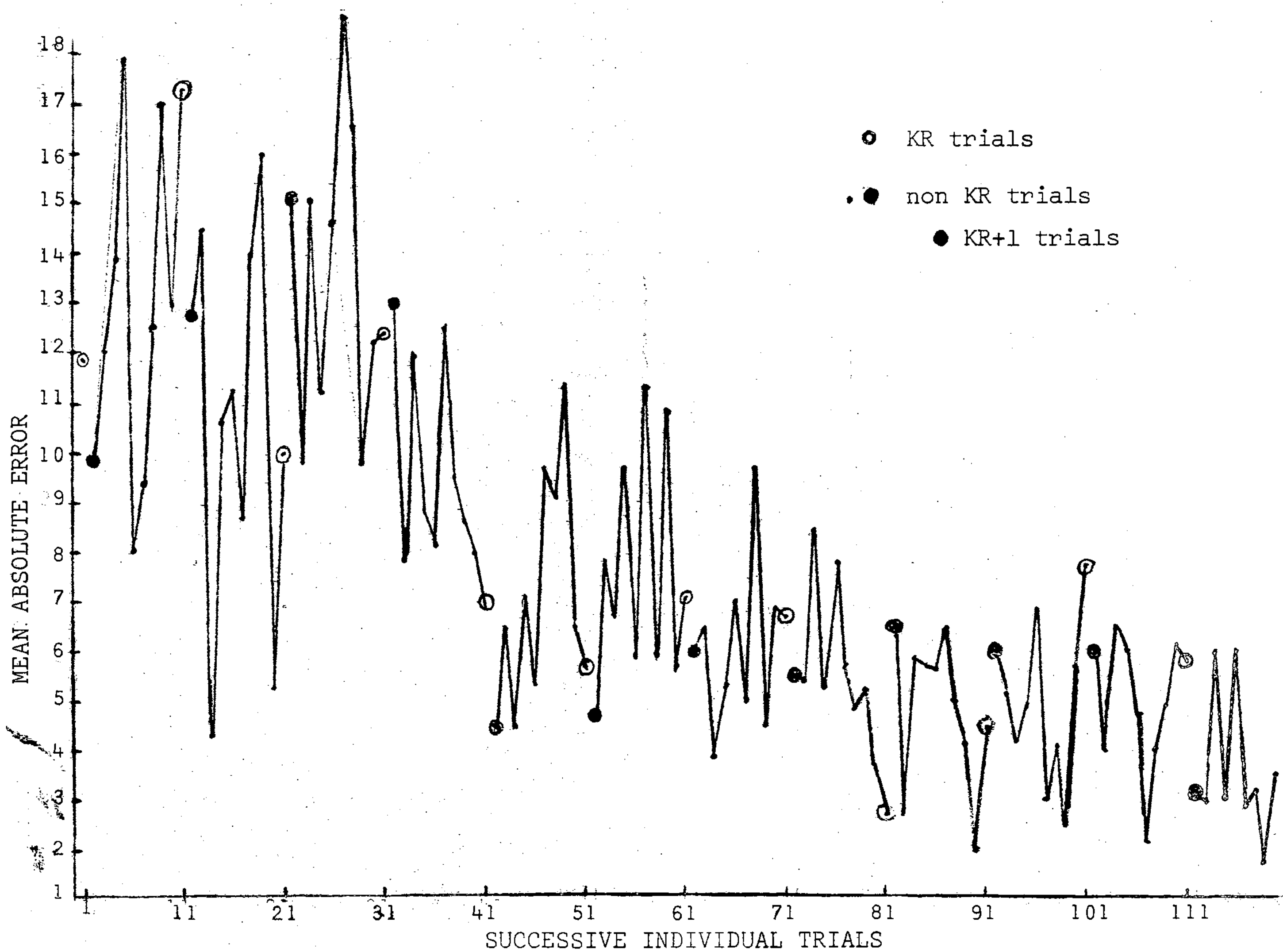


FIGURE 6. Individual data points for the fixed-ratio KR X KR Spec III X .10 treatment group with mean absolute error versus successive individual trials showing the effects of individual KR trials and non-KR trials.

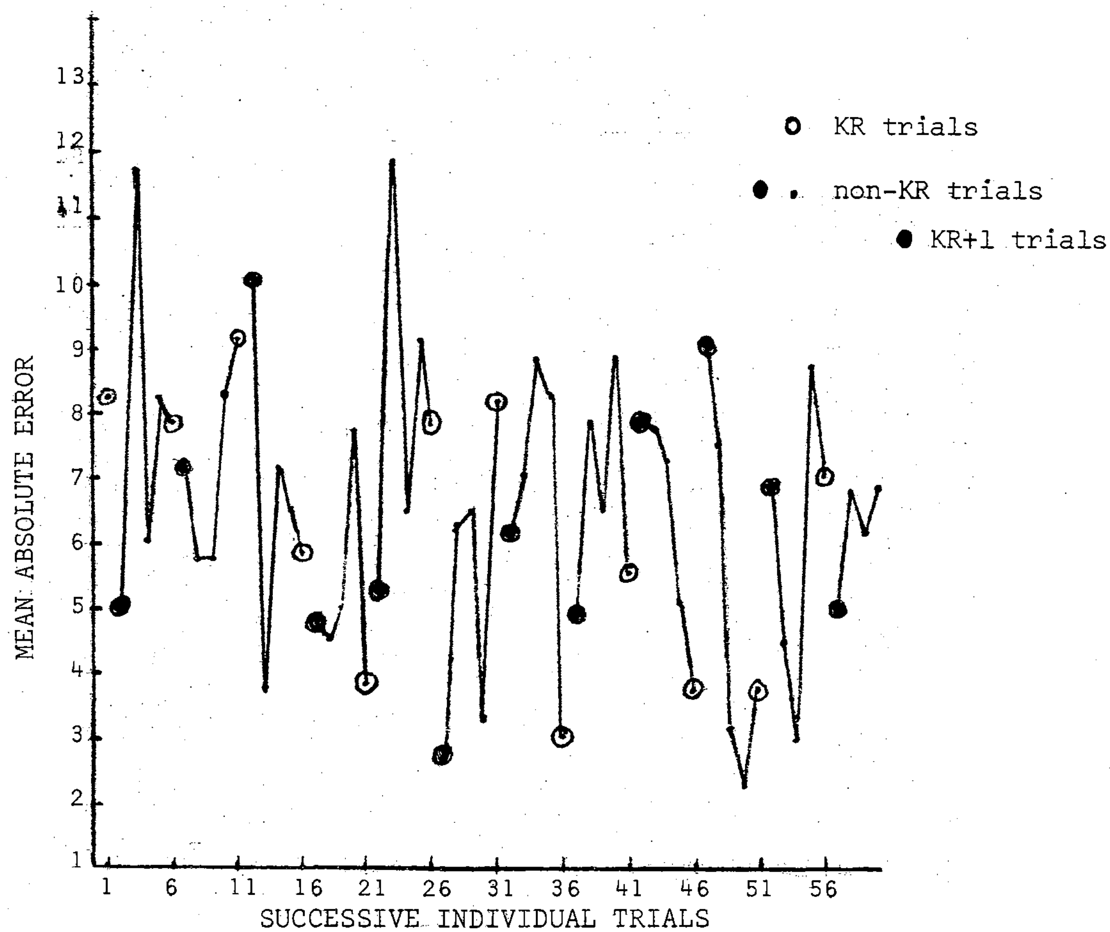


Figure 7. Individual KR trials (open Circles) and non-KR trials (dots) including the KR+1 trials (large dots) for the fixed-ratio KR X KR Spec II X .20 treatment group with mean absolute error versus successive individual trials.

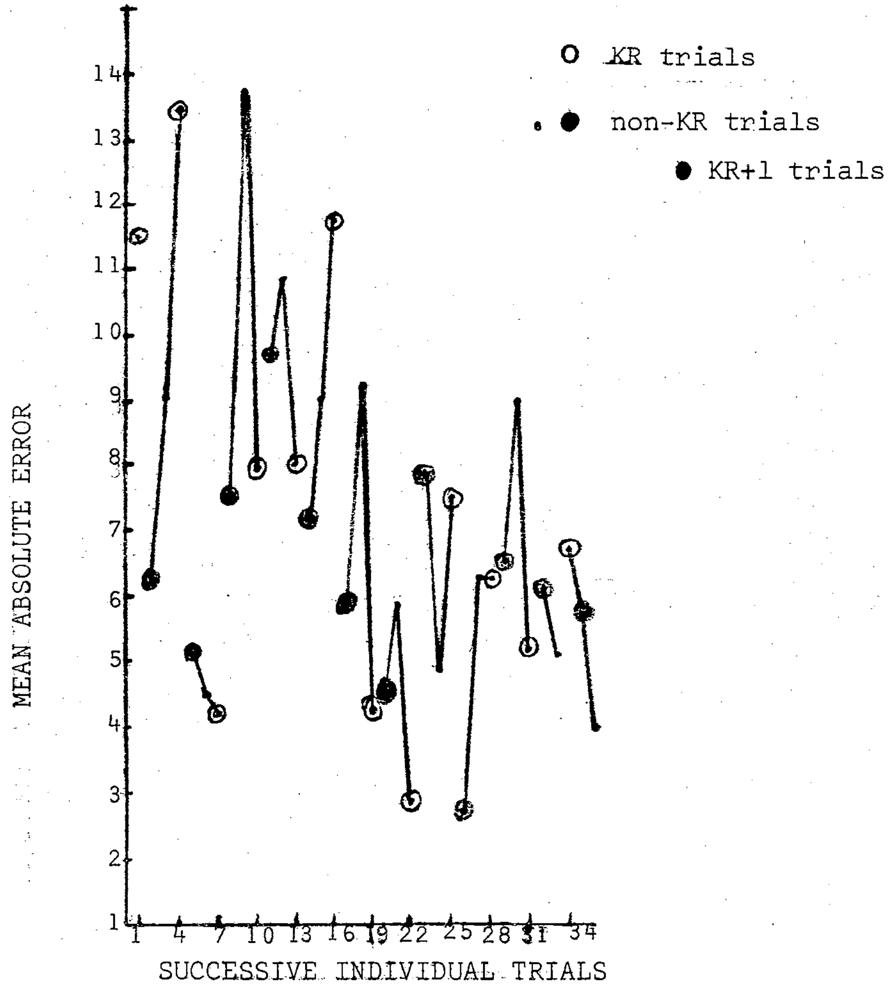


FIGURE 8. Individual KR trials (open circles) and non-KR trials (dots) including the KR+1 trials (large dots) for the Fixed-ratio KR X KR Spec III X .33 treatment group with mean absolute error versus successive individual trials.

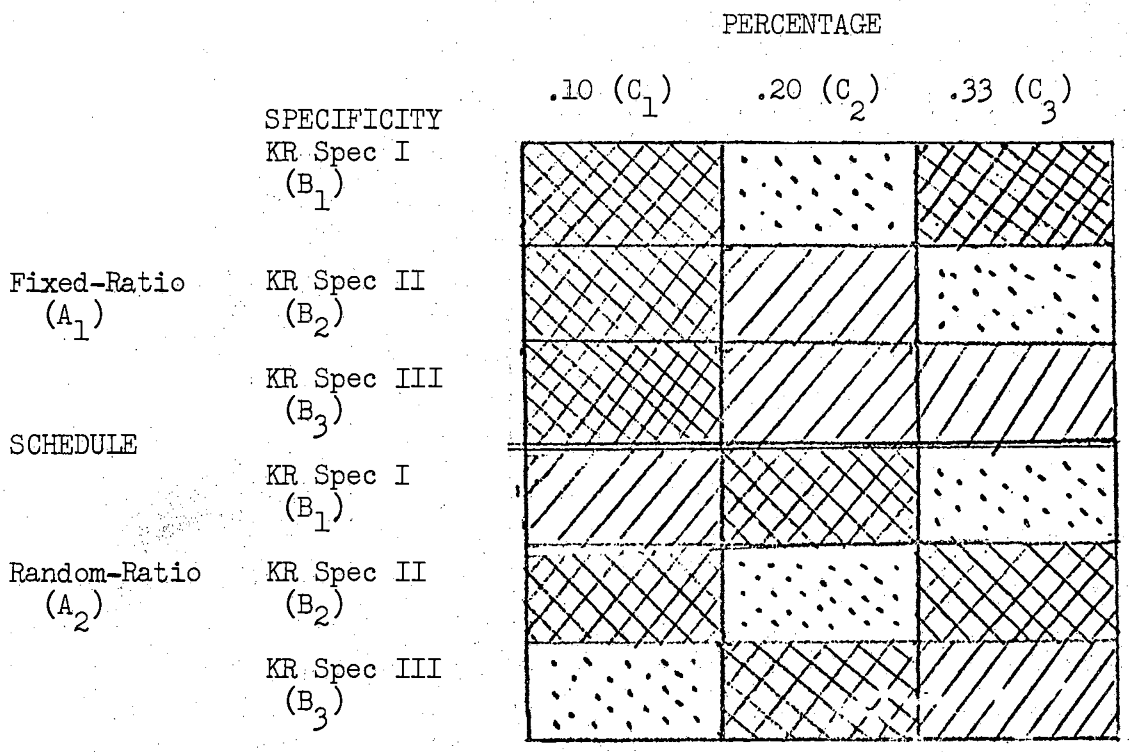
TABLE IVa

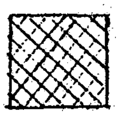
Showing the arrangement of treatment groups according to a majority of increases or decreases in or approximately equal mean absolute error responding (a difference of only one degree or less) from a KR_i to a $KR_i + 1$ trial in the individual trials where KR_i is any KR for a given treatment group, i being a number of a given KR.

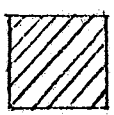
Majority KR to KR + 1 Error Decreases	"Equal" Error Responding From A KR_i to A KR_i+1 Trial	Majority KR to KR+1 Error Increases
$A_1B_1C_1$ 8/12	$A_1B_2C_2$ 6/12Inc.=6/12Dec.	$A_1B_1C_2$ 7/12
$A_1B_2C_1$ 9/12	$A_1B_3C_2$ 5/12Inc.=6/12Dec.	
$A_1B_3C_1$ 8/12	$A_1B_3C_3$ 6/12Inc.=6/12Dec.	$A_1B_2C_3$ 8/12
$A_1B_1C_3$ 7/12		
Majority KR to KR+1	No Majority	
	$A_2B_1C_1$	
$A_2B_2C_1$ 6 1/3 /12	5 ½ Inc. vs 6 1/6 Dec.	$A_2B_3C_1$ 5 1/3
$A_2B_1C_2$ 6½	$A_2B_3C_3$ 5 5/6 Inc. vs 5 1/6 Dec.	$A_2B_2C_2$ 5
$A_2B_3C_2$ 6½		$A_2B_1C_3$ 6 1/3
$A_2B_2C_3$ 6 2/3		

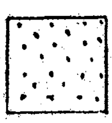
TABLE IVb

IMMEDIATE KR AFTEREFFECT: SHOWING THE ARRANGEMENT OF TREATMENT GROUPS ACCORDING TO A MAJORITY OF INCREASES OF DECREASES IN OR APPROXIMATELY EQUAL INCREASES AND DECREASES IN MEAN ABSOLUTE ERROR RESPONDING FROM A KR_i TO A KR_i+1 TRIAL IN THE INDIVIDUAL TRIALS, WHERE i IS THE NUMBER OF A GIVEN KR TRIAL




Schedule X Specificity X Percentage Groups Yielding a Majority of Decreases in Mean Absolute Error Responding from a KR_i to a KR_i+1 Trial.


"Equal" Mean Absolute Error Responding from a KR_i to a KR_i+1 Trial for Fixed-ratio Groups Or for Schedule Groups in General No "Clear" Majority of Increases or Decreases in Mean Absolute Error from a KR_i to a KR_i+1 Trial.


Schedule X Specificity X Percentage Groups Yielding a Majority of Increases in Mean Absolute Error Responding from a KR_i to a KR_i+1 Trial.

either equal in error decreases and increases or the decreases are in a minority. Such an apparent pattern does not appear for the random-ratio groups when a similar KR to KR + 1 analysis is done. Due to the random nature of the KR for each S, KR to KR + 1 averaging was done in a different manner, KR to KR + 1 responding tallied for each S and then random-ratio group averages found. In the averaging method for the fixed-ratio group individual trial averages over Ss for each FR x KR Spec x Percentage group were found first and then KR to KR + 1 responding calculated. However, it is felt that the two methods yield comparable results.

An explanation for the cases involving equal numbers of KR to KR + 1 error increases and decreases and the majority of KR to KR + 1 increases is not at hand, but an explanation for the KR + 1 error decreases can be offered in terms of aftereffects due to the KR and KR spacing. Possible explanatory variables were mentioned earlier in other sections. For example, a KR non-KR contrast hypothesis fits somewhat neatly with the immediate aftereffects analysis results and conditions of the .10 FR group though not as well with the .33 FR KR Spec I group. For example, individuals who received the .10 or decreased frequency of KR with increased KR spacing conditions might have been in a decreased tension state, less set for a KR trial, and have been relatively adapted to conditions involving trials without KR compared to individuals who are receiving higher KR frequencies. Thus, an occurrence of KR under decreased rate conditions (.10, one-hundred and twenty trials) could have resulted in greater stimulus change and contrast at the KR trial which would cause greater arousal, alertness, and tension over the immediately following trials.

Ss receiving higher KR ratios and faster KR occurrences (toward .33) could be hypothesized to be operating under greater arousal and tension levels on non-KR trials compared to arousal on decreased KR frequency (toward .10) non-KR trials; arousal and tension levels might be lower at the higher KR percentage KR trials than the tension levels for .10 decreased ratio KR trials. Of course, even the reverse could be true, i.e., KR tension increased as ratios decreased, or again, possibly there were no overall tension differences, since, as mentioned, measures for tension levels and tension level changes were not a variable in this study. However, the finding of a majority of KR to KR + 1 error increases for five groups is still unexplainable.

A complete and integrated explanation of the results of the KR to KR + 1 analysis is not yet at hand. It might be that "increased tension" is less important a variable than "contrast" or possibly greater contrast between KR and KR + 1 trials under .10 conditions causes still greater tension when KR occurs.

Estes (1960, 1963) reports paired associates, eyelid conditioning, and free verbal recall tasks to show that an all-or-none interpretation is called for in explaining results obtained from the first several training and test trials in his experiments.

It appears, however, from a look at Figures 11-15 that neither an all-or- none nor the gradual formation of S-R bonds and habit strength formulations apply closely to the results of this experiment. It appears that the latter model would more closely apply, however, although the learning curves over individual trials are far from smooth.

The dependence of learning on the KR and the small influence of practice without KR has already been mentioned in the sections concerned with the first analysis using block means. For the majority of the Fixed-ratio KR Specs II and III groups, learning in this task is gradual but often appears to be mainly dependent on the presence of KR. However, since learning is so variable for the sometimes more difficult and sometimes easier stimuli used, it is hard to compare the effects of KR and the lack of KR on learning for the various treatment groups.

The question remains, is learning still due only to the KRs or is practice actually balancing out the KR frequency variable to make the percentages in performance? Are these two variables impossible to separate. If performance is due only to KR, using one stimulus or stimuli of equal difficulty, one should get at least for all groups involving a level of KR specificity near KR Spec II or III a step function in which all groups would show the immediate effects of KR, the drop in error at KR + 1, at least until learning begins to reach an asymptotic level of error responding. Although Bilodeau and Bilodeau's (1958) Figure 1 for the .10 KR group (Bilodeau and Bilodeau's, 1958, Group ten) using a lever displacement task shows a step function of sorts, this is not always the case in this experiment. For even Fixed-ratio x KR Spec III x .10 conditions such clearly defined "steps" are not always clearly seen in the figure for this group. Error responding within a given step often exceeds error responding present in previous "steps" or before the last previous KR was given. This also seems to have occurred some in Bilodeau and Bilodeau's (1958)

Figure 1 for the .10 groups' responding later in learning (the 43rd to the 100th trial, approximately) when a decrease in error responding has greatly decelerated and the error decrease progresses in a slower negatively accelerated fashion. Additional as yet unknown variables may be operating in the particular perceptual learning situation used in this experiment. However, although learning appears to be gradual for the Fixed-Ratio-KR Spec III-.10 Ratio conditions involving higher feedback specificity, after all twelve KRs have been given and the Ss have gradually reached lower error levels of responding, the reader will note the usual effect of KR is to cause an immediate lowering of error responding with a gradual rise in error response until the responding on the next KR + 1 trial.

For the Fixed Ratio-KR Spec III-.10 Percentage group, within a block the general fall and rise trend in responding could be described as a series of variable semi-U functions. Over trials, from KR_1 to KR_2 one would expect some "forgetting," "extinction," or gradual lessening of KR aftereffect and alertness in trials after a KR trial and a function with a negative slope and decreasing rate eventually reaching a minimum asymptote; then there might occur a change to a function of positive slope with increasing rate due possibly to increased "awareness" or "alertness" due to an "expectation" of KR culminating at a response point or trial containing a second KR but below the previous KR trial in error. (However, the curve might then reach an asymptote or change to a negative acceleration — with still positive slope — before the next KR). The phase would then begin anew starting with KR_2 and again culminating at KR_3, a KR containing response point lower in absolute mean error. The final entire overall somewhat "scalloped" curve would have a negative slope and acceleration. Skinner (1938) has obtained curves containing "scallops" but apparently in different situations.

However, such responding was not found in this experiment but was much more variable than that found by Skinner though inter-stimulus differences were one possible source for trial to trial response variation. Distinct scallops are probably found more often where various rates of responding are possible between reinforcements in the distinctly operant situation. The gross rate of responding is often the dependent variable. Such was not the case in this experiment. Here, reinforcement or KR was given regardless of S's performance. KR was assigned to given trials before S entered the experimental situation and trials then given according to regular time spacings. As mentioned, in this respect conditions thus resembled a fixed- or variable-interval schedule rather than a fixed- or variable-ratio schedule. It should be pointed out that Ss under random KR conditions may feel that KR is being given on other than a preassigned schedule, that is, due to some aspect of their performance. It is remembered, however, that there were no or only small differences obtained between fixed and variable-ratio Ss (non-significant F score for the Schedule variable) although the differences were consistent. Food reinforcement is also often involved in the obtaining of scallops. A motivation variable is thus involved in the formation of scallops: The organism does not expect additional reinforcement immediately after reinforcement in a fixed-interval schedule and thus is not motivated to respond or perform the experimental task immediately after receiving reinforcement. In this experiment involving intermittent KR, it is more probable that motivation was maintained at a relatively higher level between reinforcements than on the "respond for food" task due to an assumed desire on the part of the Ss to maintain higher overall performance in the "guessing angular separation."

A final major point concerning this section's analysis is that when considering only the better feedback conditions, KR Spec II and III, learning is quicker and thus more efficient under the increased KR frequency conditions and higher percentages of feedback holding number of KRs constant although eventually under the decreased frequency conditions S's absolute error decreases to comparable lower levels occupied by groups receiving the increased KR frequency. Again, under conditions involving intermittent reinforcement, with the total number of trials held constant within a trial series or cell, the decrease in error responding occurs faster as the total number of trials is shortened and as KR occurs more often. It would seem that learning efficiency would be maximized with one-hundred per cent reinforcement, but the possibility of overloading the information processing system of the subject with too much information must be considered.

Among hypotheses which might thus be derived from this section, the following are offered as examples.

For intermittent KR conditions in which the number of KRs is held constant:

(1) the overall decline in errors over trials will become steeper as the KR rate of occurrence increases; and

(2) as the percentage is decreased the immediate effect of KR is usually an increase in performance.

Stronger confirmation of these hypotheses awaits the application of, e.g., more formal, precise analytical methods in describing the curves and the differences between levels of the KR variables.

Notes Concerning the Instructions

The instructions should probably be modified, enlarged upon, or perhaps made more specific, at least for college Ss when both sexes are included as Ss or where it is suspected that a fair number of the Ss have not had sufficient experience with geometrical terms.

Unfortunately, a limited number of Ss seemed to have difficulty in fully understanding, remembering, or following the instructions, and an attempt was generally made to clarify the instructions. The preceding as well as additional questions and discussion from Ss were handled by E in a relatively "neutral" but cordial manner. Brief discussion and instructions — some of which are mentioned in the two paragraphs below — were found to be necessary for several Ss and were included. This usually occurred before the experiment or during the early part of the trials. One might assume that most Ss eventually understood the task requirements after they had seen several of the stimulus arrangements.

For example, it should probably have been made clear that the correct answer expected from S was not the number of degrees required to point the small arrow at the tip of the long arrow, but that the correct answer involved the arrows being parallel to each other and pointing in the same, and not opposite, directions.

A description of what is meant by parallel might also have been given, and it could have been specifically pointed out that two arrows lying parallel to each other can point in the same direction. In addition, it might have been stated to S that the small arrow would not turn beyond 90° (or 180°, etc.) in order to have it lie parallel to the larger arrow and point in the same direction. E might also have made further preliminary inquiry as to S's understanding of how angles are measured.

Where a certain amount of acquired skill and experience is to be brought to the experiment by S, it might be necessary to ascertain in some way before actual responding begins as to whether S already posses the minimum skill required at the very beginning of the experiment and whether S is able to operate within the "boundaries" of performance required by the task and E. Of course, this would have to be done without training S any further in regard to performance on the task.

Generality of Results

Generalizing from results obtained from the task used in this study to those of other tasks should not be done without a consideration of the similarity between the tasks involved. [See Cotterman (1960, p. 17) for comments in this regard.] Additionally, the type of KR, KR specificity, and presentation used may well influence responding with as well as without KR. Other factors to consider might include performance or response measures, such as target tolerance(s) and response variability, and scoring methods. [Concerning the performance measures, see, for example, Annett (1959) and Stockbridge and Chambers (1959) who used two scoring systems.]

In addition, the findings of this study probably should not serve as a primary source for generating assumptions concerning retention over extended periods of time, i.e., beyond those used in this study. This would apply to time periods with or without non-KR trials. It would also apply to considerations involving transfer from the task used in this study to highly dissimilar tasks.

CHAPTER VII

CONCLUSIONS

All hypotheses advanced earlier in the hypotheses section were in general confirmed. However, certain exceptions from the general case were noted. In addition, certain additional conclusions or deductions beyond the preliminary hypotheses were reached. Generally, mean absolute error is the performance measure considered.

Concerning the KR specificity x blocks interaction results and the figures for the same, the following hypotheses were confirmed:

1. Rate and level of learning to estimate angular separation are increased at least eventually when more specific knowledge of results is given.

The following are additional hypotheses or deductions which merit further testing. It should be pointed out that all hypotheses and deductions derived from the KR Specificity x Blocks interaction data are always to be considered in the light of the significant Schedule x Percentage x Blocks interaction.

1. Effects of an increase in KR specificity, when lower error levels of responding are expected, may not be noticeable until later in learning (when KR is given intermittently). Rate and level of learning to estimate angular separation increase at different

rates and reach different levels of learning depending on the specificity of KR.

(a) KR Spec x Blocks learning curves appeared to be negatively accelerated (with a negative slope when plotting error vs. blocks with error on the ordinate) except for the highest KR specificity which appeared to be linear but with a negative slope indicating the possibility of some small learning for even the right-wrong information, KR Spec [illegible] group.

2. (a) Effects of continuous KR (Cotterman's study) are often such that treatment groups involved in the particular type of perceptual learning task described in this study will differ from each other at each successive stage of practice and will maintain the same rank order over trials (from block to block).

(b) Effects of intermittent KR (this study) appear to be such that respective treatment groups will not necessarily differ from each other at each successive stage (or block of practice trials) until the later stages of practice are reached.

3. Additional KR in this particular task under this study's conditions should eventually decrease error further to at least a level of about four degrees absolute error, a level found by Cotterman (1960) for his sixth group utilizing the same KR specificity as this study's KR specificity three, continuous KR feedback, and one-hundred and twenty total trials.

Concerning the schedule and percentage variables and the schedule x schedule percentage x blocks interaction, several trends which appear are listed:

1. For the schedule percentages used, performance under random KR occurrence did not usually differ from performance under fixed ratio KR occurrence.

2. (a) Aberrant responding was noted at schedule percentage type three (.33) where random KR was inferior to other fixed and random ratio KR groups in performance. Although it was felt that this deviant responding may not be a reliable finding, the hypothesis was offered for further testing that up to a point as the ratios increase and KR spacing and total number of trials decrease, random KR error may increase and performance decrease. Fixed ratio responding will remain constant.

(b) Again, within random KR conditions, that is, considering random conditions only, random KR may improve performance as the ratio is decreased. For the percentage method used in this study (holding the number of KR trials constant), decreasing the ratio results in higher KR spacing and greater numbers of practice trials; for example, the .10 percentage had one-hundred and twenty trials as compared to the .20 percentage which had sixty trials.

3. Within fixed ratio conditions, fixed ratio performance differs more at block one than converges; performance under random conditions appears to diverge later in training. It is interesting that with the exception of the random ratio x .33 group, all the groups exhibit the closet convergence at block two rather than at block three.

4. Learning is still faster earlier in training, decreasing in rate over time and practice trials as practice continues. Thus,

Schedule x Percentage x Blocks all appear to be curvilinear and negatively accelerated (with a negative slope when error is plotted against trials with error on the ordinate).

5. Performance or learning may be retarded more at block one under overall random conditions than for overall fixed ratio conditions.

6. Suggested by the finding of an insignificant F-score for the percentage means in the ANOVA was an additional hypothesis that for ranges not beyond ranges used in this study, differing percentages or ratios of KR occurrence are unequal as to their effect on rate of change in performance or learning to estimate angular separation and on the total amount of error but equal in their eventual effects on the level of error responding. (A possible exception may be one or more selected Percentage x Schedule x Blocks cases). One explanation for this would be that learning is largely or, for all practical purposes, solely due to the KR and not much or not all due to practice without KR. An alternate hypothesis would be that there are also learning effects due to increases or decreases in rapidity of KR occurrence (an increase in KR spacing or inter-KR intervals) which always correspond with approximately equal and opposite learning effects due to the corresponding decreases or increases, respectively, in the total number of practice trials. Thus, an individual who receives more practice trials than an individual at a larger ratio receiving less practice trials, may not be in the more advantageous position for learning since the S receiving the higher ratio and faster KR occurrence

position for learning may thus be able to make better and more efficient use of the KR when it occurs.

Comparisons made with Cotterman's (1960) and Bilodeau and Bilodeau's (1958) data point to task difficulty as a determiner of the level of performance reached but the particular comparisons made appear to leave unresolved the questions concerning the variables under-lying this study's Percentage results. However, the final performance levels reached by Cotterman's and this study's Ss lend support to the possibility of learning on non-KR trials balancing factor, the rate of KR. This relationship may break down when more extreme ratios are used in either direction. For example, an .05 percentage is in the direction of greater KR spacing, and .50 or even .75 in the direction toward decreased KR spacing; the first example, .05, could be said to be approaching zero reinforcement or KR and the last example, .75, as being closer to one-hundred per cent or continuous KR. Exactly what differences would be found between these extreme ratios and the ratios used in this study (.10, .20, .33) is not known.

Salient points concerning the error by individual trials analysis include:

1. It is readily seen in the absolute error by individual trials analysis that with total number of reinforcements (KR) held constant as the total number of trials is shortened and as KR occurs more often, the decrease in error occurs faster. (However, in general, equality in average error responding or performance was found in the block data ANOVA for the three percentage groups used).

(a) When the total number of KRs is held constant, the learning process occurs more efficiently as the percentage is increased.

Possibly this continued increase will not hold for more extreme percentage values, for example, above fifty per cent. However, Bilodeau and Bilodeau (1958), using a lever displacement task, have found that one-hundred per cent KR conditions (ten trials, ten feedbacks) were equal to .10, .25, and .33 KR conditions, holding number of KRs constant. Thus, learning occurred faster and feedback conditions were more efficient for learning the higher the ratios (still holding number of KRs constant).

2. (a) In the fixed ratio .10 (one-hundred and twenty trials, twelve KRs) treatment groups (and possibly certain other Schedule x Percentage groups), KR + 1 trials usually seemed to have responding at a lower error level than that on KR trials demonstrating that the type of KR used in this type of perceptual learning experiment often seems to have an immediate effect on behavior, if conditions involve the periodic, relatively high spacing of KR. Again, these immediate KR effects appear to occur more often as KR trials are more interspersed; that is, the immediate KR effect seems to occur more often in the .10, one-hundred and twenty trials condition rather than in the .33, thirty-six trials condition.

A KR to non-KR trial contrast hypothesis and other hypothesized variables fit somewhat neatly with these results.

(b) One .20 and one .33 fixed-ratio group and three random-ratio groups contained a majority of KR to KR + 1 trials showing an increase in KR to KR + 1 error responding; an explanation for this is not presently at hand.

(c) Other fixed-ratio and certain random-ratio groups seemed to yield either equal or approximately equal, i.e., did not reveal a clear majority of, increases or decreases in mean absolute error from KR to its following KR + 1 trial.

3. The relative effects of the absolute occurrence of KR and non-KR trials and the rate of KR were still not resolved. Reducing such variables as the stimulus differences and thus trial to trial task difficulty level might aid in delineating the relative effects of these three factors.

CHAPTER VIII

SUMMARY

One-hundred and eight undergraduates in psychology and education estimated individually with respect to 120, 60, and 36 stimulus photos how many degrees a $\frac{1}{4}$-inch arrow would have to be turned to exactly parallel an adjacent arrowheaded line drawn across a $3\frac{1}{2}$-inch circle. The stimuli were presented for five seconds with ten seconds between stimuli and longer rest intervals separating various sets of twenty-four. Each set contained examples of the same twenty-four (or less) different stimuli in random order. Correct answers ranged from eleven to forty-four degrees and were never duplicated within a set. Knowledge of results given orally after each estimation ranged in specificity from simple right-wrong information to the direction of error ("over," "under," or, if to the nearest degree, "correct") to information giving the correct answer to the nearest degree.

In addition, specificity of KR interacted factorially with three percentages of KR, .10, .20, and .33, the total number of KRs held constant. A third variable was the giving of KR or feedback in either a fixed ratio (periodic) or random ratio (aperiodic) fashion (see Chapter IV for the factorial design or layout). Due to the nature of the method of giving KR and trials, the fixed-ratio groups were also fixed-interval, and the random-ratio Ss random-interval groups.

Three block means per cell were computed from differences in mean absolute error between the correct and incorrect responses and these block mean differences between groups treated in an ANOVA format. Certain of the variables and their interaction were found to be significant. In addition, an analysis of the responding from a KR to the KR + 1 trial seemed to suggest some differences among treatment groups.

Conclusions were derived from the results as well as possible suggested trends and a discussion on the same presented. Various possible theoretical factors such as arousal or tension, contrast, expectancy, and competing and emotional responses were discussed in an attempt to offer some suggested explanation for at least a limited part of the responding found.

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APPENDIX

INSTRUCTIONS TO SUBJECTS

"Are you familiar with how angles are measured? Well, if you think of a right angle like the corner of a square, that would be ninety degrees. Half of that would be forty-five degrees, and so forth."

"In this experiment I'm going to show you a series of stimulus cards much like this one. (_E_ holds up sample.) You'll see them each time through an opening here (_E_ points). For each card imagine that you are flying a plane in the direction shown by this small arrow. The long line with the arrow on one end shows the direction in which you are _supposed_ to fly. I'd like you to tell me how many degrees you would have to turn to fly in the same direction as the long line, that is, so that the small arrow would be _parallel_ to the line."

"Do this each time immediately after I remove the card."

"I'll let you look at each one for about five seconds, wait ten seconds, show you another for five seconds and so forth until we have completed the series. Then I'll wait two minutes before beginning the next one."

"Remember to give your answer each time without hesitation or delay as soon as I remove the card."

Group I: "Sometimes I will say 'right' or 'wrong' shortly after your response to show you whether or not you have made an error."

Group II: "Sometimes I will say 'over,' 'under,' or 'correct,' shortly after your response to show you the direction of your error. 'Over' would mean that your estimate was too high.

Group III: "Sometimes I will tell you the correct answer shortly after your response so you will know the direction and amount of your error."

"Do you have any questions?"

"Ready?" . . .

TABLE III

Periodicity over Specificity x Percentage x Blocks

Periodicity	
Fixed Ratio	8.252
Random Ratio	8.976

Specificity over Periodicity x Percentage x Blocks

Specificity	
I	9.996
II	8.122
III	7.723

Percentage over Periodicity x Specificity x Blocks

Percentage		
.10	.20	.33
8.362	8.337	9.142

TABLE III (CONTINUED)

Blocks over Schedule x Specificity x Percentage

Blocks		
1	2	3
10.041	8.179	7.621

Schedule x Specificity over Percentage x Blocks

Schedule	Specificity	
Fixed Radio	I	9.382
	II	7.986
	III	7.386
Randon Ratio	I	10.609
	II	8.259
	III	8.059

Schedule x Percentage over Specificity x Blocks

	Percentage		
Schedule	.10	.20	.33
Fixed Ratio	8.784	7.664	8.306
Random Ratio	7.939	9.010	9.977

TABLE III (CONTINUED)

Schedule x Blocks over Specificity x Percentage

	Blocks		
Periodicity	1	2	3
Fixed Ratio	9.398	7.983	7.374
Random Ratio	10.685	8.375	7.867

Specificity x Percentage over Schedule x Blocks

	Percentage		
Specificity	.10	.20	.33
I	9.286	8.986	11.715
II	8.551	8.053	7.763
III	7.248	7.972	7.948

Specificity x Blocks over Schedule x Percentage

	Blocks		
Specificity	1	2	3
I	10.668	9.869	9.450
II	9.712	7.363	7.293
III	9.743	7.305	6.119

TABLE III (CONTINUED)

Percentage x Blocks over Periodicity x Specificity

KR Percentage								
.10			.20			.33		
Blocks			Blocks			Blocks		
1	2	3	1	2	3	1	2	3
10.371	7.755	6.959	9.881	7.929	7.201	9.872	8.853	8.701

Periodicity x Specificity x Blocks over Percentage

		Percentage		
Periodicity	Specificity	.10	.20	.33
Fixed Ratio	I	9.463	9.225	9.459
	II	9.206	6.417	8.335
	III	7.684	7.350	7.126
Random Ratio	I	9.109	8.747	13.971
	II	7.897	9.689	7.191
	III	6.812	8.594	8.770

TABLE III (CONTINUED)

Periodicity x Specificity x Percentage over Blocks

Periodicity	Specificity	Blocks		
		1	2	3
Fixed Ratio	I	9.471	9.719	8.957
	II	9.163	7.186	7.609
	III	9.559	7.043	5.557
Random Ratio	I	11.866	10.018	9.943
	II	10.261	7.539	6.977
	III	9.927	7.567	6.682

Periodicity x Percentage x Blocks over Specificity

KR Percentage

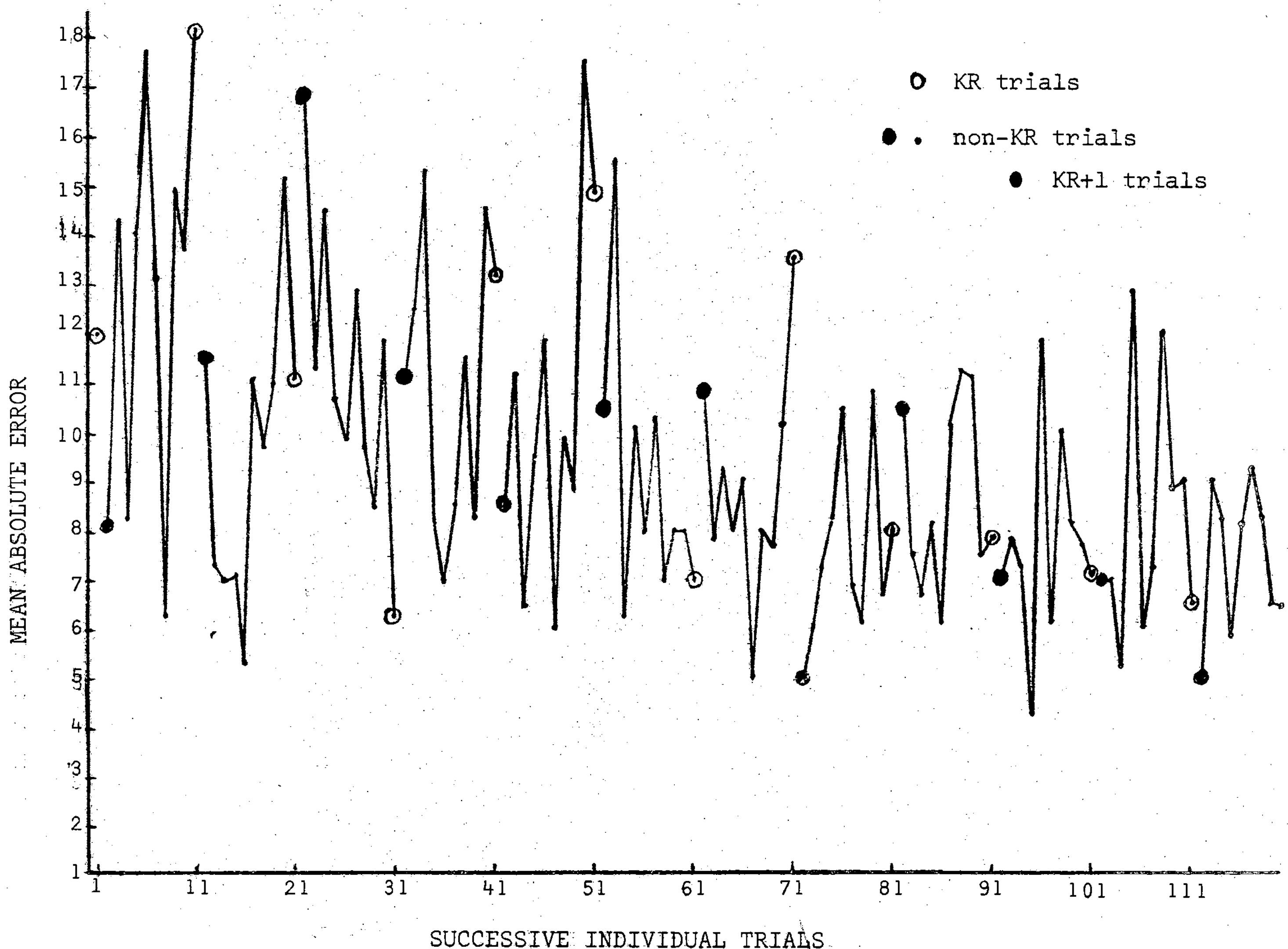

FIGURE 9. Mean Absolute Error Versus Individual Trials for the Fixed Ratio KR x KR Spec I x .10 Treatment Group.

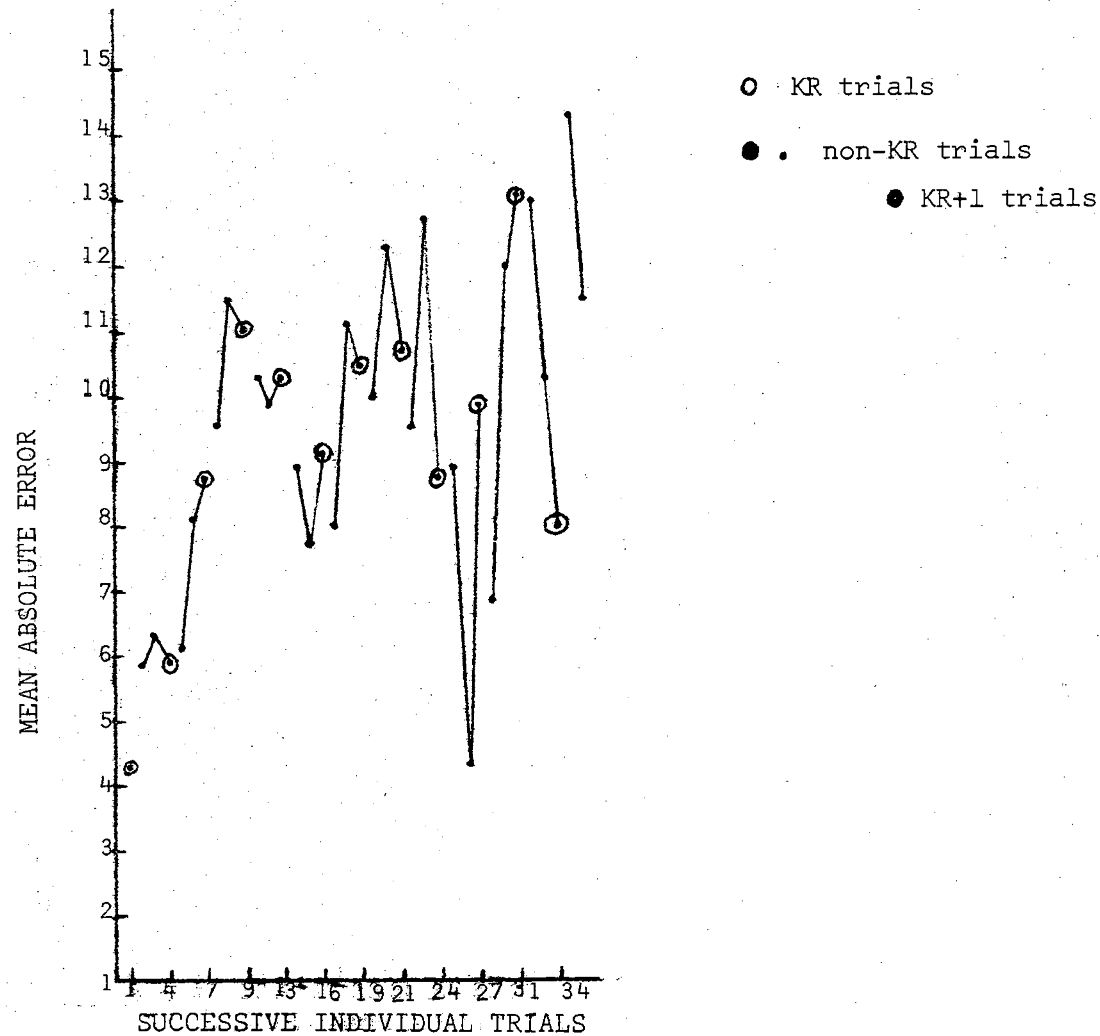

FIGURE 10. Individual KR (open circles) and non-KR trials (dots) including the KR+1 trials (large dots) for the Fixed-ratio KR X KR Spec I X .33 treatment groups with mean absolute error versus successive individual trials.

VITA

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