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Chart-Recorded Capillary Pulse Pressure Measurement as an Unobtrusive Means of Detecting Unspecified Frame-Specific Flaws in Programmed Instruction Sequences: An Experimental Study. Final Report.

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Capillary pulse pressure measurement may have potential as a covert but direct means of determining a subject's level of affect as he encounters the frame-by-frame content of programed instruction. An experiment was designed which called for recording the capillary pulse pressure of subjects as they worked through some programed instruction sequences that had specific flaws deliberately inserted in them. It was hypothesized that the record of capillary pulse pressures would show characteristics which would independently reveal these encounters without the need for further overt interaction with the subjects. Each of the high school students had a small pulse transducer taped to the end of his finger. As he worked through the specially prepared programs, the data obtained was recorded on a chart recorder. It was found that capillary pulse pressure characteristics vary from person to person, but individuals may still be placed in one of a small number of type-groups. Variation in the magnitude of an individual's capillary pulse pressure occurs both as a long term and as a short term phenomenon. It is possible to determine from the charts the level of involvement of a given subject. Samples of charts obtained, statistical charts, tables, and a bibliography supplement the report. (JY)

DEPARTMENT OF

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Los Angeles 90007

FINAL REPORT

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CHAPTER I

INTRODUCTION TO THE PROBLEM

The Problem

Statement of Problem

Programmed instruction is now finding acceptance as a solution to the problem of individualizing instruction within the framework of our national commitment to mass education. The evaluation of programs is therefore of great importance, both to those who write and produce programs and to those who purchase and apply them. Thus far, in the evolution of instructional materials evaluation, the evaluation of programs has been dependent upon such techniques as pre- and post-testing, critical observation of subjects studying programmed instructional materials, and upon questions put to the subjects while they work through the materials. But one significant problem is that such methods are either overt, and thus contaminate their own findings by causing changes in the behavior of the subject, or they are indirect and therefore lack the desired precision. This problem was the concern of this study.

The Need

There has been a need for a relatively unobtrusive means of attaining a direct measure of the subject's level of affect as he encounters the frame-by-frame content of programmed instruction. Ego defense often prevents a subject from revealing his true level of affect when it is depressed during intervals of stress. Traditional pre- and post-testing can reveal the extent of learning, but this does not reveal moments of latent stress during the learning experience which may reduce learning efficiency. Such intervals of stress are often caused by unnecessary and correctable flaws in the construction of the program. The immediate covert revelation of such stress intervals would not only suggest specific frames in programmed sequences which should be re-examined, but would also permit the relationship of intervals of latent depression of affect with outwardly manifested behavior. Certain amounts of stress may be intended at certain points in programmed instruction sequences, but there has existed a need for a way to monitor the degree to which stress affects the involvement of the subject, both for purposes of keeping stress within tolerance limits and to detect stress where it is not intended that stress should be present. Such a technique would provide a powerful tool for program validation and evaluation.

The Purpose

It was the purpose of this experimental study to examine chart-recorded capillary pulse pressure measurement as an unobtrusive means of detecting unspecified frame-specific flaws in programmed instruction sequences. In order to test the technique, in this study specifically contrived flaws were used to evaluate the effectiveness of their detection.

The Objectives

1. To evaluate the usefulness of chart-recorded capillary pulse pressure measurements in the validation, analysis, and testing of programmed instruction sequences. This objective was met through a summarizing overview of the entire experiment, including both the tests of the hypotheses and the concomitant findings. Of particular concern here was the degree of simplicity and ease with which the experimental techniques could be applied and used.
2. To determine the sensitivity of capillary pulse pressure measurements to changes in level of affect during specific encounters with single difficult frames in programmed instruction sequences. Certain specific hypotheses from all three tests (vocabulary, wording,

and step size) were used to meet this objective.

In Test One, where the subject abruptly encountered an unknown term in a critical context, two hypotheses were used. The first hypothesis predicted that, upon encountering the unknown term, the level of affect, as measured by capillary pulse pressure, would decrease significantly. The second hypothesis predicted that if the unknown term was then defined, permitting the subject to proceed successfully onward, the level of affect, as measured by capillary pulse pressure, would rise significantly.

In Test Two, where the subjects abruptly encountered a confusing and ambiguous paragraph of information, a similar pair of hypotheses predicted an immediate and significant decrease in capillary pulse pressure, followed by a significant increase when the subjects had passed through the confusing interval and began once again to experience success with the program.

Again in Test Three, where the subjects abruptly encountered a frame of great difficulty, one of the hypotheses predicted that the initial involvement with this frame would result in a significant decrease in capillary pulse pressure.

3. To determine if capillary pulse pressure measurements could be used to detect possible lingering effects in subsequently encountered frames after subjects were confused on an earlier frame in a programmed instruction sequence.

This third objective was examined by testing one of the hypotheses associated with Test Two, in which the subjects were confronted with the ambiguous paragraph. This hypothesis predicted that subjects working on the final frame of the programs would have a lower capillary pulse pressure if they had previously experienced the confusing paragraph than would test group subjects who did not have the confusing paragraphs in their versions of the programs.

In Chapter II the hypotheses will be presented in detail, along with the detailed discussions of the tests with which they are associated. In that section it will be made clear how the hypotheses were tested on the basis of the capillary pulse pressure charts that constituted the data collected in this experiment.

4. To determine more accurately than in prior studies what is actually being measured by variations in capillary pulse pressure, in order to strengthen the validation of

capillary pulse pressure techniques begun by earlier studies. This objective was met by carefully relating the specific content of the program frames to the capillary pulse pressures during encounters with those frames while, at the same time, considering available concomitant data on the appearance, behavior, and attitudes of the subjects at the times in question.

5. To seek evidence which might support the extrapolation of the findings of this study to applications of more breadth than the detection of frame specific flaws in programs. This objective was met by examination of the findings of this study to determine to what extent they were related to the particular design and constraints of this particular study.

Review of the Literature

Introduction

In this review of the literature, there will be a brief examination of affect, followed by a consideration of the relationship between the affective and cognitive domains. Next, programmed instruction will be treated, first by an examination of program evaluation as traditionally practiced without direct psychophysiological techniques, and secondly by a consideration of direct

psychophysiological techniques for program evaluation. Also included in this review is a section explaining psychophysiological techniques other than those used in this study. There is a limited consideration of the relationship of learning and level of affect. Finally, there is a consideration of some of the kinds of flaws found in programmed instruction sequences, with emphasis on the types of flaws deliberately introduced into the programs used in this study, as explained in Chapter II.

Affect

Krathwohl, Bloom, and Masia (1964) define affect as feeling tone, emotion, or degree of acceptance or rejection. It is important to note that affective sensations normally relate to thoughts which are of cognitive origin. Regardless of one's affective feelings, degree of arousal, or level of affect, these affective sensations normally relate to some mental contents, or thoughts, that are generated through cognitive processes. Affect, then, is complimentary to the cognitive functions and provides for automatic reactions to cognitive products. These affective reactions are commonly expressed as interests, attitudes, appreciations, values, arousals, or emotional sets or biases. While the mechanisms of cognition are more nearly contained within the neural circuitry of the brain and nervous system, the mechanisms of affect have both

neural-specific components, as in the pleasure center of the brain, as well as more generalized glandular secretion components, as with the release of adrenaline into the bloodstream of the body (Wooldridge, 1963).

The Unity of the Cognitive and Affective Functions

Krathwohl, Bloom, and Masia (1964) devoted a full chapter of their handbook on the affective domain to the unity of cognitive and affective behavior. According to their taxonomy, the affective aspect of mental reactions was classified according to the degree of internalization manifested. Internalization, however, upon close inspection, is seen to be a cognitive product based on the increasing construction of significance. Internalization, then, is a cognitive reaction guided by affective reactions; it functions through an internal cybernetic loop. As cognition proceeds to function through such processes as awareness, recognition, memory, association, and synthesis, affective reactions develop relative to the cognitive thoughts. These affective reactions, in turn, influence and guide further cognition, and, accordingly, alter manifest behavior. Thus, the affective domain has only an internal reaction capacity; it provides in part a servomechanism function. And it is cybernetically linked to the cognitive domain. A discussion of cybernetic functions in human behavior can be found in Smith and Smith (1966,

pp. 353-381).

The complimentary phylogeny of the affective and cognitive functions generally precludes their realistic divorce, especially in studies such as this one which deal directly with physiological functions. It is easier to separate the cognitive and affective domains conceptually using the abstractions of constructs and models, while staying away from physiological functions which tend much more strongly to force the relationship between the two.

Affective reactions which do not relate in some obvious or valid way to cognitive products or thoughts are regarded as unnatural and indicative of either mental disorders or of tampering with the chemical mechanisms. For example, in recent years the increasing use of illicit drugs has followed the widespread discovery that the chemical affective mechanisms are subject to the spurious influences of assorted narcotics. This produces an artificial divorce of the normally co-functioning affective and cognitive domains. The resulting affective experiences, under drug influence, are strangely unrelated to cognitive stimuli, or else are not reliably or validly related to cognitive content [Louria (1968); McGlothlin, Cohen, and McGlothlin (1967); Zegans, Pollard, and Brown (1967)]. Except for such artificial tampering with the physiological mechanisms, or internal malfunctioning with the same results, the unity of the cognitive and affective functions is a reality.

This present experiment has thus proved to be concerned with the unity of the cognitive and affective functions. Significant results, as are outlined in Chapter IV, relate both to the intensity of cognitive involvement and to the influence of variations in level of affect.

Bloom (1956) and Krathwohl, et al. (1964) have classified learning into three domains: cognitive, affective, and psychomotor. These terms and other technical terms introduced in this section will be defined in the next section. There has been much research using cognitive learning as the dependent variable, and, since the 1964 classification of affective objectives, a number of studies using that scheme have been concerned with affective learning. In an article on the use of educational objectives, Krathwohl (1965) discussed both cognitive and affective objectives at several levels of detail in the planning and development of instructional materials.

However, as the following review of the literature will reveal, until very recently there has been little done toward developing means to directly monitor the level of affect of subjects in learning situations. To be direct, such measures must monitor the physiological phenomena that constitute the variation in affect being examined. Techniques for such measures, originally evolved in the field of medicine, have been widely adapted for uses in the broad field of psychology, but educators have been slow to adapt these

techniques for such things as the evaluation of learning materials and situations. The summary and conclusions of Chapter IV suggest strongly that, although programmed sequences served as the vehicle for the content in this experiment, many of the results would probably hold true for reactions to contents carried by other media. This experiment might be characterized as a study of a psycho-physiological technique for the detection of certain affective influences on cognitive involvement.

Program Evaluation Without Direct Psychophysiological Techniques

Formulae for the evaluation of programs have ranged from rigidly specified criteria for amount of practice, frame size, and other factors, to absolute flexibility as proposed by Gilbert (1960) and Mager (1962). Because no method for direct monitoring of the subject's level of affect has been available in the past, these programmers have attempted laborious composition sessions, working cooperatively with student subjects to write frames which maintain the desired level of affect within the student. Markle (1964) advocates a critical analysis and editing of prepared frames, followed by repeated trials with student subjects.

Markle (1964, p. 236) suggests a "clinical" situation for interaction with a subject who is testing a sequence of prepared frames. She advocates a combination observation, questioning, and

tape recording in an effort to monitor the students' reactions to the material. However, Markle issues the highly significant warning that students who work with an interested observer hanging on their every word are far different subjects than they would be as ordinary students in a regular classroom learning situation. Fry (1963, pp. 178-179) lists twenty-nine criteria for judging programs, but none of them involves direct, covert measures of a subject's reactions to the material. Other typical references [Lysaught and Williams (1963), Ginther (1962), Gotkin (1961), and Holland (1961)] describe program evaluation and testing, but without any mention of a means of accomplish a direct physiological measurement of the critical variables that interact in subjects encountering programmed learning experiences.

The most comprehensive study of the problem of assessing the effectiveness of instructional programs was done by Lumsdaine (1965), but it was primarily concerned with learning, and did not refer to any means of directly measuring the level of affect of subjects exposed to programmed instruction.

Although in 1966 an experiment applying physiological measures to reactions to programmed instruction was conducted (Bergum and Lehr, 1966c), program evaluation studies continue to be reported using traditional methods with success limited by the inherent indirectness and obtrusiveness [Pierleoni (1968) and French

(1968)].

Conclusion: Through 1965 there existed no direct physiological measurement of level of affect which had been applied to problems of evaluation, analysis, and testing of programmed instruction. Such tasks were attempted mainly by overt methods which demanded a significant degree of observer-subject interaction, thus contaminating the results of the observations and tests. Also, there is no indication in the pre-1966 literature that measurements of level of affect could be used to indicate intrinsic flaws in programs.

Unobtrusive and Direct Psychophysiological Evaluation Techniques for Programs

In a series of significant studies, Bergum and Lehr (1966a, 1966b, 1966c, 1966d, 1966e) and Bergum, Lehr, and Dooley (1967) validated a direct, covert measurement of level of affect. The 1966c study revealed that the level of affect of subjects working on programmed instruction sequences could be determined from measurements of any of these four things: capillary pulse pressure, response latencies, eye movements, and eye blinks. Subjects who worked through a program which they did not like, as shown by both verbal responses and the above four measurements, scored the same on a criterion test as a similar group of subjects who had completed a much more preferred version of the program as measured in the same ways.

These measurements did not differentiate between learning for higher and lower levels of affect, because the affect levels varied with changes in length, intrusion of attempted humor, and other variables which were unrelated to items on the learning criterion test.

Of the four physiological measures found in these studies to be related to level of affect, chart-recorded capillary pulse pressure measurement best predicted the subjects' affective reaction and proved to be the least obtrusive physiological measure available. However, in the study that concerned programmed instruction (Bergum and Lehr, 1966c), the capillary pulse pressure was averaged over uniform time intervals so that the results were indicative of the subjects' general progress through the program, but the results were not frame-specific. The authors recommended further studies of the same general type, but with greater attention given to the manipulation of frame-specific affective values within the program.

A subsequent study (Bergum and Lehr, 1967) examined the effects of the interest value of stimuli on pulse rate, capillary pulse pressure, and overt evaluation response latencies. In this study, twelve subjects evaluated twenty four-letter words in terms of an interesting-dull dimension under both visual and auditory presentation conditions while the three measures of interest were

simultaneously recorded. While there appeared to be no relationship between pulse rate and interest level, there were significant functional relationships between both capillary pulse pressure and overt response latencies and levels of interest.

Silber (1969) attempted to use capillary pulse pressure measurement to discriminate between degrees of preference by subjects who had previously been exposed to different modes of presentation of information on different countries. This attempt was not successful, probably because the physiological measures were made long after the actual presentations rather than at the time of the presentations. The sought-after physiological effects do not persist beyond the experience that causes them, according to the results of this present experiment. Consequently, if the later recall of the experiences was insufficient stimulus to re-evoke the original degree of arousal, which is frequently the case, then the discriminatory powers of the technique would be prohibitively desensitized.

Conclusion: There now exists a relatively covert and direct physiological measure of affect which is sensitive to a subject's reaction to learning experiences with programmed instruction. However, further study is needed to explore the potential usefulness of this technique as a tool for use in program evaluation, testing, and analysis.

Other Psychophysiological Techniques

The galvanic skin response (GSR) has long been regarded by psychologists as the most sensitive physiological indicator of psychological events, according to Montagu and Coles (1966), who summarized ten years of study on the subject of GSR techniques. The previous summary had been done by Woodworth and Schlosberg in 1954. According to the recent summary, the GSR is also known as the psychogalvanic reflex (PGR) or the electrodermal response (EDR).

The GSR covers two distinct but related phenomena: the first is a drop in the electrical resistance of the skin to the passage of an applied current, discovered by Féré (1888); the second, the phenomenon of Tarchanoff (1890), is a change in the natural potential difference between two areas of the body surface. The mechanism of the resistance change is better understood, and it always drops with arousal; whereas, the change in potential difference may be biphasic (Forbes, 1936). For these reasons, the resistance change has usually been regarded as the more satisfactory measure; it is merely a rapid change in skin resistance occurring in response to a stimulus.

The responsible mechanism for the GSR phenomenon is apparently mediated solely through the sympathetic cholinergic nerve supply to the skin, with a resulting change in the sweat glands (Lader and Montagu, 1962). The changes are probably in the nature

of a decrease in polarization accompanying an increase in permeability of the cell membrane (Gildemeister, 1915). When the electrodes are placed at two positions on the surface of the skin, the electrical current passes directly through the skin beneath the electrodes, which has an exceedingly high resistance, and moves between the electrode positions through the moist tissues beneath the skin, which have a negligible resistance to electrical currents. The sweat gland response to a stimulus, which produces salt solutions in the skin layers, reduces the electrical resistance of the skin, and this results in an increase in current flow, detectable with appropriate instruments (Darrow, 1934). Montagu and Coles (1966) present a detailed summary of problems associated with GSR measurements, including a variety of electrical complications and the effects of a large number of other known variables.

The literature on GSR applications is extensive, but most of the studies have pertained to psychological applications, with very few studies directly related to educational teaching and materials problems. A number of studies, such as Lobb (1968), Lobb and Nugent (1966), and Karrer and Clausen (1967), have used galvanic skin response techniques to discriminate between mentally defective persons and those considered normal. Other studies, such as Oetting (1966), have used GSR to measure stress; in this case, during testing situations. GSR has also been used extensively in the

detection of deception, as in Gustafson and Orne (1964). A number of GSR studies have applied GSR techniques to the detection of affective arousal, such as Krugman (1965) who considered the effects of television commercials. A relatively recent study applied GSR techniques to the evaluation of different modes of projected visual presentations (Milier, 1968). Bingham (1943) studied the relation of GSR to the significance of selected words. McGlothlin, Cohen, and McGlothlin (1967) applied GSR techniques to the detection of physiological changes caused by the ingestion of LSD-25.

Several studies in recent years have related eye pupil size to attitudes and emotions [Hess (1965); Hess and Polt (1964); Hess, Seltzer, and Shlien (1965), Bergum and Lehr (1966a); and Watson (uncompleted)].

A number of psychophysiological methods are described by Ax (1964) in an essay outlining the goals and methods of psychophysiology. Brief descriptions and references are cited for the electrocardiogram, electro-encephalogram, electrodermal potential, electromyogram, electroocular potential, and the potentials from several visceral organs. Also mentioned are assorted instruments for monitoring temperatures in various parts of the body, different types of blood pressure, and internal pH levels. Finally, this essay discusses a number of the associated recorders and signal transformers associated with such psychophysiological techniques.

Coddington, Sours, and Bruch (1964) employed the electrogastrogram (EGG) to monitor changes within the gastrointestinal tracts of subjects. They found sudden changes occurring in the EGG tracing when the subjects experienced anxiety, anger, or pain.

Learning and Level of Affect

The media-related research [Ash (1949), Heidgerken (1948), Twyford (1951), VanderMeer (1954), Westfall (1934), Neu (1950), Hovland, Lumsdaine, and Sheffield (1949), May and Lumsdaine (1958), Baker and Popham (1965), Eigen (1963), Eigen and Feldhusen (1964), Hough and Revsin (1963), Roe (1960), Brandon (1955), Vernon (1953), Jorgenson (1955), Merrill (1956), Bergum and Lehr (1966c)] indicates no relationship between interest and attitudes toward instructional material and the amount learned from it.

Several non-media-related studies [Tesse and Kapp (1964), Walters and Parke (1964), Krasner, Knowles, and Ullman (1965), Brodie (1963, 1964), Amster (1964), DeLucia (1963), and Shaevitz (1963)] indicate that a heightened level of positive emotional arousal facilitates performance on a learning task. Fraley (1966) has theorized that value is a conceptualization reaction to pleasure, which is an automatic, high neural-synergy consequence of need fulfillment. This theory posits that success attainment during goal-directed learning will increase the level of affect in the learner.

Subject behavior toward a learning situation can be described using the Lewin (1935) model. A student manifests responsive behavior toward the most positive goal, perhaps a remote or abstract one, and often in the presence of more immediate negative factors which may produce a depressed level of affect during the learning experience. Mowrer (1954, 1956, 1960a, 1960b) claims that whether or not a cognitive response to a stimulus is learned depends upon which affective response--hope or fear--has been associated with that stimulus. Amosov, et al. (1965) determines how input will be evaluated and responded to, based upon the emotional state the input evokes. Bruner (1960) points out that it is necessary for the learner to develop an interest in what he is learning. Gagne (1965) defines the first step in the learning process as "signal learning"--an affective response of being alert and attentive to the stimulus. Krathwohl (1964) maintains that attending to a stimulus is prerequisite to knowing it, and that interest, hedonic tone, and motivation are effective factors that are used as means to cognitive learning.

A few psychophysiological studies involving learning have been reported. Kleinsmith and Kaplan (1963) used GSR measurements to determine arousal during a learning experiment on recall. Paired associates learned under low arousal exhibited high immediate recall value and rapid forgetting. High arousal paired

associates exhibited a marked reminiscence effect; that is, low immediate recall and high permanent memory. Levonian (1968), also using GSR to measure arousal, determined that the relation of arousal, as indicated by GSR, and retention is nearly the same for both auditory and visual learning.

Conclusions: Level of affect and learning correlate highly when (1) high level of affect and learning are both consequences of attainment in goal seeking, or (2) when high level of affect from previous success is acting as motivation in the pursuit of subsequent learning-related goals.

Level of affect and learning do not correlate highly when relatively remote or abstract goals are cognitively pursued in the absence of immediate pleasure rewards or in the presence of associated but unpleasant stimuli. The use of the phrase "level of affect" here refers more to pleasure-related emotional states, as opposed to states of relative stress intensity or intensity of cognitive involvement.

Before using capillary pulse pressure in learning experiments as the dependent variable, studies such as this experiment are needed to validate the capillary pulse pressure techniques. More knowledge of the type that this experiment is designed to gain is needed in order to determine just what is being measured by capillary pulse pressure variations.

Because of the large number of studies which have led to these conclusions, this study did not devote further concern to the relationship of affect and learning. The subjects in this study were not tested on what they had learned from the programs or how well they had learned it. The scope of this study remains limited to the capillary pulse pressure reactions upon subject encounters with specific, contrived flaws in the test programs.

Intrinsic Flaws in Programs

Most authorities on programmed instruction agree on the prevalence of certain basic flaws that appear in programs. These include poorly worded passages which cause confusion, the use of words for which the student has no adequate definition, and inappropriate step sizes. Markle (1964, pp. 227-228) lists a summary of rules for good frames and sequences, in which rule number one concerns good English and rule number fourteen concerns step size.

A smaller step size seems favored, but variations in defining step size and research characteristics will not allow a blanket statement in this area [Evans, et al. (1959); Shay (1961); and Smith and Smith (1966, p. 311)].

Lysaught and Williams (1963, pp. 142-143) point out that assumptions about learners, such as assumptions about the

educational level of the learner's parents, can cause the programmer to assume a certain vocabulary not consistant with the reading test data.

Fry (1963) presents a comprehensive, seven-and-one-half-page classification of variables involved in a programmed learning situation. It is in outline form with twenty-six major divisions, each of which typically has several subheadings. In this outline, readability is covered in section C, 4 with vocabulary specifically covered by the secondary heading C, 4, a. The magnitude of conceptual and creative difficulties of steps is covered under headings C, 3 (number of ideas) and C, 8 (probability of correct response). These specific citations constitute recognition by an authority on programmed instruction of the specific variables chosen for use in this study.

Programs which are interesting to students can be written, but after the initial novelty wears off, students are usually neutral in their feelings toward programmed instruction. In cases where a high acceptability remains, this is probably because students like immediate knowledge of results. If a "pall level" sets in (point where learning stops), this is probably due to boredom rather than physical fatigue [Eigen (1963); Audio-Visual Instruction, No. 6, pp. 150-151 (1961); Pressey (1950); and Rigney and Fry (1961)].

Students taught by programmed instruction usually do as well

as or better than the control group, and take less time. Studies exploring the age variable, elementary through adult students, and the ability variable, retarded through gifted, have found programmed instruction effective with all groupings along these variables [Hough (1962); Hughes (1962); Hughes and McNamara (1961); and Porter (1959)].

The programs designed for this study bring the subjects to an involving confrontation with some insoluble problems, which is a stress-producing situation. The threat of failure to succeed was necessarily felt by all or most of the subjects as repeated efforts failed to yield the breakthrough that was needed to proceed. Such situations produce a psychological state known as "situational anxiety" (Ausubel, 1958, p. 330):

> . . . the normal type of anxiety that arises in relation to exogenous threats to self-esteem. It is a self-protective reaction which is limited to the duration of the situation that elicits it and is proportionate to the objective magnitude of the threat involved. Situational anxiety is inherent in almost any new ego-involved task or problem that exposes the individual to the possibility of frustration, failure, or loss of self-esteem.

The capillary pulse pressure techniques used in this study were applied to the detection of the elicited situational anxiety, but, as Chapter IV reveals, the techniques seemed equally or more sensitive to the psychological withdrawal phenomenon that is a common subsequent reaction in order to escape situational anxieties.

Many of the studies involving psychophysiological techniques describe measurements of "arousal," while others mention that it is "stress" that is being measured. Exactly what these terms mean and exactly what it is that they measure is often somewhat vague. There is a tendency to simply cite earlier validation studies which relate the variable in question to "stress" or "arousal." In this study, considerable concern was devoted to determining as accurately as possible just what was being measured by the variations in capillary pulse pressure with the result that the phrase "intensity of cognitive involvement" was finally coined and used. This phrase seemed to be the most accurate description of the dependent variable that could be derived from the total results of this study considered alone. It seems apparent that some, although not necessarily all, of the previously cited studies which use the terms "stress" or "arousal" are referring to this same variable.

Conclusions:

1. It is authoritatively recognized that significant intrinsic flaws in programs include vocabulary of inappropriate level, poor wording which can cause confusion, and difficulty steps of inappropriate size.
2. Age and ability are not significant variables relative to the potential effectiveness of programmed instruction.
3. The confrontations with insoluble problems in the test

situations loaded into certain of the program versions can be expected to cause situational anxiety in many, or all, of the subjects who encounter them.

Definition of Certain General Terms

Cognitive

"Cognitive" is used as an adjective to describe learning objectives which emphasize remembering or reproducing something which has presumably been learned, as well as objectives which emphasize the solving of some intellective task for which the individual has to determine the essential problem and then reorder given material or combine it with ideas, methods, or procedures previously learned (Krathwohl, p. 6).

Psychomotor

"Psychomotor" is used as an adjective to describe objectives which emphasize some muscular or motor skill, some manipulation of material and objects, or some act which requires a neuro-muscular coordination (Krathwohl, p. 7).

Affective

"Affective" is used as an adjective to describe objectives which emphasize a feeling tone, an emotion, or a degree of acceptance or rejection . . . [and which are] expressed as

interests, attitudes, appreciations, values, and emotional sets or biases (Krathwohl, p. 7).

Level of Affect

"Level of affect" is the relative location of feeling tone, emotion, acceptance, interest, attitude, appreciation, value, and emotional set on a continuous scale between a positive extreme related to pleasure, satisfaction, and satiation and a negative extreme related to frustration, despair, and unfulfilled need.

Program

A program in this study is a formal programmed instructional sequence of specific frames.

Delimitations

1. Learning

This study was concerned with exploring the potential of a new tool for use in instructional materials design and evaluation through the physiology of learning. The problem of the efficiency and effectiveness of learning as a function of level of affect was not examined in this study.

2. Instructional Material Evaluated

Programmed instruction was the only type of instructional

material used in this study.

3. Subjects

The subjects were approximately one hundred twenty tenth through twelfth grade students selected at random from the student body at Pacific Shores High School, Manhattan Beach, California, in the South Bay Union High School District. This community is a close Los Angeles suburb. Data from subjects whose general scholastic inability or low reading level prevented them from completing the test programs in the time allowed for each session were rejected; about one in twenty subjects was rejected for this reason.

4. Level of Affect Measurements

Level of affect was measured by only one method, that of chart-recorded capillary pulse pressure (Bergum and Lehr, 1966c, p. 5).

5. Subject Matter

The content of the three short programs was creative problem-solving; each program taught the necessary approach to a different problem type with initial analysis of the problem and subsequent synthesis of the solution (Appendix B).

6. Intrinsic Flaws

The only three kinds of intrinsic flaws in programs studied

were (1) the use of unfamiliar vocabulary, (2) confusing wording, and (3) excessive step size in terms of difficulty.

7. Level of Difficulty

The short programs used in this study were validated for use with high school level students or higher.

CHAPTER II

EXPERIMENTAL DESIGN AND METHODOLOGY

The Experimental Design

The experimental design called for recording the capillary pulse pressure of subjects as they worked through some programmed instruction sequences that had some specific flaws deliberately inserted into them. It would then be possible to determine if the records of the capillary pulse pressures would show characteristics that would independently reveal these encounters without the need for any further overt interaction with the subjects.

Rather than have just one program into which to load the contrived flaws, it was decided to design and use three short programs in order to counter and detect effects intrinsic to specific programs. The three programs dealt with techniques used in creative problem-solving and were intended to be interesting and quite similar in construction, yet with related but different content. The entire experiment was then repeated three times, once using each of the three programs. This proved to be a fortuitous course,

because one of the more significant results of the study was the revelation that capillary pulse pressure measurements could discriminate between certain subtle differences between these different programs.

The experimental paradigm (Fig. 1) shows the three programs listed across the top of the chart. Down the left side are the types of flaws that were inserted into the programs, with the control version being relatively flawless. One problem was that after a subject had been used once, he could not be used again, because experience with the programs and their contents would act to contaminate the results. This required dividing the subjects into groups, with each group being used only once.

Furthermore, in order to prevent an encounter with a specific flaw from altering, in some unknown way, the effect of an encounter with a second flaw, it was decided that only one flaw at a time would be tested. Each version of each of the three programs would contain only one flaw, or no flaws in the case of control versions. This necessitated a new group of subjects for testing each flaw in each program. There were thus twelve groups of subjects who worked on twelve program versions (A-L), as shown in Figure 1.

The control versions were intended to be relatively easy for the subjects and free of significant stress intervals. Groups getting

TEST CHARACTERISTIC	VERSIONS OF PROGRAM 1	VERSIONS OF PROGRAM 2	VERSIONS OF PROGRAM 3
Unfamiliar Term	A	B	C
Confusing Wording	D	E	F
Excessive Step Size Between Frames	G	H	I
CONTROL (Relatively Flawless)	J	K	L

Fig. 1. --Experimental Paradigm

test versions of the programs got versions altered only slightly to allow the insertion of test frames; the inserted test frames were contrived to be in critical context so that the intended encounter could not logically be circumvented by the subjects. Thus, the subjects were forced by the construction of the programs into an involving confrontation with three typical difficulties found in programmed instruction sequences. These typical difficulties, chosen for use in this study and inserted as flaws in certain versions of the programs, included unfamiliar terms, confusing or ambiguous wording, and abruptly excessive step difficulty between frames.

The flaw involving the unfamiliar term consisted of a meaningful sounding non-word invented for this study and inserted in a critical context into the program; three such non-words were used, one for each of the three programs. Confrontations with these non-words were in tests labelled Test One. The ambiguous wording, in tests labelled Test Two, consisted of confrontations with familiar words and phrases woven into a paragraph of meaningless statements. The abruptly excessive step size, in tests labelled Test Three, were confrontations with insoluble problems that were implied to be somewhat readily soluble.

In the remainder of this chapter, there is detailed discussion on the subjects used, the physical arrangements for the experiment, and the construction, presentation, and evaluation of

each of the three tests involving the three chosen types of flaws.

The Subjects

The Selection of Subjects

The nature of this study suggested that a population of high school students would be the best source from which to draw subjects, but the rigid and formal structure of operations within most high schools prevented their cooperation in this project. It became necessary to find a high school which featured a flexible scheduling program with reduced inherent rigid structuring. An agreement of cooperation was established with the administration of Pacific Shores High School in Manhattan Beach, California. This institution serves the South Bay Union High School District as a continuation high school.

An orientation session in advance of the experiment elicited the interest of the student body without compromising the content of the test materials, and during the data collection phase of the experiment about one hundred sixty students volunteered as subjects. This was nearly all of the regularly attending student population of this school. The orientation session introduced students and faculty members to the experimental design, data collection procedures, and equipment to be used. The significance of the experiment was stressed, and apprehensions about the use of the equipment in a lie

detection capacity were placated.

Characteristics of the Subjects

The subjects were of high school age and were in grade levels ten through twelve. They attended Pacific Shores High School on referral from the other high schools within the district, mostly because of adjustment problems at those other schools. Typical reasons for such referrals included law violations, pregnancy, and the inability to tolerate the rigid structure of the more traditional high schools. At Pacific Shores High School, these students were treated in a relatively adult manner in a rather informal, low pressure atmosphere. Smoking and dress regulations were minimal, and students worked at their own pace on individually prescribed programs; attendance was voluntary. Most of the students were working at academic levels below the average for their ages, but some, whose adjustment problems had stemmed from their high intelligence, were academically advanced. The students generally liked this school, were relaxed there, and were rather well adjusted.

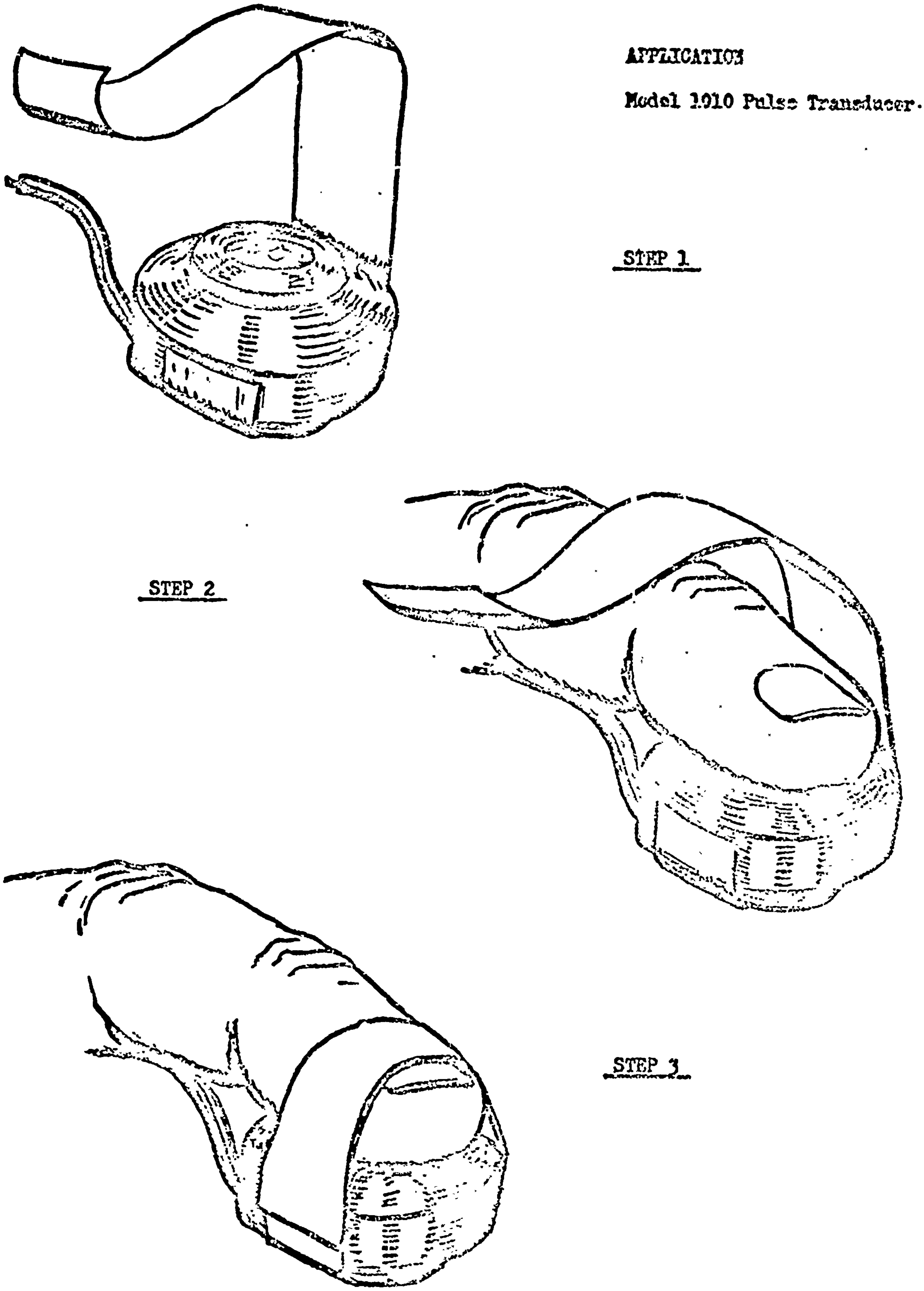
The students at Pacific Shores High School were already accustomed to individualized instruction, some of it a formally programmed format, so the test materials in programmed form were not strange to them. Because cited research exploring the

age and ability variables have failed to find programmed instruction ineffective with any grouping along these variables, these students were not rejected on the basis of these criteria. The only reason found for rejecting students as subjects was for reading speeds so slow that it became logistically impractical to wait for them to finish the test programs. It was possible to screen out the bi-lingual students with very low English reading skills in advance, but all others were allowed to participate. When it became necessary to terminate a session before one or more of the subjects present had completed the test program, the session was ended without implying in any way that the lagging subjects were inadequate, but their data were voided. This happened with about one in twenty subjects.

Data Recording

Throughout the entire data collecting process, each subject, as he worked on the programs, had a small pulse transducer taped to the end of his index finger on his non-writing hand, with masking tape, as shown in Figure 2. The transducers used were Biocom Model 1010 Pulse Transducers manufactured by Biocom, Inc., 5883 Blackwelder Street, Culver City, California 90231. The pulse transducers generated a significantly stronger signal when the fingers to which they were attached were clean and warm. The pulse transducers were connected to an eight-channel chart recorder

Fig. 2--Application of the pulse transducer



manufactured by the Offner Division of Beckman Instruments, Inc. The capillary pulse pressure of each subject was continuously recorded throughout his interaction with the test program on which he worked. The chart recorder put electrostatic spark marking on the chart paper which advanced at the rate of one hundred millimeters per minute.

It was necessary to be extremely careful in grounding both the subject and the equipment, because the slightest loss of grounding contact resulted in the pickup and amplification of sixty-cycle electromagnetic waves generated by the alternating current in the wiring circuits of the building. Capillary pulse pressure is so weak that the chart recorder had to be operated near the most sensitive limits. At this extreme sensitivity, the sixty-cycle interference completely obscures the weaker pulse signals, as shown in Figure 3. Black conducting paint on the transducers was adequate to ground the subjects when the index fingers to which they were attached were clean and slightly moist, but dirt, grease, and extreme dryness caused grounding failures in some cases.

It proved necessary for the subjects to hold the instrument contacting hand very still during the entire data collecting interval to prevent bursts of static like those shown in Figure 4 from obscuring the pulse signals. Such static was generated by the movement of connecting cables, shifting of the position of the hand,

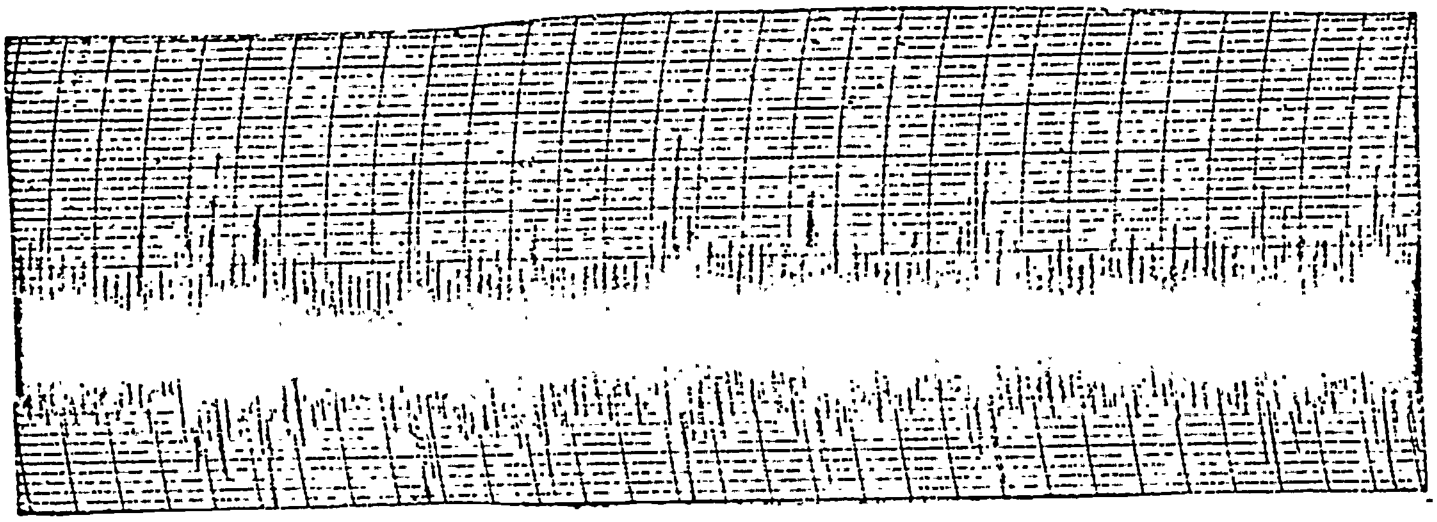


Fig. 3.--Sixty-cycle A.C. interference superimposed on a pulse

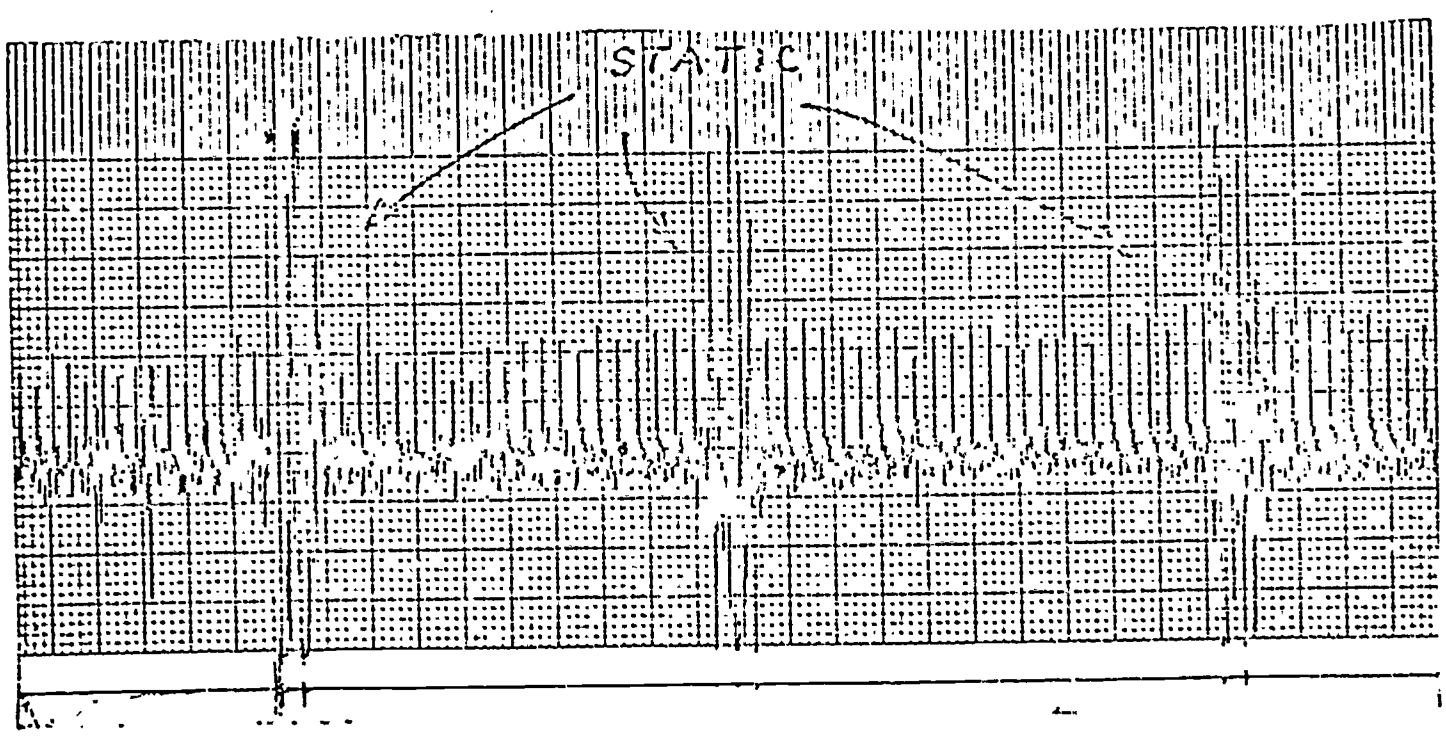


Fig. 4.--Three occurrences of noise or static
caused by hand movements

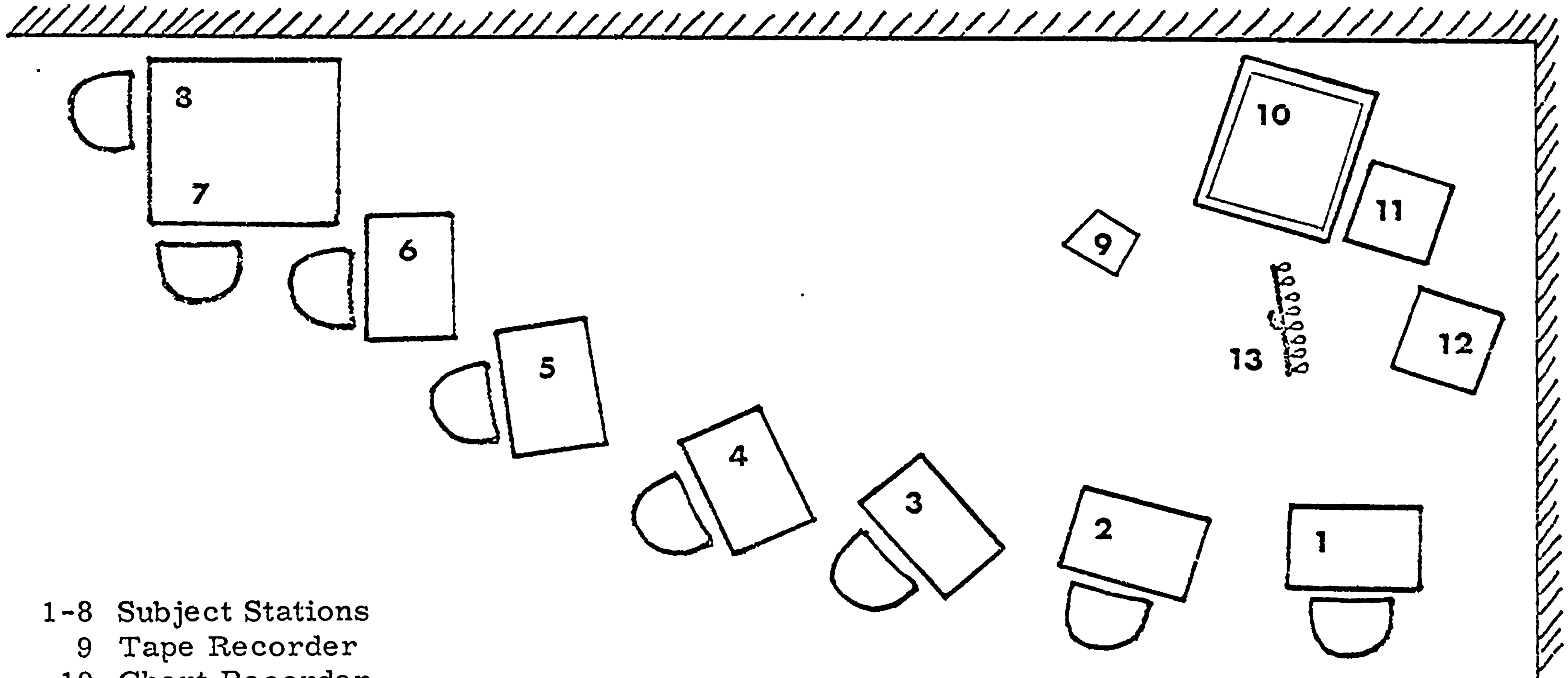
scraping the transducer against clothing or other fingers, and allowing the transducer to rest against any solid object such as the table top or chair arm. The use of chairs with arms reduced this interference by allowing the subjects to rest their arms with the transducer-connected finger dangling motionless in space. Capillary pulse pressure is often noticeably stronger when the wired finger is held lower near lap level as opposed to higher near chin level.

Mode of Presentation of Programs

The programs were mimeographed in black ink on standard white 8 1/2" x 11" mimeograph paper. The programs were three-hole punched and placed in a loose-leaf notebook. Each page contained a single frame. Between each program page a 9" x 12" sheet of colored construction paper was inserted, each with a small tape tab along the outside edge to facilitate page-turning with one hand. The tabs were arranged so that in each case the uppermost tab would turn to the next page. The shortest version of any program used had thirteen frames, and the longest had sixteen frames.

The Experimental Station

Figure 5 shows the arrangement of the experimental station which was set up in one corner of a standard sized classroom. Eight subjects were tested at one time, and they were seated



1-8 Subject Stations
9 Tape Recorder
10 Chart Recorder
11 Chair for Operator of Chart Recorder
12 Chair for Observer of Subjects
13 Battery of Signal Lamps

Fig. 5.--Arrangement of the data collection stations

individually at small tables in an arc, facing inward toward the corner of the room. The chart recorder, about two feet square and seven feet tall, was placed within the included corner area. Two chairs were located at the chart recorder, one directly in front of the controls for the operator and the other immediately behind and slightly to the side of that chair for the subject observer. The observer watched the subjects closely to detect each instance of page-turning and quietly informed the operator by subject station number when pages were turned. The operator then marked the appropriate chart channel by drawing a line across it. Thus, the progress of each subject through the programs could later be studied on a frame-by-frame basis. The operator also assisted the observer in spotting page turns by subjects whenever his attention could be directed away from the controls.

In order to decrease data losses caused by the occasional failure of the observer-operator team to detect a page turn, the help of one additional assistant was enlisted. This person moved quietly back and forth behind the subject stations holding up cards with large numbers to signify the frame of the program on which the given subject was then working. These numbers were recorded on the charts by the operator, thus providing definitely known fixes every few frames along each subject's chart record. Carpeted floors made possible the inaudible movement of the card-flashing

assistant so that the working subjects were generally unaware of his presence and activity.

Also included in the corner area was a tape recorder which was used to play tape-recorded instructions to the subjects. This provided uniformity between groups and freed the operator and assistants to adjust the recorder controls and check the incoming signals from the transducers. The directions are presented in Appendix A.

On the corner of each subject's desk was a small box containing a graphite pencil with eraser, a fluid marking pen, and a small clear plastic straightedge. Also present was a small button switch which the subject could push, as directed in the program, to turn on a light located beside the operator. The row of eight lights located there were used to indicate certain critical events, and the turning on of a light was recorded on the appropriate subject's chart by the operator.

The complex network of wiring that covered the floor of the experimental area was covered with small rugs which permitted safe walking in the area.

In order to reduce the distraction of the subjects during the data collection process, the front of the chart recorder was turned away from their view and a cardboard shield taped to the side of the chart recorder to further hide the controls and the operator as

he manipulated the various controls while the subjects worked.

The Tests

Time and Place of Tests

The data collected in this study were collected from November 18, 1968, through November 26, 1968, at Pacific Shores High School, Manhattan Beach, California. Data were collected only between 8:00 A.M. and 3:00 P.M. during regular school days with from two to five data collecting sessions held per day.

The Validation of the Instruments

The programs used in this study were written in the spring of 1968, specifically for this research project. They were first administered to individuals and small groups comprised of adults and secondary school students. An attempt was made to utilize test subjects with limited formal education. After much editing based on the results of the initial trials, the programs were then administered to approximately ninety undergraduate education majors attending summer classes at West Virginia University. These students also critiqued the programs, and further editing was done. Finally the programs were administered to about ten high school students of relatively average academic ability, after which the final editions were prepared. The final editions, as given to the subjects in this

study, are presented in Appendix B.

Control Versions

The control versions of each program were designed so that the target population could achieve relatively easy success at solving the types of problems presented in the programs. It was intended that the control versions lead the subjects easily through the short programmed lessons culminating in success on a final test frame which, prior to the programmed lesson, would have been relatively difficult.

The control groups worked through the programs, and were instructed to press the button in front of them upon achieving success in the final test frame. The pressing of the button turned on a light signaling the operator to record the culminating event on the appropriate chart, but the capillary pulse pressure was monitored long enough beyond this point to test for related changes in capillary pulse pressure following the culminating moment of success.

Test One--Vocabulary

A special test frame was blended into the control version of each program at or near frame ten. The inserted frame contained a word which had to be understood in order to proceed, but which none of the subjects understood. To insure ignorance in this critical context, a meaningful sounding nonword was created for this purpose.

The subjects were admonished in the frame instructions not to proceed without successfully completing the frame response according to the directions given in the frame.

After a seventy-five second period of frustration with this frame, each subject was told by the data collection assistant to go on to the next frame. In the next frame the unknown term was immediately defined for the subject, and the same problem was again presented as it was in the previous frame. The definition rendered the frame easy, and the subjects then succeeded and continued on through the remaining frames in the program. Test One frames are in Appendix B and in Figures 10-18.

Hypotheses:

1. When the unknown and undefined term is encountered, the level of affect as measured by capillary pulse pressure will decrease significantly.
2. When the undefined term is defined and the subject continues successfully through the next frame, the level of affect, as measured by capillary pulse pressure, will rise significantly.

Test Two--Wording

A pair of specially designed test frames (Appendix B and Figures 21-29) were inserted into the programs at or near frame ten

which first presented apparent information that was loaded with previously encountered words and phrases from earlier frames. However, this information was contrived to be nonsense so that every subject who read it correctly would necessarily be confused by it. There were no admonitions against proceeding, and the subjects eventually turned to the next frame. There they were immediately furnished with answers to the test frame questions which could not possibly have been logically derived from the information provided. The remainder of this second frame was devoted to a resumption of the control versions of the program.

While very few programmers actually write frames that are confusing to all subjects, this test was designed to produce confusion on the critical frame in all of the subjects in order to test the sensitivity of the capillary pulse pressure measurements to confusion initiated by exposure to a single frame, and to determine if subsequent performance on later frames is thereby affected in such a way that capillary pulse pressure measurements can detect it.

Hypotheses:

1. The subjects will experience a significant decrease in level of affect as measured by capillary pulse pressure during exposure to the test frame.
2. The decreased level of affect, in subjects who experience it in the test frame, will persist in these subjects until

they are reinforced by success or anticipated success on the next frame after the test frame. (The test for re-elevated mean capillary pulse pressure will be made on an interval in the first several seconds of the second frame after the test frame. It will be there, where answers to questions in the previous frame are given, that the subject gets his first opportunity for positive reinforcement after experiencing the confusion of the test frame.)

3. The mean capillary pulse pressure for all subjects in Test Two on the final test frame of the program will be significantly lower than the corresponding mean for subjects in the control group. (This reflects the possibility that the depressed level of affect resulting from an encounter with a confusing frame might persist through subsequent frames.)

A diagram of Test Two is presented in Figure 6.

Test Three--Step Difficulty

This test was designed to study the reaction of a subject to an abrupt increase in step difficulty in a programmed instruction sequence. To insure that all subjects experienced what they perceived to be too difficult a step, the testing frames of the

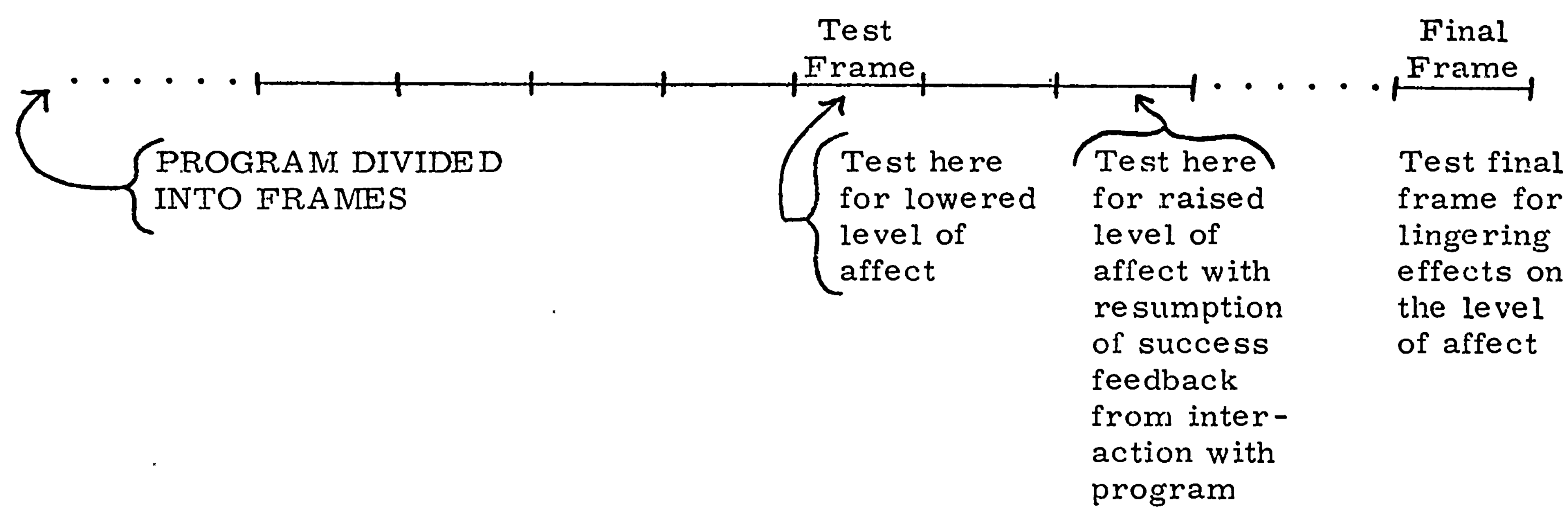


Fig. 6.--Diagram of Test Two

programs required a solution to a problem which is insoluble as given (Appendix B and Figures 34, 35, 38, 39, 42, and 43).

After the body of the program elicited the interest of the subject and broadened his insight into solution techniques, he encountered at least one easy practice frame and was rewarded with success. He was then given a final testing frame, supposedly only slightly more difficult, but which actually presented an insoluble problem. It was intended that the subjects begin to work on the test frame with a high degree of confidence acquired from successes in the preceding frames.

The subject was instructed, both in the initial program instructions and again in the directions printed in the final test frame, to indicate the moment when he either first started losing interest, became bored, became frustrated, or developed some negative attitude relative to this insoluble test frame. This instruction was kept as free as possible of any implication that the frame was indeed insoluble. The method for indicating the decrease in level of affect was to press a button that resulted in an incident mark on the capillary pulse pressure chart in the recorder.

Hypotheses:

1. Capillary pulse pressure during the interval from the start of the test frame until the button is pushed will be significantly lower than for an appropriate interval

immediately preceding the final frame.

2. Capillary pulse pressure during the interval from the start of the test frame until the button is pressed will be significantly higher than during an appropriate interval following the moment when the button was pressed.

3. The capillary pulse pressure during a short interval immediately after the button is pressed will be significantly lower for this test group than for the control group.

The Test Three hypotheses reflected the possibility that pressing the button, or making any overt admission of frustration or stress, would be ego-deflating and would be resisted. Thus, it was thought possible that the level of affect would actually be significantly lowered, because of the encountered fault in the program, before the typical subject would admit it. It is this possible ego defense contamination in overt testing of subject reactions which this covert capillary pulse pressure monitoring may be capable of overcoming.

This test was also designed to reveal whether a program flaw of this type can be latent relative to capillary pulse pressure detection methods while the subject continues to perceive only a stimulating challenge. The answer to this question has been revealed by examination of capillary pulse pressure in the final insoluble test frame. The programs are designed to lead the

subject to this final frame with a high success expectancy. If, however, the problem is immediately perceived as being discouragingly difficult, anxiety and withdrawal could be expected at once. But if the subject attacks the problem with initial confidence, there would be tolerated stress, possibly without anxiety, at least in the beginning. The question, then, for this test, is how the flaw in the frame is going to be detected.

This question depends largely on what it is that is measured by the changes in capillary pulse pressure. If stress can be thought of as a constraining mental force, then stress would be inherent in all, or most, cognition, especially the more complex or higher level cognition. When cognitive efforts begin to be perceived as failing to meet the needs which motivate them, then anxiety is experienced; anxiety is an unpleasant awareness of threat or impending ill. As Chapters III and IV reveal in great detail, capillary pulse pressure appears to vary directly with the intensity of cognitive involvement, which can probably be regarded as stress. However, the onset of anxiety, which is inevitable with an insoluble problem, tends to elicit the simple defensive maneuver of withdrawal. Withdrawal not only removes the threat of failure and thus eliminates the anxiety, but it also necessarily reduces cognitive involvement and, hence, lowers the stress level. This appears to be what happened in this experiment. Involvement was revealed, but it was anxiety

that apparently could remain latent until it became severe enough to elicit a withdrawal, at which time its presence was revealed. It was only then that the flaw was detected, because the flaw was revealed by the withdrawal that it caused.

A program flaw that simply elicits greater cognitive effort will probably remain latent, because it cannot be distinguished from something of interest in the program; but a flaw that remains enough of an obstacle to cause anxiety and thence withdrawal will be revealed by the detection of the withdrawal.

Presentation Order in Program Administration

Because high school student subjects could be expected to communicate freely about the content of the programs being used, it became necessary to give some consideration to the order in which the different versions of the programs would be revealed during the nine-day interval of data collection. It was decided to work with one program at a time until all four versions of it had been administered before going on to another program. This was intended to reduce the time allowed for information about each program to be disseminated among the students before all versions of that program had been used. For similar reasons, it was necessary to present the four versions of each program in a particular order. Test Three, with the insoluble last frame, was used first to prevent

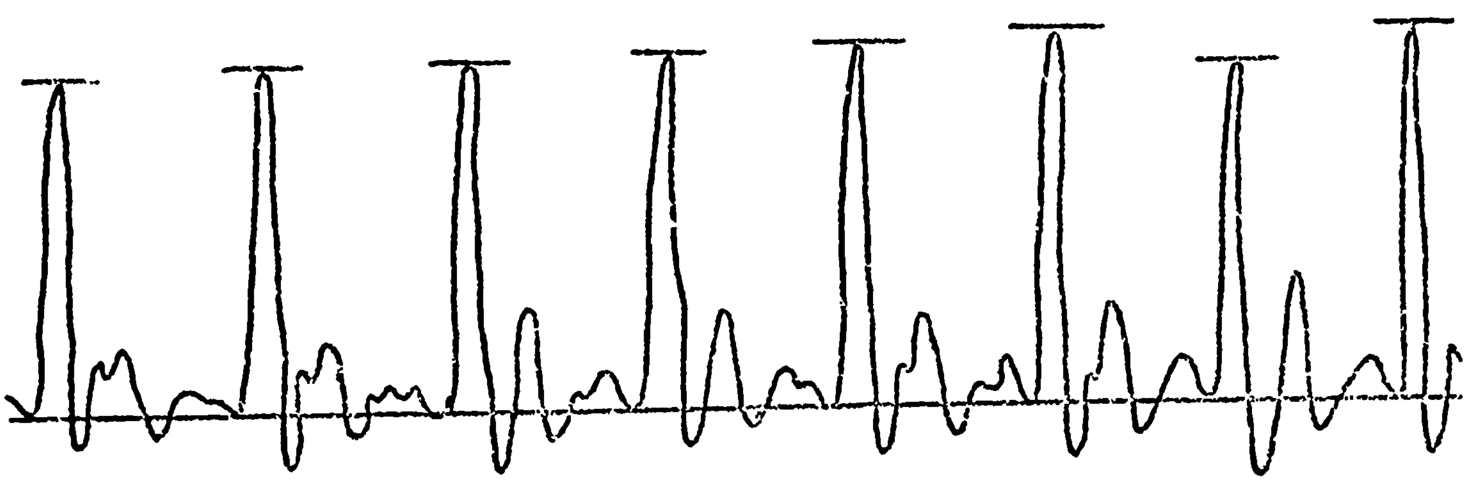
the spread of the correct final problem and solution as well as the unknown term and confusing statements of Tests One and Two. Test Three was followed with Tests One and Two, administered concurrently with no more than three subjects on Test One at a time. This was because subjects on Test One had to be monitored and allowed exactly seventy-five seconds on the test frame, and the data collection assistant could do this for no more than three of the eight subjects working at one time. The control version was held until last, because it was intended that this version be as easy as possible and prior information would only facilitate progress. Correct information would aid directly, and incorrect reports of difficulties stemming from the test frames of other versions would bolster confidence by their absence.

Statistical Treatment

Some of the hypotheses in this study have required the comparison of specified pairs of intervals on the chart records of individuals. Because each pair of intervals is generated by a single individual, the samples which these intervals represent are correlated. The procedure used has been a test for the significance of the difference between two means for correlated samples (Ferguson, 1959, p. 138). This procedure groups all subjects who have completed a given program version and yields a result related

to the whole group rather than to the individuals within it.

In order to determine the means for the appropriate pair of intervals, it was necessary to select a base line bearing an inherent relationship to the shape characteristics of the recorded pulse traces. This base line had to be the same for all subjects in order for the ratios of change to be comparable from one subject to another. Examination of the charts shows that the primary spikes are separated by smaller secondary spikes which range from prominant in some subjects to nearly absent in others. The base line chosen for treatment of all data in this study was the level at which the ascending sweep began toward the top of the primary spikes. The amplitude of each primary spike was measured upward from this base line which is illustrated in the sketch below.



This base line was the most consistantly well defined base line, but for a minority of the subjects a base line at the bottom of the downstroke from the primary spikes was better defined than the one chosen. Regardless of this variation among the subjects, the

base line in the above sketch was used in all cases. Thus, pairs of means could be compared directly for two intervals on the chart of a single subject, and also, the ratio of that pair of means could be compared to similar ratios from other subjects.

A slightly different statistical procedure had to be used for testing those hypotheses requiring a comparison of the reactions of one group of subjects with those of another group. In these cases, the samples were independent rather than correlated as they were when the comparison was between two intervals of reaction by the same individual. The procedure used for the comparison of two groups was a test for the significance of the difference between two means for independent samples (Ferguson, 1959, p. 136).

Again, it is not possible to make a direct comparison of the capillary pulse pressures of different individuals within the two groups to be compared. The program versions used by the test groups and the control groups were identical up to a point, thus permitting a ratio to be obtained of a base frame in the identical portions and the later interval of interest that was different for the test and control groups. Thus, any difference between the test and control groups was expressed as the differences in the means of these ratios for the two groups. The ratio was determined for each individual in the test group and the mean of these ratios was determined; the same thing was done for the control group. The

significance of the difference between these means for these two independent samples was then determined as follows:

$\frac{X_1}{X_2}$	Ratio of the base frame mean to the test interval mean determined for each subject.
$\left(\overline{\frac{X_1}{X_2}}\right)$	Mean ratio for either the test group or the control group.
$\sum\left[\left(\frac{X_1}{X_2}\right)-\left(\overline{\frac{X_1}{X_2}}\right)\right]^2$	Sum of the squares of the differences between the individual ratios and the mean of the ratios for either the control group or the test group.
N	The number of individuals in a group.

The unbiased estimate of population variance is then:

$$S^2 = \frac{\sum\left[\left(\frac{X_1}{X_2}\right)-\left(\overline{\frac{X_1}{X_2}}\right)_1\right]^2 + \sum\left[\left(\frac{X_1}{X_2}\right)-\left(\overline{\frac{X_1}{X_2}}\right)_2\right]^2}{N_1 + N_2 - 2}$$

The unbiased variance estimate s^2 is used to obtain an estimate of the standard error of the difference between the two means. Thus,

$$S_{\left(\overline{\frac{X_1}{X_2}}\right)_1 - \left(\overline{\frac{X_1}{X_2}}\right)_2} = \sqrt{\left(\frac{S^2}{N_1}\right) + \left(\frac{S^2}{N_2}\right)}$$

The difference between mean ratios, $\left(\overline{\frac{X_1}{X_2}}\right)_1 - \left(\overline{\frac{X_1}{X_2}}\right)_2$, is then divided by this estimate of the standard error to obtain the ratio.

$$t = \frac{\left(\overline{\frac{X_1}{X_2}}\right)_1 - \left(\overline{\frac{X_1}{X_2}}\right)_2}{S_{\left(\overline{\frac{X_1}{X_2}}\right)_1 - \left(\overline{\frac{X_1}{X_2}}\right)_2}} = \frac{\left(\overline{\frac{X_1}{X_2}}\right)_1 - \left(\overline{\frac{X_1}{X_2}}\right)_2}{\sqrt{\left(\frac{S^2}{N_1}\right) + \left(\frac{S^2}{N_2}\right)}}$$

This ratio has a distribution of t with $N_1 + N_2 - 2$ degrees of freedom.

When grouping individuals during the statistical treatment, it was necessary to use the ratios of the pairs of means rather than

their differences, because the amplitudes of the pressure spikes of one individual cannot be compared to those of another individual. This is because each channel of the chart recorder is adjusted separately, and the amplitude of sweep on one channel is unrelated to the amplitudes on other channels. It is the ratios of change that have been meaningfully compared.

The significance of the difference between two means for the correlated samples from the data in this study was determined in the following way. N individuals provide N pairs of interval means X_1 and X_2. Rather than take the difference of each pair, $X_1 - X_2$, the ratio $(X_1 - X_2)/X_1$ is determined for each pair of means. Letting this ratio be the D that is used, the mean, $\overline{D}$, is determined by $\overline{D} = \Sigma D/N$ for all pairs of interval means X_1 and X_2. In addition, each D is squared, and the sum of these squares, ΣD^2, is determined.

The variance of the D's is given by:

$$s_D{}^2 = \frac{\Sigma D^2}{N} - \overline{D}^2$$

An estimate of the variance of the sampling distribution of $\overline{D}$, using an unbiased estimate of the population variance, is

$$s_{\overline{D}}{}^2 = \frac{s_D{}^2}{N - 1}$$

The appropriate t ratio is obtained by dividing $\overline{D}$ by $s_{\overline{D}}$. Thus,

$$t = \frac{\bar{D}}{s_{\bar{D}}} = \frac{\bar{D}}{\sqrt{s_D^2/(N-1)}}$$

The number of degrees of freedom used in evaluating *t* is (N - 1).

Assumptions

Conceptual Assumptions

Two conceptual assumptions were made in developing and designing this study:

1. Programmed instruction is of importance to the future of education.
2. Variation in level of affect is physiological and only physiological and is, therefore, governed by mechanisms constrained by physical laws.

Methodological Assumptions

Seven methodological assumptions were made in developing, designing, and conducting this study:

1. Overt measurements of a subject's behavior or reactions tend to alter the behavior or reactions being measured.
2. The capillary pulse pressure of human subjects is similar enough from one subject to the next to be meaningfully comparable using chart-recorded records.
3. An encounter with a nonsense term in an implied context

produces a reaction in a subject similar to the reaction produced by an encounter with an actual word for which the subject has no previously learned definition.

4. An encounter with a nonsense paragraph composed of familiar words, phrases, and clauses, and arranged for meaningless but easy reading will produce a reaction in a subject similar to that produced when the subject is confused by an encounter with a poorly stated paragraph.
5. The reaction of a subject to an insoluble problem that is perceived as soluble will be similar to that subject's reaction to an encounter with a problem known by the subject to be soluble, but too difficult for the subject to solve.
6. The sample of subjects chosen for this study is not a biased sample relative to the tests to be conducted in this study.
7. Significance, if established for the intervals chosen to be tested for hypotheses verification, can be interpreted as significance for the validation of the capillary pulse pressure instrument for the corresponding purposes specified in the experimental objectives.

CHAPTER III

PRESENTATION AND ANALYSIS OF DATA

Introduction

Capillary pulse pressure data appear to the inexperienced observer to be characterized by unmanageable diversity. Individual differences are extreme, and further complications are introduced by the necessity of recording different subjects with different sensitivity settings on the equipment. Consequently, it is necessary for the beginning interpreter to understand some of the general characteristics of capillary pulse pressure chart-records. There are long-term variations in capillary pulse pressure, with short-term variations superimposed on them; these are described in the following sections. It will also be illustrated how changes in instrument sensitivity greatly affect the appearance of the changes in amplitude on the charts. Once the observer develops the familiarity needed to look beyond the characteristic diversities, it becomes possible to detect the variations that bear significant relationships to the content with which the subject was involved.

General Characteristics of the Data

Long-Term Variations

Capillary pulse pressure, as measured in this experiment, was found to vary as a function of the interaction of the subjects with the programs. Two significant types of such variations were observed. The first type of variation was a long-term, general change in capillary pulse pressure which might extend over the entire duration of the program, usually about half an hour. This effect was frequently characterized by a long, slow increase in capillary pulse pressure followed by a long, slow decrease through the last half of the program. It soon became obvious during the data collection phase that the initial sensitivity of the chart recorder had to be set relatively low in order to avoid having to reduce it in the middle of the run. The magnitude of these changes was commonly by factors of two to four. Of the 148 subjects whose data were of adequate quality to permit a judgment to be made, 106, or 73 per cent, showed these long-term variations as determined by subjective visual observations. The method of determination was to step back from the chart to a distance of four feet or more and render a quick subjective judgment as to whether long, relatively steady changes lasting more than about eight minutes were immediately obvious or not.

These findings substantiate the Bergum and Lehr study (1966c) which reported similar long-term changes in capillary pulse pressure, determined by taking a series of measurements at four-minute intervals. In that study one group of subjects, which reported that it liked the program with which it worked, showed a rise and fall cycle in capillary pulse pressure lasting twelve minutes, followed by a steady increase lasting an additional twelve minutes until the end of the program. A second group of subjects, which reported that it did not like the program version with which it worked, experienced a general but not significant decrease in capillary pulse pressure throughout the program.

Short-Term Variations

The second type of capillary pulse pressure variation is the short-term type which is superimposed on the long-term variations described above. These short-term variations may be initiated within a span of only two or three pulses and persist from a few seconds to a few minutes in duration. The hypotheses in this experiment are concerned primarily with this short-term type of variation, and an attempt is made to relate such variations to specific encounters between the subjects and items in the programs.

Although it was possible to detect at least traces of both types of changes in capillary pulse pressure of nearly all subjects,

there was considerable variation among subjects relative to the number and magnitude of the changes which they exhibited. It was not difficult to subjectively divide the subjects into three groups through a visual inspection of their capillary pulse pressure charts, primarily on the basis of short-term variations. Subjects placed in the first group exhibited frequent and extreme short-term variations. The second group exhibited some obvious variations, but not as extreme as the first group. The third group consisted of those individuals who exhibited a relatively constant capillary pulse pressure with variations so slight that a casual visual observation of their chart records may fail to detect them. Figure 7 presents representative intervals from subjects in these three categories. Of 149 charts examined and found to be of adequate quality for a visual subjective judgment to be made, 23, or 15 per cent, were placed in group one; 103, or 70 per cent, were placed in group two; and 23, or 15 per cent, were placed in group three. The objectives of this experiment made subjects who exhibited little capillary pulse pressure variation seem less desirable than those who showed relatively greater variation effects, but in this study no subjects were rejected on the basis of their intrinsic capillary pulse pressure characteristics.

Of the 149 subjects whose data were judged for the presence or absence of short-term variations, two subjects exhibited a third

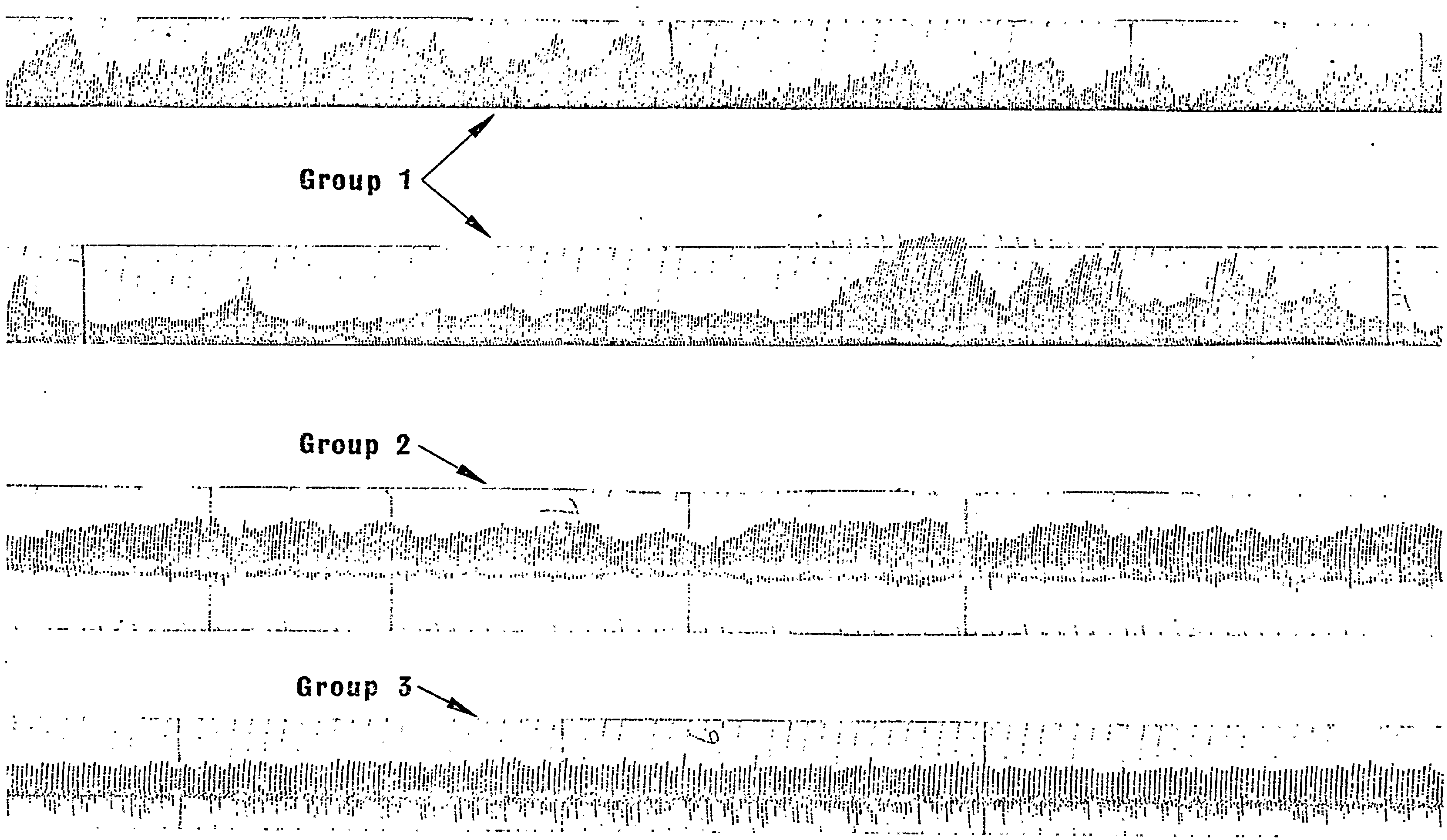


Fig. 7.--Standard exemplifications of the three arbitrary capillary pulse pressure characteristic types

order variation that was superimposed on the previously described short-term variations. These third order variations were nearly regular cycles lasting about five seconds in one case and about eight seconds in the other case. The resulting appearance of the top of the pulses on the chart was sawtoothed or serrated.

When comparing short-term variations exhibited by different subjects, it is necessary to take into consideration the relative amplitudes of the trace excursions in the intervals being compared. The variations in low amplitude excursions are not nearly as obvious as they would be if the same excursions were amplified by a factor of two or more. This is exemplified by Figure 8, which shows how variations that are quite obvious with large excursions are of much less apparent significance when the sensitivity of the chart recorder is reduced to a much lower excursion amplitude. The proportions of the variations in the reduced interval are the same as those in the larger amplitude regions.

Test One--Vocabulary: The Unknown Term

Tests for the Hypotheses, Test One

The two hypotheses associated with Test One predicted that the capillary pulse pressure of the subjects would decrease significantly upon abruptly encountering an unfamiliar term used in a critical context, and that the capillary pulse pressure would later

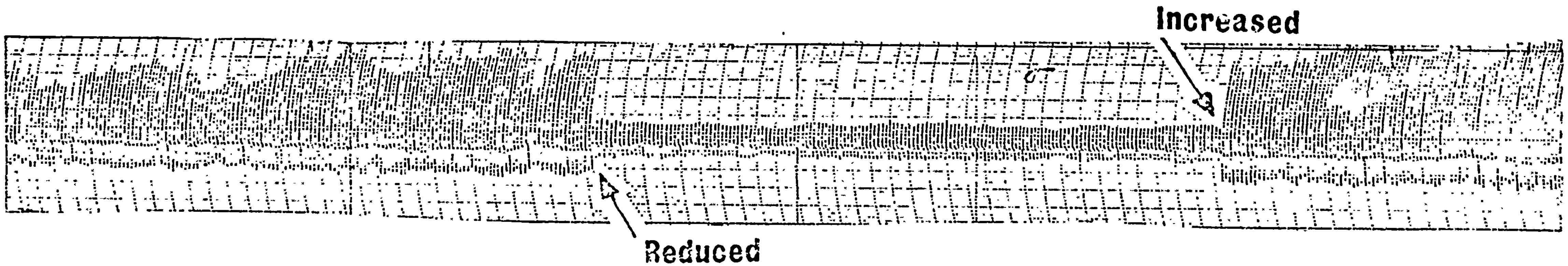


Fig. 8. --Effect of amplitude scaling changes on the appearance of the local variations

rise significantly when the term was defined for the subjects and they could continue successfully onward. To test for the decrease in capillary pulse pressure predicted by the first hypothesis, the capillary pulse pressure in the test frame where the term was encountered was compared to the capillary pulse pressure in an equally long interval measured back into the immediately preceding frame, or until all of that frame was used if it was shorter than the test frame.

The test for the recovery of the capillary pulse pressure predicted by hypothesis two was made by comparing the test frame of each subject with an equal interval going into the next frame, or all of the next frame if it was shorter than the test frame. It was at the start of this next frame that the unknown term was defined.

Figure 9 presents intervals from three Test One charts which exhibit variations of capillary pulse pressure conforming to the predictions of hypotheses one and two for Test One. The uppermost chart is from Program Three; and the two others, from Program Two. Although the general characteristics of these charts are obviously quite different, the depression effect in the test frame is clearly evident in each of them.

Presentation and Treatment of Data, Test One

Data from each of the three programs are presented

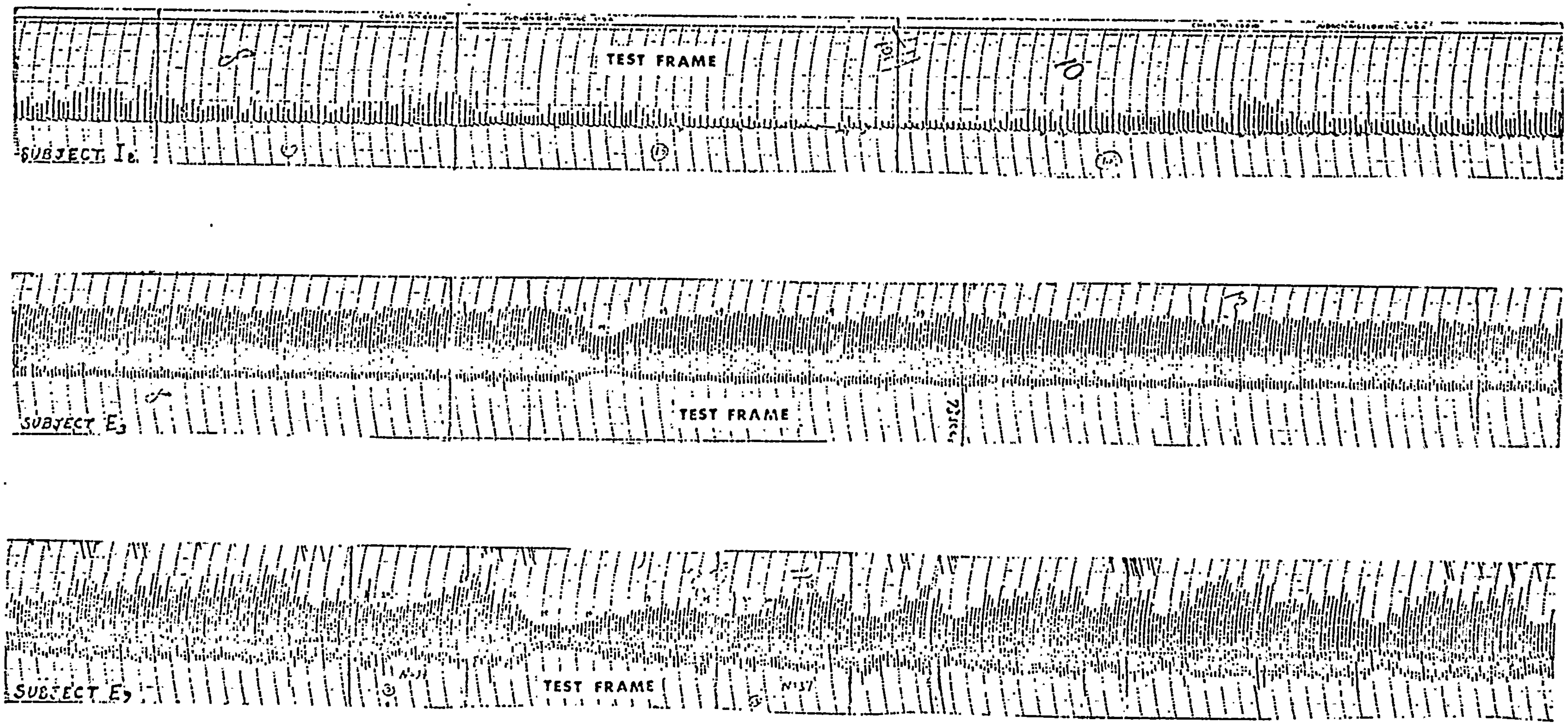


Fig. 9. --Charts exemplifying confirmation of hypotheses one and two of Test One (encountering an unknown term)

separately. First, hypothesis one is considered for Program One, followed by hypothesis two for the same program. This was necessary, because the different programs yielded different reactions although they were originally constructed to be very similar. The following tests reveal that for Program One both hypotheses were sustained, because the decrease and subsequent rise of capillary pulse pressure were both significant. For Programs Two and Three, significance was not attained for either hypothesis. In Program Two there was some tendency toward the predicted variations in capillary pulse pressure, but significance was not closely approached. In Program Three the variations were actually opposite to the predicted directions, but again not to a significant degree.

As will be explained in Chapter IV, the significance of the findings of this study rests more with the discovery that capillary pulse pressure variations are more related to those aspects of affect having to do with stress, arousal, and intensity of involvement, rather than those aspects having to do with pleasure, appreciation, or value. It will be shown that the failure of several of the hypotheses to be sustained was apparently caused by the initial assumption that the tests were probing pleasure related functions. When the results are re-examined in Chapter IV on the basis of the more correct relationship, then all results, including the unsustained

hypotheses, are subject to rather rational prediction.

In Tables I-VI, which follow, the results of Test One are presented. The results from each program are presented in two tables, the first reporting on hypothesis one, predicting a decrease in capillary pulse pressure; and the second reporting on hypothesis two, predicting a subsequent increase. The intervals X_1 and X_2 in each of the following tables refer to a pair of selected intervals on the chart records of the subjects, which were compared to determine if the predicted change had occurred. The exact intervals used in each case can be reviewed by referring back to the more detailed descriptions of the tests in Chapter II. The degree of significance attained, or not attained, in each case is presented below each table.

Characteristics of the Tested Intervals, Test One

In Programs One, Two, and Three, during the timed test frame there were two, four, and three subjects respectively who turned the page before the seventy-five-second interval had expired. This was contrary to taped directions before the program began and also contrary to directions printed on the test frame. This failure of nine out of thirty subjects to wait according to directions was attributed to the greater disinclination of the subjects at this continuation high school to follow directions in academic situations. Of the nine who turned to the next frame prematurely, seven

TABLE I

PROGRAM ONE, TEST ONE (UNFAMILIAR TERM), HYPOTHESIS 1 (DECREASE), VERSION (A)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	20.31	19.53	.0384
2	15.25	12.79	.1613
3	16.76	15.58	.0704
4	20.26	18.00	.1115
5	15.64	14.38	.0805
6	7.07	6.23	.1188
7	20.51	21.61	-.0536
8	9.76	10.59	-.0850
9	11.07	10.63	.0397
10	8.25	7.63	.0751
		Sum	.5571
		Mean	.0557
		$\sum D^2$	.0823

$t = 2.4977$

Significant at the .025 level:
$t > 2.262$

TABLE II

PROGRAM ONE, TEST ONE (UNFAMILIAR TERM), HYPOTHESIS 2 (INCREASE), VERSION (A)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	20.88	19.53	.0646
2	16.17	12.79	.2090
3	23.70	15.58	.3426
4	22.60	18.00	.2035
5	17.20	14.38	.1639
6	10.54	6.23	.4089
7	20.19	21.61	-.0703
8	21.45	10.59	.5062
9	12.43	10.63	.1448
10	7.19	7.63	-.0611
		Sum	1.9121
		Mean	0.1912
		ΣD^2	0.6860

$t = 3.2351$

Significant at the .01 level:
$t > 2.821$

TABLE III

PROGRAM TWO, TEST ONE (UNFAMILIAR TERM), HYPOTHESIS 1 (DECREASE), VERSION (E)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	21.30	15.97	.2502
2	4.48	5.40	-.2053
3	18.86	15.55	.1755
4	16.34	13.42	.1787
5	3.95	5.75	-.4556
6	7.24	6.70	.0745
7	23.54	30.38	-.2905
8	15.06	11.37	.2450
9	18.82	14.12	.2497
10	22.72	15.93	.2988
		Sum	.5210
		Mean	.0521
		ΣD^2	.6762

t = .6143

t is NOT significant at the .10 level: $t < 1.383$

TABLE IV

PROGRAM TWO, TEST ONE (UNFAMILIAR TERM), HYPOTHESIS 2 (INCREASE), VERSION (E)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	12.60	15.97	-.2674
2	5.86	5.40	.0784
3	17.81	15.55	.1268
4	16.84	13.42	.2030
5	9.54	5.75	.3972
6	8.25	6.70	.1878
7	21.37	30.38	-.4216
8	10.09	11.37	-.1268
9	19.31	14.12	.2687
10	13.15	15.93	-.2114
		Sum	.2347
		Mean	.0234
		ΣD^2	.6381

t = .2799

t is NOT significant at the .10 level: $t < 1.383$

TABLE V

PROGRAM THREE, TEST ONE (UNFAMILIAR TERM), HYPOTHESIS 1 (DECREASE), VERSION (I)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	8.14	8.54	-.0491
2	12.13	12.11	.0016
3	2.87	2.85	.0069
4	15.94	17.86	-.1204
5	26.39	21.01	.2038
6	6.71	6.52	.0283
7	5.63	6.83	-.2131
8	5.78	3.32	.4256
9	15.10	15.91	-.0536
10	16.74	22.75	-.3590
		Sum	-.1290
		Mean	-.0129
		ΣD^2	.4171

$t = -.1902$

t is NOT significant at the .10 level: $t < 1.383$

TABLE VI

PROGRAM THREE, TEST ONE (UNFAMILIAR TERM), HYPOTHESIS 2 (INCREASE), VERSION (I)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	8.59	8.54	.0058
2	12.82	12.11	.0553
3	4.25	2.85	.3294
4	15.20	17.86	-.1750
5	7.82	21.01	-1.6867
6	5.43	6.52	-.2007
7	4.34	6.83	-.5737
8	5.29	3.32	.3724
9	16.86	15.91	.0563
10	26.88	22.75	.1536
		Sum	-1.6633
		Mean	-.1663
		$\sum D^2$	3.5215

$t = -.8766$

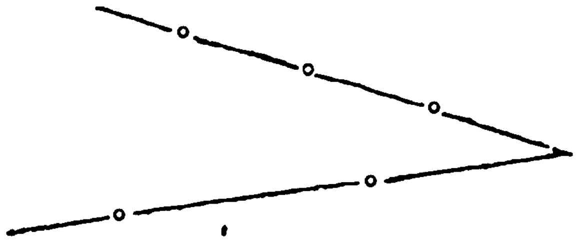
t is NOT significant at the .10 level: $t < 1.383$

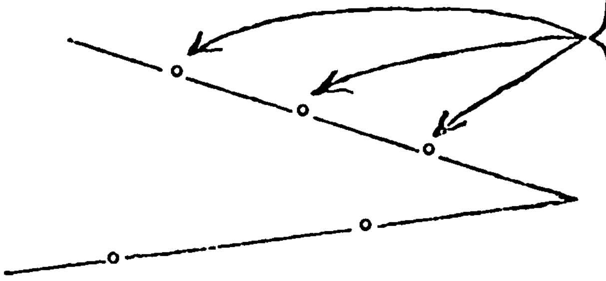
experienced obviously significant decreases in capillary pulse pressure in the test frame before turning the page.

The three programs were originally designed to be similar in structure, and the slight differences in them, especially in the test intervals, were not believed to be significant. Overt reactions gathered from subjects during the validation process failed to reveal significant differences in subject reaction to the three programs. However, it is of considerable significance that capillary pulse pressure measurements have clearly discriminated between the programs. When the capillary pulse pressure charts are related to the content of the frames for the test frames and the single frames immediately preceding and following them, it becomes possible to see that the programs do affect the subjects differently. Careful re-examination of the content of the frames in question can then expose the relatively subtle differences that produce the significant differential effects that have occurred.

The frame prior to the test frame for Test One was intended to be a simple, straightforward, and relatively short frame that would lead the subject into the test frame in a relatively streee-free condition; these three lead-in frames can be compared by referring to Figures 10, 13, and 16, or to Appendix B, or where these frames are presented in their respective programs. The pertinent hypothesis called for the capillary pulse pressure to drop upon

(9) Correct solution:





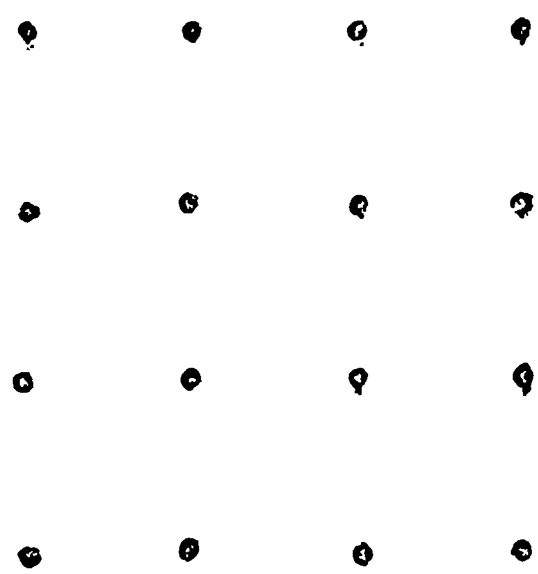
WHEN THREE OR MORE POINTS
LIE IN A STRAIGHT LINE
in such puzzles as these,
then these points can be
connected with a <u>single</u> line.

THUS, FINDING THREE OR MORE POINTS THAT CAN FALL ON ONE DRAWN LINE LETS YOU SOLVE THE PUZZLE <u>USING FEWER LINES</u>.

Go on to the next frame

Fig. 10.--Test One, lead-in frame, Program One

(10) Below is a pattern of sixteen points. Circle all dimatrical points, but only dimatrical points, and then take only the circled points as a puzzle, and, without lifting your pencil or retracing (doubling back), solve the puzzle with only three lines, ignore, for the time being, the non-dimatrical points, and do not consider them in your solution.

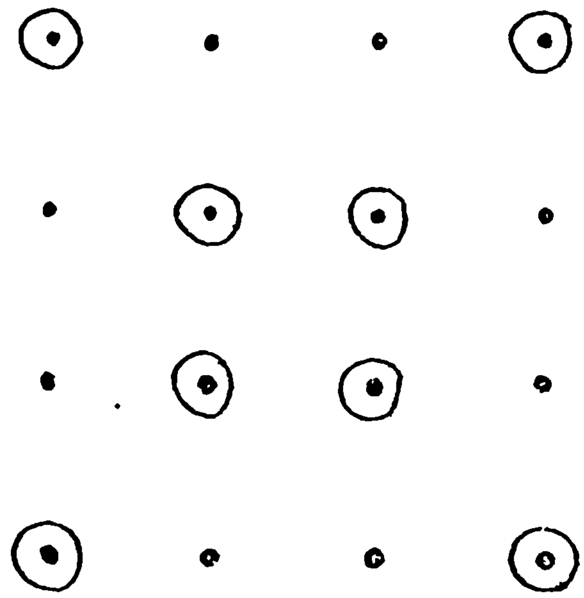


STOP

Do not go to the next frame until you have successfully completed this frame, or until you are told to continue by the person in charge.

Fig. 11.--Test One, test frame, Program One

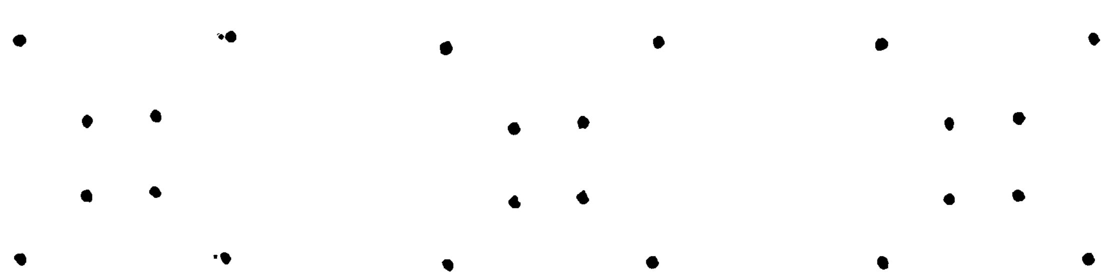
(11) "Dimatrical" points are points on the diagonals of the pattern as shown below:



Now, using only these points for the puzzle, solve it with only three lines.

Remember: You may not retrace a line, you must not lift your pencil, but lines may cross. Use only three lines.

PRACTICE



Go on to the next frame

Fig. 12.--Test One, follow-up frame, Program One

(9) (B) gives (A) his six-link chain and gets (A)'s four links back as change.

REMEMBER:

1) It is possible to free more links or divide a chain into more pieces by cutting a link that is somewhere in the middle of a chain.

2) When using the links as coins of money, it is possible to make change using different combinations of links.

Go on to the next frame

Fig. 13.--Test One, lead-in frame, Program Two

(10) Look at the long chain shown below. If you cut and remove all illative links from this chain, how many separate peices of chain and links would you then have altogether?

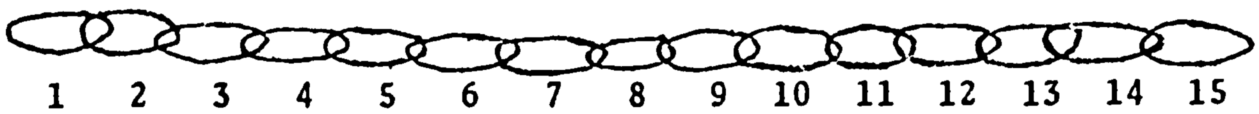
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

STOP

DO NOT GO TO THE NEXT FRAME UNTIL YOU HAVE SUCCESSFULLY COMPLETED THIS FRAME OR UNTIL YOU ARE TOLD TO CONTINUE BY THE PERSON IN CHARGE.

Fig. 14.--Test One, test frame, Program Two

(11) "Illative" links are even-numbered links.

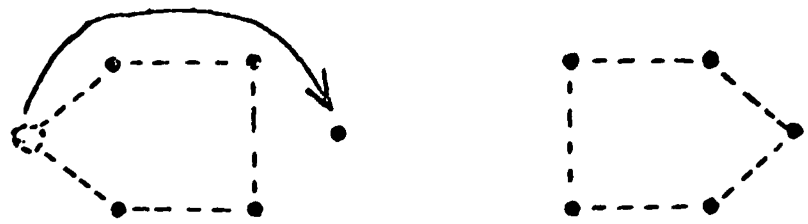


Now, if you cut and remove all illative links from this chain, how many separate pieces of chain and links would you have altogether?

Go on to the next frame

Fig. 15.--Test One, follow-up frame, Program Two

(8)

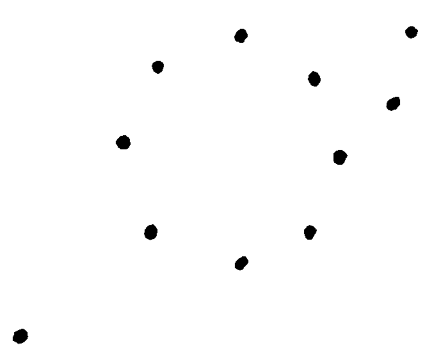


Note that the symmetrical box-like pattern of four dots did not change.

REMEMBER:

If a pattern of dots has a direction to it, that direction can be changed by moving dots that are not symmetrical and leaving any included symmetrical patterns alone.

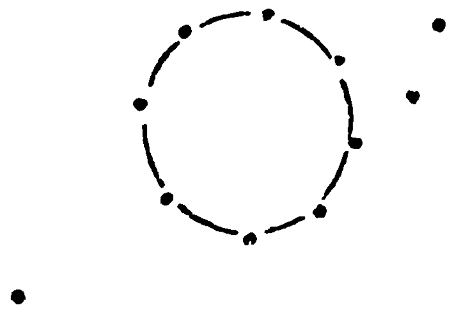
Find the largest symmetrical pattern in the grouping of dots below and draw it in with your pencil.



Go on to the next frame

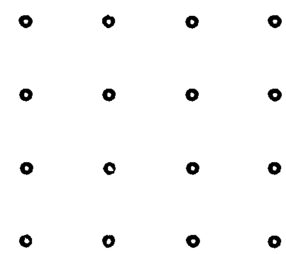
Fig. 16.--Test One, lead-in frame, Program Three

(9)



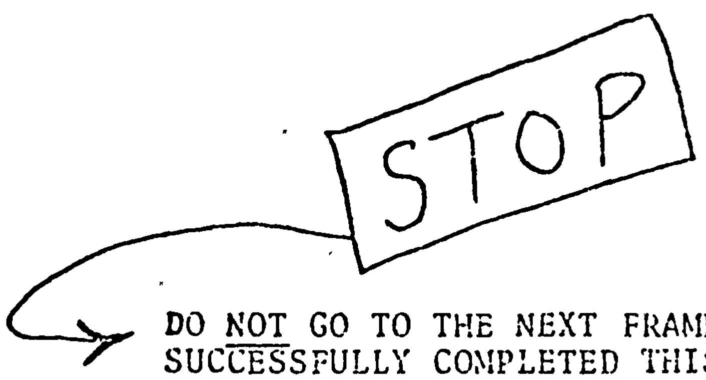
The symmetrical pattern is a circle.

In the pattern of points shown to the right, draw straight lines from the invortice point to each of the geoboard points.



Notice that these lines divide the pattern of points into smaller subgroupings.

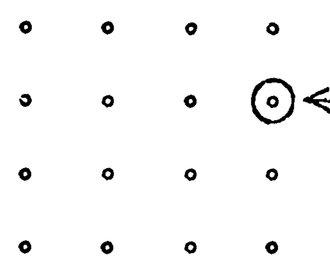
List the number of points in each of these subgroups that have no line running through them.



DO NOT GO TO THE NEXT FRAME UNTIL YOU HAVE SUCCESSFULLY COMPLETED THIS FRAME OR UNTIL YOU HAVE BEEN TOLD TO CONTINUE BY THE PERSON IN CHARGE.

Fig. 17.--Test One, test frame, Program Three

(10)



This is the "invortice" point.

The "geoboard" points are the four corner points.

Now, draw the straight lines from the invortice point to <u>each</u> of the geoboard points (use a straightedge).

List the number of points in each area or zone marked off by these lines (<u>count only points with NO lines through them</u>).

Go on to the next frame

Fig. 18.--Test One, follow-up frame, Program Three

entering the test frame following this lead-in frame. Examination of the ten charts from each program for Test One reveals that in Program One the lead-in frame (9) exhibited a generally steady pulse, with two out of the ten showing visually obvious dips during the frame. Any depressions in the pulse in this frame tend to lower the mean pulse pressure for the frame and thus decrease the contrast in frame means upon which the hypothesis depends for significance. In Program Two this lead-in frame was again generally steady, but there were three charts showing depressions in the lead-in frame (9), as opposed to two in Program One. Furthermore, two of these three exceptions were relatively extreme, and this explains in part why hypothesis one was not sustained by statistical significance in Program Two. In Program Three, a much greater difference occurred in the lead-in frame, frame (8), where seven out of ten charts showed visually significant dips or general decreases from the previous frame. Thus, an effect which occurred in only two or three cases in the first two programs was the predominant effect in Program Three, with the result that the prediction of the hypothesis was reversed although not to a significant degree.

If one now looks again at the three lead-in frames with full cognizance of the above revelations, it is not difficult to discern the differences to which the capillary pulse pressure measurements

were probably sensitive. In Program One frame (9) is characterized by graphic clarity, relative simplicity, and the exertion of little pressure on the subject; it is an explanatory, summarizing frame in which no questions are posed for the subject. In Program Two, where pulse depression effects were greater in magnitude and slightly greater in number, the lead-in frame (9) is characterized by being somewhat more verbal and less graphic; it is more abstract and its summarization does not stand alone as well as that from Program One; a subject who had not previously managed to learn the content being summarized might even tend to be confused by the summary presented. In Program Three, the lead-in frame (8), which produced the very different pulse pressure effects, is seen to present a graphic answer to a previous question and make a summary statement; but in addition there is also an additional problem at the end of this frame which the corresponding frames in the first two programs did not have. Apparently, the presence of this simple problem, which was intended to clarify and supplement the summary being made in the frame, actually had a depressing effect on capillary pulse pressure.

A consideration of the test frames, which were intended to cause decreases in capillary pulse pressure, again reveals how capillary pulse pressure measurements can detect initially latent but potentially significant characteristics in frames. In Programs

One and Two, the test frames (10) were very similar, and capillary pulse pressure measurements did not discriminate significantly between them. These two frames, presented in Figures 11 and 14, are both characterized by graphic clarity; they are straightforward in approach and, with nothing else on the page, they bring the subject to an unexpected and relatively abrupt halt. Upon encountering the unknown term in its critical context, the subject is at once stymied and there is little or no pertinent content remaining to provide help or to suggest an outlet for further meaningful endeavors. Thus, the test frame in both Program One and Program Two resulted in corresponding charts characterized by obvious depressions, general decreases, and unsteadiness; in Program One, nine out of the ten subjects recorded such effects, and in Program Two, eight out of the ten also produced these effects in the test frame.

However, in the test frame of Program Three, presented in Figure 17, only four of the ten subjects produced charts showing visually obvious depressions or general decreases from the lead-in frame; five of the subjects even produced charts showing steady increases in capillary pulse pressure through the test frame. However, examination of the test frame in Program Three reveals that relative to the test frames of Programs One and Two, it is less clearly abrupt in bringing the subject to a halt. First, the Program

Three test frame begins with the answer to the question asked in the lead-in frame, so that the subjects begin work on the test frame with an interval of consideration devoted to an aspect which is not an intrinsic part of the test. Furthermore, the frame contains directions outlining some further work that is to be performed on the basis of the answer to the specific test question. The subject would not feel as hopelessly stymied here as would be the case when the frame ended quickly after presenting the unfamiliar term. Here the subject can read and ponder the additional instructions concerning subsequent work, seeking, as he proceeds, some clue as to the meaning of the unknown term. The most obvious consequence of this is that the subject's involvement is prolonged and possibly intensified by the possibility of deducing the meaning of the unknown term as opposed to the test frame of Programs One and Two which provided almost no alternative to an abrupt termination of subject involvement with the frames.

The discriminatory powers of the capillary pulse pressure measurements are further revealed by the results on the three frames which follow the test frames in their respective programs. These follow-up frames are presented in Figures 12, 15, and 18. Again, the results from Programs One and Two are similar for the follow-up frames; the charts show a resumption of general steadiness after the decreases in the test frames. Three out of ten

subjects recorded visually obvious upsurges in capillary pulse pressure in both programs during this frame. These results are in keeping with the hypothesis which predicted higher pulse pressures in this frame where the blocking effect of the unknown term is removed by the immediate presentation of the definition. Recall that both the terms and their definitions were fabricated for use in this study. Examination of the follow-up frames for Programs One and Two reveals that in both cases the subjects were given the definitions and that, although the problem still had to be solved, it was rendered elementary by the definitions provided. The subjects could perceive at once that success was now possible with modest effort which they then willingly expended.

However, in the follow-up frame of Program Three, presented in Figure 18, the recovery of the capillary pulse pressure did not occur. Instead, there were seven out of the ten charts showing visually obvious depressions or general decreases. Examination of this frame reveals that the subjects got the definition as in Programs One and Two which did render the fundamental test problem soluble; but unlike the follow-up frames in the first two programs, this frame went on to require what was, in effect, a secondary problem solution based on the answer to the fundamental problem. Careful analysis of this secondary problem reveals that it might tend to be confusing to some subjects, although initially it

was intended only as a part of the final successful completion of the frame after getting past the blocking effect of the unknown term. Thus, what was intended as a reinforcing enlargement of the culminating success experience of the test interval was revealed by the capillary pulse pressure measurements to have been acting, instead, as a depression agent on the capillary pulse pressure. This is probably explained by the fact that the subjects available at the school where the experiment was performed were at the bottom of the range of academic ability for which these programs were validated. In general, these subjects were much more challenged by the programs than was anticipated during the program writing and validation phase. It is possible, however, that subjects who would have found these programs unchallenging and trivial would not have manifested the changes in capillary pulse pressure that made the previous discriminations possible.

Figure 19 presents some examples from those seven Program Three (Version I) subjects who did experience decreases in capillary pulse pressure in frame (10) (see Fig. 18). Some of these subjects recovered from their pulse pressure decreases while still working on the frame, while others experienced a decrease which persisted. Apparently these seven subjects tended to react positively to the initial problem and its relatively quick and easy solution in the first part of this frame, because the depressions

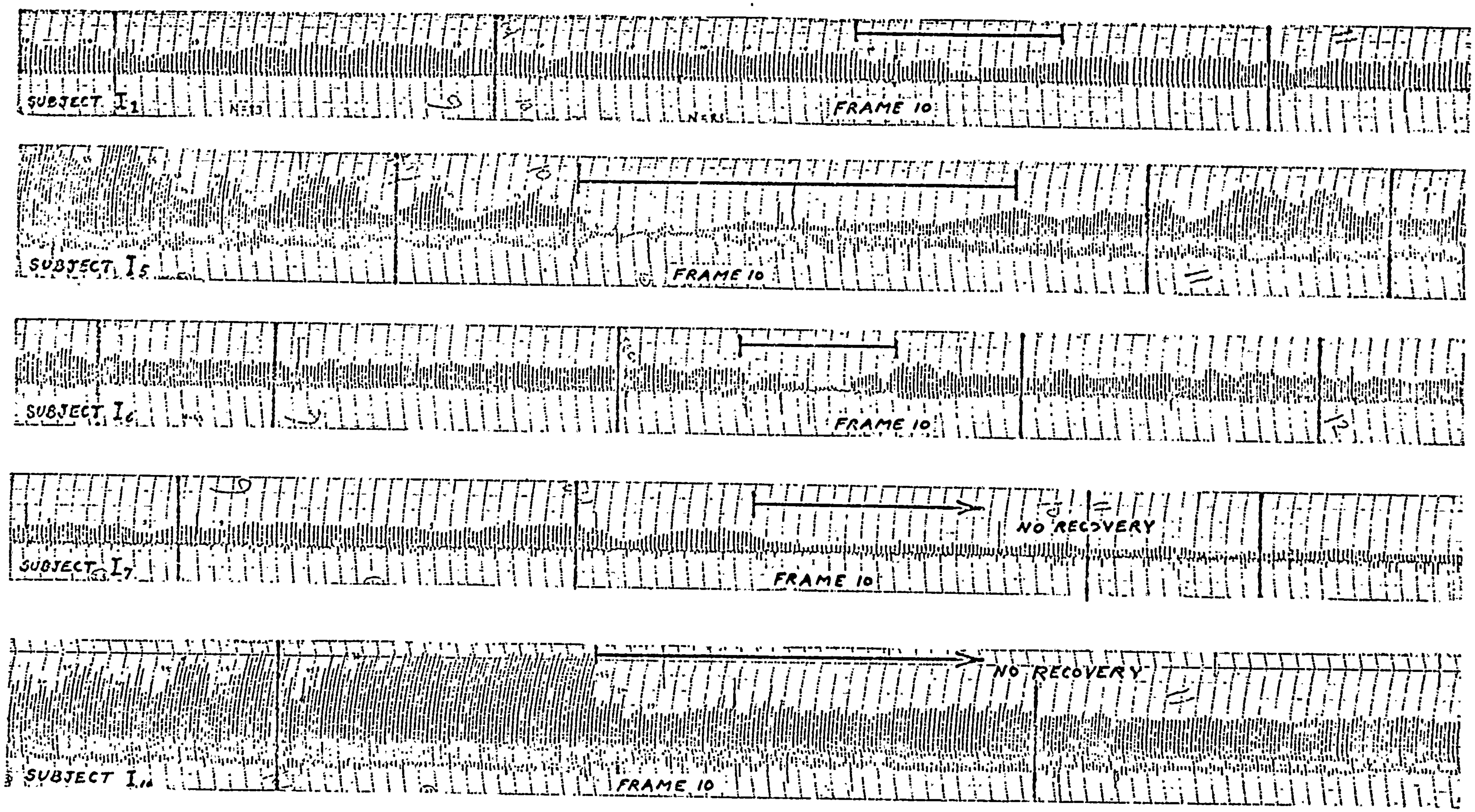


Fig. 19.--Revelation of a latent depression capacity of the last half of frame ten, Test One, Program Three

in capillary pulse pressure generally occurred a half minute or more into the frame. The decreases thus seem to be associated with the secondary problem involving the identification of delineated zones and the number of points isolated within them. This constituted an unexpected revelation through capillary pulse pressure measurements of a latent repulsion element, not only within a frame but within a specific portion of a single frame and before any re-examination of the frame in question was initiated.

Test Two--Wording: The Confusing and Ambiguous Paragraph

The Hypotheses of Test Two

There were three hypotheses connected with Test Two, a test in which the subjects experienced an abrupt encounter with a block of meaningful-sounding information that was contrived to be ambiguous nonsense and with a follow-up question apparently based on that information which could not be answered correctly on the basis of the information as presented. Figure 6, presented in an earlier chapter, diagrams Test Two; the first two hypotheses predicted a significant decrease in capillary pulse pressure upon encountering the test frame, with a significant recovery of the pressure in the second frame thereafter, when success experiences could be resumed for the first time after encountering the nonsense paragraph. The third hypothesis predicted that the Test Two

subjects would have a lower capillary pulse pressure at the end of the program than would be exhibited by the control group; this was to test the possibility that a detectable depression effect would persist beyond the immediate test interval as a consequence of the encounter with it.

The Test of Hypothesis One, Test Two

The test of hypothesis one was accomplished by a comparison of the mean of the lead-in frame immediately preceding the test frame and the mean for the first half of the test frame, or all of it if it was shorter than about forty-five seconds.

Presentation and Treatment of Data, Test Two, Hypothesis One

The presentation and treatment of data for the test of hypothesis one is divided according to programs, because the results differed considerably among the programs, although they were originally constructed to be very similar. As the following three tables (VII-IX) reveal, hypothesis one, predicting a significant decrease in capillary pulse pressure in the test frame, is sustained by significance at the .10 level for Program One, but not sustained or even approached for Programs Two and Three.

Treatment of Hypothesis Two, Test Two

No statistical test was made of hypothesis two, because it

TABLE VII

PROGRAM ONE, TEST TWO (AMBIGUITY), HYPOTHESIS 1 (DECREASE), VERSION (G)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	12.64	12.27	.0292
2	18.80	9.64	.4872
3	12.35	11.49	.0696
4	8.42	7.15	.1508
5	16.68	11.81	.2919
6	7.93	8.29	-.0453
7	11.78	10.19	.1349
8	←	VOID	→
9	6.18	7.08	-.1456
10	26.15	26.10	.0019
		Sum	.9746
		Mean	.1082
		$\sum D^2$	.3920

$t = 1.7339$

Significant at the .10 level: $t > 1.397$

TABLE VIII

PROGRAM TWO, TEST TWO (AMBIGUITY), HYPOTHESIS 1 (DECREASE), VERSION (B)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	8.61	9.21	-.0696
2	17.29	17.41	-.0069
3	16.00	15.41	.0368
4	6.35	9.75	-.5354
5	14.53	12.20	.1603
6	30.74	25.36	.1750
7	11.61	11.98	-.0318
8	10.97	9.81	.1057
9	26.52	22.48	.1523
10	←	VOID	→
		Sum	-.0136
		Mean	-.0015
		$\sum D^2$	.3841

t = -.0206

t is NOT significant at the .10 level: t<1.397

TABLE IX

PROGRAM THREE, TEST TWO (AMBIGUITY), HYPOTHESIS 1 (DECREASE), VERSION (F)

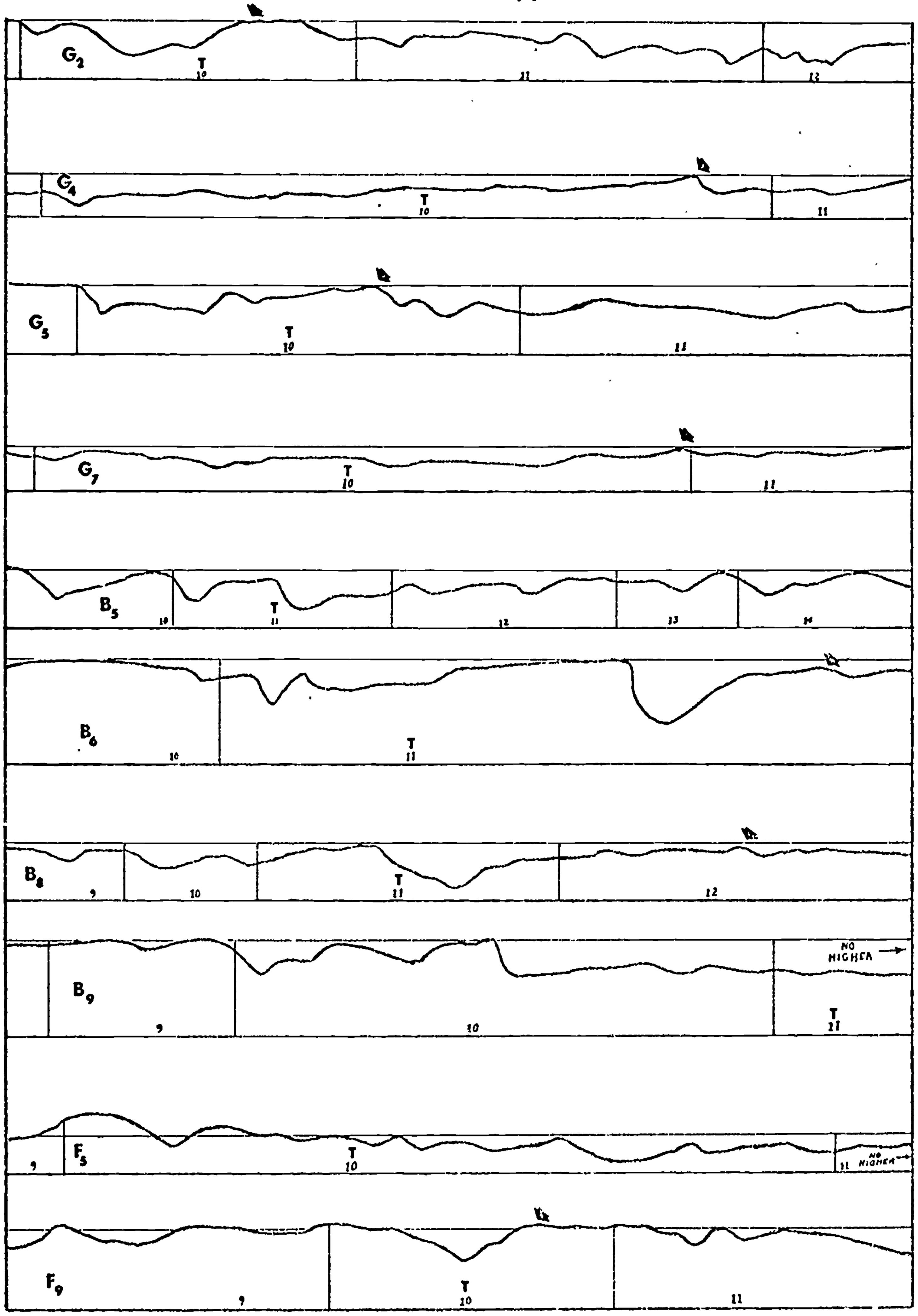
Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	20.04	20.83	-.0394
2	16.21	16.73	-.0320
3	11.87	12.55	-.0572
4	5.46	6.19	-.1336
5	16.23	12.21	.2476
6	20.63	18.09	.1231
7	24.64	27.24	-.1055
8	13.91	14.99	-.0776
9	18.56	16.35	.1190
10	←	VOID	→
		Sum	.0444
		Mean	.0049
		ΣD^2	.1310

$t = .1155$

t is NOT significant at the .10 level:
$t < 1.397$

was at once visually obvious that where depression effects did occur according to the prediction of hypothesis one, recovery of the capillary pulse pressure would occur either within the test frame itself or in the following frame. In none of the twenty-seven usable charts for Test Two subjects did recovery have to await resumption of success rewards in the second frame after the test frame. Figure 20 presents capillary pulse pressure curves for all Test Two subjects who exhibited visually obvious depressions of capillary pulse pressure in the test frame. These twelve-minute intervals are divided into the program frames which were worked during the intervals; the "T" symbol indicates the test frame in each interval. In each interval presented the lower horizontal line represents the base line, the upper horizontal line represents an arbitrarily located guide line, and the curve represents a trace along the tops of the capillary pulse pressure excursion spikes. The arrows which appear along seven of the ten curves indicate positions where the recovery of the test-related depressions has been completed. In two of the cases, B_9 and F_5, the decreases in capillary pulse pressure that occur in the test frame persist through the remainder of the program without recovery. Thus it can be concluded that recovery of the capillary pulse pressure in Test Two of this study was not a function of the resumption of success feedback after the test encounter.

Fig. 20. --Test Two recovery patterns showing the contradiction of hypothesis 2



The Test of Hypothesis Three, Test Two

Although hypothesis three requires that there be a comparison of the final frames for the Test Two groups and the control groups, a direct comparison was not possible because of the independent adjustment of each channel on each run, and also because of the individual differences between any two subjects. Consequently, in order to test hypothesis three, it was necessary to calculate the ratio of change between an early frame and the final frame for each individual, and then determine if these ratios differed significantly between test group and control group subjects in accordance with the extrapolated prediction of the hypothesis. First, a short frame was selected in the middle of each program which tended to cause relatively little variation in capillary pulse pressure. This frame was chosen from the programs at a point prior to the inserted test frames so that the control group and the test groups had identical frames from the beginning of the programs up through this chosen frame; frame nine was selected in Program One, and frame eight was selected in Programs Two and Three. The ratio was then determined of the mean of this frame and the mean of the combined first and fourth half-minute intervals of the last frame. The subjects worked on the last frame for a long period of time, and it became necessary to select only a portion of it for determination of the mean. An examination of the last frames

for all subjects revealed that the first and fourth half-minute intervals of the last frame would result in acceptable representative means for purposes of this test.

Because it was assumed that the earlier frame should be the same for both test and control groups, any difference between them revealed by the calculated ratios must be caused by the denominator, or mean of the last frame. The hypothesis predicts a lower final frame for the Test Two subjects than for the control subjects. This would mean a lower denominator in the calculated ratios and would result in a higher value for the ratios of the Test Two subjects. The complete test thus required means for the earlier, selected frame and for the last frame, the calculation of the ratios of the earlier frame to the last frame for all subjects in both the Test Two and control groups, calculation of the mean ratio for the Test Two subjects and the mean ratio for the control group subjects, and the performance of a "t"-test to determine if the differences in the mean ratios were significant (see Tables X-XII). Again, each program is treated separately because of significant differences in the results from the different programs.

Only subjects who exhibited decreases by hypothesis one were used in the test of hypothesis three, because subjects who did not exhibit the decrease in capillary pulse pressure in the test frame presumably could not have lingering results in the last frame

TABLE X

TEST TWO, HYPOTHESIS THREE, PROGRAM ONE, VERSIONS (G) AND (J)

Subject	X_1 Frame 9	X_2 1st plus 4th half-minute intervals in last frame	$\frac{X_1}{X_2}$	Mean Ratio
G_2	18.80	9.71	1.9361	1.5845
G_4	8.42	6.12	1.3758	
G_5	16.68	8.60	1.9395	
G_7	11.78	10.84	1.0867	
J_1	7.53	4.44	1.6951	1.4008
J_2	9.59	9.13	1.0504	
J_3	27.43	20.49	1.3387	
J_4	6.13	6.95	.8820	
J_5	11.07	5.50	2.0127	
J_6	6.15	4.06	1.5148	
J_7	14.76	9.79	1.5077	
J_8	7.42	7.81	.9501	
J_9	8.46	7.06	1.1983	
J_{10}	15.94	8.58	1.8578	

$1.4008 < 1.5845$ The difference in mean ratios is in the direction predicted by the hypothesis, but the following test for the significance of the difference between two means for independent samples reveals that this difference is not significant.

	$G\left(\frac{X_1}{X_2}\right)$	$J\left(\frac{X_1}{X_2}\right)$
N	4	10
$\left(\overline{\frac{X_1}{X_2}}\right)$	1.5845	1.4008
$\sum\left[\frac{X_1}{X_2} - \left(\overline{\frac{X_1}{X_2}}\right)\right]^2$	.5409	1.3338
S^2	.1562	
t	.7863	

$t < 1.356$

The difference is NOT significant at the .10 level.

TABLE XI

TEST TWO, HYPOTHESIS THREE, PROGRAM TWO, VERSIONS (B) AND (K)

Subject	X_1 Frame 8	X_2 1st plus 4th half-minute intervals in last frame	$\frac{X_1}{X_2}$	Mean Ratio
B_5	20.98	14.13	1.4847	
B_6	13.83	21.31	.6489	1.2728
B_8	10.22	6.86	1.4897	
B_9	23.30	15.87	1.4681	
K_1	7.08	7.80	.9077	
K_2	11.27	6.39	1.7637	
K_3	7.63	2.53	3.0158	
K_4	5.44	10.59	.5137	
K_5	6.75	4.63	1.4579	1.6710
K_6	4.27	1.31	3.2595	
K_7	12.09	11.06	1.0931	
K_8	30.22	26.97	1.1205	1.2520 with
K_9	32.84	17.22	1.9071	K_3 and K_6 omitted

$1.6710 > 1.2728$ The difference in mean ratios is opposite to the direction predicted by the hypothesis, although, as the following test for the significance of the difference between two means for independent samples reveals, the difference is not significant.

	$B\left(\frac{X_1}{X_2}\right)$	$K\left(\frac{X_1}{X_2}\right)$
N	4	9
$\left(\frac{\bar{X}_1}{\bar{X}_2}\right)$	1.2728	1.6710
$\sum\left[\frac{X_1}{X_2} - \left(\frac{\bar{X}_1}{\bar{X}_2}\right)\right]^2$	.5192	7.0001
S^2	.6835	
t	.6004	

$t < 1.363$

The difference, in the direction opposite to the prediction of the hypothesis, is NOT significant at the .10 level.

TABLE XII

TEST TWO, HYPOTHESIS THREE, PROGRAM THREE, VERSIONS (F) AND (L)

Subject	X_1 Frame 8	X_2 1st plus 4th half-minute intervals in last frame	$\frac{X_1}{X_2}$	Mean Ratio
F_5	14.03	4.08	3.4387	2.4864
F_9	17.12	11.16	1.5341	
L_1	9.52	10.05	.9473	1.2615
L_2	19.67	20.47	.9609	
L_3	21.01	19.80	1.0611	
L_4	13.50	30.35	.4448	
L_5	←	VOID	→	
L_6	13.82	10.90	1.2679	
L_7	8.15	10.72	.7603	
L_8	13.17	4.25	3.0988	
L_9	13.93	7.44	1.8723	
L_{10}	1.58	1.68	.9405	

$1.2615 < 2.4864$ The difference in the mean ratios is in the direction predicted by the hypothesis and is significant as revealed by the following test for the significance of the difference between two means for independent samples.

	$F\left(\frac{X_1}{X_2}\right)$	$L\left(\frac{X_1}{X_2}\right)$
N	2	9
$\left(\overline{\frac{X_1}{X_2}}\right)$	2.4864	1.2615
$\sum\left[\frac{X_1}{X_2} - \left(\overline{\frac{X_1}{X_2}}\right)\right]^2$	1.8136	4.9988
S^2	.7569	
t	1.8013	

$t > 1.383$

The difference in means is significant at the .10 level; the hypothesis is sustained.

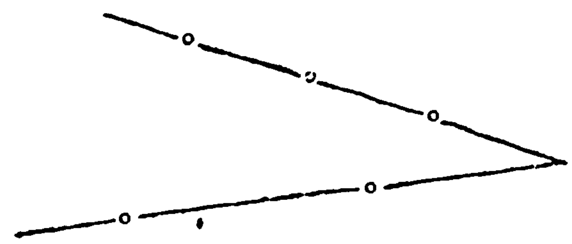
of what had not occurred in the test frame.

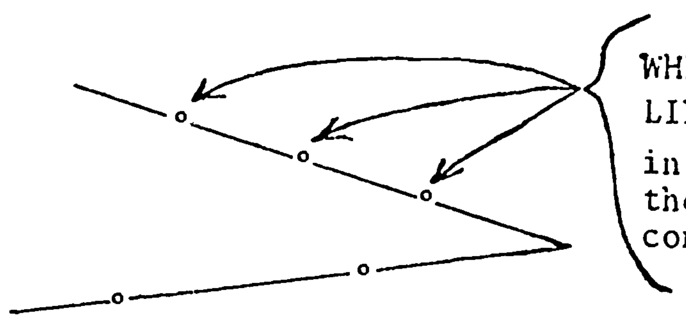
Characteristics of the Tested Intervals, Test Two

In general, Test Two failed to sustain the hypothesis to a greater degree than did the other two tests in this study, and visual examination of the test intervals on the charts revealed fewer obvious decreases in capillary pulse pressure. One explanation for this is that the subjects used in the study were near the lower limit of academic ability for which the programs were validated. Therefore, the subjects may have tended to be somewhat similarly confused by other parts of the programs as they were by the ambiguous test intervals and, thus, did not regard the test intervals as much of a contrast with the rest of the programs. Another explanation is that the type of subject involvement elicited by Test Two is not of the type that tends to lower capillary pulse pressure in most subjects.

The Test Two intervals are presented in Figures 21-29. Hypothesis one, which was sustained by Program One and not sustained by Programs Two and Three, depended on the relative difference in the mean capillary pulse pressure of the lead-in frame and the immediately following test frame. Examination of the charts from Program One reveals that significance was the result of relative decreases during the test frame, as was predicted, rather than increases occurring in the lead-in frame.

(9) Correct solution:





WHEN THREE OR MORE POINTS
LIE IN A STRAIGHT LINE
in such puzzles as these,
then these points can be
connected with a <u>single</u> line.

THUS, FINDING THREE OR MORE POINTS THAT CAN FALL ON ONE DRAWN LINE LETS YOU SOLVE THE PUZZLE <u>USING FEWER LINES</u>.

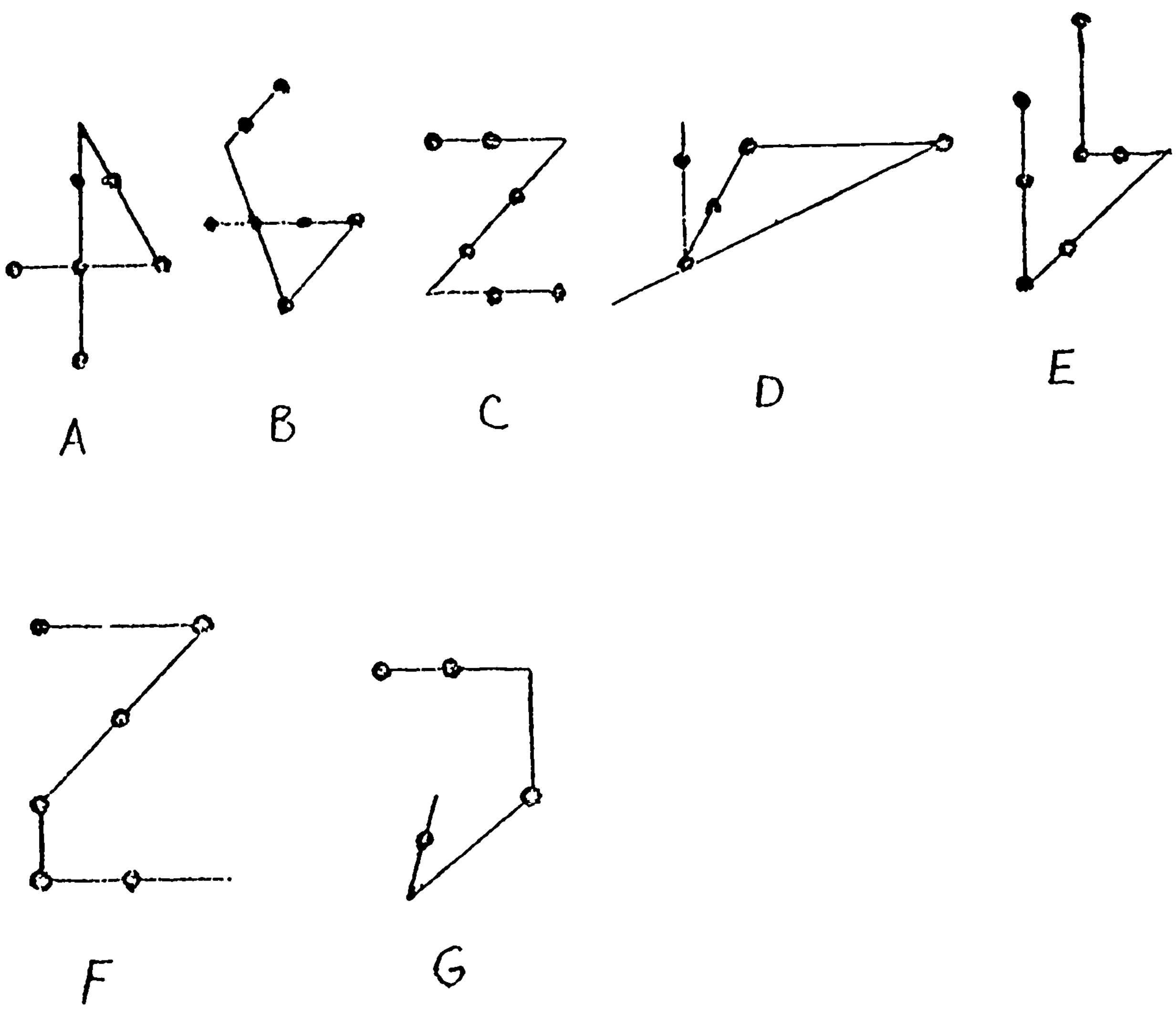
Go on to the next frame

Fig. 21.--Test Two, lead-in frame, Program One

(10) REMINDER:

Remember that doubling back on crossed lines is not permitted when two or more lines meet away from some point.

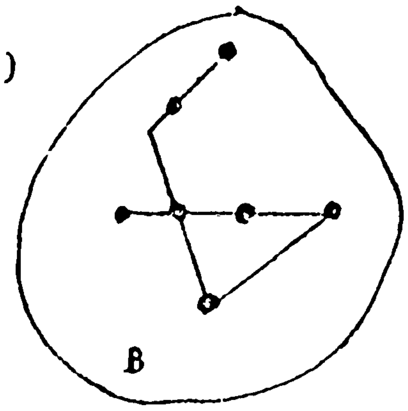
Find the TWO of the following six puzzle solutions which must be rejected because of the above rule. Circle these solutions and write beside each of them the key word pertaining to the circled solution from the above reminder.



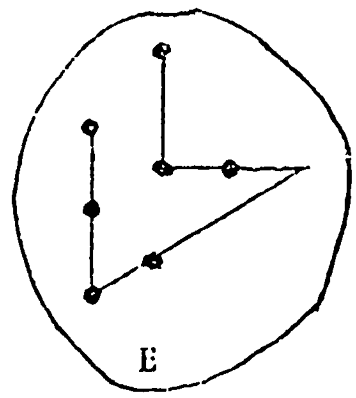
Give your best answer before going on.

Fig. 22.--Test Two, test frame, Program One

(11)

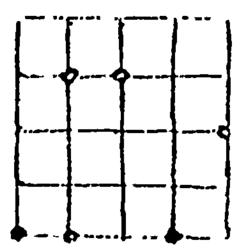


"Doubling"



"Points"

In this frame below you are given a six point puzzle. The six points are placed on a grid of fine lines so that you can see more clearly how they are aligned. You draw in the solution using ONLY THREE STRAIGHT LINES.

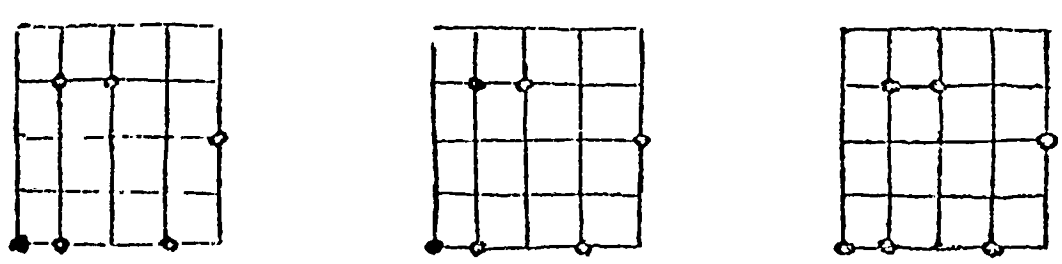


REMEMBER:

1) LINES MAY CROSS.

2) LINES MAY MEET AWAY FROM ANY GIVEN POINTS (AND AWAY FROM THE GRID)

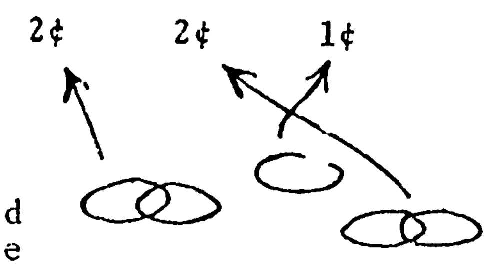
PRACTICE (use only three lines)



Go on to the next frame

Fig. 23.--Test Two, follow-up frame, Program One

(10) One cut in link (3).



Cutting and removing the <u>third</u> link, as shown to the <u>right</u>, would provide the needed pair of two-cent chains and the single one-cent link to buy the boxes.

Note how the cut link, when removed from the MIDDLE of the chain, always becomes a single 1¢ piece while providing two other link-coins from the ends of the cut chain.

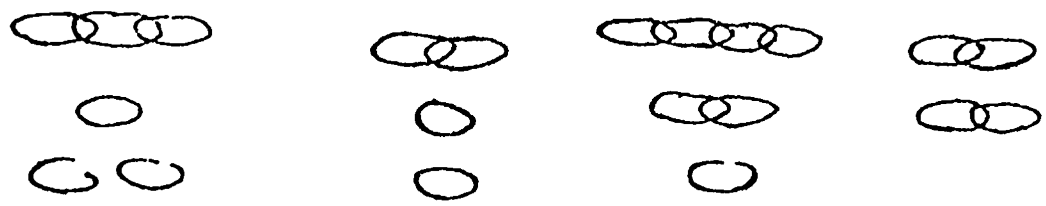
Go on to the next frame

Fig. 24.--Test Two, lead-in frame, Program Two

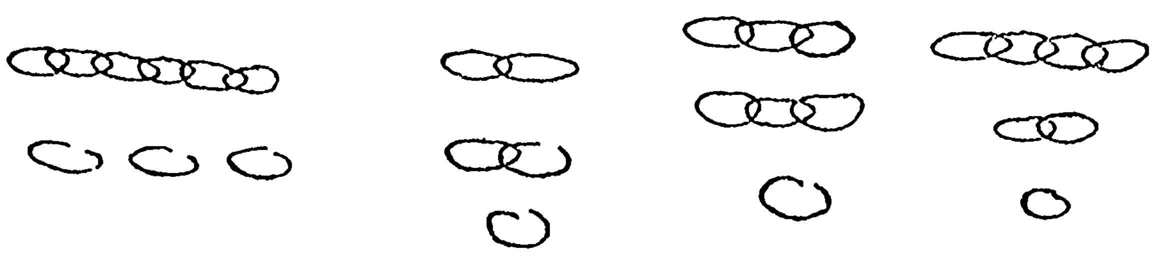
(11) REMEMBER:

Middle link welds, following cuts which divide multiple chains, can be used to obtain additional change combinations. This allows money usage in one-cent and five-cent combinations for three-cent purchases if unwelded links are used first.

With this information, select those combinations from among the ones below which would permit chain purchases as described above. (More than one answer may be correct.) Write the key word pertaining to each of your choices from the paragraph above beside the combinations that you choose.



A B C D

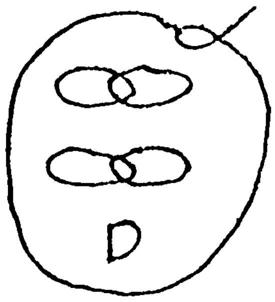


E F G H

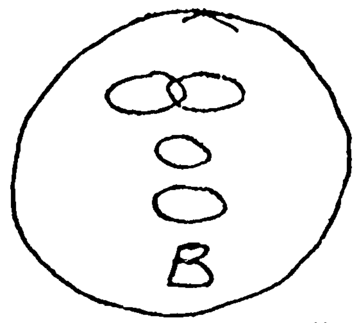
GIVE YOUR BEST ANSWER BEFORE GOING ON

Fig. 25.--Test Two, test frame, Program Two

(12)

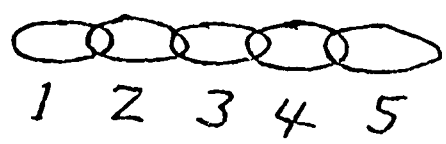


"change"



"combinations"

Suppose you have the five-link chain shown to the right, and each link will buy <u>one</u> glass of water, You want to buy <u>one</u> glass of water each day, and you must pay each day for that day's water, no credit and no advance payments. If the seller will keep the links that you have paid him and use them to make change for you later during the five-day period, what is the smallest number of cuts that you will have to make in your chain, and which links would you cut?



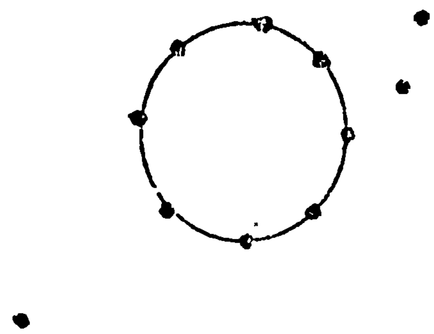
<u>Remember:</u>

The problem is to determine how few cuts would have to be made in your chain to assure that between you and the seller each day there would be the CORRECT CHANGE available for that day's one-link purchase.

Go on to the next frame

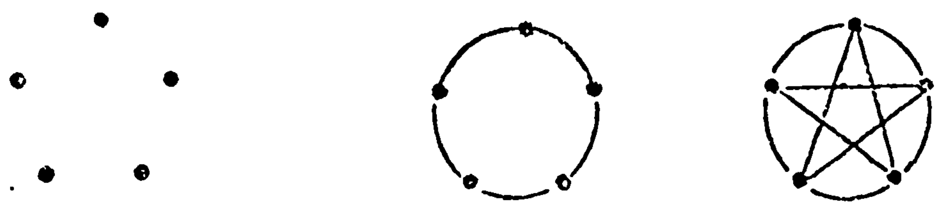
Fig. 26.--Test Two, follow-up frame, Program Two

(9)



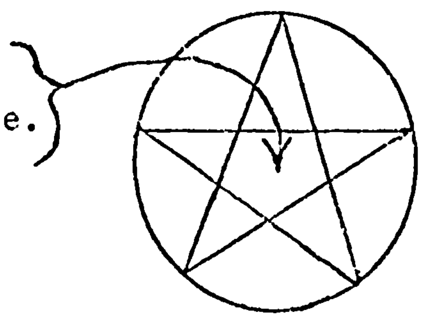
The symmetrical pattern is a circle.

<u>Learn to look for the patterns:</u>

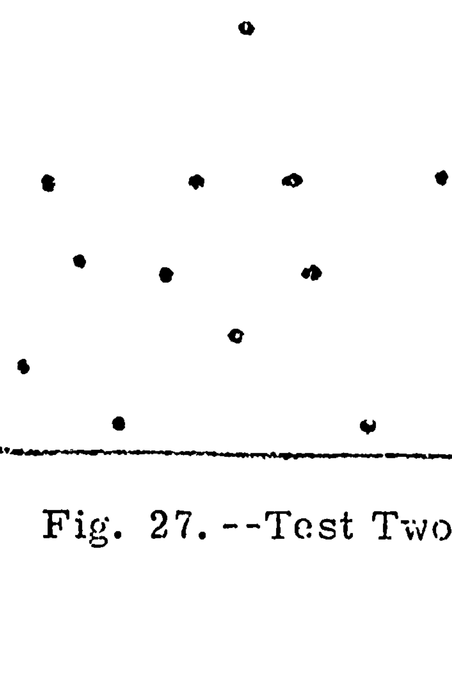


The same five
points may be........on a circle......or on the
points of a
star.

Note the smaller five-point
pattern within the larger one.



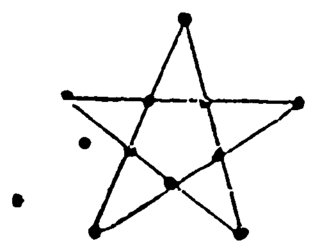
WITH YOUR PENCIL:
Draw in the largest symmetrical pattern hidden in these dots shown below -- using the largest possible number of dots.



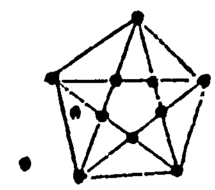
Go on to the next frame

Fig. 27.--Test Two, lead-in frame, Program Three

(10)



Star pattern.

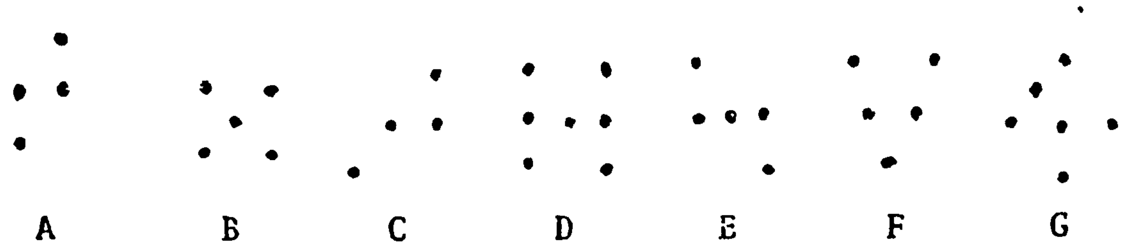


Perhaps you drew it this way which is also correct.

REMEMBER:

The average symmetry pattern can be pointed with lines in the opposite direction so that familiar designs can be seen if one is able to look correctly at the connections. This is not true, however, unless the symmetry is not originally grouped.

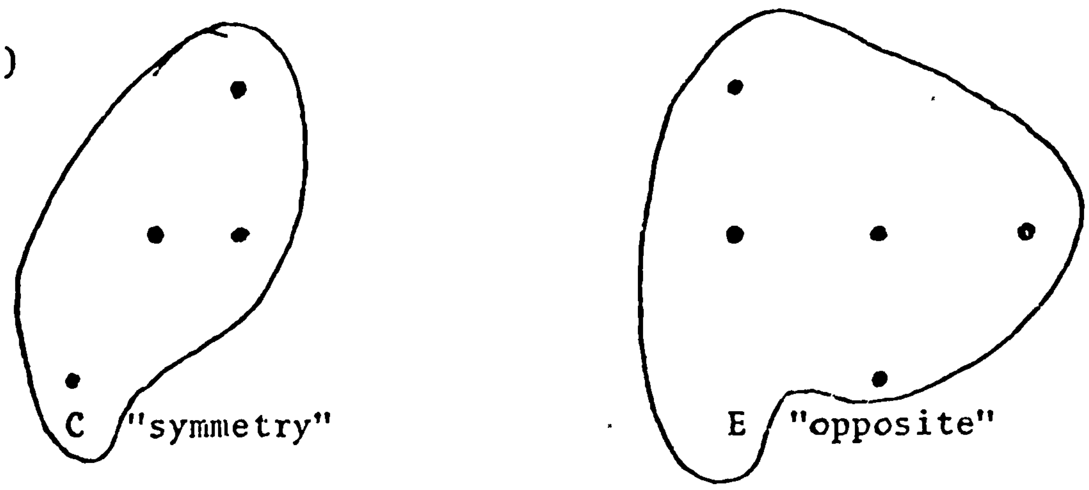
From this information tell which of the designs below has the appropriate line-connected symmetry, and beside each design that you choose write the most related word from the paragraph above.



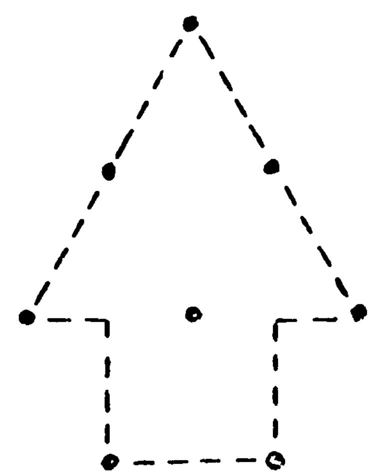
GIVE YOUR BEST ANSWER BEFORE GOING ON.

Fig. 28.--Test Two, test frame, Program Three

(11)



Look at the arrow pattern to the right:



Find the LARGEST symmetry pattern among the dots forming the arrow and draw it in completely with lines.

HINTS:
Ignore the dashed lines.

The largest hidden symmetry pattern involves seven of the eight dots and is not a triangle.

Go on to the next frame

Fig. 29.--Test Two, follow-up frame, Program Three

When capillary pulse pressure decreased in the lead-in frame, the probability of significance for hypothesis one was lessened. In Program One, only two subjects out of ten experienced visually obvious depressions in capillary pulse pressure in the lead-in frame (Fig. 21). However, in Program Two, six out of nine subjects experienced such decreases in the lead-in frame (Fig. 24), and in Program Three, four of nine experienced such decreases in the lead-in frame (Fig. 27). The reasons for these differences seem apparent when a close examination of the three lead-in frames is conducted. In Program One, the lead-in frame tends to be relatively graphic, clean, simple, short, clear, and relatively elementary. In addition, most subjects who eventually examined all three programs concluded that Program One was the easiest of the three. Thus, subjects arriving at the lead-in frame in Program One would perhaps tend to have more confidence. The lead-in frame in Program Two (Fig. 24) is characterized by a more verbal nature; relative to its Program One counterpart, it presents a more complex explanation and proceeds to make a more subtle and complex point with more abstract reasoning required for comprehension. The capillary pulse pressure measurements have apparently discriminated between these two quite similar frames on the basis of the differences delineated above. The lead-in frame in Program Three (Fig. 27) throughout the first two-thirds of its length is more similar to the

lead-in frame of Program One. Although a little longer, it is graphic, straightforward, elementary, and understood about as rapidly as it is read by most subjects. However, unlike the lead-in frames in the other two programs, this one presents a final problem involving identification of a pattern in a field of dots, with the answer presented at the top of the test frame. Of the four subjects who exhibited visually obvious decreases in capillary pulse pressure during this lead-in frame, two dropped abruptly in the middle of the frame upon encountering this final problem. These two abrupt decreases are presented in Figure 30, the arrows indicating positions where they occur. This suggests that were it not for this final problem, the reactions to this Program Three lead-in frame would have been about the same as reactions to the lead-in frame in Program One which it otherwise closely resembles in nature.

The test frames themselves, presented in Figures 22, 25, and 28, did not tend to cause many obvious decreases in capillary pulse pressure. Those that did occur were previously presented in Figure 20; four subjects in both Program One and Program Two, and two subjects in Program Three. Repeated reading of the three test frames tends to suggest that in Programs One and Two the test frames are perhaps a little more obviously nonsense than in Program Three; the futility inherent in them was perhaps a little more obvious. In Program One, the confrontation with the

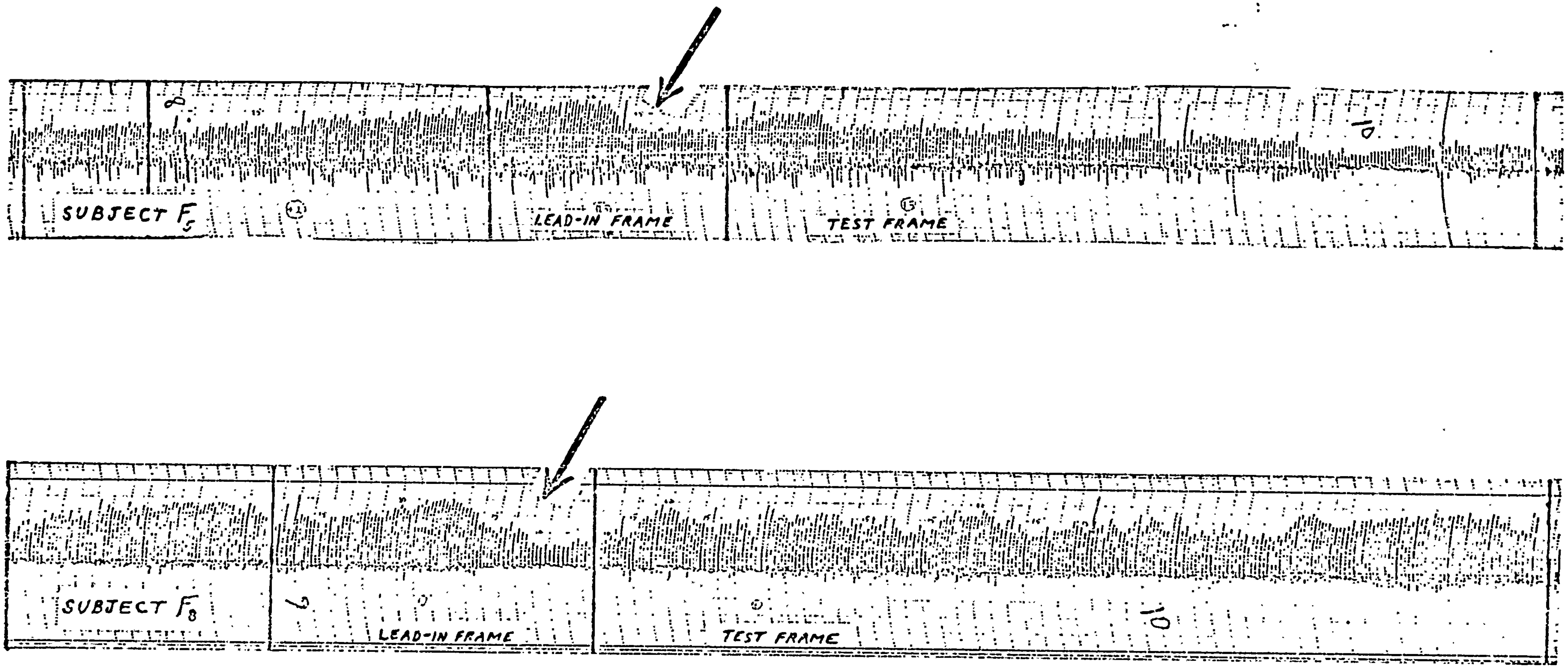


Fig. 30.--Abrupt decreases in capillary pulse pressure near the end of frame nine, Test Two, Program Three

ambiguity is more abrupt than in the other two programs, because there are only two and one-half lines of confused wording as opposed to five lines in each of the other two programs. The implication is that in Program Three the subjects may have tended to remain involved longer and to a greater degree than they did in Programs One and Two. Also, the test frame in Program Three is contaminated by the presence of an answer to a previous question; whereas, the test frames in the other two programs went immediately to the test content.

Hypothesis three in Test Two was concerned with possible lingering effects following exposure to the test frame. The statistical test was intended to detect latent effects that were not visually obvious. Only in Program Three was statistical significance attained, but closer examination of the charts reveals that this significance is probably not meaningful. The statistical significance for Program Three was obtained because one of the only two version (F) subjects that could be used had an unusually high ratio of base frame to final frame. The chart of that subject, F_5, revealed that the subject experienced a long, steady fatigue pattern with a steady decrease in capillary pulse pressure starting with the drawing exercise at the end of frame (9) and continuing on to the end of the program, where the capillary pulse pressure had reached a very low level. Only two of the nine version (F) subjects experienced

such fatigue effects over the last half of the program. The selection of subject F_5 was based on a localized depression in the test frame, and had nothing to do with the long-term fatigue pattern. Thus, if this subject had been chosen from among the seven others who did not experience the long fatigue pattern, it is unlikely that statistical significance would have been attained in Program Three for hypothesis three.

Although meaningful significance was not attained for hypothesis three, there was, nevertheless, one factor present that might have acted to produce statistical significance. The programs were short, and during the validation process fatigue was not found to be significant, yet capillary pulse pressure measurements revealed clear fatigue patterns in about half of the subjects tested. This was partly caused by the fact that the subjects used were at the lower limit of the range of academic ability for which the programs were validated. The insertion of the test interval resulted in the test versions being one or two frames longer than the control versions with which they were compared in this test. From this it might have been expected that the final frame in the test versions would be lower than in the control versions. This effect probably contributed to the statistical significance attained from Program Three, because of the fatigue exhibited by subject F_5, as previously discussed.

Test Three--Step Size: The Insoluble Problem

The Hypotheses of Test Three

In Test Three, the subjects were confronted with a final test frame at the end of the program which they were led to believe was soluble on the basis of what they had learned in the program, but which was actually an insoluble problem. The first hypothesis predicted a relatively quick decrease of capillary pulse pressure upon entering this frame; the second predicted that a further significant decrease would follow the pressing of a button, whereby the subjects indicated overtly that they were frustrated; and the third hypothesis predicted that capillary pulse pressure after this button was pressed would be lower for the test subjects than for a control group working on a similar final frame that was soluble.

The Test of Hypothesis One, Test Three

The test of hypothesis one was accomplished by a comparison of the mean capillary pulse pressure in frame (12), the next to last frame, with the mean capillary pulse pressure in frame (13), the final frame, between the start of the frame and the point at which the button was pushed. Not all subjects pushed the button, and only those who did could be used to test this hypothesis. Of the ten subjects who worked on Test Three in each of the programs, four pushed the button during Program One, seven pushed it during

Program Two, and five pushed it during Program Three. Hypothesis one was sustained by statistical significance for all three programs.

The Test of Hypothesis Two, Test Three

The test of hypothesis two was accomplished by a comparison of mean capillary pulse pressure in the interval from the start of the final test frame to the point where the button was pushed with the mean of the first one-minute interval immediately following the pressing of the button. Not all of the subjects who were used in the test of hypothesis one could be used in this test of hypothesis two, because some subjects pressed the button to indicate that they were frustrated and then immediately quit working, contrary to prior instructions to continue trying to solve the problem. In Program One, only three of the four button-pushers could be used; in Program Two, only four of seven continued working; but in Program Three all five continued working so that none had to be dropped. Hypothesis two was sustained by statistical significance only for Program Three.

The Data and its Treatment, Hypotheses One and Two, Test Three

The results of Test Three, hypotheses one and two, are presented in Tables XIII-XVIII.

The Test of Hypothesis Three, Test Three

Hypothesis three, which predicted a lower capillary pulse

TABLE XIII

PROGRAM ONE, TEST THREE (STEP SIZE), HYPOTHESIS 1 (DECREASE), VERSION (D)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1			
2			
3	11.12	11.25	-.0117
4			
5			
6	23.87	20.15	.1558
7			
8	12.41	9.26	.2538
9	7.21	4.55	.3689
10			
		Sum	.7668
		Mean	.1917
		ΣD^2	.2249

Subjects 1, 2, 4, 5, 7, and 10 did not press the button.

$t = 2.3796$

Significant at the .05 level: $t > 2.3553$

TABLE XIV

PROGRAM ONE, TEST THREE (STEP SIZE), HYPOTHESIS 2 (DECREASE), VERSION (D)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1			
2			
3	11.25	11.92	-.0596
4			
5			
6	20.15	14.56	.2774
7			
8	Subject 8 did not continue working after pressing the button.		
9	4.55	4.09	.1011
10			
		Sum	.3189
		Mean	.1063
		ΣD^2	.0907

Subjects 1, 2, 4, 5, 7, and 10 did not press the button.

$t = 1.0924$

t is NOT significant at the .10 level: $t < 1.886$

TABLE XV

PROGRAM TWO, TEST THREE (STEP SIZE), HYPOTHESIS 1 (DECREASE), VERSION (H)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	3.85	4.62	-.2000
2	17.33	11.98	.3087
3	11.84	7.21	.3910
4	15.79	13.62	.1374
5	9.13	5.44	.4042
6	18.56	23.68	-.2759
7	8.21	4.89	.4044
8			
9			
10			
		Sum	1.1698
		Mean	.1671
		ΣD^2	.7101

Subjects 8, 9, and 10 failed to push the button during the last frame.

$t = 1.5099$

Significant at the .10 level: $t > 1.440$

TABLE XVI

PROGRAM TWO, TEST THREE (STEP SIZE), HYPOTHESIS 2 (DECREASE), VERSION (H)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	4.62	5.77	-.2489
2			
3			
4			
5	5.44	8.33	-.5313
6	23.68	16.25	.3138
7	4.89	5.20	-.0634
8			
9			
10			
		Sum	-.5298
		Mean	-.1325
		ΣD^2	.4467

Subjects 2, 3, and 4 did not continue working after pressing the button.

Subjects 8, 9, and 10 failed to push the button during the last frame.

$t = .7481$

t is NOT significant at the .10 level in the direction opposite to the prediction of the hypothesis: $t < 1.638$

TABLE XVII

PROGRAM THREE, TEST THREE (STEP SIZE), HYPOTHESIS 1 (DECREASE), VERSION (C)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	13.36	11.83	.1145
2	7.15	3.48	.5133
3	22.11	20.36	.0791
4	9.00	8.78	.0244
5	5.38	4.20	.2193
6			
7			
8			
9			
10			
		Sum	.9506
		Mean	.1901
		ΣD^2	.3315

Subjects 6, 7, 8, 9, and 10 did not press the button during the last frame of the program.

$t = 2.1893$

Significant at the .05 level: $t > 2.132$

TABLE XVIII

PROGRAM THREE, TEST THREE (STEP SIZE), HYPOTHESIS 2 (DECREASE), VERSION (C)

Subject	Mean of First Interval X_1	Mean of Second Interval X_2	Ratio of Difference $D = \frac{X_1 - X_2}{X_1}$
1	11.83	10.54	.1090
2	3.48	3.01	.1351
3	20.36	18.48	.0923
4	8.78	4.42	.4966
5	4.20	3.09	.2643
6			
7			
8			
9			
10			
		Sum	1.0973
		Mean	.2195
		ΣD^2	.3551

Subjects 6, 7, 8, 9, and 10 did not press the button during the last frame of the program.

$t = 2.9050$

t is significant at the .025 level: $t > 2.776$

pressure after the button was pushed for the test group than for a control group, had to be tested using ratios of decrease. As in previous tests of this type, this was necessitated by the impossibility of direct comparisons between the charts of different individuals. First, the mean capillary pulse pressure for frame (12) was determined by using either all of frame (12) or the middle .8 minute if the time spent on the frame exceeded that. Next, the mean of the .8 minute interval immediately following the pushing of the button was determined. A ratio of these means, X_{12}/X_{13}, was then calculated for each subject. For this test, all three programs were combined, and the mean ratio determined. This entire process was then repeated for the combined control groups. The assumption was that, because frame (12) was very nearly the same in both the test versions and the control versions, any significant differences in these mean ratios should be caused by differences in the reactions to the final frame. The hypothesis predicted a lower capillary pulse pressure in the last frame for the test versions, which would, in turn, produce a higher ratio, because it appears in the denominator.

However, as the following tables (XIX-XXI) reveal, the mean ratio from the test versions was actually less than that from the control versions, so that hypothesis three is not sustained. As the figures indicate, the difference in the mean ratios in the

TABLE XIX

TEST THREE, HYPOTHESIS THREE: THE MEAN RATIO (X_{12}/X_{13}) FOR TEST THREE VERSIONS OF ALL PROGRAMS

Subject	X_{12}	X_{13}	$\frac{X_{12}}{X_{13}}$
Program One, Test Three, Version (D)			
D_3	11.12	11.92	.9329
D_6	23.87	14.56	1.6394
D_9	7.21	4.09	1.7628
Program Two, Test Three, Version (H)			
H_1	3.85	5.77	.6672
H_5	9.13	8.33	1.0960
H_6	18.56	16.25	1.1422
H_7	8.21	5.20	1.5788
Program Three, Test Three, Version (C)			
C_1	13.36	10.54	1.2676
C_2	7.15	3.01	2.3754
C_3	22.11	18.48	1.1964
C_4	9.00	4.42	2.0362
C_5	5.38	3.09	1.7411

Mean Ratio: 1.4530

TABLE XX

TEST THREE, HYPOTHESIS THREE: THE MEAN RATIO (X_{12}/X_{13}) FOR CONTROL VERSIONS OF ALL PROGRAMS

Subject	X_{12}	X_{13}	$\frac{X_{12}}{X_{13}}$
Program One, Control, Version (J)			
J_1	6.10	4.85	1.2577
J_2	9.06	6.85	1.3226
J_4	11.57	3.71	3.1186
J_5	3.26	6.08	.5362
J_7	11.45	3.33	3.4384
J_8	7.56	9.61	.7867
J_9	7.96	2.50	3.1840
Program Two, Control, Version (K)			
K_3	3.02	2.60	1.1615
K_4	7.88	4.33	1.8199
K_5	5.46	3.49	1.5645
K_8	29.67	22.01	1.3480
K_9	23.71	16.33	1.4519
Program Three, Control, Version (L)			
L_2	17.48	18.04	.9690
L_3	18.79	19.69	.9543
L_5	13.32	4.16	3.2019
L_6	10.68	11.34	.9418
L_7	13.92	10.02	1.3892
L_9	11.54	7.89	1.4626
L_{10}	3.93	1.13	3.4779
L_{11}	8.49	7.18	1.1825

Mean Ratio: 1.7285

TABLE XXI

TEST THREE, HYPOTHESIS THREE: TEST FOR THE SIGNIFICANCE OF THE DIFFERENCE IN MEAN RATIOS

	Controls	Test 3
N	20	12
$\bar{X}$	1.7285	1.4530
$\sum (X-\bar{X})^2$	17.7579	2.6327

$t = 0.9152$

t is NOT significant at the .10 level: $t < 1.310$

direction opposite to that predicted is not statistically significant.

Characteristics of the Tested Intervals, Test Three

An examination of the final test frames on the charts reveals that the capillary pulse pressure underwent visually obvious decreases, either temporary or extended, in the majority of cases. Such incidents occurred in seven out of ten cases in Program One, nine out of ten cases in Program Two, and five out of ten cases in Program Three. However, the control groups, confronted with very similar last frames that were soluble because of the difference in one or two critical words, also exhibited similar reactions: seven out of ten in Program One, nine out of ten in Program Two, and seven out of ten in Program Three. This suggests that these decreases in capillary pulse pressure in the last frame were not generally caused by perception of the great relative difficulty as in Test Three, but were instead caused by confrontation with this type of test frame situation. The subjects were affected by the confrontation, but capillary pulse pressure measurements did not discriminate between the soluble and the insoluble versions. This is not a surprising revelation, because the programs were constructed to disguise the fact that the test versions were insoluble, and there is no reason to expect different reactions to differences that are not perceived. Subjects with higher ability, who might have found the

control versions quite easy, would probably not have exhibited as many decreases in capillary pulse pressure in the last frame of the control versions as did the subjects in this study. Figures 31-42 present the Test Three frames and the corresponding control intervals.

Figure 43 shows some typical reactions to a confrontation with a final test frame in Test Three. This subject, H_{10}, working on Program Two, encountered frames (12) and (13), which are presented in Figures 35 and 36. The capillary pulse pressure decreased abruptly upon entry into the test frame, increased back toward the previous level for about twenty seconds, and then plunged once again to a very low level. This was followed by a gradual recovery which never again attained more than about two-thirds of the level prior to entry into the test frame.

It was hoped that Test Three would demonstrate whether capillary pulse pressure measurements would detect the subject's lowered level of affect before he would make some overt admission of that fact. Of the thirty Test Three subjects, twenty-six (87 per cent) made overt admissions of difficulty within the frame, either by pressing the button as instructed or by such obvious gestures as closing the program book, putting down the pencil and looking away, or leaning back in the chair as if daydreaming without further consideration of the programs. Of the twenty-six who made overt,

(12)

Yes, it is also correct. You may not lift the pencil or double back on a line, but this does not prohibit the lines crossing each other.

REMEMBER: The lines 1) may cross

2) may meet away from any given points

In the next frame you will be given a box-like pattern of nine points. Without lifting your pencil or doubling back on any line, use ONLY FOUR STRAIGHT LINES to contact every point at least one time.

If you have understood the previous frames, this next frame should be a pleasantly interesting challenge, but not too difficult for you.

As soon as you solve the puzzle, press the button in front of you immediately and then sit quietly until you are told that the session is finished.

Go on to the next frame

Fig. 31.--Next-to-last frame, control version, Program One

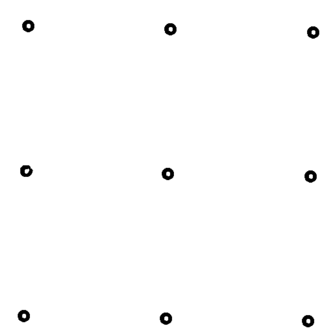
(13)

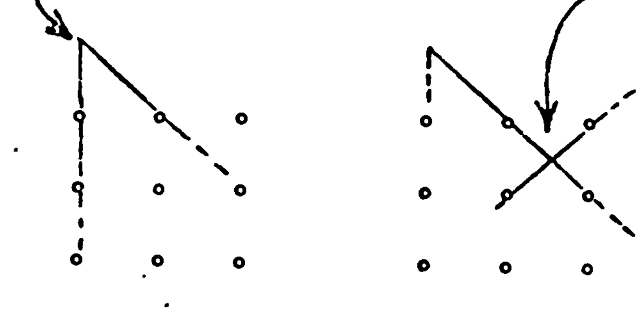
USE ONLY FOUR LINES.
DO NOT LIFT PENCIL
OR RETRACE.

REMEMBER:

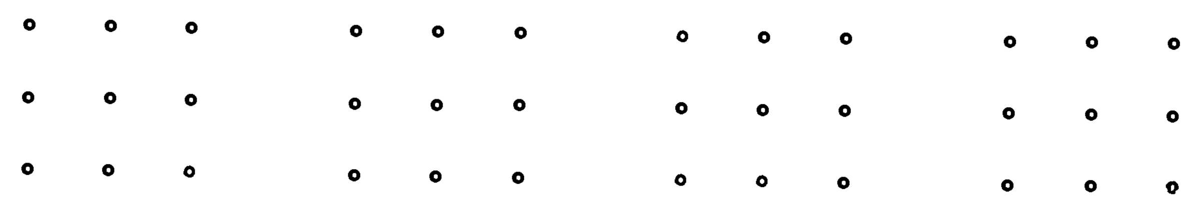
LINES MAY MEET AWAY FROM GIVEN POINTS

AND LINES MAY CROSS





PRACTICE
(use only FOUR lines)



PRESS THE BUTTON WHEN YOU GET A CORRECT SOLUTION AND REMAIN SEATED QUIETLY.

STOP-THIS IS THE END.

DO NOT TURN PAGE

DO NOT CLOSE BOOK

Fig. 32.--Final frame, control version, Program One

(12) Yes, it is also correct. You may not lift the pencil or double back on a line, but this does not prohibit the lines crossing each other.

REMEMBER: The lines 1) may cross

2) may meet away from any given points

In the next frame you will be given a box-like pattern of nine points. Without lifting your pencil or doubling back on any line, use ONLY THREE STRAIGHT LINES to contact every point at least one time.

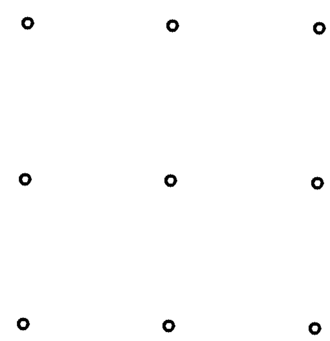
If you have understood the previous frames, this next frame should be a pleasantly interesting challenge, but not too difficult for you.

If you start to feel bored, disgusted, or like the activity is no longer fun, press the button IMMEDIATELY, but continue trying to solve the puzzle until you are told to stop.

Go on to the next frame

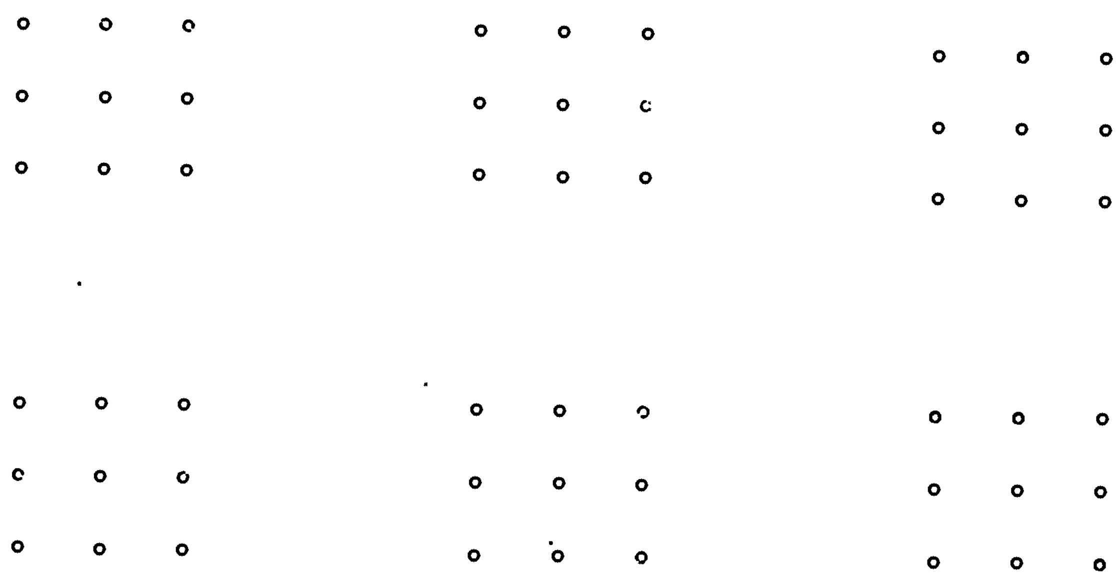
Fig. 33.--Lead-in frame, Test Three, Program One

(13) USE ONLY THREE LINES



Press the button if you should become displeased with the game, but continue working.

PRACTICE (use only three lines)



PRESS THE BUTTON IF YOU SHOULD BECOME DISPLEASED WITH THE GAME, BUT CONTINUE WORKING.

DO NOT TURN PAGE - - - THIS IS THE END STOP

DO NOT TURN PAGE

Fig. 34.--Final test frame, Test Three, Program One

(12) You give him a pair of joined links (), and he gives you a single link as change.

Suppose you own a valuable gold chain, as will be shown to you in the next frame, and you need a hotel room for several days. You have no money, but the hotel owner will take one link of your gold chain each day as payment; you must pay each day, one link per day, and the hotel owner will have the links there that you have already paid to him each time that you come to pay. By the time your chain is all gone you will have gotten the money to buy back your chain, so you do NOT want to cut it any more than is necessary.

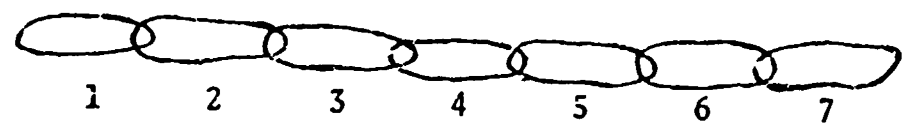
Go to the next frame, look at the chain, and show how you could get by with cutting only ONE link.

As soon as you solve the puzzle, PRESS THE BUTTON IN FRONT OF YOU IMMEDIATELY and then sit quietly until you are told that the session is finished.

Go on to the next frame

Fig. 35.--Next-to-last frame, control version, Program Two

(13) Here is the gold chain:



MAKE ONLY <u>ONE</u> CUT

Remember that you need possible combinations of links totalling one, two, three, four, five, six, and seven links, for payment on each of the seven days. Tell which link you would cut and sketch the seven needed combinations that you could get from that <u>ONE</u> cut.

PRESS THE BUTTON WHEN YOU GET A CORRECT SOLUTION AND REMAIN QUIETLY SEATED.

STOP - DO <u>NOT</u> TURN PAGE

THIS IS THE END - DO <u>NOT</u> TURN PAGE

Fig. 36.--Final frame, control version, Program Two

(12) You give his a pair of joined links (), and he gives you a single link as change.

Suppose you own a valuable gold chain, as will be shown to you in the next frame, and you need a hotel room for several days. You have no money, but the hotel owner will take one link of your gold chain each day as payment; you must pay each day, one link per day, and the hotel owner will have the links there that you have already paid to him each time that you come to pay. By the time your chain is all gone you will have gotten the money to buy back you chain, so you do NOT want to cut it any more than is necessary.

Go to the next frame, look at the chain, and show how you could get by with cutting only ONE link.

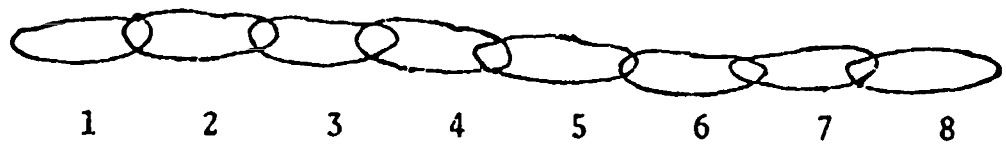
If you have understood the previous frames, this next frame should be a pleasantly interesting challenge, but not too difficult for you.

If you should begin to feel bored, disgusted, or like the activity is no longer fun, press the button IMMEDIATELY, but continue trying to solve the puzzle until you are told to stop.

Go on to the next frame

Fig. 37.--Lead-in frame, Test Three, Program Two

(13) Here is the gold chain:



MAKE ONLY ONE CUT.

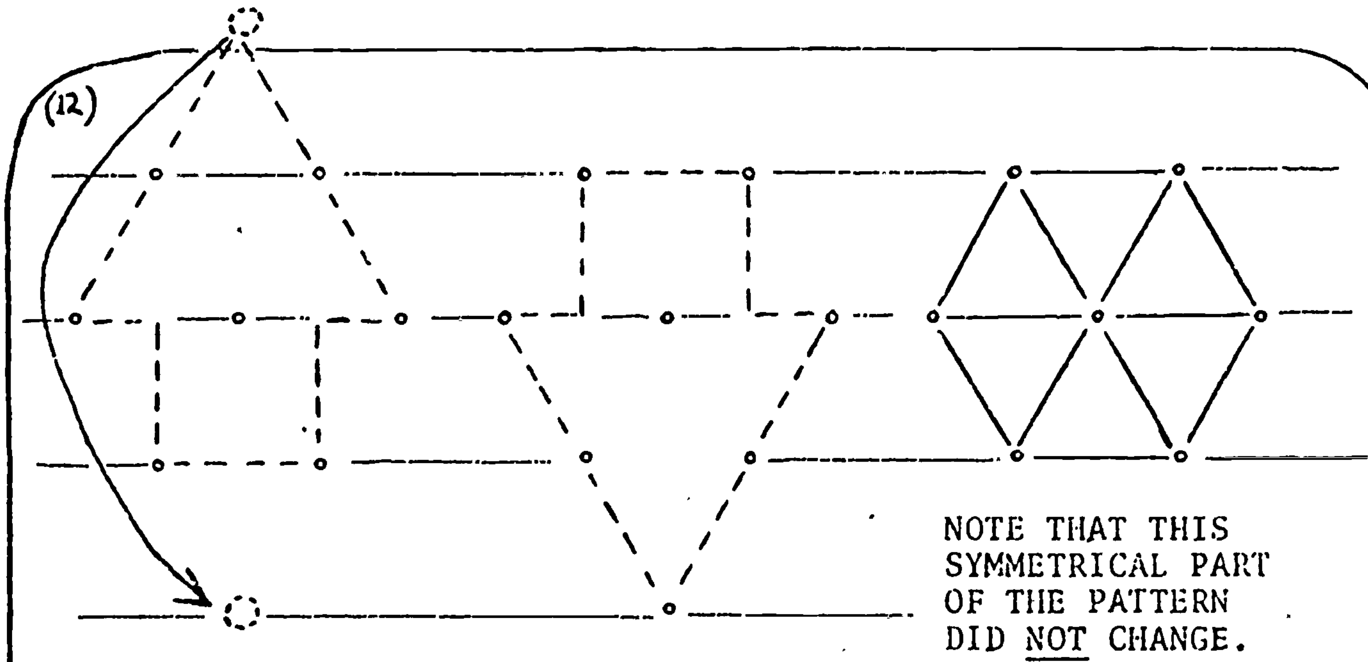
Remember that you need possible combinations of links totalling one, two, three, four, five, six, seven, and eight days. Tell which link you would cut and sketch the eight needed combinations that you could get from that ONE cut.

PRESS THE BUTTON IF YOU SHOULD BECOME DISPLEASED WITH THE GAME, BUT CONTINUE WORKING.

STOP — THE END — DO NOT TURN PAGE

DO NOT TURN PAGE

Fig. 38.--Final test frame, Test Three, Program Two



In the next frame you will be given another kind of arrowhead pattern. By moving only THREE points to different positions, make the same arrow point in the opposite direction.

If you have understood the previous frames, this next frame should be a pleasantly interesting challenge, but not too difficult for you.

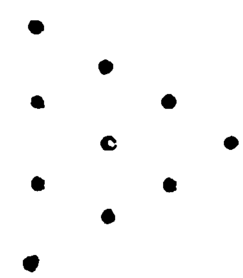
As soon as you solve the puzzle, press the button in front of you immediatly and then sit quietly until you are told that the session is finished.

Go on to the next frame

Fig. 39.--Next-to-last frame, control version, Program Three

(13)

Move THREE points to new positions so that the arrow points in the opposite direction (to the left).

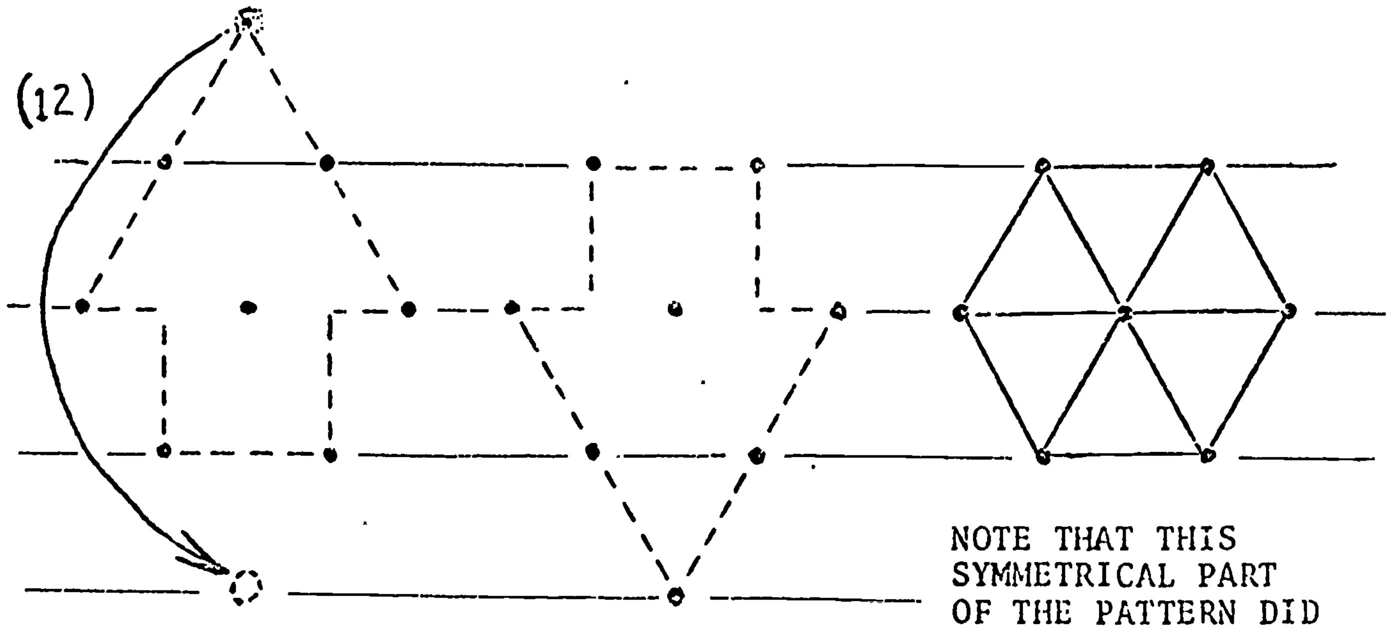


PRESS THE BUTTON AS SOON AS YOU GET A CORRECT SOLUTION AND REMAIN SEATED QUIETLY.

DO NOT TURN PAGE THIS IS THE END

STOP — DO NOT TURN PAGE

Fig. 40.--Final frame, control version, Program Three



In the next frame you will be given another kind of arrowhead pattern. By moving only TWO points to different positions, make the same arrow point in the opposite direction.

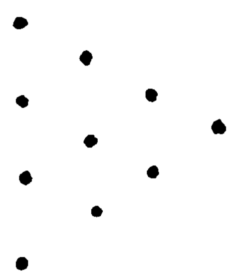
If you have understood the previous frames, this next frame should be a pleasantly interesting challenge, but not too difficult for you.

If you should begin to feel bored, disgusted, or like the activity is no longer fun, press the button IMMEDIATELY, but continue trying to solve the puzzle until you are told to stop.

Go on to the next frame

Fig. 41.--Lead-in frame, Test Three, Program Three

(13) Move TWO points to new positions so that the arrow points the opposite way (to the left).



MOVE ONLY TWO POINTS.

PRESS THE BUTTON IF YOU SHOULD BECOME DISPLEASED WITH THE GAME, BUT CONTINUE WORKING.

STOP DO NOT TURN PAGE. THIS IS THE END. STOP

DO NOT TURN PAGE

Fig. 42.--Final test frame, Test Three, Program Three

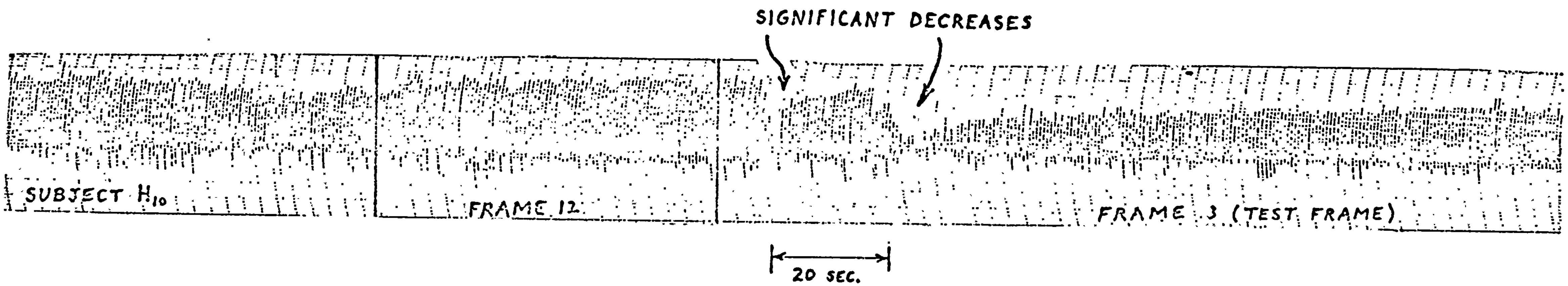


Fig. 43.--Typical capillary pulse pressure reactions to a confrontation with a final test frame in Test Three

obvious admissions of decreased level of affect, fifteen (57.7 per cent) experienced visually obvious decreases in capillary pulse pressure prior to their overt gestures of admission, and eight (30.8 per cent) exhibited the decrease after the gesture. One subject experienced a decrease in capillary pulse pressure just as he pressed the button, and two other subjects who made gestures of admission of lowered level of affect exhibited no decrease in capillary pulse pressure. Both of these latter two subjects were of the group three type previously identified as exhibiting little variation in capillary pulse pressure throughout the experiment.

There was a general tendency for capillary pulse pressure to decrease considerably whenever the subject quit working on the programs. Of the eight subjects who did not experience a visually obvious decrease in capillary pulse pressure until after their overt admission of decreased level of affect, five experienced the decrease immediately after their admission gestures. This suggests that their conscious awareness of frustration may have come upon them suddenly, whereupon they quickly pressed the button or made another gesture of overt admission, and then began to exhibit the associated pulse pressure drop that signaled their relaxation.

Not all subjects attempt to hide their lowered level of affect during work on programmed instruction sequences, yet in this experiment the capillary pulse pressure measurements revealed

that over half of the subjects experienced a lowered level of affect before overtly admitting it. It is concluded that capillary pulse pressure measurement is more effective in revealing decreased level of affect than reliance on elicited overt admissions.

The greatest difference in the programs as revealed by Test Three was the reaction tested in connection with hypothesis two which predicted that after the button was pushed the capillary pulse pressure would decrease still further. In Program One, this hypothesis was almost sustained by significance at the .10 level, and in Program Three it was sustained. However, in Program Two, not only was the hypothesis not sustained, but the capillary pulse pressure variation went in the opposite direction to that predicted and it was almost, but not quite, significant at the .10 level. This difference in reaction came as a complete surprise, because prior to the experiment, the final test frames in the three programs were believed to be very similar in nature. However, a more careful examination of these three frames (Figures 31, 35, and 39) reveals some previously latent characteristics which apparently did not elude the discriminatory capacity of capillary pulse pressure measurements.

The chain link combination problem in the final frame of Program Two cannot be shown to be insoluble as quickly as can the problems in Programs One and Three. In Program One, the quick

accumulation of some attempts at a solution soon confronts the subject with an array of graphic evidence that the problem cannot be solved; the graphic nature of the trial explorations are readily visible and are in a form that lends itself to reference and profiting from previous abortive attempts. The subjects did not work as long on this final test frame in Program One as on the corresponding frame in the other two programs. Involvement tended to further decrease after the button had been pushed. In the case of Program Three, much of the same can be said. The subjects tended to stay with the final insoluble frame a little longer than in Program One, but again the strong suggestion of futility was rather quick to emerge from solution attempts, and involvement waned rather quickly after the button was pushed.

In Program Two, however, there appear to be a greater number of possible combinations to explore. The previous graphic solutions in this case do not lend themselves as readily to an accumulative picture revealing the insolubility of the problem. The subjects in all three programs sensed and admitted frustration after about the same interval of time had elapsed, but in Program Two the subjects tended to be less convinced that the problem was insoluble and continued to try more possible solutions. Their lingering involvement with the problem apparently tended to re-elevate the capillary pulse pressures. Thus, the capillary pulse

pressure measurements in Test Three of this experiment have revealed that the frame in Figure 35 will elicit a more lengthy sustained subject involvement than will the frames in Figures 31 and 39, for reasons which, while apparently subject to rational analysis, are subtle enough to measure the skills of many programmers.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The Problem

It is recognized that overt responses elicited from subjects concerning subject reaction to instructional materials tend to contaminate the content of those responses. This study explored the potential usefulness of capillary pulse pressure measurement as a covert and unobtrusive means of determining some aspects of subject reaction to certain types of instructional materials.

The Methodology Followed

Subjects worked through different versions of three short programs while small pulse transducers taped to their fingertips resulted in chart recordings of their capillary pulse pressure. These charts were then analyzed for their relationships to the content of the programs.

The Results

1. Capillary pulse pressure characteristics vary

considerably from person to person, but it is possible to place individuals in one of a small number of arbitrary type-groups without much difficulty.

2. Variations in the magnitude of an individual's capillary pulse pressure occurred as long-term variations over periods of at least half an hour, during which long, steady increases or decreases were recorded. At the same time, there were short-term variations superimposed on the long-term changes. The long-term variations appeared to be related to a general arousal-fatigue cycle; whereas, the short-term fluctuations appeared to be relatively immediate reactions to specific localized encounters.

3. Short-term variations in capillary pulse pressure have a specificity that can be measured in terms of a few heart-beats or a few tenths of a second.

4. An encounter between a subject and an unfamiliar term was manifested as a short-term depression in capillary pulse pressure, apparently in direct proportion to the abruptness and finality of the impasse which the term presented. The evidence suggested that when an unfamiliar term is perceived as an abrupt and absolute impasse, there will be a significant decrease in capillary

pulse pressure, closely associated in time with that encounter.

5. An encounter between a subject and a short, ambiguous paragraph apparently caused short-term decreases in capillary pulse pressure in proportion to its capacity for abruptly terminating the subject's efforts to proceed. Ambiguous paragraphs have less capacity for doing this than do unfamiliar terms used in critical contexts.
6. The evidence suggests that subject encounters with other types of specific situations and content items that tend to be perceived as abrupt impasses also result in short-term decreases in capillary pulse pressure.
7. Subjects who experienced significant short-term decreases in capillary pulse pressure upon encountering ambiguous paragraphs did not tend to exhibit lower final capillary pulse pressure at the end of the programs than did control groups who had not encountered the ambiguous paragraphs.
8. Subjects who encountered a culminating test frame that was too difficult to offer any immediately obvious solution, yet was implied to be readily soluble, experienced a significant short-term decrease in capillary pulse pressure at the time of the encounter.

Recovery from this decrease later in the frame was apparently aided by the capacity of the problem to elicit subsequent continuing efforts toward a solution, and hindered by revelations of apparent futility.

9. In a group of twenty-six subjects who made some overt gesture of reduced level of affect while working on an insoluble problem, the reduction in level of affect was revealed by capillary pulse pressure decreases prior to the gesture in 58 per cent of the cases. In 4 per cent of the cases, the gestures and the capillary pulse pressure decrease were simultaneous; and in 31 per cent of the cases, the decreases followed the gestures. Only in 8 per cent of the cases did capillary pulse pressure fail to reflect any visually obvious decrease during the frame in question.

10. Capillary pulse pressure was lower before and after work on the programs and during intervals of distraction within the programs than it was during efforts of concentration on the content of the programs.

11. Subjects who were frustrated enough by an insoluble problem to admit it overtly had higher capillary pulse pressure at that time than did another group of subjects who had just completed work on a similar but soluble

version of the same problem.

12. Capillary pulse pressure variations are apparently related to those aspects of affect having to do with the release of glandular chemicals into the bloodstream, such as stress and arousal. The evidence in this study tends to contradict the hypothesis that capillary pulse pressure variations are direct functions of those aspects of affect having a more neural locus, such as pleasure (Wooldridge, 1963).

Conclusions

The Emergence of a Theory of Causation

The original Bergum and Lehr study (1966c) concentrated on capillary pulse pressure discriminations on the basis of the relative attractiveness of different program versions. They found higher capillary pulse pressure when the subjects did not like the programs. Thus, from this initial study, capillary pulse pressure variations were linked to pleasure functions. The Krathwohl definition of "affective" that was presented in Chapter I implies value-related pleasure functions. Therefore, in the formulation stages of this study, the hypotheses were based on the expectation of variations in pleasure-related emotional reactions. Some short pilot studies revealed that capillary pulse pressures tended to vary in a

predictable way as a function of the subject's affective reaction to the scenes in motion picture films. This further suggested that capillary pulse pressure measured the position of an emotional set on a scale between likes and dislikes.

In this study, it is obvious that the revelation of results has altered this initial assumption, and, as has been strongly implied in Chapter III, it is now believed that capillary pulse pressure variations more directly measure the relative intensity of cognitive involvement by the subject. Affective reactions consist of at least two basic types: the first is the mental pleasure-sensation associated with that particular part of the brain known as the pleasure center. These sensations of pleasure are associated with cognitive products in the mind, thus giving rise to higher level affective reactions such as appreciation, love, or value. The pleasure center is normally activated through a mechanism which apparently involves the satiation of felt needs (Fraley, 1967). The second type of affective reaction involves a general arousal or stress reaction related to the release of certain substances into the bloodstream, such as adrenaline or noradrenaline. It is this second type of affective reaction that capillary pulse pressure variation apparently measures. Some of the earlier research reports seem to have been confused, or at least vague, on this distinction.

With all cognition there is a certain amount of associated stress. This stress triggers the release of certain substances into the bloodstream, thus giving rise to affective reactions of that type. Capillary pulse pressure measurements regarding the extent of this type of stress are thus indicative of the intensity of cognitive involvement.

The affective reactions of this type involving stress can persist long after the pleasure related affective reactions have decreased. A subject can be striving for success under great stress and with high cognitive involvement during which time he senses unpleasantness. Every scholar is familiar with intense cognitive involvements which, while most distasteful, are, nevertheless, pursued toward some temporarily delayed goal. In such cases it is now believed that capillary pulse pressure measurements would correlate positively with the intensity of the cognitive involvement rather than with the level of affect. It was in such situations that the hypotheses of this study generally failed to be sustained. In Test Two, where the subjects could hardly be assumed to be pleased with the confusing ambiguous paragraph, capillary pulse pressures did not drop to the degree previously anticipated. This is now believed to be because of the elicited cognitive involvement with efforts to derive meaning from the paragraph. In Test Three, after overtly admitting to frustration,

subjects working on versions which allowed what seemed like a little more chance of cognitively deriving a solution with continued effort did not experience the degree of reduced capillary pulse pressure that their admitted displeasure might suggest. Instead, the capillary pulse pressure seemed more closely related to the prolonged cognitive involvement.

Physiological Considerations

It has long been recognized that such physiological functions as heart rate and blood pressure are subject to variations which are chemically induced internally as emotional reactions. A recent series of research studies conducted primarily in Sweden has probed the effects of the catecholamines adrenaline and noradrenaline as they are released within the body of subjects during stress. Although catecholamine excretions have been thought of ad indicators of emotional reactions, these studies have examined the relationship between catecholamines and cognitive functions.

One experimental study (Frankenhaeuser, et al., 1968) measured the excretion of the hormones adrenaline and noradrenaline in subjects during periods of quiet inactivity and periods of audio-visual stress requiring a high intensity of cognitive involvement. The excretion of these hormones was related to performance on the tests under stress conditions. In an earlier study (Frankenhaeuser,

et al., 1961), in which the qualitative differences in emotional reactions to injections of adrenaline and noradrenaline were not observed, the effects of psychological factors on physiological functions were of particular interest. It was clearly shown that the performance of certain psychological tasks was accompanied by an increase in heart rate, arterial pressure, and urinary excretion of catechols. Furthermore, the stress involved in anticipation of the test period and/or the concomitant catheterization of blood vessels produced an adrenaline excretion considerably above normal.

It has been learned (Bjurstedt and Matell, 1967) that subjects at quiet rest who are suddenly given mental arithmetic to perform will typically experience several physiological changes as they begin to become cognitively involved with the problem. Respiration increases, and heart rate may nearly double. According to Levi (1967), pleasant stimuli evoking amusement are nearly as potent as unpleasant ones in provoking a catecholamine increase. He concluded that the apparent relationship is to the intensity of affective arousal rather than the quality.

Patkái, et al. (1967a) discusses evidence to suggest that adrenaline secretion serves to increase arousal and counteract the monotony and boredom of a situation demanding sustained concentration under prolonged time periods. It is pointed out that apart from

the severity and duration of the stress, there are a number of other features in the experimental situations that may influence the complex interaction among the amount of adrenaline and noradrenaline excreted, the performance efficiency, and the intensity of the stress experienced. Thus, the subject's cognitive appraisal of the situation in which he finds himself is likely to be important. If, for example, the subject feels that he is able to master the situation, say by performing well, he may interpret his psychological state in less negative terms and give lower stress estimates than a subject who performs poorly, or who has to remain passive while exposed to a threatening situation such as riding in a human centrifuge, receiving electric shocks, or getting injections of adrenaline. In all of these situations, the estimates of stress intensity have been found to be positively related to adrenaline level.

Patkái (1967b) and Patkái and Hagdahl (1967) cite experimental evidence to show some differentiation in the reactions to adrenaline and noradrenaline. The amount of noradrenaline excreted was positively correlated with improvement in performance during stress, specifically with situations requiring attention upon specific features of complex stimulus situations. Noradrenaline was apparently associated with more complex psychophysiological relationships and, hence, the amount of noradrenaline excreted may tend to vary for the same individual in different stress situations.

It seems possible that the short-term variations in capillary pulse pressure identified in the present study could be caused by noradrenaline. The two studies cited above report evidence to suggest that adrenaline excretion is more related to general arousal and is a basic emergency reaction of an organism to stress. In the present study, the long-term variations in capillary pulse pressure seem more closely related to the reactions described for adrenaline excretion.

Capillary pulse pressure has been technically referred to as "digital vascomotor activity" (Graham, Cohen, and Sanford, 1967), and variations in capillary pulse pressure have been called "peripheral vascular responses." A shift in blood volume in response to a specific stimulus is called the "alpha" response. According to these authors, this response seems clearly due to vasoconstriction in the peripheral vascular bed, although it is difficult to determine whether it is because of arterial or venous changes. It appears that the "short-term" variations identified in this present study are the "alpha" responses to specific stimuli mentioned by these authors.

One additional study of apparent relevance (Frankenhaeuser and Patkái, 1965) reported experimental evidence to suggest that personality traits associated with depression are related to the excretion of catecholamines. Individuals with depressive tendencies

had a relatively weaker adrenaline reaction during stress. It is possible that such subjects constituted what was arbitrarily labelled as "group three" in this present study. Group three subjects were characterized by exhibiting very steady capillary pulse pressures with relatively little variation, either long-term or short-term.

Withdrawal from Involvement

Cognitive involvement with content is intrinsically stress-laden, and an alternative to a long period of such stress in pursuit of an elusive goal is to withdraw from cognitive involvement, thus terminating the increasing situational anxiety. This is one of the greatest problems faced by educators, because it has long been recognized that the desired learning derives from the involvement. The designer of instructional materials must seek that narrow balance between adequate difficulty for challenge, motivation, and sustained involvement and the excessive measure of difficulty that encourages withdrawal as an easy alternative to sustaining the stress. In the physiological experiments previously cited, such withdrawals were not significantly discussed, because the subjects were either physically constrained to remain in the stress situation or voluntarily did so as part of the experiment. However, in this experiment, as is characteristic of typical learning situations,

there were many instances of withdrawal by subjects during the experiment.

Withdrawal is apparently manifested in capillary pulse pressure as a significant decrease from which there is no recovery until involvement resumes. It seems probable that through a withdrawal from involvement, a subject is able to reduce the release of the chemicals responsible for the elevated capillary pulse pressure, probably catacholamines. Withdrawal from cognitive involvement is accomplished through a variety of devices. A number of examples of withdrawal incidents are presented in the remainder of this section, accompanied, in many cases, by figures showing the corresponding capillary pulse pressure chart recordings.

One of the first things noticed about the charts when the data collection was started was the fact that capillary pulse pressure tended to show slight decrease-recovery cycles associated with the turning of the program pages in the loose-leaf notebooks. The turning of the page apparently presented an opportunity to momentarily relax and disengage. The effect often does not appear at all, or may appear at only a few page turns during the program. In the most extreme case noted, subject H_4, the capillary pulse pressure decreased by one-third to one-half at eleven of twelve page turns, with an average decrease-recovery cycle time of seventeen seconds. It is probable that this subject was in the habit

of using page turns as rest periods.

It has long been realized by educators that the embarrassment of a learner must be avoided, because embarrassment tends to cause withdrawal from the learning involvement. During this experiment, an attempt was made to avoid embarrassing the subjects in any way. However, in two cases during the experiment, one of the eight subjects in a test group worked so slowly that the other seven completed the programs and were waiting in quiet boredom for the last subject to finish. When the time came that the other subjects had to leave in order to meet schedule demands, they were quietly released while the one remaining subject was left to continue working. Figure 44 shows that in both cases, when the others departed, the remaining subject experienced a highly significant decrease in capillary pulse pressure.

One supporting piece of evidence that has been previously mentioned is the fact that most subjects, sitting quietly and uninvolved before and after work on the programs, tended to exhibit much lower pulse pressures than during the interval of concentration on the programs. A few exceptions can be found in which this pattern is reversed, but this would be expected in those few cases where subjects have something demanding to think about before and after their work on the relatively less demanding programs.

Figure 45 presents the chart of a subject who was confronted

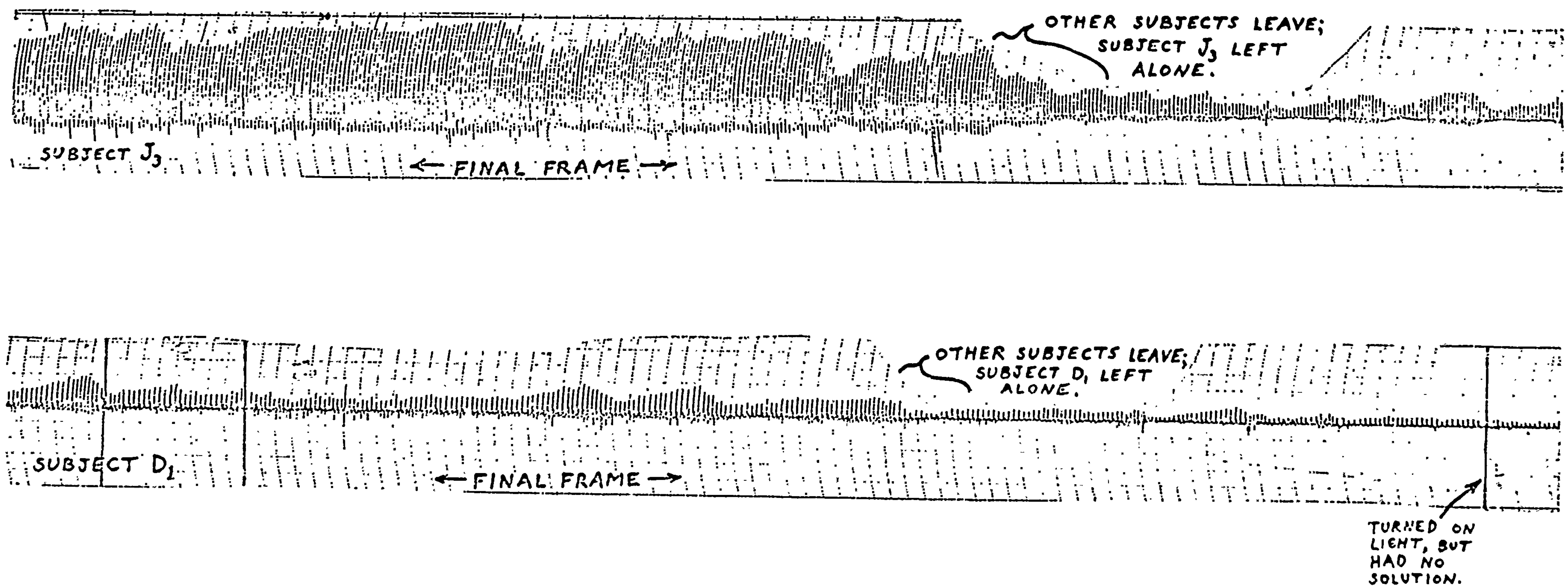


Fig. 44. --Embarrassment-induced withdrawals from involvement revealed by concurrent decreases in capillary pulse pressure

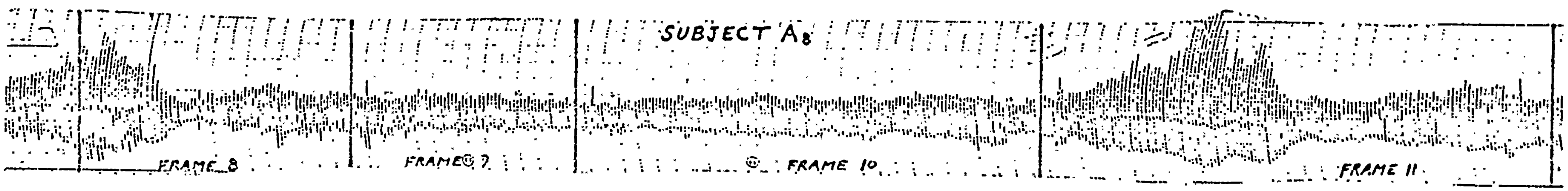


Fig. 45. --Extended interval of depressed capillary pulse pressure upon encounter with a graphic problem and an unknown term

with a graphics problem in the middle of frame (8), and experienced an abrupt and relatively extreme decrease in capillary pulse pressure. This was accompanied by a decrease in heart rate. The subject's capillary pulse pressure remained rather low through the following frame, where the answer and explanation of the previous problem were presented. This then led immediately into frame (10), where another graphic solution was required, this one being insoluble because of the use of an unfamiliar term in a critical context. The capillary pulse pressure remained low, but in the first part of frame (11) where the definition of the unknown term is given and the problem thus rendered soluble, the capillary pulse pressure increased significantly as the subject perceived that with effort, success was attainable.

Figure 46 presents an assortment of reactions which accompanied various indicated gestures of temporary disengagement from concentration. Typical of such gestures were brief deliberate facial expressions communicating that the subject was stymied. One of the reactions shows what typically happened to the capillary pulse pressure when subjects looked away from the programs for a brief moment of rest before resuming concentration. Still another shows the slight decrease in capillary pulse pressure while a subject took time out to erase an incorrect solution. After a further interval of involvement with the problem, that subject got the

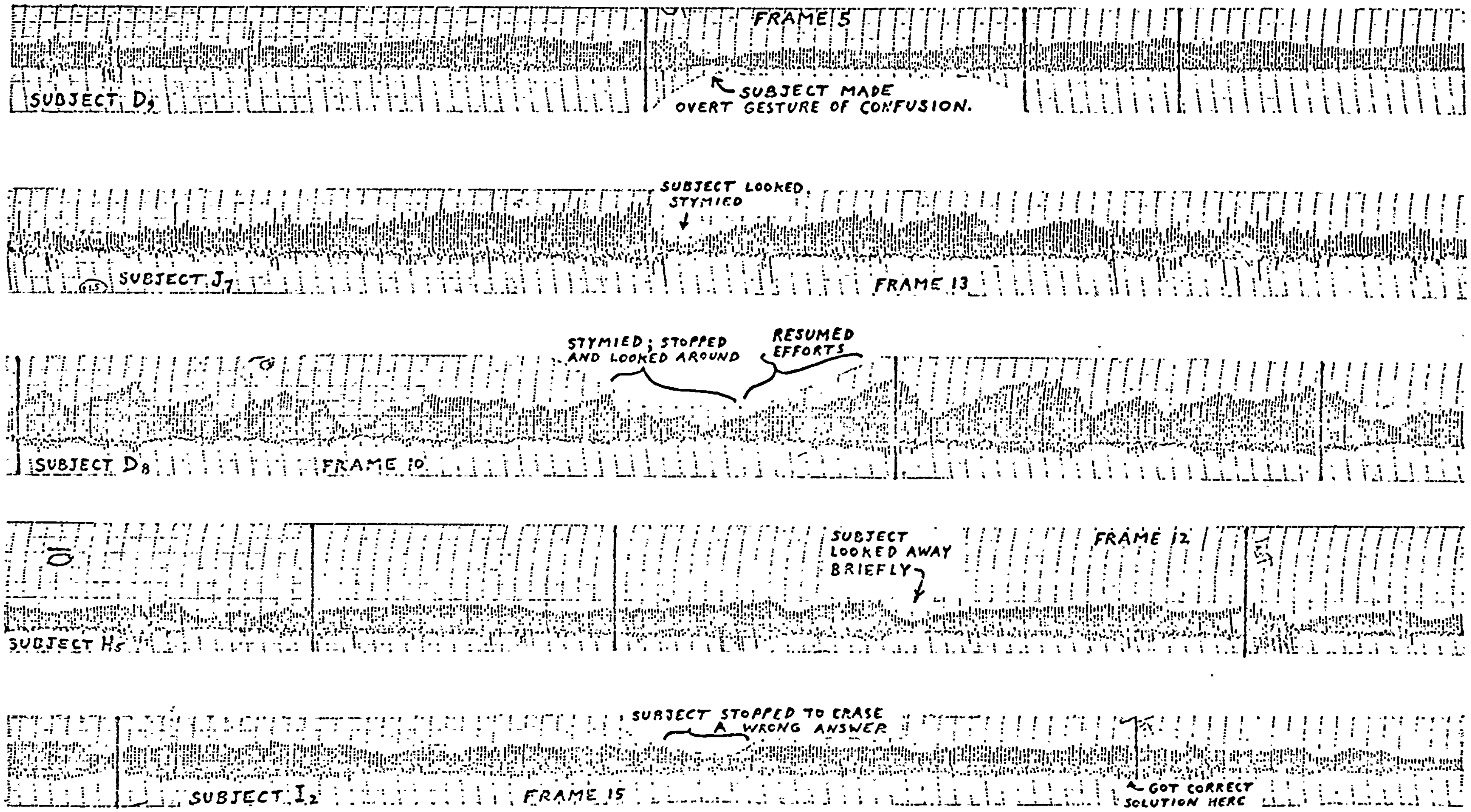


Fig. 46.--Localized depressions in capillary pulse pressure during assorted types of temporary disengagements from concentration

correct answer. It was not a planned part of this particular experiment to record observations of the subject's overt reactions, but a few notations were made during the experiment as time permitted. One subject, whose chart is not shown, experienced a slight drop in capillary pulse pressure when, momentarily blocked by a problem, he broke off his concentration to steal a glance at the work of another subject seated nearby.

The final frame in the programs was the most challenging frame, and it was implied to the subjects that this final frame was a test of what they had learned. The confrontation with this frame tended to cause an immediate decrease in the capillary pulse pressure of many subjects. It is believed that in such cases the involvement of the subjects was reduced, probably as an escape from stress or fear of failure. Figure 47 presents three examples of such immediate decreases upon entry into the final frame; the arrows point to the locations of the decreases.

In Figure 48, there are three examples of subjects who became increasingly involved with the problem in the last frame as they worked toward a solution. In such cases, the capillary pulse pressure can be seen to rise as the subject approached attainment of what he believed to be a correct solution. When the solution was attained and the concentration abated, the capillary pulse pressure dropped abruptly. The graphic noise in the chart of subject K_4 was

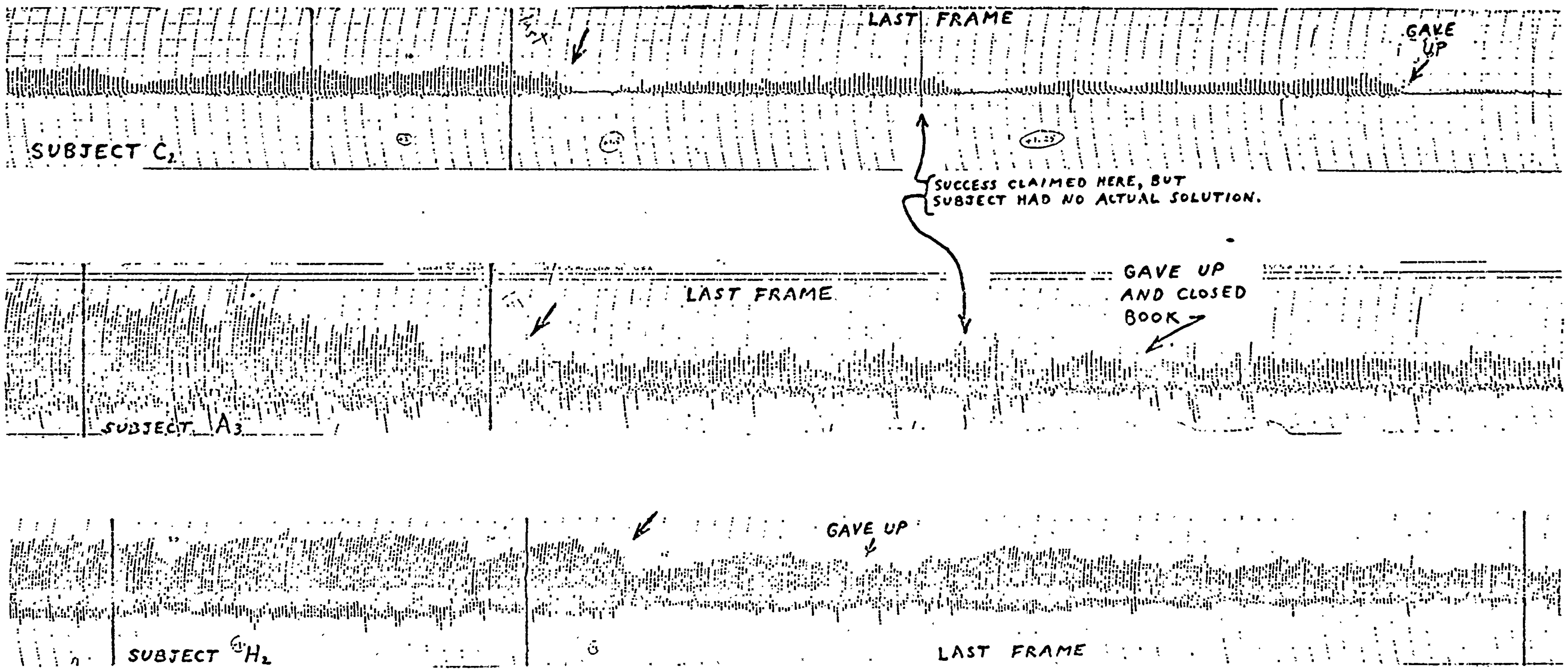


Fig. 47.--Examples of immediate decreases in capillary pulse pressure upon entry into the final test frame

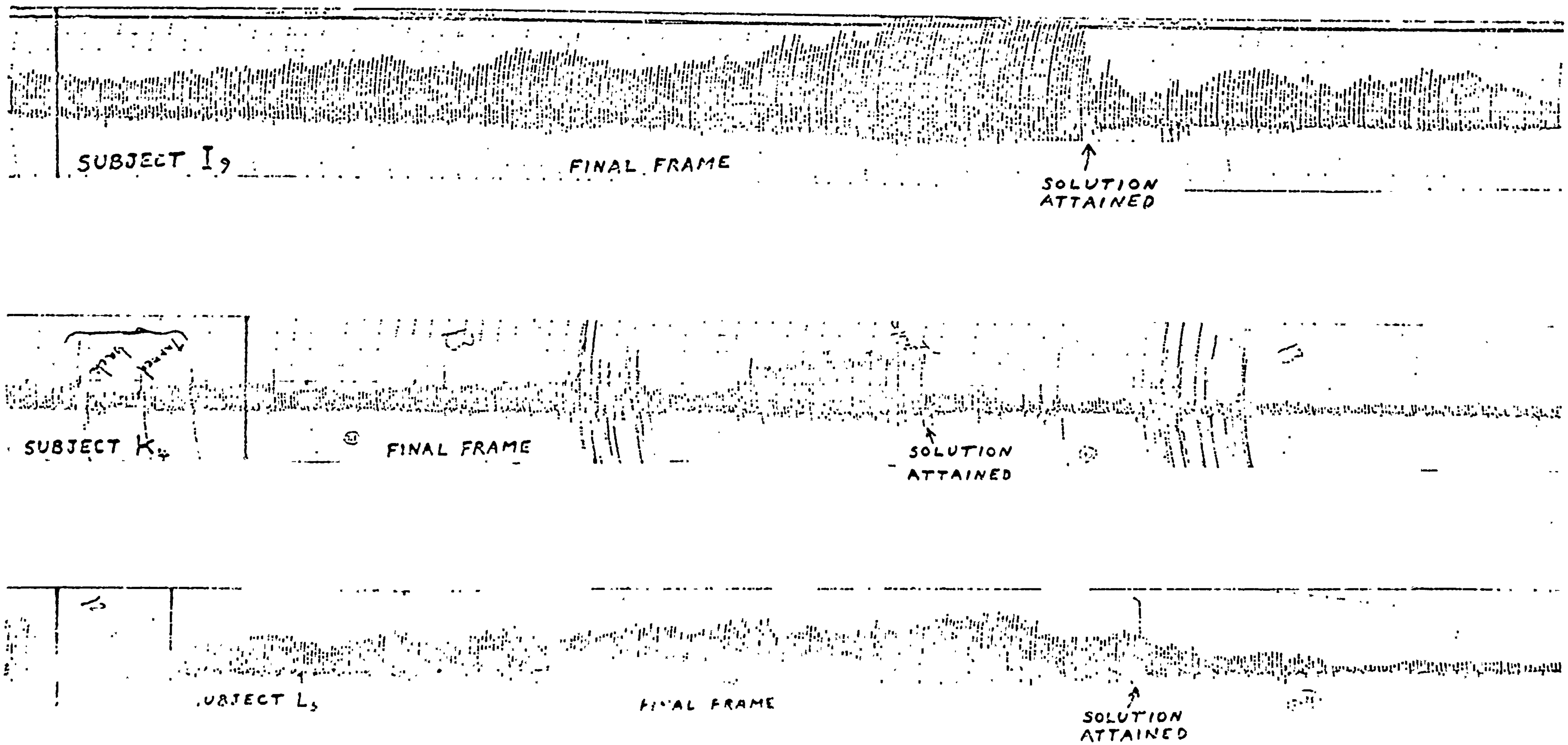


Fig. 48.--Examples of capillary pulse pressure increases during problem-solving effort, followed by decreases after solution was attained

caused by excessive movements of the hand to which the pulse transducer was attached, and has nothing to do with the characteristics of that subject's pulse.

The capacity of capillary pulse pressure measurements to detect latent problems in the interaction of the subject and the program is illustrated by Figure 49. This subject, F_1, was a group-three type who exhibited very little change in capillary pulse pressure throughout the program. The subject experienced a sharp decrease in capillary pulse pressure upon entering the final test frame, but the pressure quickly recovered within about fifteen seconds. The subject then worked on the problem for an additional 2.7 minutes without further changes in capillary pulse pressure and without success on the problem. The chart then reveals that the subject began to experience a drop in capillary pulse pressure that lasted for 0.7 minutes before the subject pressed the button to indicate that he had attained a solution. It was later noted upon examination of the subject's work that he had not attained a solution. After pressing the button and ceasing his efforts on the problem, the capillary pulse pressure of this subject recovered to the relatively steady level that it had held throughout the program. It is believed that this chart represents the revelation of a subject giving up on a difficult problem, decreasing his involvement with it, and then pretending to have been successful. The chart unobtrusively

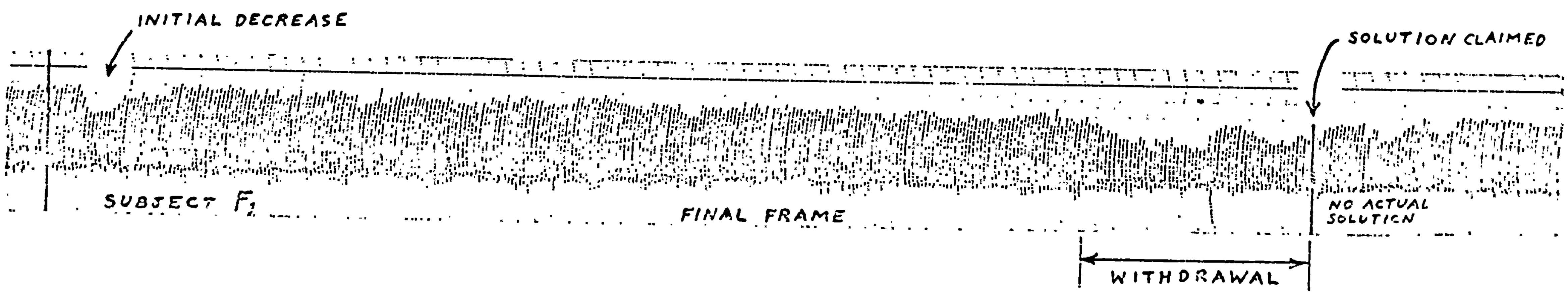


Fig. 49. --Revelation of a withdrawal from involvement prior to a false overt claim of success

circumvents the extrinsic ego defense posture of the subject and exposes his latent defeat by the problem.

It was noted early in the data collection phase of this study that subjects who, while working on the final test frame problem, would alternately give up and then return to the problem for another attempt would exhibit corresponding variations in capillary pulse pressure. Although the experimental design and physical arrangement did not permit systematic observation of all overt subject reactions, several instances of these concentration-relaxation cycles were noted and recorded in the experiment session notes. Figure 50 presents an assortment of such cases. Some subjects exhibiting these characteristics began the final frame with a decrease in capillary pulse pressure, while others had a steady capillary pulse pressure going through the first portion of the frame. However, all of these subjects were observed to be alternately working and relaxing, apparently getting ideas, trying them, and finding them unworkable. It is noteworthy that the four of these five subjects who worked on soluble versions of the test problem (E_7, I_8, L_1, and L_8) claimed at some point during the frame to have attained a solution, although later examination of their work revealed that none of them had solved the problem.

One subject, D_4, whose chart is not shown, began work on the last frame and within one minute experienced a very great drop

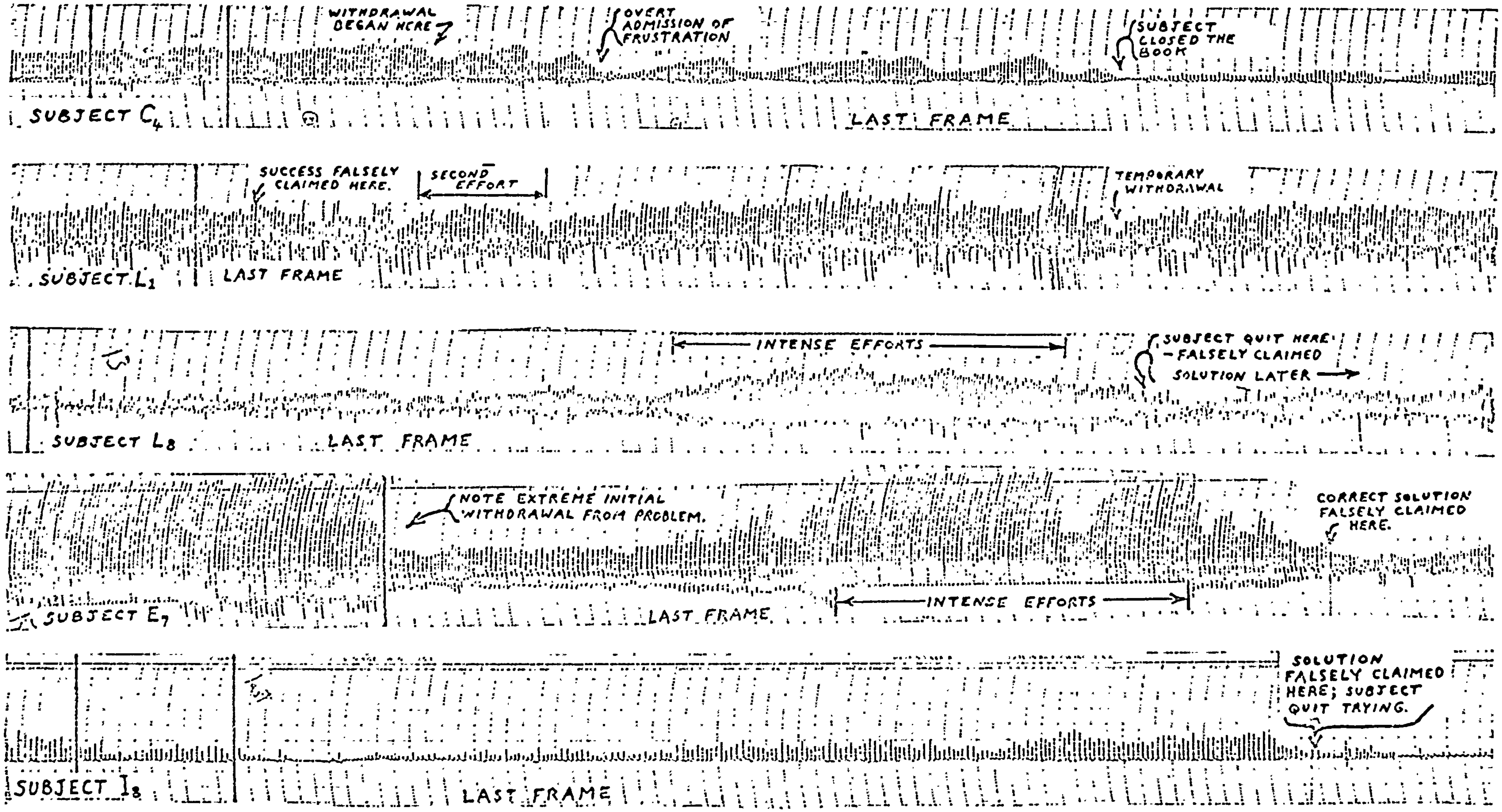


Fig. 50.--Assorted concentration-withdrawal cycles, ultimately unsuccessful, during final frame

in capillary pulse pressure. He then began a series of repeated attempts to solve the problem that continued for an additional 11.7 minutes, during which time his capillary pulse pressure underwent seventeen increase-decrease cycles. At the end of that extended series of efforts, the subject ceased all efforts to solve the problem and looked away from the page, whereupon his capillary pulse pressure dropped to its lowest value throughout the program and remained there.

Throughout the data collection phase of this study, it was noticed that subjects who pass from an interval of concentration on problem-solving into an interval of reading would tend in many cases to experience a decrease in capillary pulse pressure that would persist through the reading interval. This suggests the possibility that reading, for those who already know how to read, is initially a relatively lower involvement mode in which the initiative functions of cognition are temporarily somewhat suspended while the subject awaits new stimuli for cognition to eject from the monitored cybernetic cycle of reading. Apparently, if comprehension falters, as in Tests One and Two, the monitoring level of cognition may be reduced because it is unrewarding and the withdrawal reflected as a decrease in capillary pulse pressure. On the other hand, if the monitoring mode yields stimuli for higher level cognitions, then it is believed that capillary pulse pressure increases

accordingly as the subject experiences a more intense involvement.

When the reading material is comprehended but fails to provide stimuli for increased involvement, it is possible for capillary pulse pressure to remain unchanged. One female subject, A_4, was observed to work on the final test frame of the program for approximately eight minutes without success. During this time the subject experienced several short-term variation cycles in capillary pulse pressure which were superimposed on a long trend decrease indicative of progressive fatigue. Figure 51 presents the chart for this subject's work on the extended final frame. It is suggested by the chart that serious efforts involving relatively intense concentration actually subsided approximately two minutes before the subject exhibited overt quitting behavior. After ceasing all efforts at a solution, the subject sat quietly for an additional three minutes while others around her continued to work; during this time capillary pulse pressure continued to hold relatively steady at a very low level. At the end of this interval, the capillary pulse pressure exhibited a slight rise, followed immediately by some noise caused by the subject moving to withdraw a small New Testament Bible from her handbag. The subject opened the Bible immediately and began to pass the time by reading, without any outward sign of particular interest or enthusiasm. As the chart reveals, capillary pulse pressure remained steady and very low

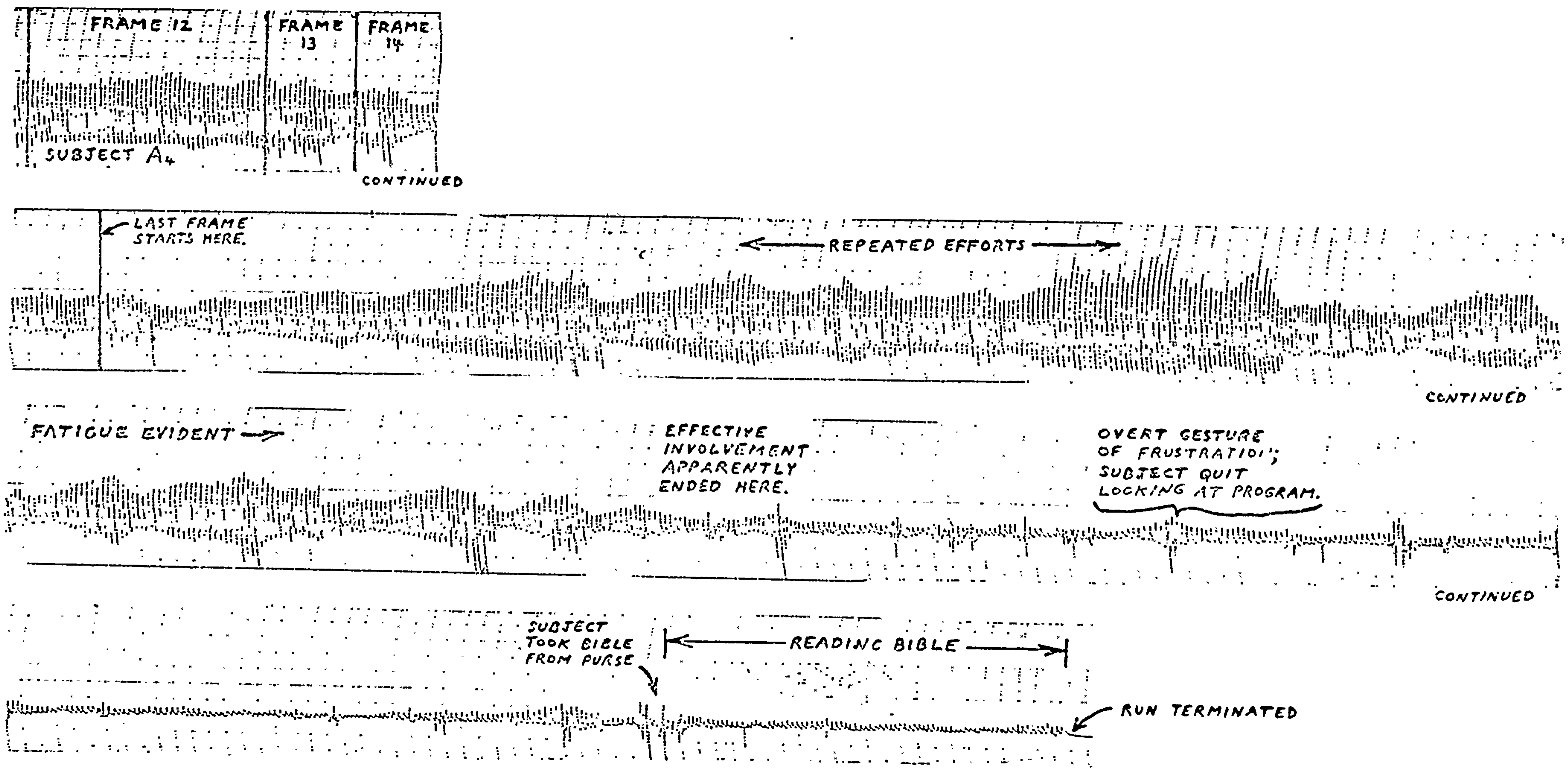


Fig. 51.--Extended final frame illustrating initial withdrawal, increasing involvement, repeated effort cycles, fatigue, latent withdrawal, prolonged boredom, and low involvement reading

through the next minute of quiet reading, whereupon the data collection run was terminated.

Implications of the Study

Instructional materials are intended to promote involvement of the learner, and it appears that capillary pulse pressure measures the relative magnitude of that involvement. Capillary pulse pressure measurements appear to have much potential for the evaluation of new, and old, instructional materials. The techniques developed in this study also appear to offer a new means to overcome the ego defense contaminations of overtly elicited reactions to instructional materials. This should also be useful in cases where reliable overt reactions are difficult to obtain, perhaps in the case of certain physical or mental handicaps, or in the case of the very young learner. These techniques also provide more reliable means of studying the different learning characteristics of people, as well as the differing capacities of the materials that they study.

There is a wide general awareness of the significance of involvement, and it is manifested in many ways, among them the assortment of popular colloquial expressions using the phrases "turn on" and "turn off." It is concluded from this study that capillary pulse pressure can measure that phenomenon.

Recommendations

This study has suggested several possibilities for subsequent research. Some of these are listed below:

1. A replication study should be conducted to learn whether the findings of this study can be verified.
2. The capillary pulse pressure reactions of widely differing age groups should be examined to see whether these techniques would be equally effective for all age levels, including the very young.
3. The use of these techniques in predicting learning efficiency should be explored to test the theory that involvement is being measured and that the involvement promotes learning.
4. There should be a study designed to closely observe overt subject reactions as the capillary pulse pressure is being recorded. This could perhaps be done by using split screen videotape recording with the chart recorder emitting the pulse record on one-half of the screen and the subject on the other half. The present study was designed to reveal what could be learned without considering specific learner responses, but it is logical that the findings ultimately be related to the outwardly manifested

behavior of the subjects.

5. More knowledge is needed about changes in the characteristics of the capillary pulse pressure of individuals as they change cognitive modes. It would be useful to record charts of individuals who spend equal time intervals at quiet rest, reading dry, uninteresting material, reading exciting material which they like, concentrating intensely on math problems, daydreaming, viewing uninteresting pictures, viewing interesting pictures, and other activities. Capillary pulse pressure techniques might be used to probe the question of whether or not decreasing the resolution of visuals promotes an increase in the involvement of the subject, as Marshall McLuhan suggests.

6. Further studies probing the subtle differences in similar learning situations now seem possible, based on the results of this study. The further delineation below of the contrived test characteristics in this study suggests the sensitivity of the discriminations that might now be attempted using capillary pulse pressure measurements.

   Test 1: Subject encounters an unfamiliar term which must be understood in order to proceed. After

a brief interval the term will be defined for the subject and he will be allowed to proceed in his success attainment.

This is an encounter with a simple, straightforward impedence which is somewhat extrinsic to the learning situation in that the unknown term is perceived as a temporarily isolated element which will not affect the learning set of which it is a part once it can be defined. The validity and the reliability of the learning are not threatened. There is only a temporary suspension of progress.

Test 2: Subject encounters what appears to be a summation of prior learning which is actually a meaningless synthesis of familiar terms and phrases. The subject is asked to proceed on the basis of this information when such progress is not possible.

Here the validity and reliability of the prior learning is threatened. Whereas before, the unknown term did not seriously damage the subject's confidence in his prior learning, in this case the subject's comprehension of his

prior learning is abruptly undermined. Here the subject's confidence will not be restored as it was in the first test; he will proceed without further contrived obstructions to his progress but with whatever lingering effects this undermining experience may have produced.

Test 3: Subject arrives with relatively high success expectancy at a final test which has been contrived to appear straightforward but which is characterized by latent insolubility.

Here there is no overt challenge to the self-image of the subject or to any of his prior learning. His confidence is left intact to dissipate as it will with the inevitable increasing frustration. There is no abrupt blocking or confusion as in the two previous tests.

7. Much more study of the physiological aspects of capillary pulse pressure is needed. The use of the fingertip as a signal source causes obvious problems that could be overcome by finding a less important and conspicuous location on the body for this purpose. The question of whether capillary pulse pressure characteristics would vary qualitatively as a function of location

on the body needs to be investigated. Also, the chemical mechanisms responsible for capillary pulse pressure variations need much more investigation. All future studies of these phenomena should be reported using correct physiological terminology in order to minimize divergence and ambiguity between two fields that must henceforth work more closely together.

8. Curriculum designers have recently been concerned with improving the synthetic reality of learning situations through student involvement with realistic games, contests, and dramatizations. These activities are being used in place of more traditional learning activities, such as reading and listening to lectures. Capillary pulse pressure techniques might be employed in a study to compare the relative degrees of involvement of students engaged in these different types of learning activities.

9. One interesting way to probe the revelation capacities of capillary pulse pressure measurements might be to employ the capillary pulse pressure techniques during a study of a rigged poker game. Poker, and many similar games, can be ordinarily played with considerable cognitive activity, frequently of an intense nature

but masked behind a deliberate outward posture of deceptive apparent calmness and near disinterest. A comparison could be made of the outwardly manifested posture, the cards in the subjects' hands, and the capillary pulse pressures being recorded. It might be useful to use split-screen television techniques with three cameras to record these three things simultaneously on one videotape.

10. There has long been a need for a more direct way to study the more subtle differences in the effects of media which, at first consideration, would seem to be very similar. One possible study that has been suggested along these lines would utilize capillary pulse pressure measurements to try to discriminate between the elicited involvement of subjects reading from traditional printed matter and subjects reading from microreaders. Vast commitments have already been made to substitute microreaders for much of what has been handled through traditional printed materials. Yet relatively little research has been done to explore the differences inherent in the use of these different media; in most cases it has simply been assumed that any existing differences would not be significant. It now

seems possible that capillary pulse pressure techniques can provide a powerful new tool with which many of the past media comparison studies could profitably be repeated with greater accuracy and increased sensitivity.

11. During the present study, there was an occasional hint that capillary pulse pressure might be affected by such things as drowsiness, cigarette smoking, diet pills, aspirin, and other internal medications. There was stronger evidence that the pick-up of the pulse signals from the fingertips of subjects was affected by the cleanliness of the skin, moisture on the skin, the presence of calluses on the fingertip, and skin temperature. It would be useful if there were a comprehensive study of the extraneous factors affecting the measurement of capillary pulse pressure, and the extent to which these factors are significant.

APPENDICES

APPENDIX A

TAPE RECORDED INSTRUCTIONS TO THE SUBJECTS

The following instructions were played on a tape recorder to each group of subjects just prior to their beginning work on the programs. During the playing of the tape, the chart recorder was allowed to run in order to test the signal pick-up and establish a pre-work capillary pulse pressure level. The first section, "General Directions," was played for all subjects; then this was followed by a short paragraph related to the particular version of the program to be presented in that session.

General Directions

On the table in front of you is a notebook containing a short programmed lesson which will be presented in a series of easy steps with one step on each page. The steps are called frames. You are to proceed through this lesson, one frame at a time, with no turning back allowed. Also, there are pencils, erasers, and a straight-edge.

On some of the frames you will be asked questions, or you may be asked to draw something, or simply decide on an answer and keep it in mind. You may write on the white test pages, and space has been left for you to write wherever this is required. In some cases, where you might be asked to draw something, part of it may be drawn for you in a practice area at the bottom of the page. This will save you time. The correct answers are always given at the

top of the next page, but do not go on to the next frame until you have given your best answer, because you may not come back for a second try. At the bottom of each page will be a statement telling you either to go on to the next frame or to wait or to stop. Your drawings and your answers do not have do be neat, so don't waste your time on excessive neatness; just keep moving through the program.

As you work through this lesson, a small device will be taped to your fingertip on your non-writing hand. This small device records your pulse just as you can feel it when you touch your own wrist. However, this device is very sensitive and can detect the pulse in the tiny blood vessels near the surface of the skin at the fingertip. During the lesson, you must not hit the device with your other fingers or scrape the device across your clothing, because it is so sensitive that it picks up noise and static from this which can spoil the experiment. Hold the hand with the device attached loosely and comfortably in your lap so that the device is not touching anything but the fingertip. Hold that hand still unless it becomes uncomfortable. If that happens, move the hand to a new position smoothly and quickly and then hold it still again.

The notebook pages have tabs to help you in turning pages with only one hand. The uppermost tab will turn the next in each case.

In the program on which you will work, some of the frames are very easy and simple; these do not have hidden tricks. They are easy. Just complete them quickly and move on. There are some other frames which will require a little more thought.

In front of you is a button which you are to use if so directed during the last frame in the lesson. Do not bother the button until you get to the last frame, where you will be told again how to use it.

We will now test the button to be sure that it is working and that you know when it is turned on. If you are told to use the button on the last frame of the program, you are to push it down once and leave it on. At this time you should test it. Reach over now and press it downward until it clicks on, and then release it .. (five or six second delay) .. All right, press it again to turn it off, and it will be ready for later use, if needed.

Special Directions, Tests One, Two, and Control

The following instructions were added to the end of the general directions for all versions of Test One, Test Two, and the control versions (versions A, B, E, F, G, I, J, K, and L).

In the last frame you will be presented with a little puzzle which will test how well you have learned the lesson. On this last frame, as soon as you solve the puzzle, you are to press the button in front of you immediately, and then sit quietly until you are told that the session is finished.

All right now, wait until you are told to begin; then turn the first page and start working. Work as rapidly and as steadily as possible without making errors. You may not ask questions; just do the best you can, and entirely on your own.

Special Directions, Test Three

The following instructions were added to the end of the general directions for all versions of Test Three (versions D, H, and C).

In the last frame you will be presented with a little puzzle which will test how well you have learned the lesson. On this last frame, if you start to feel bored, disgusted, or like the activity is no longer fun, you will be asked to press the button immediately, but to continue trying to solve the puzzle until you are told to stop.

All right now, wait until you are told to begin; then turn the first page and start working. Work as rapidly and as steadily as possible without making errors. You may not ask questions; just do the best you can, and entirely on your own.

APPENDIX B

THE COMPLETE PROGRAMS USED IN THIS EXPERIMENT

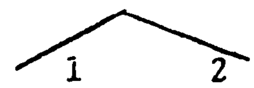
On the following pages are presented the three programs used in this study. In each case the control version is presented first, followed by the short set of frames that were inserted for Tests One, Two, and Three with the program in question. The inserted test frames are numbered as they were when inserted; frames occurring in the programs beyond the inserted set were renumbered as necessary in those versions.

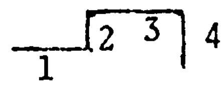
Program One, Control, Version J

(next 13 pages)

(1) In this program the number of lines in a figure is the number of straight line segments in it (see examples below).

This is one line: 

This is two lines: 

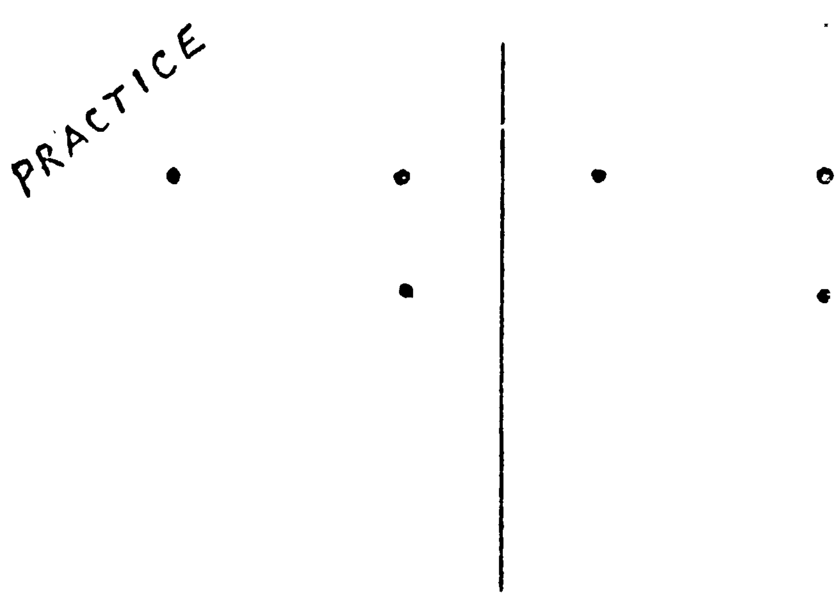
This is four lines: 

All "lines" in this program are straight lines.

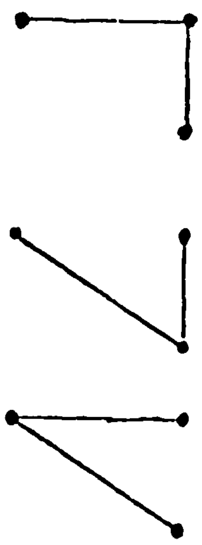
Here are three points. In this program points drawn on the page like these are sometimes called "given points".

Without lifting your pencil from the paper, draw two straight lines such that EACH POINT IS ON AT LEAST ONE LINE. Do not retrace or double back on any line, and do not lift your pencil.

You may practice drawing it on the point sets below; there are several correct solutions.



Go on to the next frame

(2) 

Here are three ways that you could have done it.

Each is a correct solution.

There are other correct solutions, BUT DO NOT STOP TO FIND THEM NOW.

GO ON IMMEDIATELY

Do you recall having been told in this program that any of the lines have to stop at the points, or could any of the straight lines pass on through a point?

YES or NO ?

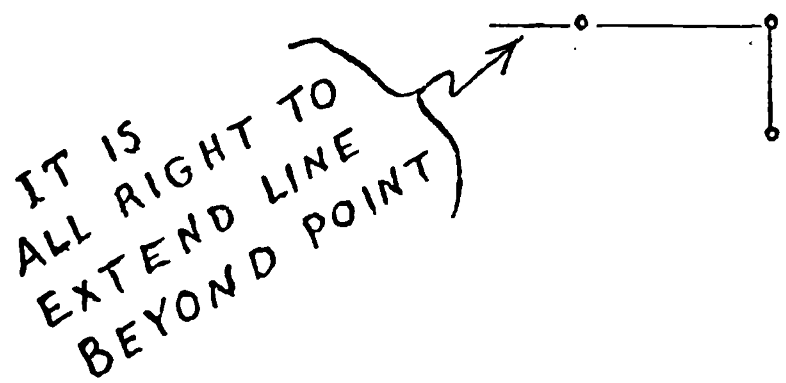
Get your answer in mind

and then go on . . . . . .

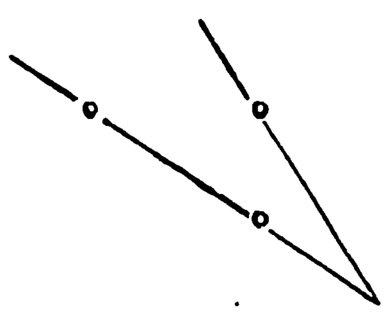
Go on to the next frame

(3) A line may pass through a point.

You were told only that you must not raise your pencil or retrace a previously drawn line. According to the directions given, the solution shown below is just as correct as the others.



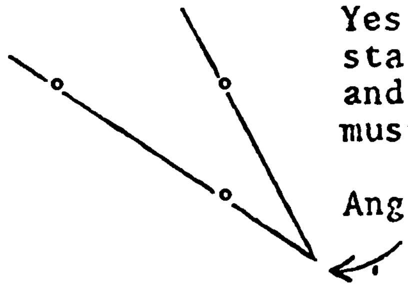
Is the following solution correct?



YES or NO ?

Go on to the next frame

(4)



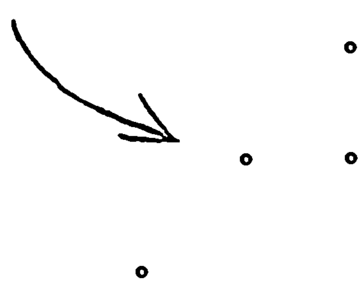
Yes. You were not told that lines must start or end at one of the given points, and you were not told that the lines must intersect at a given point.

Angles may be far away from any given point.

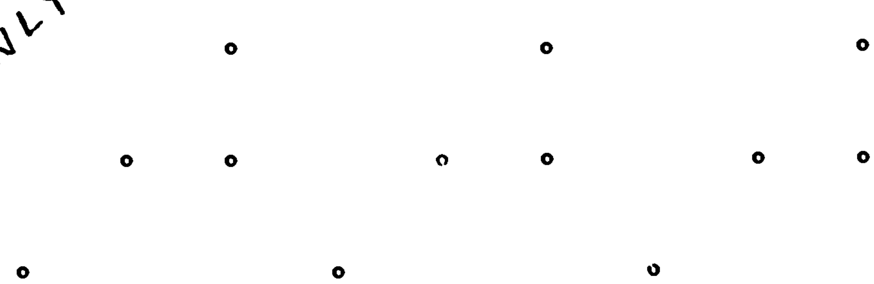
THIS SOLUTION IS CORRECT.

Without lifting your pencil from the paper, draw TWO straight lines such that EACH POINT in the figure below IS ON AT LEAST ONE LINE. Do not retrace or double back on any line.

There is more than one correct solution.

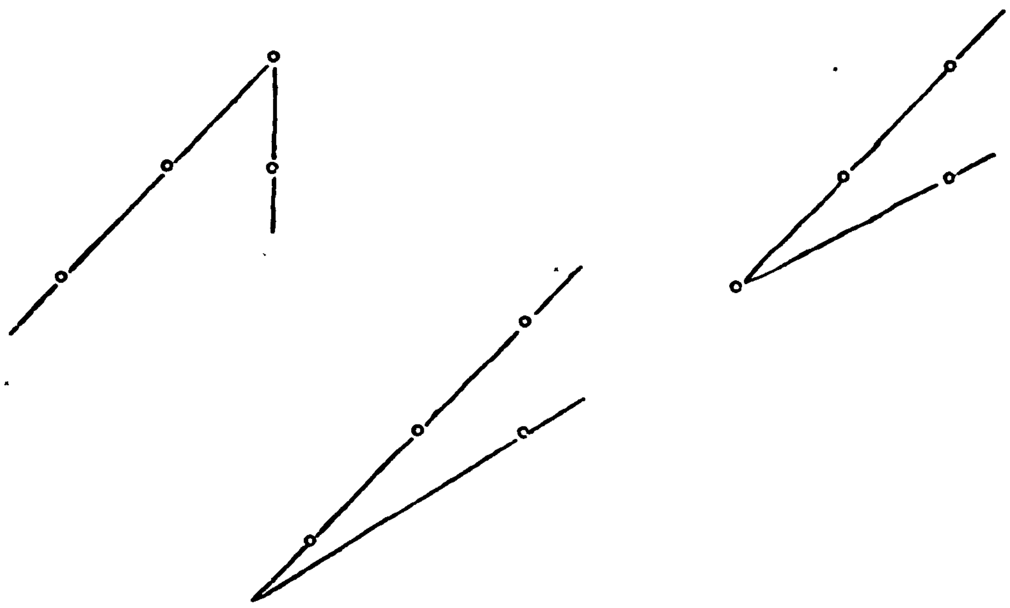


PRACTICE
(USE ONLY TWO LINES)



Go on to the next frame

(5) Here are some possible correct solutions.



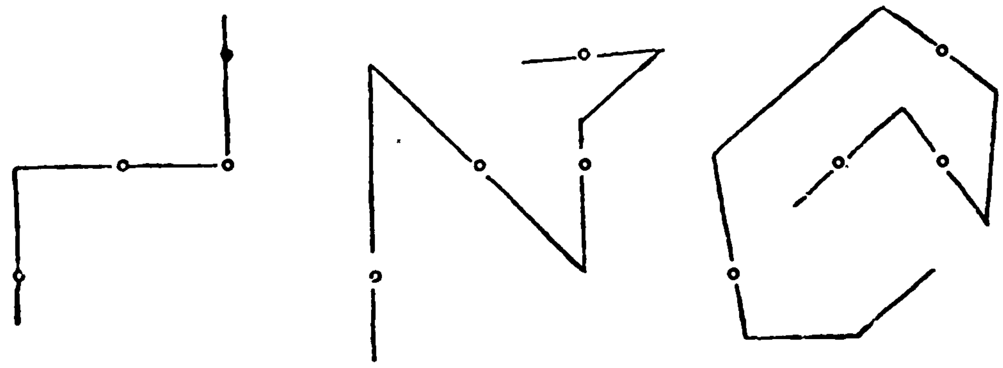
If you had been told to USE THREE OR MORE LINES instead of just two, could you have put each given point on at least one line without retracing and without lifting your pencil ?

THINK!

If you could use more lines, would this make it easier ?

GET YOUR ANSWER IN MIND,
then go on to the next frame.....

(6) Yes. Using more lines is easier. Here are solutions using three, five, and eight lines to connect the SAME SET of four points.



Did <u>every</u> line used above pass through, or reach one of the four given points ?

LOOK AT THEM. YES or NO ?

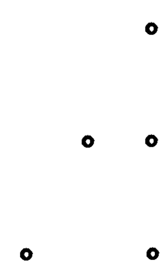
Go on to the next frame.

(7) No, some lines did not contact any of the given points.

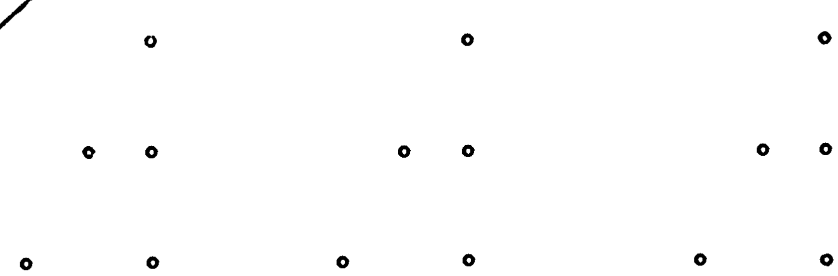
If more lines are allowed than are actually needed, then some lines may be "wasted" by not touching any point. You were not told in frames 5 and 6 that every line must contact a point or that a minimum number of lines were to be used.

You can now see that the problem, or puzzle, becomes difficult and challenging only when the solution must be done WITH THE LEAST POSSIBLE NUMBER OF LINES.

What is the smallest number of lines that could be used to connect the following set of points following the rules for this type of puzzle? (No retracing and no lifting the pencil.)

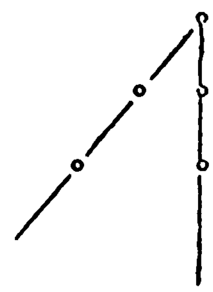


PRACTICE

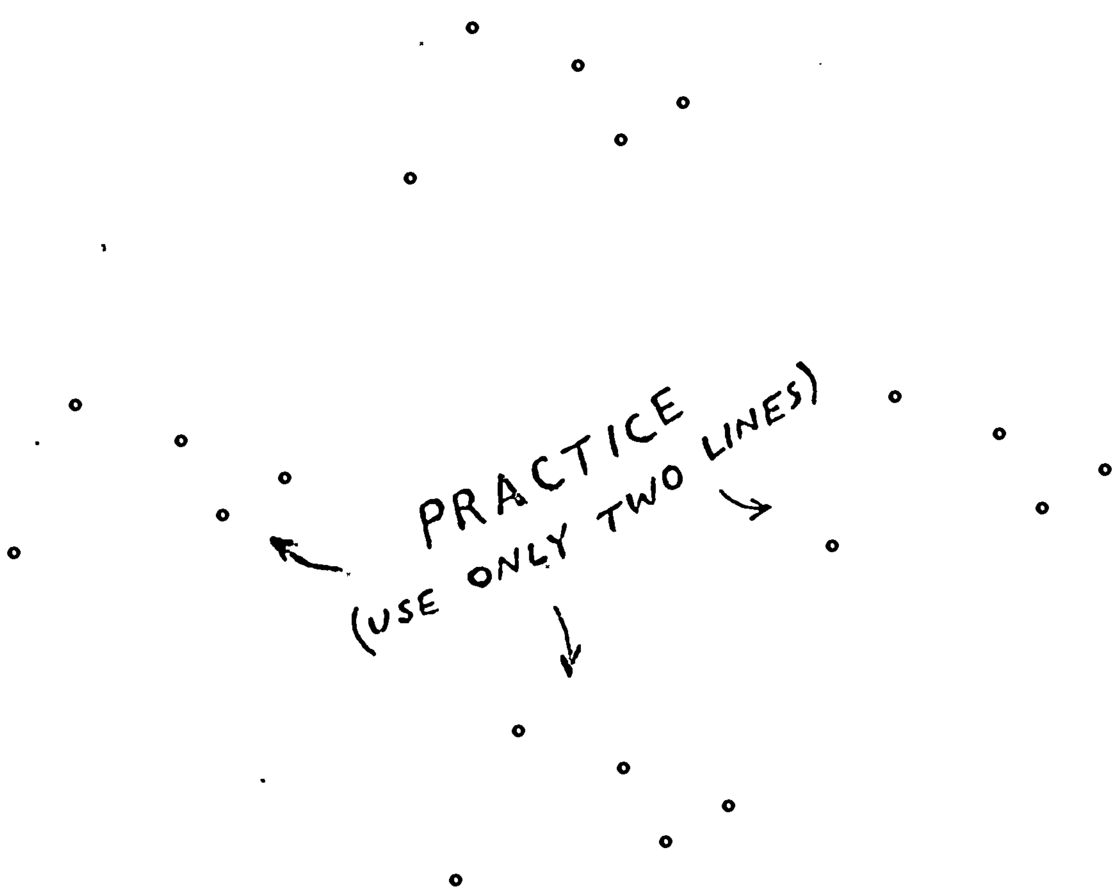


Go on to the next frame

(8) A minimum of two lines are needed as shown here:

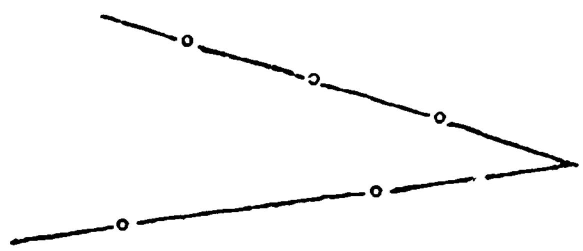


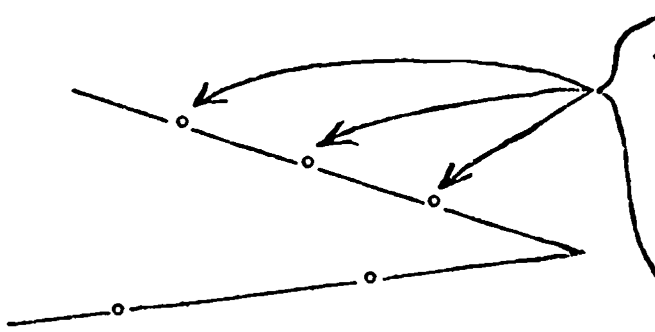
Below is a set of points which you are to connect USING ONLY TWO STRAIGHT LINES without lifting your pencil or doubling back.



Go on to the next frame

(9) Correct solution:



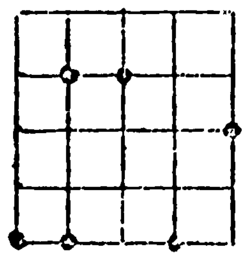


WHEN THREE OR MORE POINTS
LIE IN A STRAIGHT LINE
in such puzzles as these,
then these points can be
connected with a single line.

THUS, FINDING THREE OR MORE POINTS THAT CAN FALL ON ONE DRAWN LINE LETS YOU SOLVE THE PUZZLE USING FEWER LINES.

Go on to the next frame

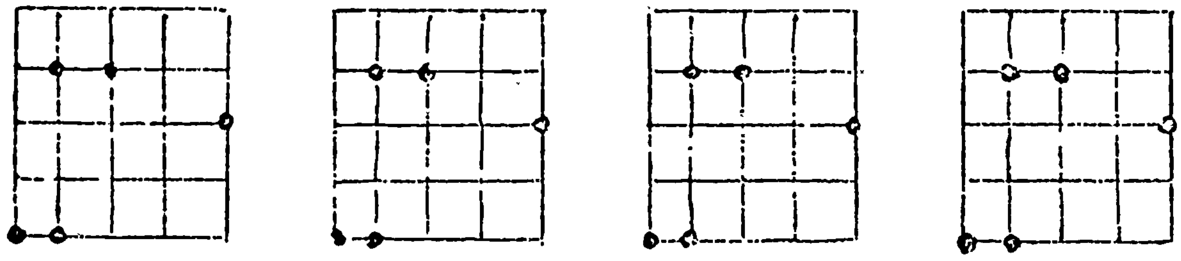
(10) In this frame you are given a six point puzzle. The six points are placed on a grid of fine lines so that you can see more clearly how they are aligned. You draw in the solution using ONLY THREE STRAIGHT LINES.



REMEMBER:

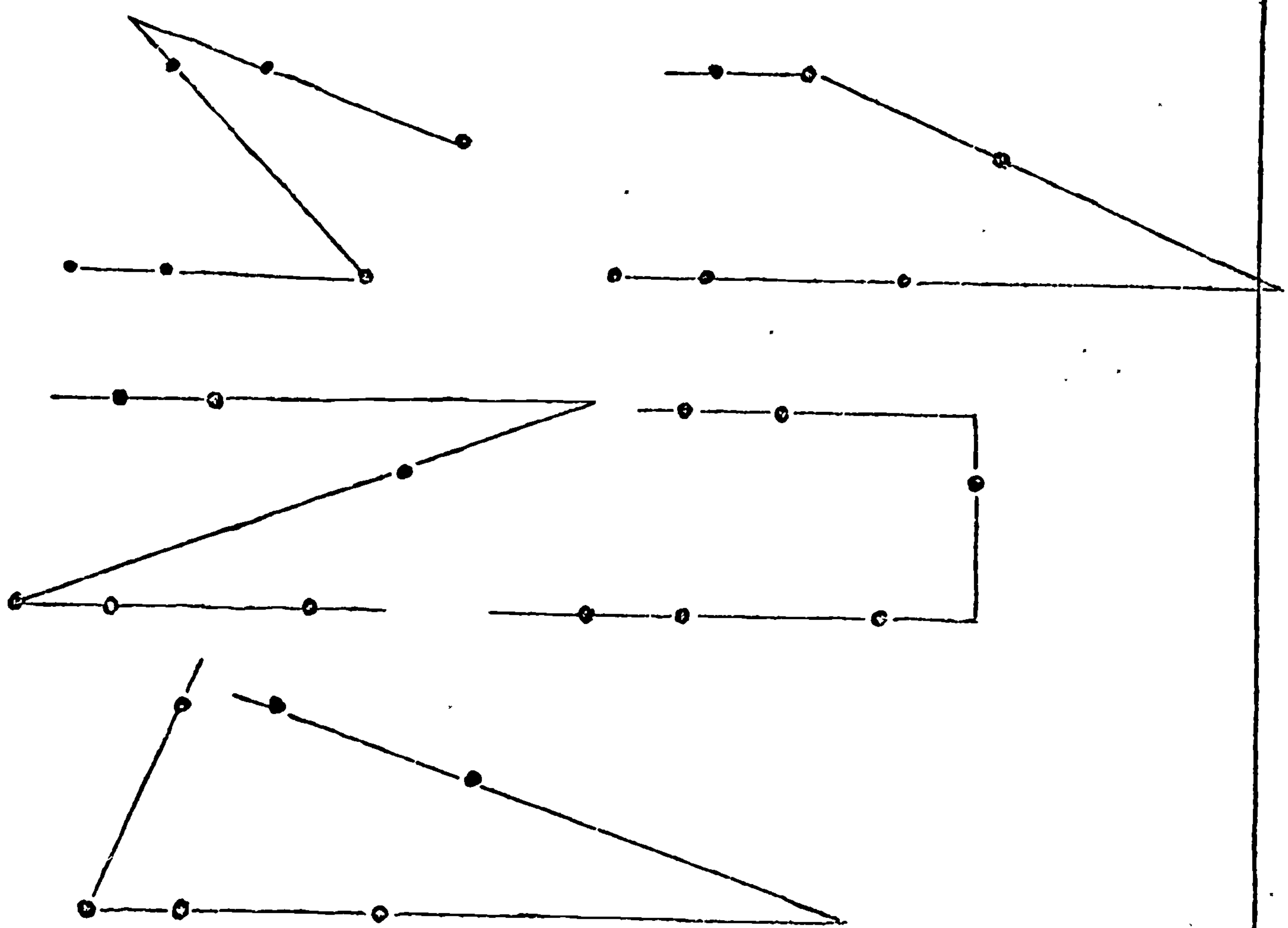
1. LINES MAY CROSS.
2. LINES MAY MEET AWAY FROM ANY GIVEN POINTS (AND AWAY FROM THE GRID).

PRACTICE
(USE ONLY THREE LINES)



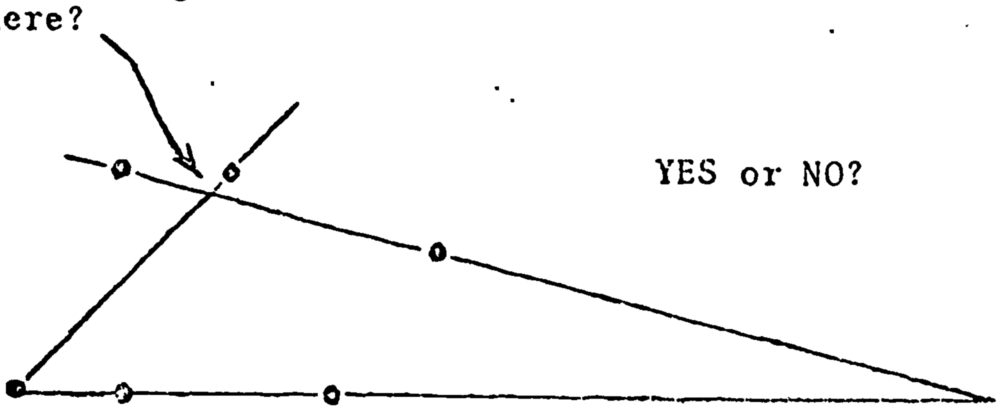
Go on to the next frame

(11) Here are some solutions; there are other correct solutions.



Note that many of the lines MEET AWAY FROM THE GIVEN POINTS. This allows a line to extend to just the right point in space to angle back through another row of aligned points.

Would this be a correct solution even though two of the lines cross here?



YES or NO?

Go on to the next frame

(12)

Yes, it is also correct. You may not lift the pencil or double back on a line, but this does not prohibit the lines crossing each other.

REMEMBER: The lines 1) <u>may cross</u>

2) <u>may meet away from any given points</u>

In the next frame you will be given a box-like pattern of nine points. Without lifting your pencil or doubling back on any line, use ONLY <u>FOUR</u> STRAIGHT LINES to contact every point at least one time.

If you have understood the previous frames, this next frame should be a pleasantly interesting challenge, but not too difficult for you.

As soon as you solve the puzzle, press the button in front of you immediately and then sit quietly until you are told that the session is finished.

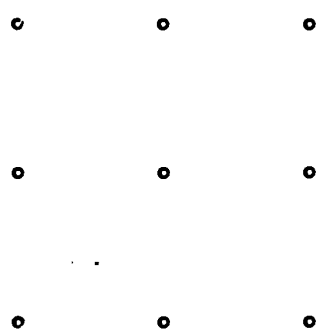
Go on to the next frame

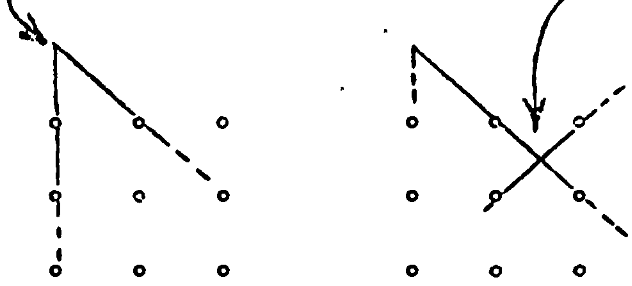
(13)

USE ONLY FOUR LINES.
DO NOT LIFT PENCIL
OR RETRACE.

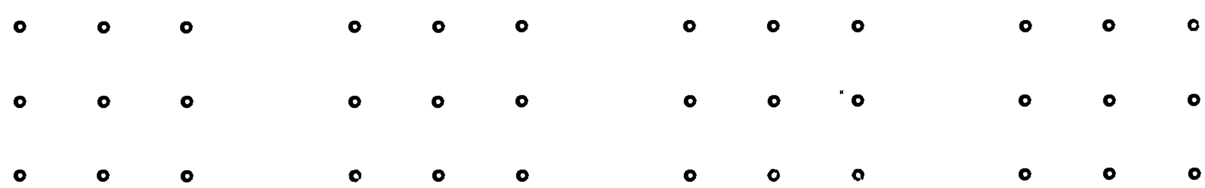
REMEMBER:
LINES MAY MEET
AWAY FROM GIVEN
POINTS

AND LINES
MAY CROSS





PRACTICE
(use only FOUR lines)



PRESS THE BUTTON WHEN YOU GET A CORRECT
SOLUTION AND REMAIN SEATED QUIETLY.

STOP-THIS IS THE END.

DO NOT TURN PAGE

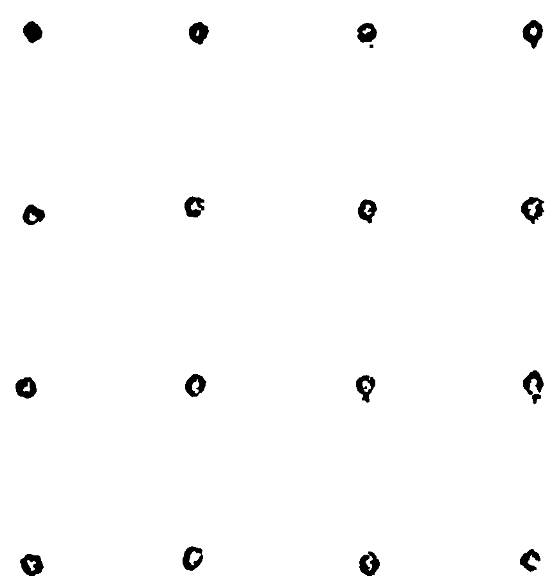
DO NOT CLOSE BOOK

Insert Set for

Program One, Test One, Version A

(next 3 pages)

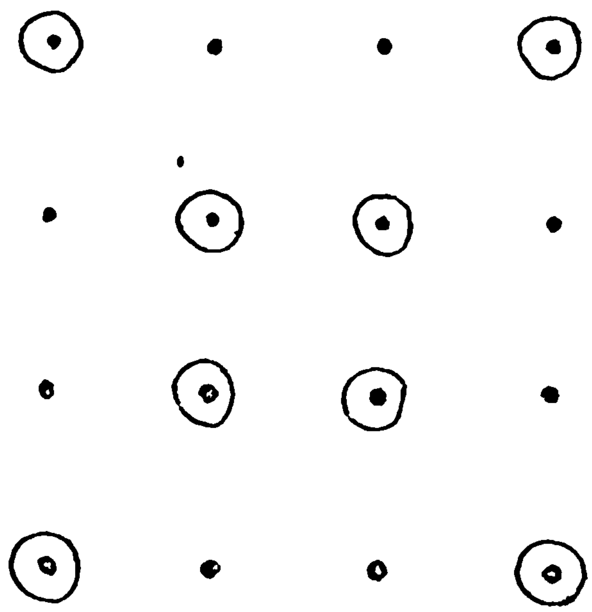
(10) Below is a pattern of sixteen points. Circle all dimatrical points, but only dimatrical points, and then take only the circled points as a puzzle, and, without lifting your pencil or retracing (doubling back), solve the puzzle with only three lines, ignore, for the time being, the non-dimatrical points, and do not consider them in your solution.



STOP

Do not go to the next frame until you have successfully completed this frame, or until you are told to continue by the person in charge.

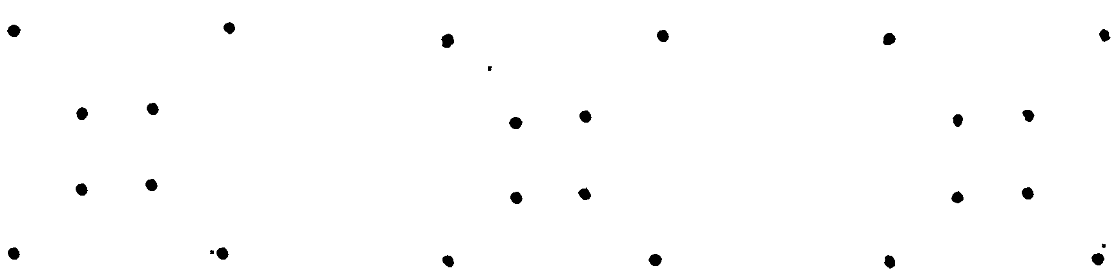
(11) "Dimatrical" points are points on the diagonals of the pattern as shown below:



Now, using only these points for the puzzle, solve it with only three lines.

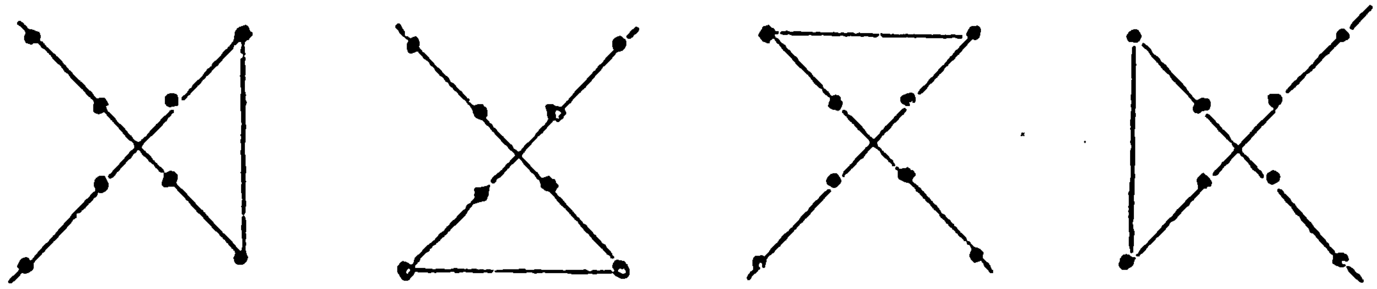
Remember: You may not retrace a line, you must not lift your pencil, but lines may cross. Use only three lines.

PRACTICE

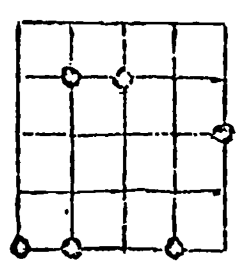


Go on to the next frame

(12) Here are the possible solutions:



In this frame you are given a six point puzzle. The six points are placed on a grid of fine lines so that you can see more clearly how they are aligned. You draw in the solution using ONLY <u>THREE</u> STRAIGHT LINES.

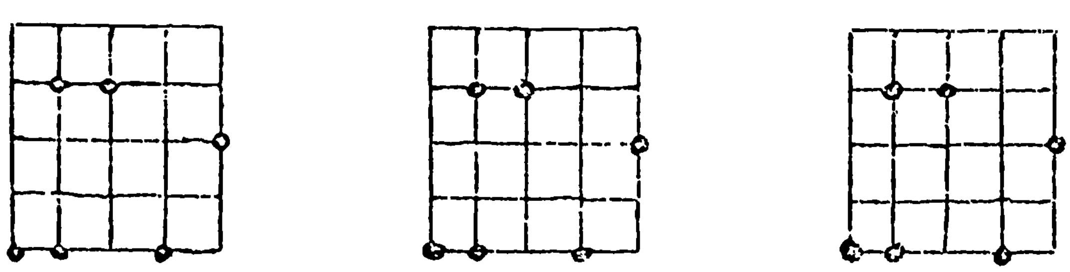


<u>Remember</u>:

1) LINES MAY CROSS.

2) LINES MAY MEET AWAY FROM ANY GIVEN POINTS (AND AWAY FROM THE GRID).

PRACTICE (use only <u>three</u> lines)



Go on to the next frame

Insert Set for

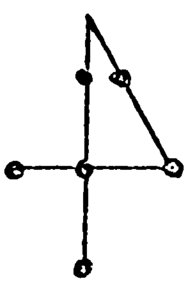
Program One, Test Two, Version G

(next 2 pages)

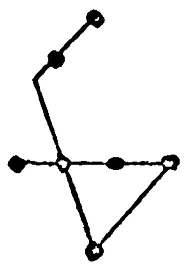
(10) REMINDER:

Remember that doubling back on crossed lines is not permitted when two or more lines meet away from some point.

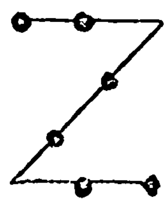
Find the TWO of the following six puzzle solutions which must be rejected because of the above rule. Circle these solutions and write beside each of them the key word pertaining to the circled solution from the above reminder.



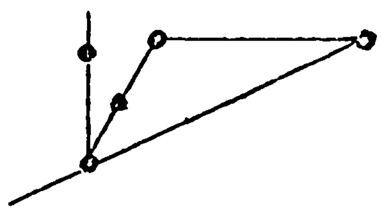
A



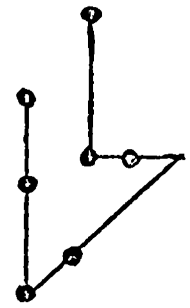
B



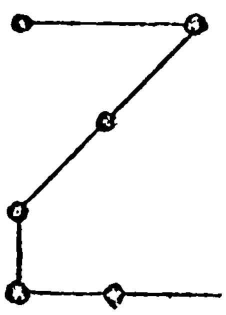
C



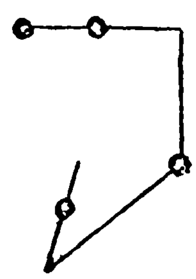
D



E



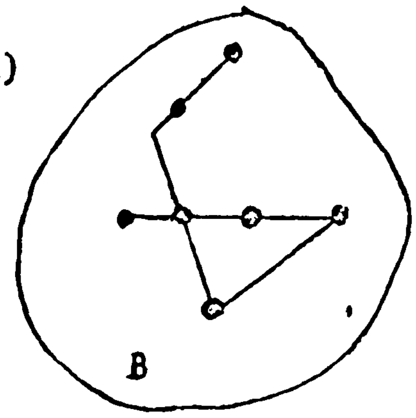
F



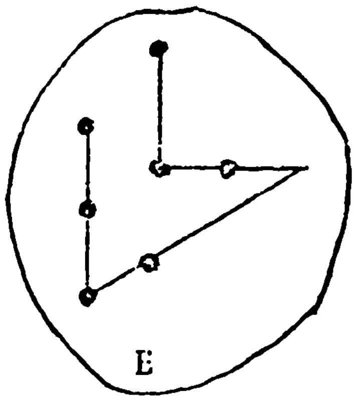
G

Give your best answer before going on.

(11)

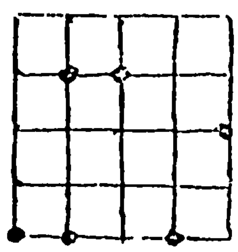


"Doubling"



"Points"

In this frame below you are given a six point puzzle. The six points are placed on a grid of fine lines so that you can see more clearly how they are aligned. You draw in the solution using ONLY THREE STRAIGHT LINES.

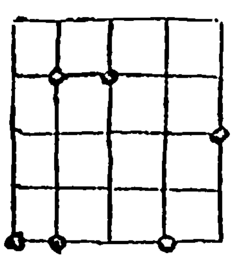


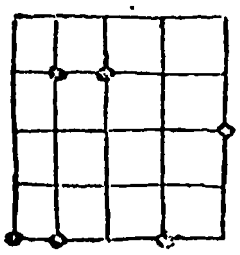
REMEMBER:

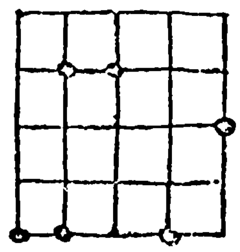
1) LINES MAY CROSS.

2) LINES MAY MEET AWAY FROM ANY GIVEN POINTS (AND AWAY FROM THE GRID)

PRACTICE (use only three lines)







Go on to the next frame

Insert Set for

Program One, Test Three, Version D

(next 2 pages)

(12) Yes, it is also correct. You may not lift the pencil or double back on a line, but this does not prohibit the lines crossing each other.

REMEMBER: The lines 1). may cross

2) may meet away from any given points

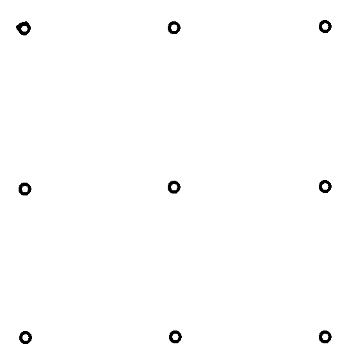
In the next frame you will be given a box-like pattern of nine points. Without lifting your pencil or doubling back on any line, use ONLY THREE STRAIGHT LINES to contact every point at least one time.

If you have understood the previous frames, this next frame should be a pleasantly interesting challenge, but not too difficult for you.

If you start to feel bored, disgusted, or like the activity is no longer fun, press the button IMMEDIATELY, but continue trying to solve the puzzle until you are told to stop.

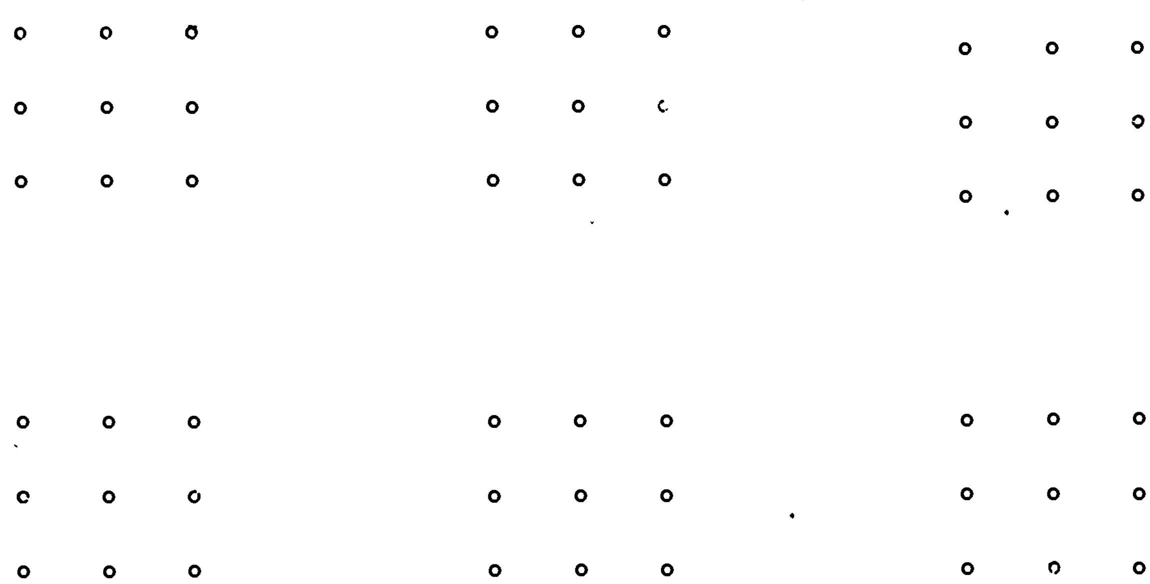
Go on to the next frame

(13) USE ONLY THREE LINES



Press the button if you should become displeased with the game, but continue working.

PRACTICE (use only three lines)



PRESS THE BUTTON IF YOU SHOULD BECOME DISPLEASED WITH THE GAME, BUT CONTINUE WORKING.

DO NOT TURN PAGE - - - THIS IS THE END STOP

DO NOT TURN PAGE

Program Two, Control, Version K

(next 13 pages)

(1) The symbol to the right represents a metal chain link: 

This symbol represents two metal chain links fastened together: 

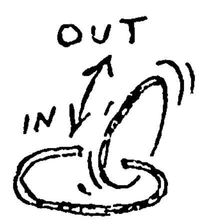
In the space below, draw <u>four</u> chain links fastened together in a straight line running from left to right:

Go on to the next frame

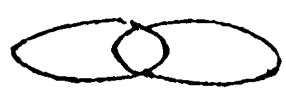
(2)  Correct Sketch

A metal chain link can be cut and opened like the one to the right:

This allows other links to be slipped into or out of this cut link.



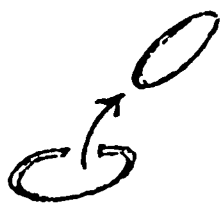
In order to separate the two joined links shown below, do both of them have to be cut?



YES or NO?

Go on to the next frame

(3) No. If one is cut, the other uncut link can be slipped out of it as shown:

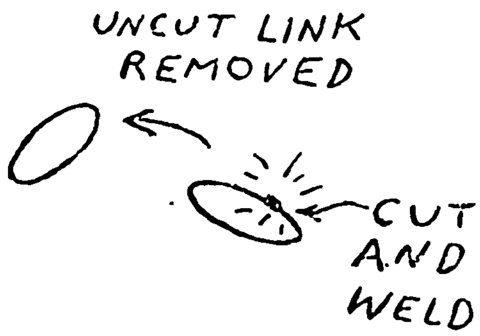


If a previously cut link has its cut ends refastened together, this is called a "weld".

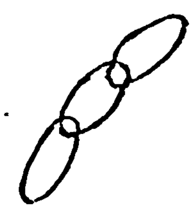
If you want to separate the two joined links at the right and make two whole, uncut links, what is the smallest number of cut-and-welds that would allow you to do this?

Go on to the next frame

(4) One. You cut one link, slip the other link out of it, and weld the cut closed.



At the right is a chain of three links. If you cut off one of the END links, the chain would be in two pieces. Draw the two pieces below; show the cut link rewelded.



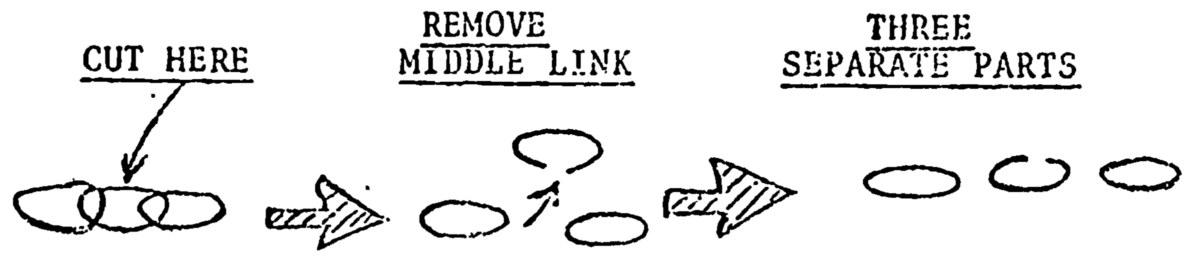
Go on to the next frame

(5)  Answer to frame (4)

How many pieces would the chain now be in if you had cut and removed the middle link instead of one of the end links?

Go on to the next frame

(6) Three. Cutting an end link allows only that link to be removed from the chain, but cutting a link in the middle of the chain divides the chain into three parts: 1) the cut link by itself; 2) the links to the right of it; and 3) the links to the left of it.



Suppose each link of our chain is worth one cent. A single link ( ) would then be like a penny. WHAT COIN WOULD THE CHAIN BELOW REPRESENT?

Go on to the next frame

(7) A nickel. Five "penny-links" equal 5¢, or one nickel.

 = 5 ¢

Remember:
Any size coin is possible.

For example, here are two-cent and four-cent coins:


a 2¢ piece


a 4¢ piece

You do not need a large number of separate links in order to make coins.

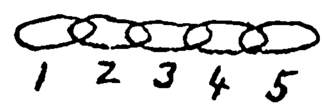
QUESTION:

Suppose you have such a five-link chain shown below and you are trying to buy at a store that takes only chains and links as money (each link is worth 1¢). What is the SMALLEST number of cuts that you would have to make in your chain to buy something that costs 3¢?

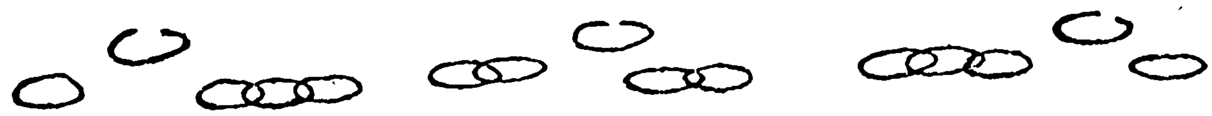

your chain

Go on to the next frame

(8) One cut. By cutting either link 2, or 3, or 4, the chain could be divided so that you could keep two links and buy something with the other three.

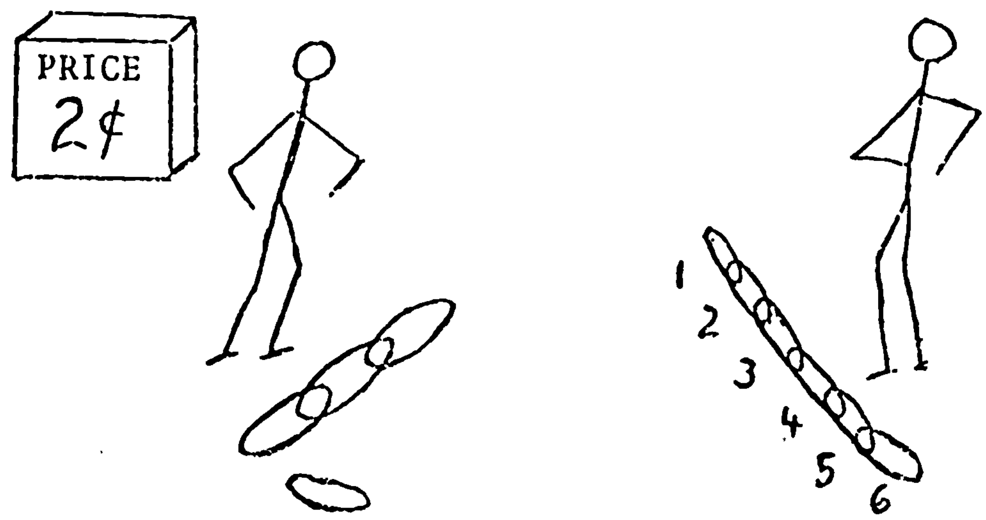


link 2 cut link 3 cut link 4 cut



Below are two men, A and B, each of whom has the chains and single links shown beside him. (B), on the right, wishes to buy a box costing 2¢ which (A), on the left, wants to sell. If the two men cooperate, what is the simplest way that (B) could buy the 2¢ box from (A) WITHOUT EITHER MAN CUTTING ANY CHAIN OR LINK?

A (SELLER) B (BUYER)



NO CUTTING ALLOWED THIS TIME.

Go on to the next frame

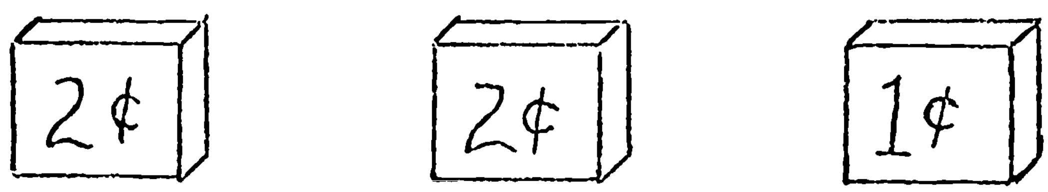
(9) (B) gives (A) his six-link chain and gets (A)'s four links back as change.

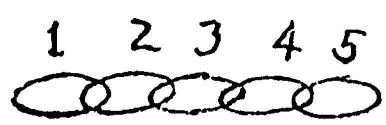
REMEMBER:

1) It is possible to free more links or divide a chain into more pieces by cutting a link that is somewhere in the middle of a chain.

2) When using the links as coins of money, it is possible to make change using different combinations of links.

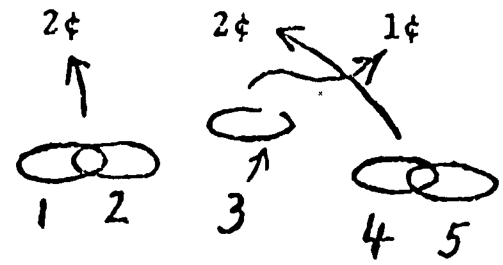
Below are three boxes, priced as marked, which you want to buy. Suppose you have the five-link (5¢) chain shown. What is the SMALLEST number of links that you would have to cut in order to have the EXACT change (in link coins) to buy each box one-at-a-time?





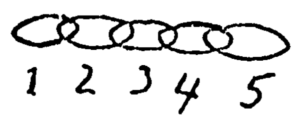
Go on to the next frame

(10) One cut in link (3). Cutting and removing the third link, as shown to the right, would provide the needed pair of two-cent chains and the single one-cent link to buy the boxes.



Note how the cut link, when removed from the MIDDLE of the chain, always becomes a single 1¢ piece while providing two other link-coins from the ends of the cut chain.

Suppose you have the five-link chain shown to the right, and each link will buy one glass of water. You want to buy one glass of water each day, and you must pay each day for that day's water, no credit and no advance payment. If the seller will keep the links that you have paid him and use them to make change for you later during the five-day period, what is the smallest number of cuts that you will have to make in your chain, and which links would you cut?

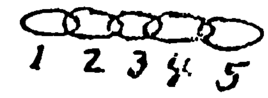


Remember:
The problem is to determine how few cuts would have to be made in your chain to assure that between you and the seller each day there would be the CORRECT CHANGE available for that day's one-link purchase.

Go on to the next frame

(11)

Only one link need be cut, either (2) or (3) or (4).

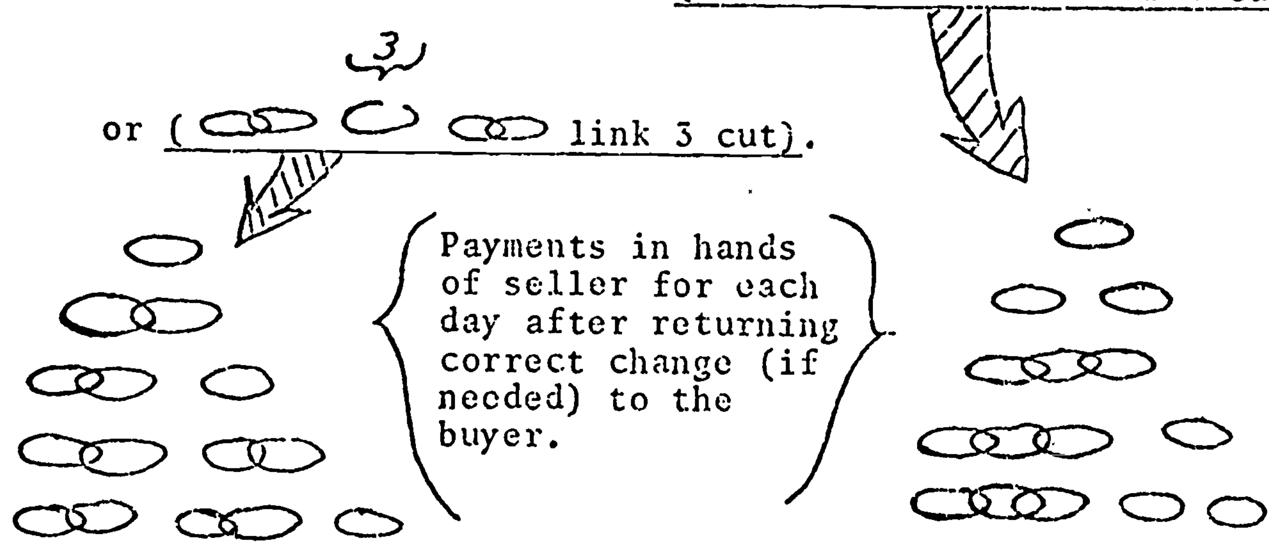


2 or 4

You would have either (link 2 or 4 cut

3

or (link 3 cut).



REMEMBER: For this type of problem, whatever cuts you make must yield possible combinations that total one link for each day that has passed.

Test Your Understanding:

If you had chosen to cut your chain at link (3) so that you were working with the combinations of links on the left above, when you came back on the fourth day, what would you give the seller and what would he give to you as change?

Go on to the next frame

(12)

You give him a pair of joined links ( ),
and he gives you a single link as change.

Suppose you own a valuable gold chain, as will be shown to you in the next frame, and you need a hotel room for several days. You have no money, but the hotel owner will take one link of your gold chain each day as payment; you must pay each day, one link per day, and the hotel owner will have the links there that you have already paid to him each time that you come to pay. By the time your chain is all gone you will have gotten the money to buy back your chain, so <u>you do NOT want to cut it any more than is necessary</u>.

Go to the next frame, look at the chain, and show how you could get by with cutting only <u>ONE</u> link.

As soon as you solve the puzzle, <u>PRESS THE BUTTON IN FRONT OF YOU IMMEDIATELY</u> and then sit quietly until you are told that the session is finished.

Go on to the next frame

(13) Here is the gold chain:

1 2 3 4 5 6 7

MAKE ONLY ONE CUT

Remember that you need possible combinations of links totalling one, two, three, four, five, six, and seven links, for payment on each of the seven days. Tell which link you would cut and sketch the seven needed combinations that you could get from that ONE cut.

PRESS THE BUTTON WHEN YOU GET A CORRECT SOLUTION AND REMAIN QUIETLY SEATED.

STOP - DO NOT TURN PAGE

THIS IS THE END - DO NOT TURN PAGE

Insert Set for

Program Two, Test One, Version E

(next 4 pages)

(9) (B) gives (A) his six-link chain and gets (A)'s four links back as change.

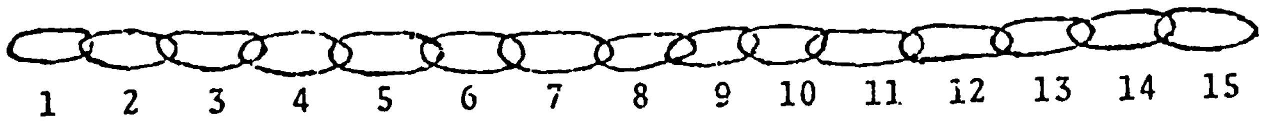
REMEMBER:

1) It is possible to free more links or divide a chain into more pieces by cutting a link that is somewhere in the middle of a chain.

2) When using the links as coins of money, it is possible to make change using different combinations of links.

Go on to the next frame

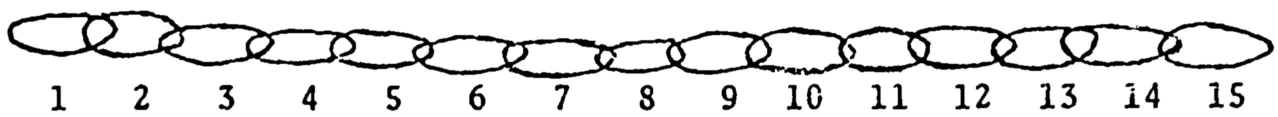
(10) Look at the long chain shown below. If you cut and remove all illative links from this chain, how many separate peices of chain and links would you then have altogether?



STOP

DO NOT GO TO THE NEXT FRAME UNTIL YOU HAVE SUCCESSFULLY COMPLETED THIS FRAME OR UNTIL YOU ARE TOLD TO CONTINUE BY THE PERSON IN CHARGE.

(11) "Illative" links are even-numbered links.

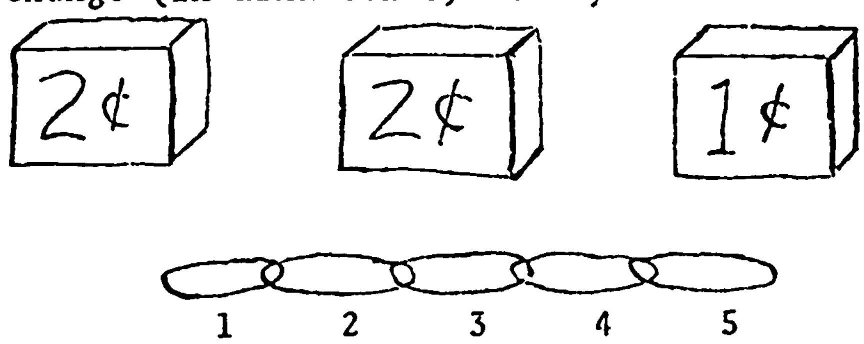


Now, if you cut and remove all illative links from this chain, how many separate pieces of chain and links would you have altogether?

Go on to the next frame

(12) All links would be separated; you would have fifteen separate pieces.

Below are three boxes, priced as marked, which you want to buy. Suppose you have the five-link (5¢) chain shown. What is the SMALLEST number of links that you would have to cut in order to have the EXACT change (in link coins) to buy each box one-at-a-time?



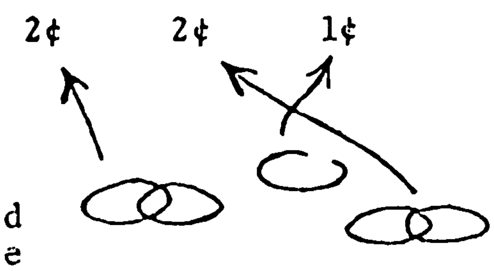
Go on to the next frame

Insert Set for

Program Two, Test Two, Version B

(next 3 pages)

(10) One cut in link (3).



Cutting and removing the third link, as shown to the right, would provide the needed pair of two-cent chains and the single one-cent link to buy the boxes.

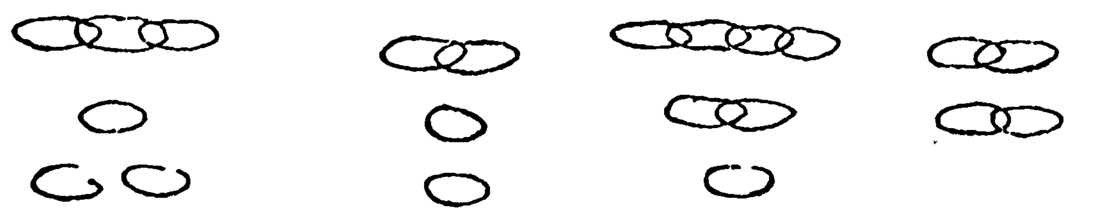
Note how the cut link, when removed from the MIDDLE of the chain, always becomes a single 1¢ piece while providing two other link-coins from the ends of the cut chain.

Go on to the next frame

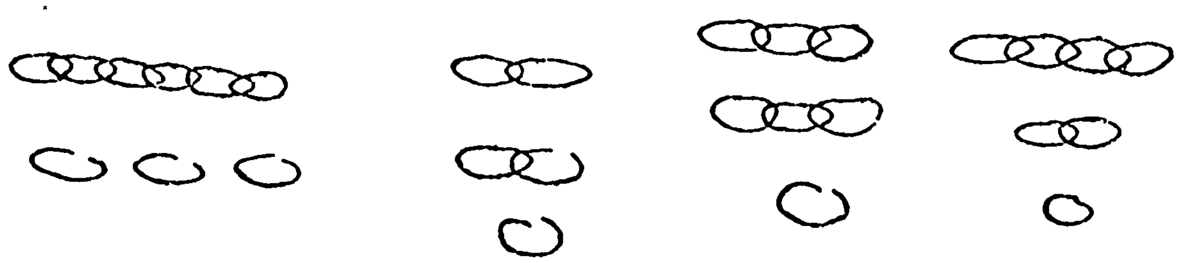
(11) REMEMBER:

Middle link welds, following cuts which divide multiple chains, can be used to obtain additional change combinations. This allows money usage in one-cent and five-cent combinations for three-cent purchases if unwelded links are used first.

With this information, select those combinations from among the ones below which would permit chain purchases as described above. (More than one answer may be correct.) Write the key word pertaining to each of your choices from the paragraph above beside the combinations that you choose.



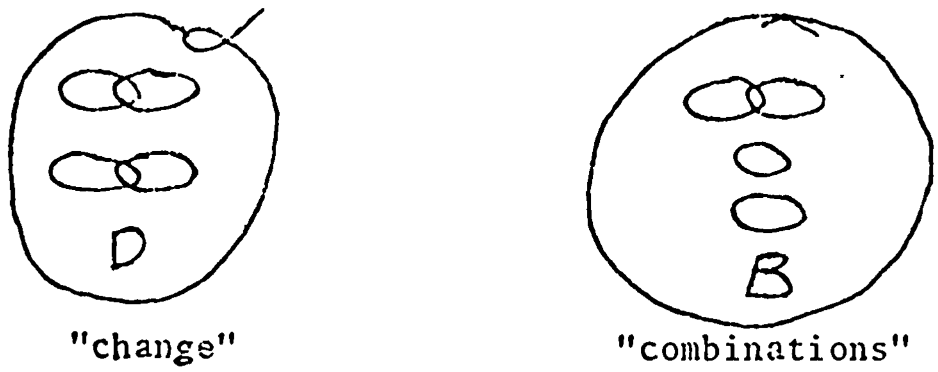
A B C D



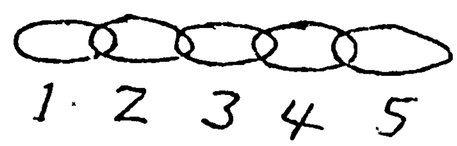
E F G H

GIVE YOUR BEST ANSWER BEFORE GOING ON

(12)



Suppose you have the five-link chain shown to the right, and each link will buy one glass of water, You want to buy one glass of water each day, and you must pay each day for that day's water, no credit and no advance payments. If the seller will keep the links that you have paid him and use them to make change for you later during the five-day period, what is the smallest number of cuts that you will have to make in your chain, and which links would you cut?



Remember:

The problem is to determine how few cuts would have to be made in your chain to assure that between you and the seller each day there would be the CORRECT CHANGE available for that day's one-link purchase.

Go on to the next frame

Insert Set for

Program Two, Test Three, Version H

(next 2 pages)

(12) You give his a pair of joined links (), and he gives you a single link as change.

Suppose you own a valuable gold chain, as will be shown to you in the next frame, and you need a hotel room for several days. You have no money, but the hotel owner will take one link of your gold chain each day as payment; you must pay each day, one link per day, and the hotel owner will have the links there that you have already paid to him each time that you come to pay. By the time your chain is all gone you will have gotten the money to buy back you chain, so you do NOT want to cut it any more than is necessary.

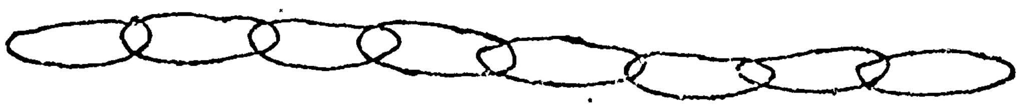
Go to the next frame, look at the chain, and show how you could get by with cutting only ONE link.

If you have understood the previous frames, this next frame should be a pleasantly interesting challenge, but not too difficult for you.

If you should begin to feel bored, disgusted, or like the activity is no longer fun, press the button IMMEDIATELY, but continue trying to solve the puzzle until you are told to stop.

Go on to the next frame

(13) Here is the gold chain:



1 2 3 4 5 6 7 8

MAKE ONLY ONE CUT.

Remember that you need possible combinations of links totalling one, two, three, four, five, six, seven, and eight days. Tell which link you would cut and sketch the eight needed combinations that you could get from that ONE cut.

PRESS THE BUTTON IF YOU SHOULD BECOME DISPLEASED WITH THE GAME, BUT CONTINUE WORKING.

STOP — THE END — DO NOT TURN PAGE

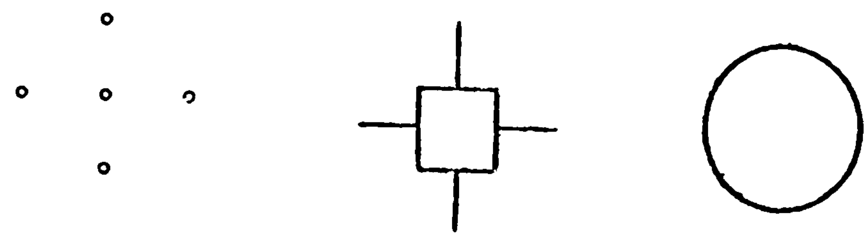
DO NOT TURN PAGE

Program Three, Control, Version L

(next 13 pages)

(1) A pattern that appears to be the same when viewed from different angles is said to be "symmetrical".

These patterns are symmetrical:

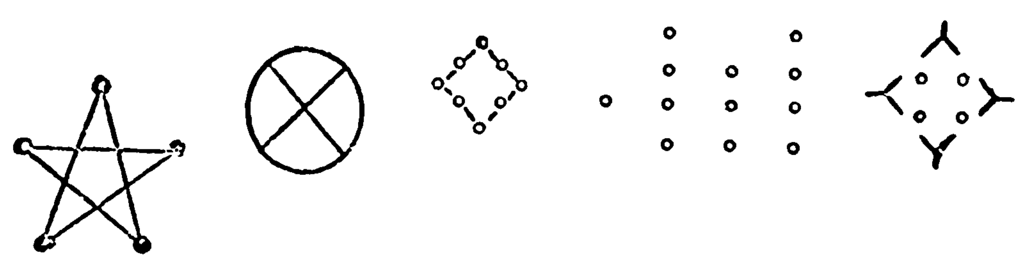


To check a pattern for symmetry, look at it from different directions: look at it from the top, from the bottom, and from both sides at all angles around the figure.

If there are two or more different directions from which it looks the same, it is symmetrical.

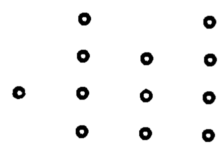
Which one of the following patterns is not symmetrical?

A B C D E



Go on to the next frame

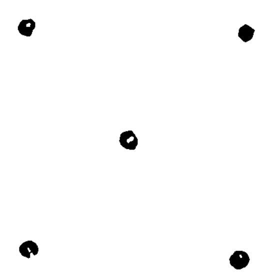
(2)



D

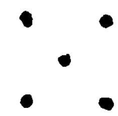
This pattern of dots is <u>not</u> symmetrical.

Is this pattern of dots symmetrical?

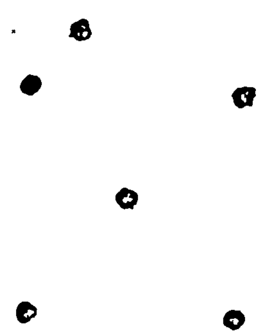


<u>YES or NO?</u>

Go on to the next frame

(3) <u>Yes</u>, this is a symmetrical pattern: 

If a dot is now added to the previous pattern, as shown below, is the pattern still symmetrical?

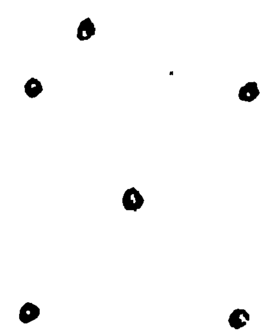


YES or NO?

Go on to the next frame

(4) No, it is no longer symmetrical.

Here is the pattern with its extra dot:

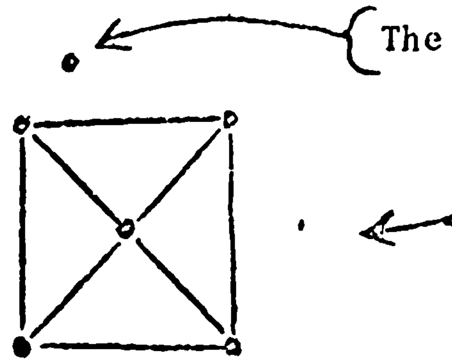


If you look closely, you can still see the original symmetrical pattern within the above group of dots.

With your pencil draw in the <u>original</u> symmetrical pattern on the above set of dots by connecting all of its points with straight lines. Ignore the one non-symmetrical point.

Go on to the next frame

(5)

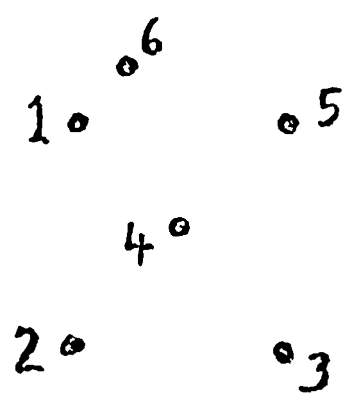


The ignored extra dot

Here is the original symmetrical pattern drawn in with lines.

Below, you are given this <u>same</u> set of dots which have now been numbered.

This pattern of dots could be turned up-side-down (inverted) by being rotated <u>clockwise</u> ( ) as though it were turning about a pin stuck through the paper at dot number 4 in the center [rotate].

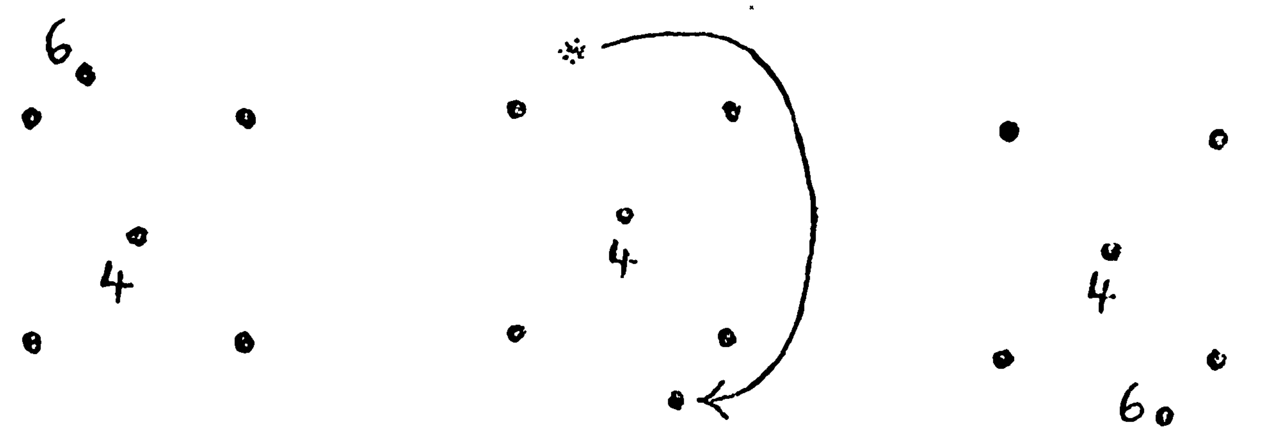


If you are now told to draw this same dot pattern as it would appear up-side-down <u>after</u> the clockwise rotation, HOW MANY DOTS WOULD HAVE TO BE MOVED TO DIFFERENT POSITIONS IN THE PATTERN to show it inverted?

Which dots would move (refer to the numbers)?

Go on to the next frame

(6) Only ONE dot would have to be moved; dot (6) moves from top to bottom as shown below:



Invert by rotation about center point 4.

Only point 6 appears to have moved.

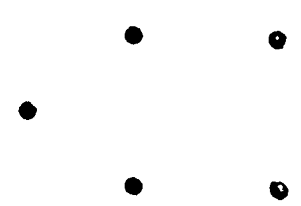
Does the symmetrical part of the pattern appear to have changed position in any way after turning the pattern up-side-down in this way?

YES or NO?

Go on to the next frame

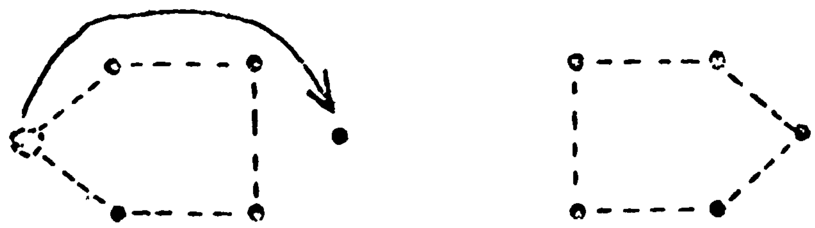
(7) No. The symmetrical part ( ) does not appear changed; it looks the same.

The dots below form an arrow pointing to the left as shown. Move only ONE point and make a similar arrow pointing to the right.



Go on to the next frame

(8)

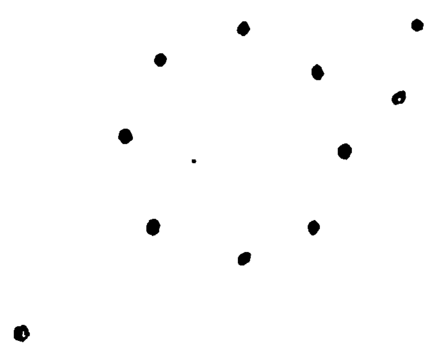


Note that the symmetrical box-like pattern of four dots did <u>not</u> change.

REMEMBER:

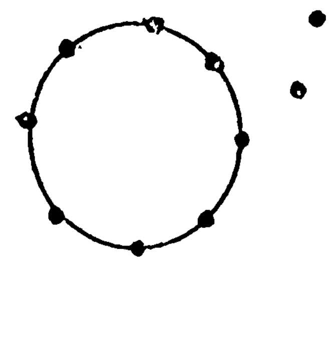
If a pattern of dots has a direction to it, that direction can be changed by moving dots that are not symmetrical and <u>leaving any included symmetrical patterns alone</u>.

Find the largest symmetrical pattern in the grouping of dots below and draw it in with your pencil.



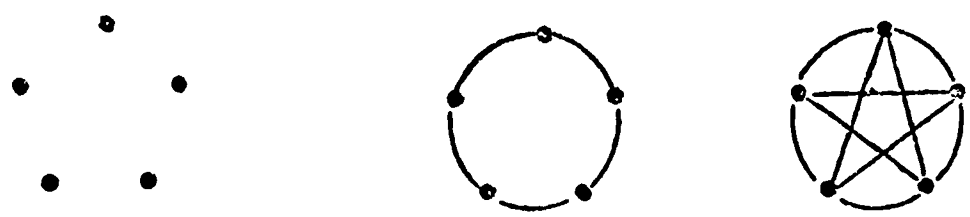
Go on to the next frame

(9)



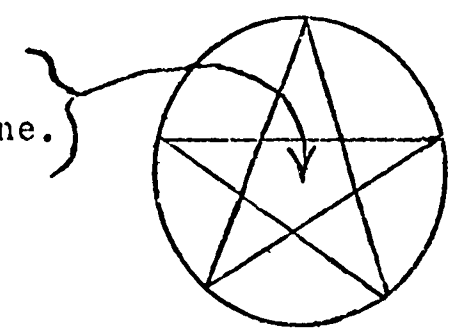
The symmetrical pattern is a circle.

Learn to look for the patterns:

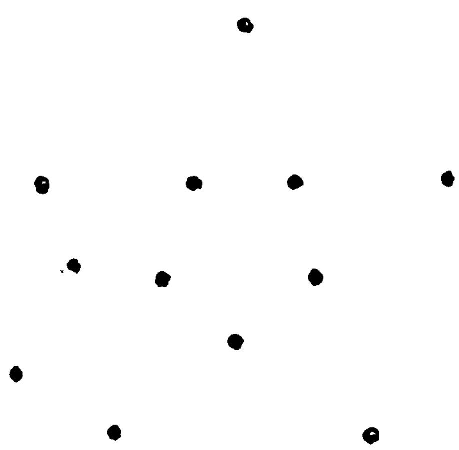


The same five points may be........on a circle......or on the points of a star.

Note the smaller five-point pattern within the larger one.

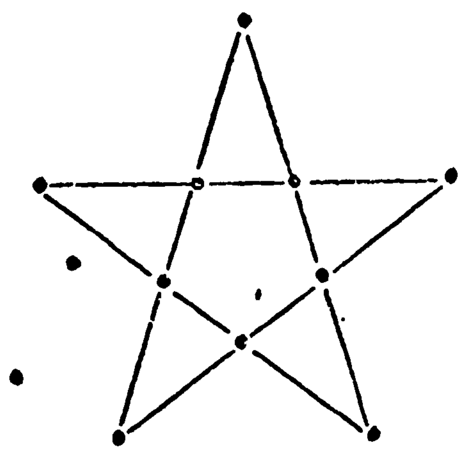


WITH YOUR PENCIL:
Draw in the largest symmetrical pattern hidden in these dots shown below -- using the largest possible number of dots.

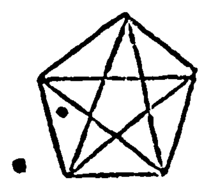


Go on to the next frame

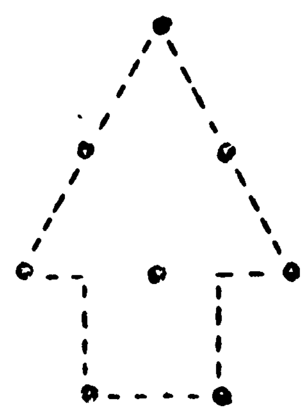
(10)



Star pattern. Perhaps you drew it as shown below, which is also correct.



Look at the arrow pattern to the right:



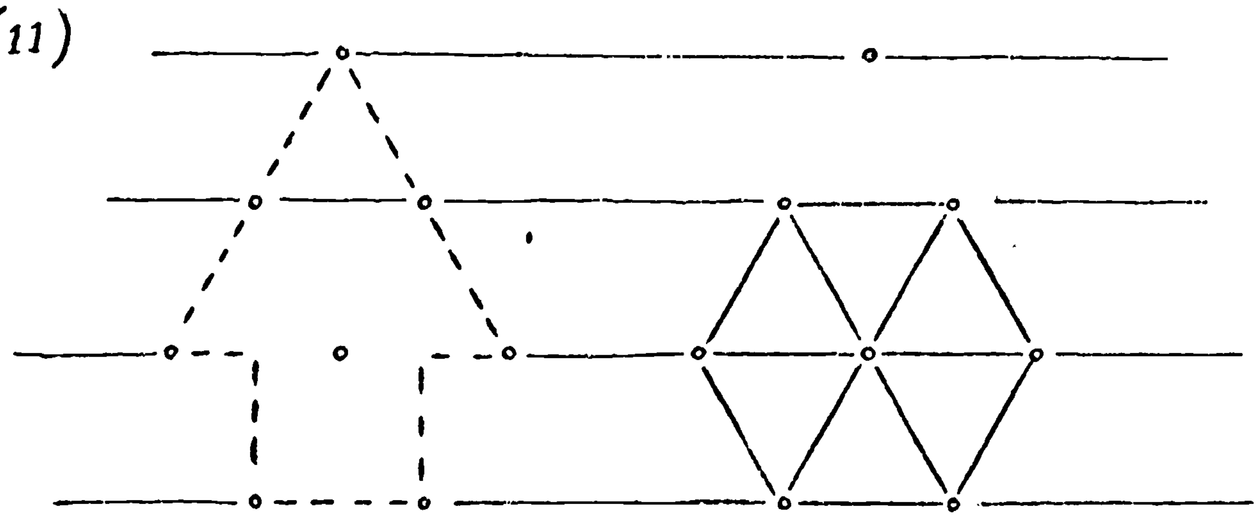
Find the LARGEST symmetry pattern among the dots and draw it in completely with lines.

HINTS:
Ignore the dashed lines.

The largest hidden symmetry pattern involves seven of the eight dots and is not a triangle.

Go on to the next frame

(11)

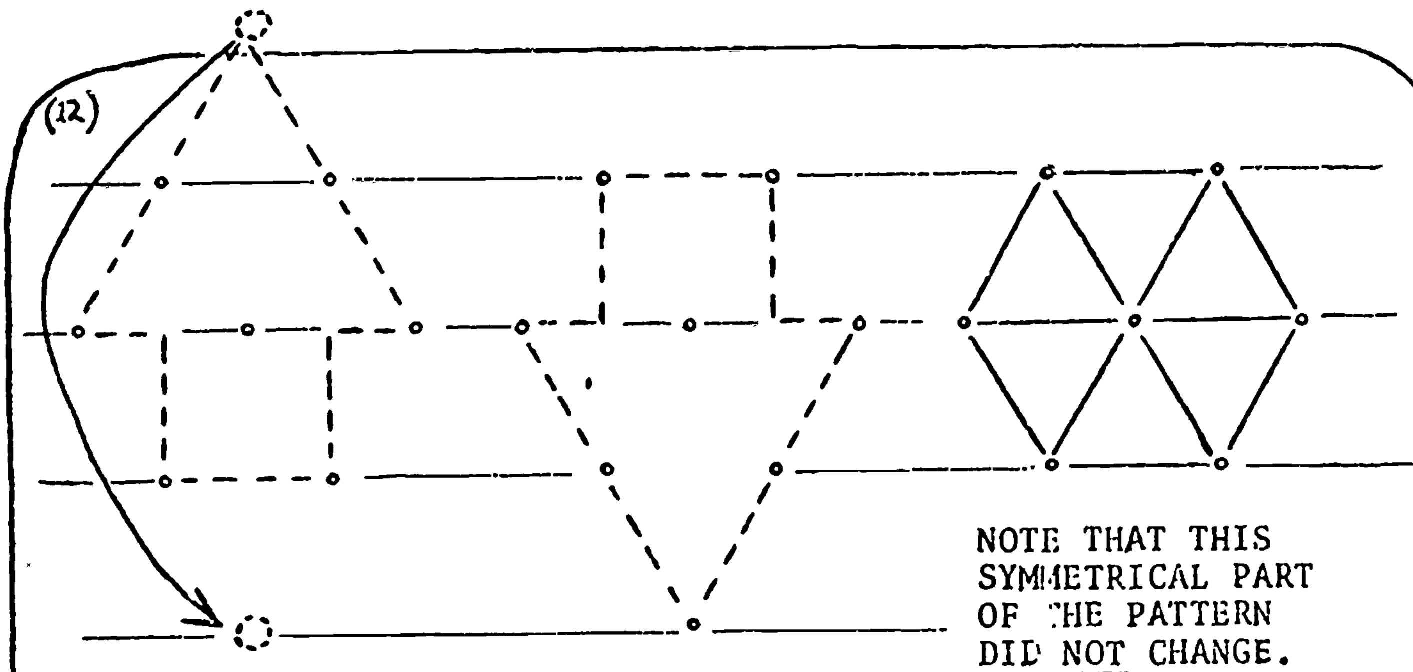


This arrow pattern......contains this six-sided symmetry pattern.

Now, move only ONE point and thereby cause the arrow to point in the opposite direction (downward).

Go on to the next frame

(12)



NOTE THAT THIS SYMMETRICAL PART OF THE PATTERN DID NOT CHANGE.

In the next frame you will be given another kind of arrowhead pattern. By moving only THREE points to different positions, make the same arrow point in the opposite direction.

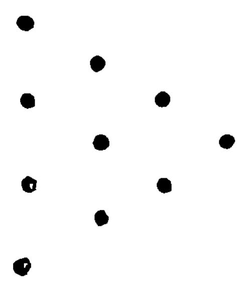
If you have understood the previous frames, this next frame should be a pleasantly interesting challenge, but not too difficult for you.

As soon as you solve the puzzle, press the button in front of you immediatly and then sit quietly until you are told that the session is finished.

Go on to the next frame

(13)

Move THREE points to new positions so that the arrow points in the opposite direction (to the left).



PRESS THE BUTTON AS SOON AS YOU GET A CORRECT SOLUTION AND REMAIN SEATED QUIETLY.

DO NOT TURN PAGE THIS IS THE END

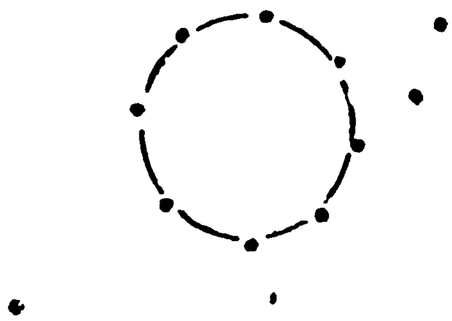
STOP - DO NOT TURN PAGE

Insert Set for

Program Three, Test One, Version I

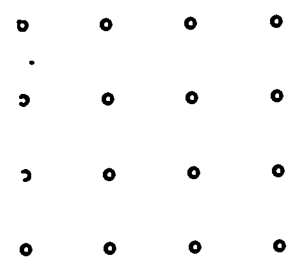
(next 3 pages)

(9)



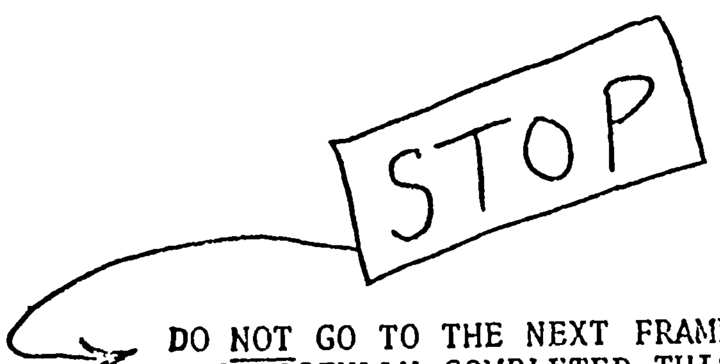
The symmetrical pattern is a circle.

In the pattern of points shown to the right, draw straight lines from the invortice point to each of the geoboard points.



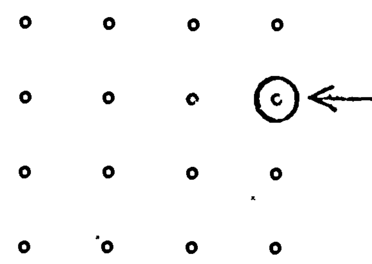
Notice that these lines divide the pattern of points into smaller subgroupings.

List the number of points in each of these subgroups that have <u>no</u> line running through them.



DO NOT GO TO THE NEXT FRAME UNTIL YOU HAVE SUCCESSFULLY COMPLETED THIS FRAME OR UNTIL YOU HAVE BEEN TOLD TO CONTINUE BY THE PERSON IN CHARGE.

(10)



This is the "invortice" point.

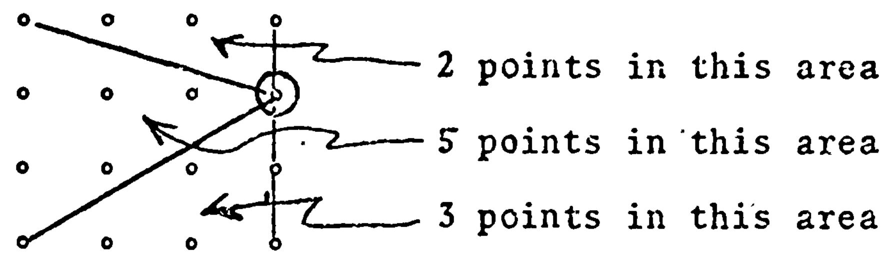
The "geoboard" points are the four corner points.

Now, draw the straight lines from the invortice point to each of the geoboard points (use a straightedge).

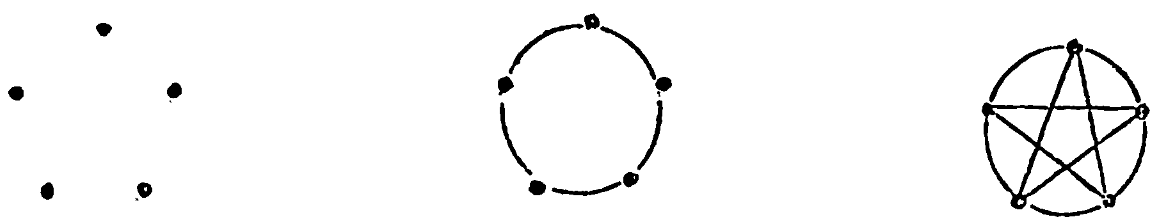
List the number of points in each area or zone marked off by these lines (count only points with NO lines through them).

Go on to the next frame

(11)

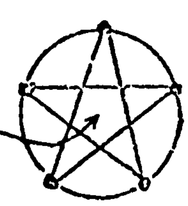


Learn to look for the patterns:



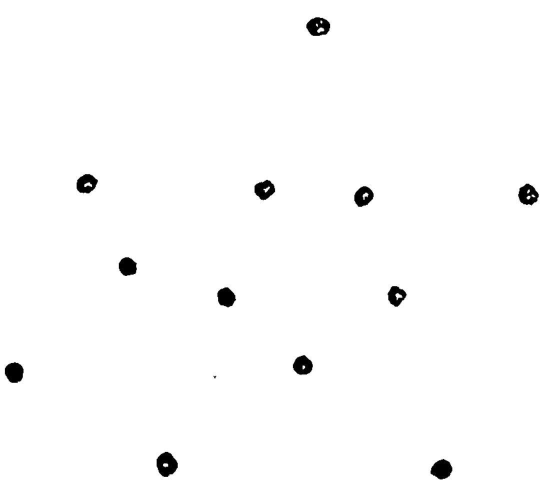
The same five points may be...........on a circle..........or on the points of a star.

Note the smaller five-point pattern within the larger one.



WITH YOUR PENCIL:

Draw in the largest symmetrical pattern hidden in these dots shown below -- using the largest possible number of dots.



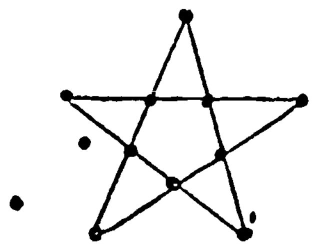
Go on to the next frame

Insert Set for

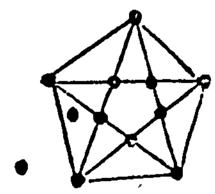
Program Three, Test Two, Version F

(next 2 pages)

(10)



Star pattern.

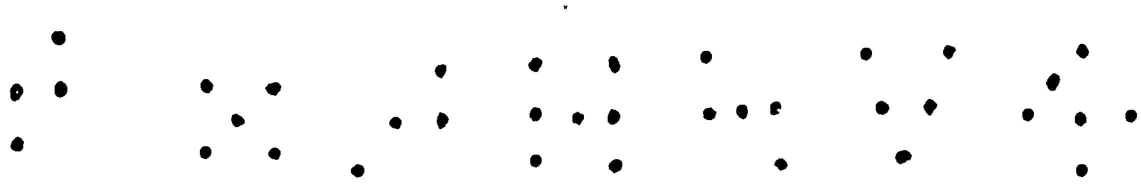


Perhaps you drew it this way which is also correct.

REMEMBER:

The average symmetry pattern car. be pointed with lines in the opposite direction so that familiar designs can be seen if one is able to look correctly at the connections. This is not true, however, unless the symmetry is not originally grouped.

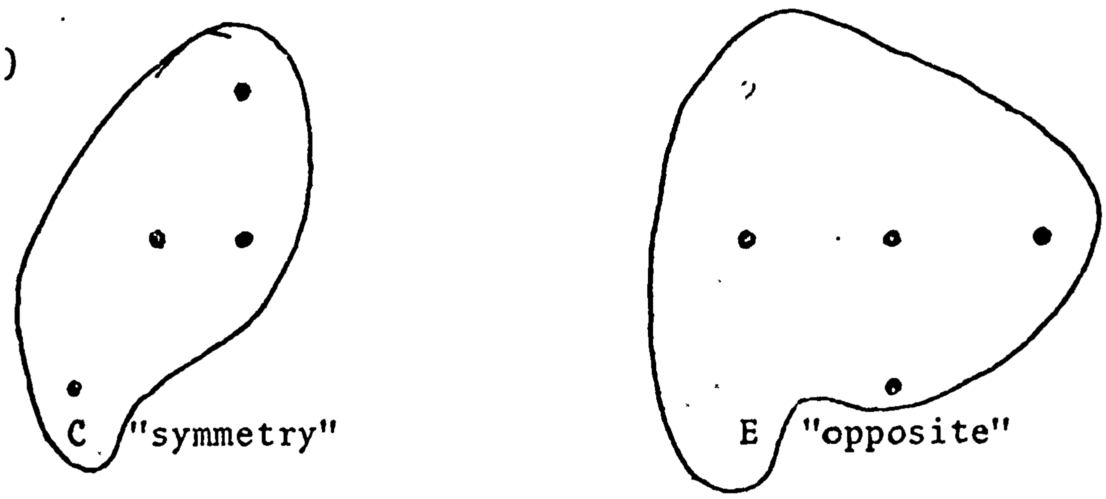
From this information tell which of the designs below has the appropriate line-connected symmetry, and beside each design that you choose write the most related word from the paragraph above.



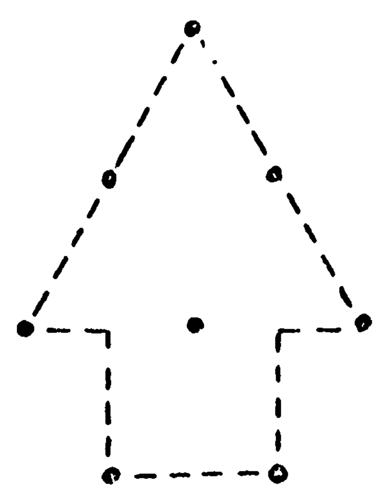
A B C D E F G

GIVE YOUR BEST ANSWER BEFORE GOING ON.

(11)



Look at the arrow pattern to the right:



Find the LARGEST symmetry pattern among the dots forming the arrow and draw it in completely with lines.

HINTS:

Ignore the dashed lines.

The largest hidden symmetry pattern involves seven of the eight dots and is not a triangle.

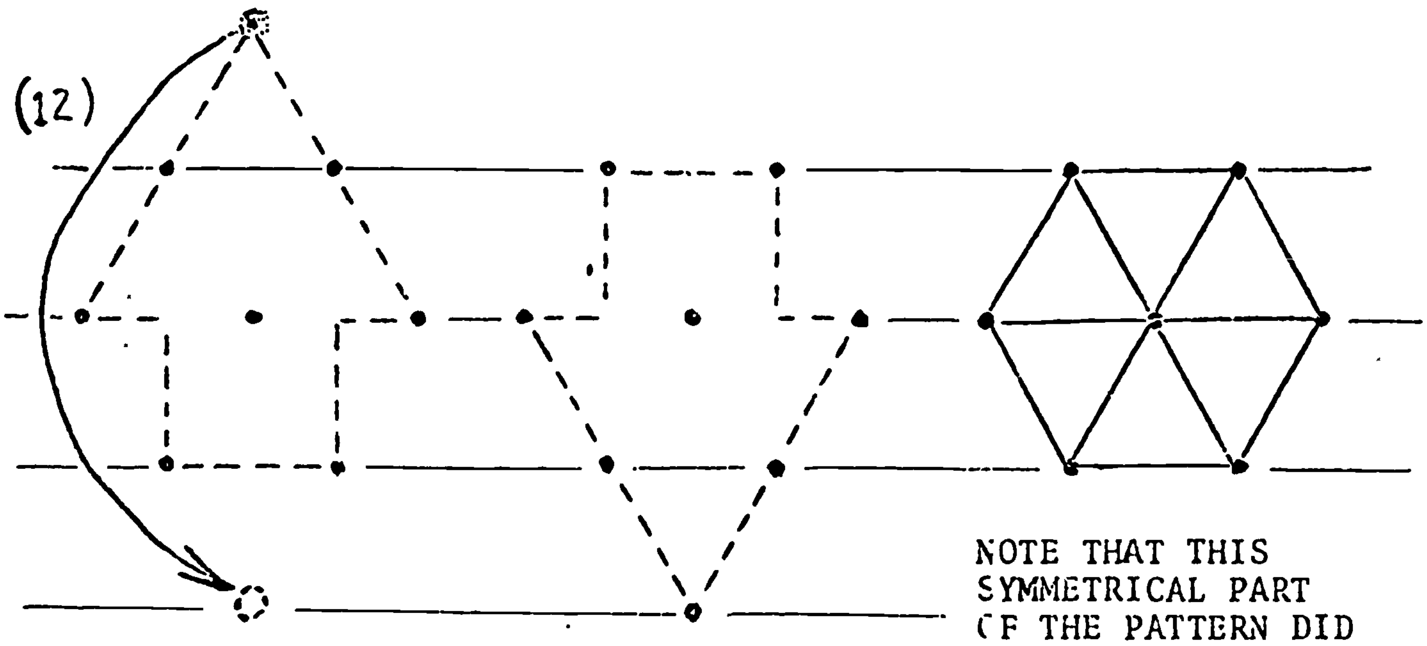
Go on to the next frame

Insert Set for

Program Three, Test Three, Version C

(next 2 pages)

(12)



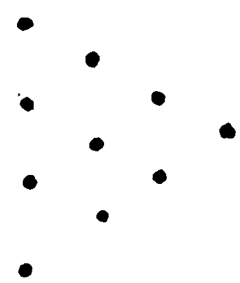
In the next frame you will be given another kind of arrowhead pattern. By moving only TWO points to different positions, make the same arrow point in the opposite direction.

If you have understood the previous frames, this next frame should be a pleasantly interesting challenge, but not too difficult for you.

If you should begin to feel bored, disgusted, or like the activity is no longer fun, press the button IMMEDIATELY, but continue trying to solve the puzzle until you are told to stop.

Go on to the next frame

(13) Move TWO points to new positions so that the arrow points the opposite way (to the left).



MOVE ONLY TWO POINTS.

PRESS THE BUTTON IF YOU SHOULD BECOME DISPLEASED WITH THE GAME, BUT CONTINUE WORKING.

STOP DO NOT TURN PAGE. THIS IS THE END. STOP

DO NOT TURN PAGE

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