NAME OF AUTHOR/*NOM DE L'AUTEUR* BRYAN DOUGLAS HARTMANN

TITLE OF THESIS/*TITRE DE LA THÈSE* A REVIEW OF CONCEPTUAL TEMPO AND AN EXAMINATION OF THE DEFINITION OF THIS CONSTRUCT IN RELATION TO INTELLIGENCE, PROBLEM DIFFICULTY AND CRITICAL ALTERNATIVE INSTRUCTION.

UNIVERSITY/*UNIVERSITÉ* UNIVERSITY OF ALBERTA

DEGREE FOR WHICH THESIS WAS PRESENTED/ *GRADE POUR LEQUEL CETTE THÈSE FUT PRÉSENTÉE* DOCTOR OF PHILOSOPHY

YEAR THIS DEGREE CONFERRED/*ANNÉE D'OBTENTION DE CE GRADE* 1977

NAME OF SUPERVISOR/*NOM DU DIRECTEUR DE THÈSE* DR. GERARD KYSELA

DATED/*DATÉ* OCTOBER 25, 77 SIGNED/*SIGNÉ* B. D. Hartmann

PERMANENT ADDRESS/*RÉSIDENCE FIXE* INST[illegible]TE FOR RESEARCH IN HUMAN ABILITIES
MEMOR[illegible]L UNIVERSITY OF NEWFOUNDLAND
ST. JOHN'S, NEWFOUNDLAND A1C 5S7

THE UNIVERSITY OF ALBERTA

A REVIEW OF CONCEPTUAL TEMPO AND AN EXAMINATION OF THE DEFINITION OF THIS CONSTRUCT IN RELATION TO INTELLIGENCE, PROBLEM DIFFICULTY, AND CRITICAL ALTERNATIVE INSTRUCTION

by

© BRYAN DOUGLAS HARTMANN

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA

FALL, 1977

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "A Review of Conceptual Tempo and an Examination of this Construct in Relation to Intelligence, Problem Difficulty, and Critical Alternative Instruction," submitted by Bryan Dou las Hartmann, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Supervisor

External Examiner

DATE May 27, 1977

ABSTRACT

Conceptual tempo concerns the relatively stable response latency and error rates of people that occur in situations of multialternative response uncertainty. A review of this construct prompted an examination of three research questions.

Experiment One examined the relationship between conceptual tempo and intelligence. A 2 (sex) x 4 (tempo) way ANOVA indicated there were no significant sex or tempo main effects on any of the IQ variables, though there were two significant sex x tempo interactions that were not anticipated. These results were not consonant with previous research. This discrepancy may have been a consequence of an interaction between the speededness of the intelligence measures and conceptual tempo.

Experiment Two manipulated conceptual tempo problem difficulty to determine the direction and magnitude of change in the latency-error relationships that define conceptual tempo. Grade five subjects were administered the MFF and the Conceptual Tempo Test (CTT), a difficulty ordered matching-to-sample test. Initial 3 (difficulty) x 4 (tempo) ANOVAS of the CTT latency and error variables revealed significant main effects for both the difficulty and tempo factors on both variables, as well as significant interactions between the two factors. The difficulty manipulation produced appropriate latency and error differences. Analysis of the tempo x difficulty interaction indicated that contrary to expectation latency, not accuracy was the most reliable index of performance across the three levels of problem difficulty. To verify this assumption, the data were re-

analyzed with a 2 (latency) x 2 (error) x 3 (difficulty) ANOVA. While response latency and problem difficulty were both highly significant variables, response error was not significant for any aspect of CTT performance.

Experiment Three investigated the effect of critical alternative instruction upon the latency and error scores of a conceptual tempo transfer task. Critical alternative instruction involved the use of educational toy and language methods (Olson, 1970) to inform subjects of the types of feature differences that constitute the critical alternatives in measures of conceptual tempo. Subjects were randomly selected and assigned to either the experimental instruction or control condition of a 2 (instruction) x 4 (conceptual tempo) factorial design. The instruction main effect was significant for only the error variable. The tempo main effect and the tempo x instruction interaction were significant for both the latency and error variables. Subsequent analysis revealed that significant differences among the four tempo conditions occurred only for control group subjects. Instruction concerning the types of alternatives used on conceptual tempo tasks served to eliminate the significant differences between reflective and impulsive subjects. Further analysis indicated that this result was due exclusively to the increase in response latency and decrease in response errors of fast-inaccurate subjects. These results suggest that some of the variance attributed to conceptual tempo may be due to insufficient information about the types of alternatives that constitute critical alternatives for the task.

ACKNOWLEDGEMENTS

With sincere appreciation I would like to acknowledge the assistance of several people for their major contributions to this often frustrating but ultimately enjoyable learning experience. First, to my wife, Donaleen, and my boys, Gregory and Stephen, simply thank you; it is to you that this work is dedicated. Second, to my parents, thank you for your consistent and extensive support. Third, I gratefully acknowledge Drs. Karagianis, Ivany and Jones for their faith and encouragement. Fourth, to my fellow students, Gary, Wayne, Dave, Mike, Murray, Malcolm, and Terry, thank you for many things. Fifth, to Mary Lawlor thank you, it was your competence that made the frightening typing and editing tasks seem so easy. Finally, I would like to thank the members of my thesis committee, Dr. C. Anderson, Dr. W. Fagan, Dr. L. Stewin, and Dr. R. Peters for their time, their challenging questions, and their very helpful suggestions. To my committee chairman and advisor, Dr. G. Kysela, thank you for your intellect, integrity and compassion. I appreciate that the physical distance between us greatly increased your workload at a time that was tragically inopportune. Yet, in spite of these difficulties I was fortunate enough to have a truly outstanding advisor. Your effort on my behalf will always be appreciated.

TABLE OF CONTENTS

CHAPTER | | Page

LIST OF TABLES

TABLE Page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The following discussion of conceptual tempo consists of two major parts. Part one is a general review of conceptual tempo research literature that is summarized under four major headings; (1) a theoretical outline of conceptual tempo; (2) operational definitions of conceptual tempo; (3) postulated explanations of conceptual tempo; and (4) educational implications of conceptual tempo. This review is not directed toward any specific research question; rather, it represents a general review of the conceptual tempo research published to date.[1] It was conducted for the purpose of examining conceptual tempo as a psychological construct and identifying aspects of this construct that might benefit from further investigation. Part two is a set of three investigations of specific aspects of conceptual tempo. Experiment One is concerned with the consequences of employing a response latency and error, dual-median split as the operational definition of conceptual tempo. Specifically, it attempts to determine the number of subjects eliminated by this procedure, and the relationship between conceptual tempo and intelligence that occurs when

---

[1]Research concerned with the many correlates of conceptual tempo was also reviewed. A summary of these investigations is provided in Appendix A.

subjects are not eliminated by this operational definition. Experiment Two is concerned with the role of problem difficulty in the operationalization of conceptual tempo. The review of the tempo literature has indicated that valid determinations of conceptual tempos are contingent upon employing tempo tasks of moderate difficulty. Tasks that are either too easy or too difficult will not produce performance differences attributable to conceptual tempo. Unfortunately, the review of the literature also revealed that despite the postulated importance of the difficulty variable for the tempo construct, only one investigation has attempted to examine this aspect of the tempo construct. Experiment Two is a second attempt. Experiment Three is concerned with the role of alternatives in conceptual tempo behavior. The importance of this variable is indicated in the initial conceptualization of the tempo construct:

> Reflection is defined semantically as the consideration of alternative solution hypotheses (either classifications or problem-solving sequences) when many are available simultaneously. (Kagan, Rosman, Day, Albert, & Phillips, 1964, p. 33)

and again in Jerome Kagan's most recent publication on the topic (Kagan and Messer, 1975) wherein the above quotation is cited as a conceptualization of conceptual tempo that is still valid. The particular aspect of the alternatives question examined in Experiment Three is the role of perceived alternatives; that is, asking if instruction concerning the nature of the alternatives that exist among stimuli will facilitate subjects' perception of the alternatives that exist in the test stimuli, such that this knowledge will transfer to a subsequent tempo task, and improve the performance of subjects in particular conceptual tempo categories.

CHAPTER 2

A THEORETICAL OUTLINE AND REVIEW OF CONCEPTUAL TEMPO RESEARCH

Beginning with an investigation of types of conceptual classifications and related behaviors, (Kagan, Moss, & Sigel, 1963), Kagan has postulated an "evaluative" cognitive style dimension. Kagan defines cognitive style as, "...stable individual preferences in mode of perceptual organization and conceptual categorization of the external environment (Kagan, Moss, & Sigel, 1963, p. 74, italics added)." The cognitive style construct is particular to a problem-solving context and, for the purpose of explanation, has been interpreted by Kagan within the theoretical framework of an information processing approach to problem solving (Kagan & Kogan, 1970). Specifically, Kagan postulates the existence of six discrete processes in a problem-solving sequence. In brief, these are: (1) encoding (or decoding), (2) memory, (3) generation of hypotheses, (4) evaluation of hypotheses, (5) implementation of hypotheses - deduction, and (6) public report. Individual differences in the evaluation process are presumed to arise as a consequence of differences in the degree to which individuals pause to evaluate the quality of their cognitive products. Such evaluation affects the quality of each of the preceding processes in the problem-solving sequence; namely, encoding, memory and hypotheses generation. These differences involve the amount of time taken to generate alternative hypothetical solutions to the problem, and to reflect upon the differential validity of these alternatives prior to their implementation. The term "conceptual tempo" has been used by Kagan to describe stable individual differences in the degree to which an individual reflects upon alternative classifications of a stimulus or alternative solution hypotheses in situations in which several response alternatives are available simultaneously. The most predominant aspect of conceptual tempo is a dimension that Kagan has labelled reflection-impulsivity. At one end of this continuum, impulsive individuals impulsively report the first classification that occurs to them or execute the first solution hypothesis that appears appropriate. At the other end, reflective individuals characteristically delay before reporting a classification or executing an hypothesis.

OPERATIONAL DEFINITIONS OF REFLECTION-IMPULSIVITY

Prior to reviewing the conceptual tempo research, a description of the measures that have been employed to operationally define individual differences in conceptual tempo will facilitate subsequent discussion.

Matching Familiar Figures

Kagan (1965c) has noted that of all the measures used to operationalize reflection-impulsivity, the Matching

Familiar Figures (MFF, Lee, Kagan, & Rabson, 1963) provides the greatest degree of response uncertainty and consistently yields the highest correlations with external criterion variables. The MFF employs a matching-to-sample procedure whereby the subject is simultaneously presented with black and white line drawings of a standard figure (with which he is presumed to be familiar), and six test figures that comprise five minor variations and one duplicate of the standard stimulus. The subject's task is to identify the alternative stimulus that matches the standard (Figure 1). The variables scored are the mean response latency to first selection and the total number of incorrect selections up to a maximum number of six. If the subject fails to answer correctly, he is shown the correct answer.

Delayed Recall of Designs

The Delayed Recall of Designs (DRT, Kagan, Rosman, Day, Albert, & Phillips, 1964) is a matching-to-sample task similar to the MFF. However, unlike the MFF, the DRT stimuli are black and white line drawings of geometric designs (see Figure 2), and the test includes a memory factor; that is, the test procedure requires that the sample stimulus be presented for five seconds, removed, then followed fifteen seconds later by the presentation of twelve alternative test stimuli. The dependent variables are mean response latency to first selection and the total number of errors.

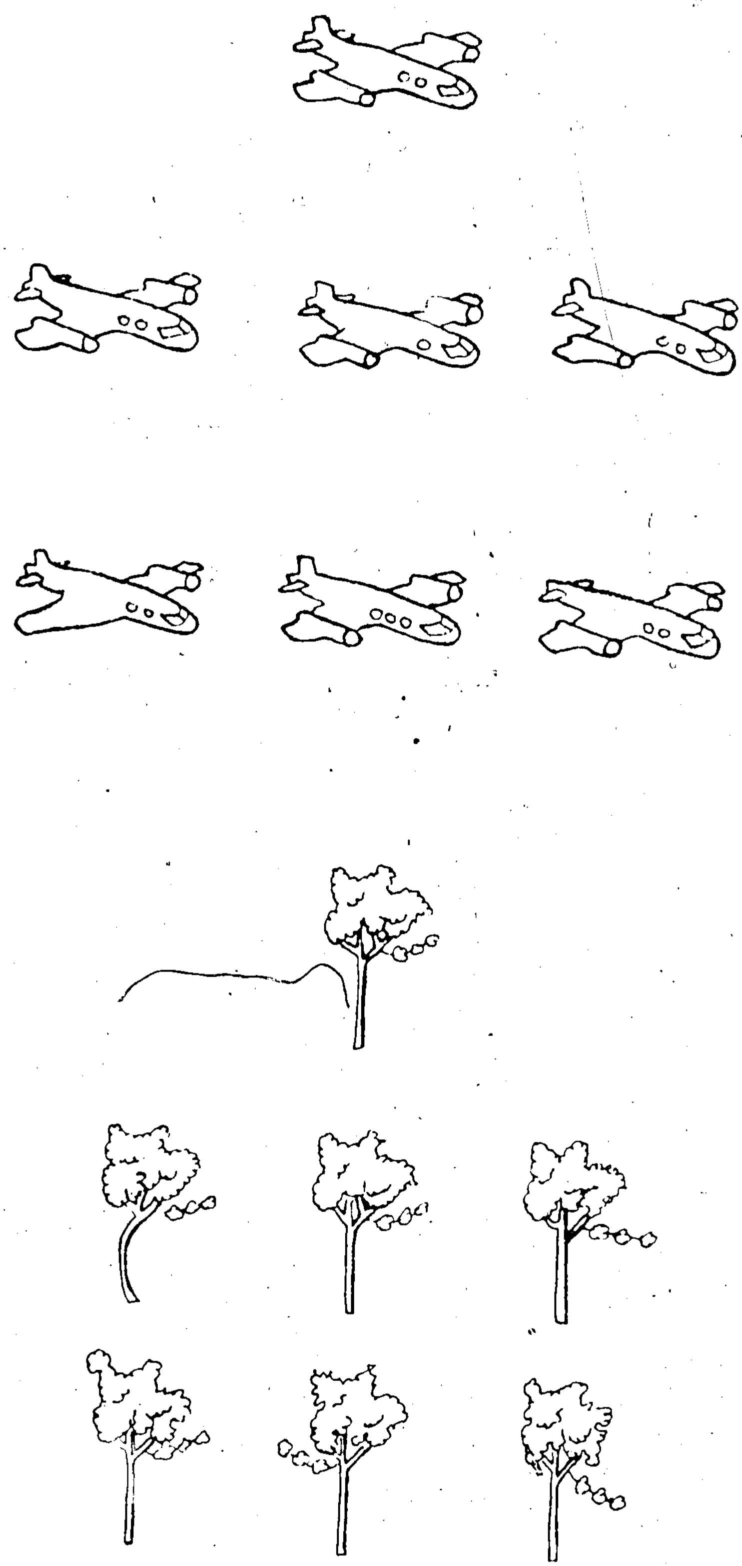

FIG. 1. [illegible] from [illegible] Matching Familiar Figures test

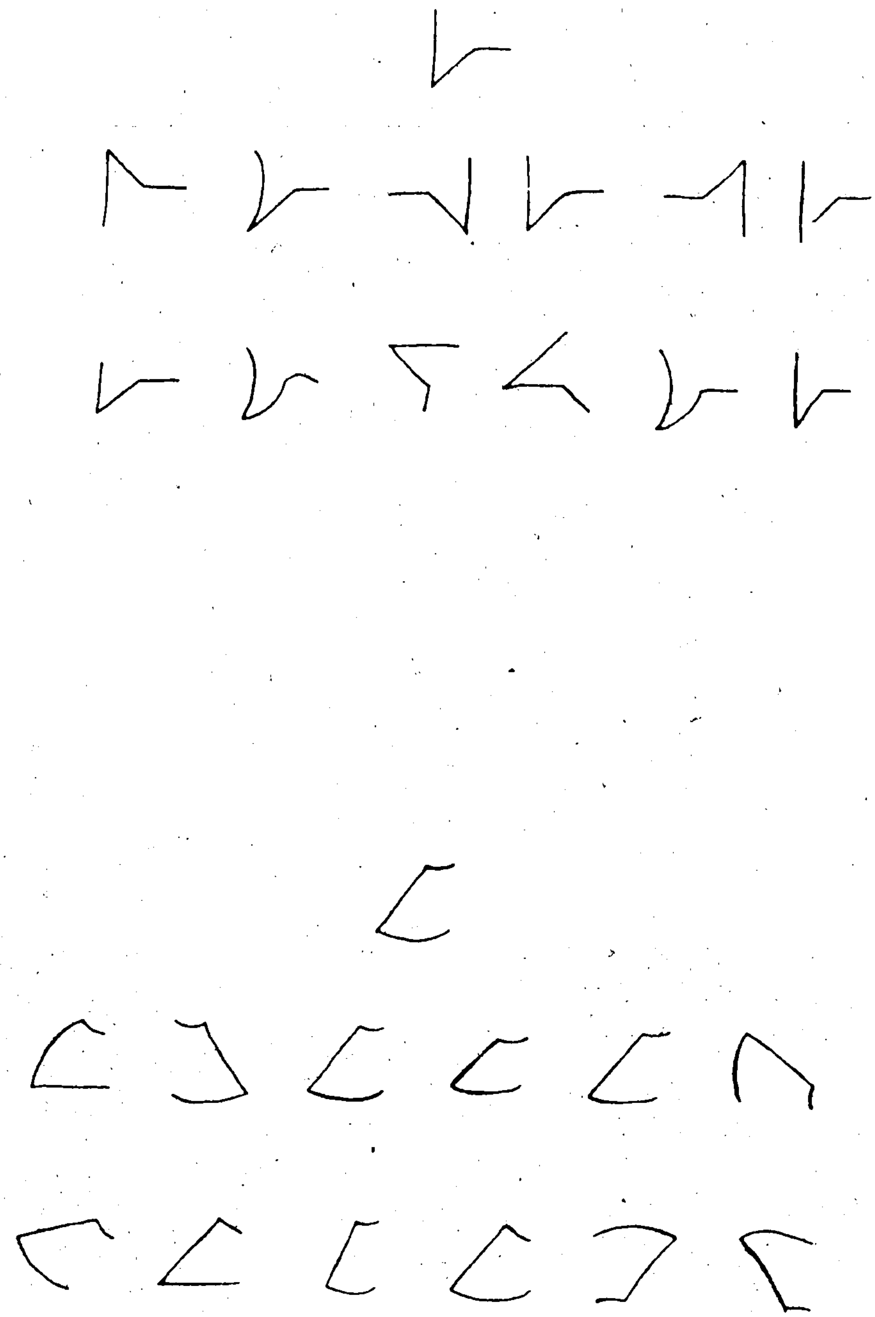

FIG. 2. Example items from the Delayed Recall for Designs test

Haptic Visual Matching

The Haptic Visual Matching Test (HVM, Kagan et al., 1964) is a cross-modal matching-to-sample task which requires the subject to haptically explore a wooden form that is hidden from view. The subject is allowed an unlimited amount of time to explore the form. Following exploration, a visual array of five black and white line drawings is presented to the subject (see Figure 3). His task is to select the drawing which matches the haptically explored form. Three variables are scored: palpation latency, mean response latency to first selection, and the total number of errors.

Visual Analysis

The Visual Analysis Test (VA, Kagan et al., 1964) assesses the degree to which the subject attaches a verbal label to component parts of a visual stimulus while learning to associate that label with a whole stimulus complex. The stimuli are abstract designs that contain three distinct components: (1) background, (2) figural form, and (3) elements. The background component is a repetitive pattern; the figural form is the shape formed by a particular combination of discrete elements; and the elements are discrete geometric shapes. Figure 4 illustrates a sample item. With reference to this illustration, the subject is shown the composite stimulus, to which he learns to associate a nonsense syllable. The right parentheses comprise the background component; the delta signs, the element component; and the

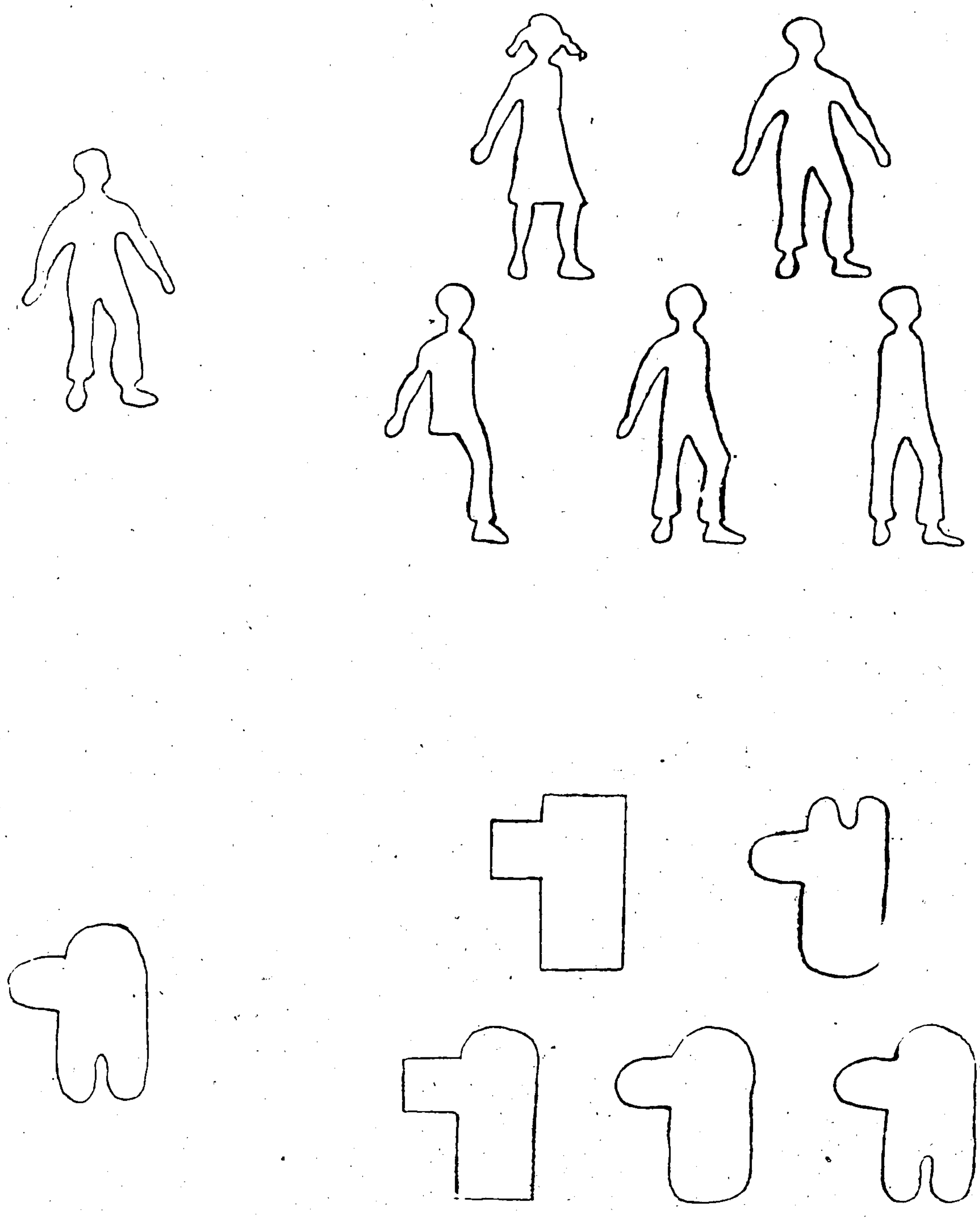

FIG. 3. Example items from the Haptic Visual Matching test

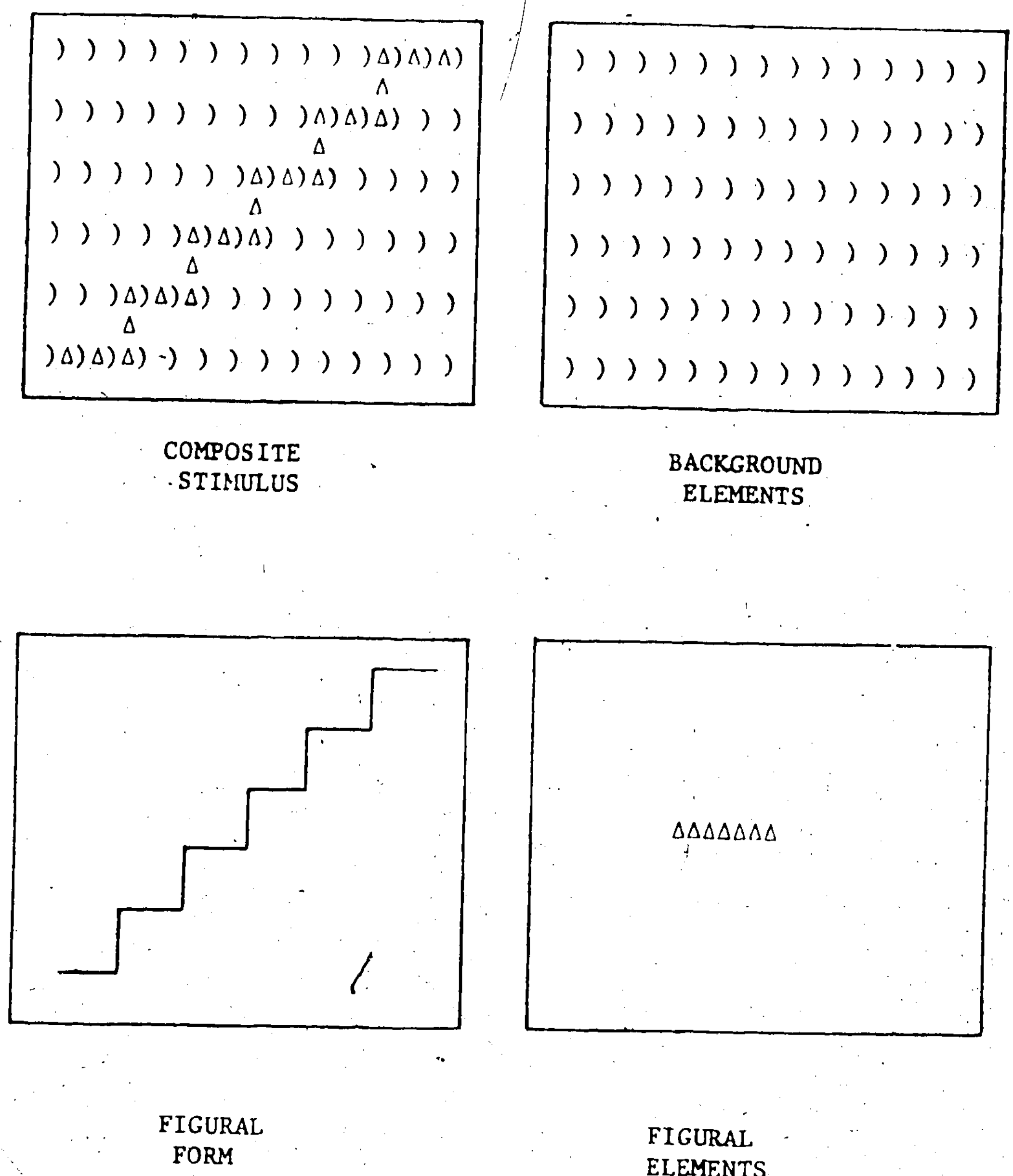

FIGURE 4. Example item from the Visual Analysis test.

"staircase" pattern, the figural component. The subject first learns to associate a different nonsense syllable to each of four complex designs. Upon reaching a criterion of eight consecutive correct trials, he is shown separate illustrations of the background, figure, and element components of each of the four composite stimuli. He is then asked to associate with each component stimulus the nonsense syllable that was previously associated with the composite stimulus that included the test component. The variable scored on this task is the number of correct responses for each of the components.

Individual conceptual tempos are determined by calculating the latency and error scores of subjects on the MFF, DRT, or HVM. Tempos are described by the joint relationship of these variables following calculation of the medians for each variable. Subjects scoring above the latency median and below the error median are said to have a reflective conceptual tempo. Subjects scoring below the latency median and above the error median are said to have an impulsive tempo. Two other categories that result from this dual-median split definition of conceptual tempo are subjects scoring above both medians (slow-inaccurate) and subjects scoring below both medians (fast-accurate). Research on conceptual tempo has focused almost exclusively upon the reflective and impulsive tempos. The fast-accurate and slow-inaccurate categories are said to include only a small number of subjects for whom the tempo problems are either too difficult or too easy (Kagan, 1964). Consequently, the few subjects exhibiting these tempos are generally excluded from conceptual tempo investigations to permit a more precise examination of the reflection-impulsivity dimension.

Validity and Reliability of the Measures of Conceptual Tempo

Estimates .. the construct validity of the tempo measures are provided by the intercorrelations among the postulated measures of reflection-impulsivity. Kagan et al. (1964) report several significant correlations between the MFF and both the DRT and HVM tasks. The dependent variables, response latency and errors to first correct selection, were both found to be moderately consistent across the three tasks. Errors on the MFF, DRT, and HVM were positively correlated and ranged from $\underline{r}$ = .33 to .52 ($\underline{p}$'s < .01). Response time correlations among the three tests ranged from $\underline{r}$ = .48 to $\underline{r}$ = .82 ($\underline{p}$'s < .01). In addition, response times were inversely correlated with error scores for all three tests. This correlation was higher for the MFF ($\underline{r}$ = -.53 $\underline{p}$ .001) than for either the DRT ($\underline{r}$ = -.30 $\underline{p}$ < .05) or the HVM ($\underline{r}$ = -.38 $\underline{p}$ < .01). According to Kagan, the MFF has a greater degree of response uncertainty than does either the DRT or HVM, and it is response uncertainty that contributes variance to both the response latency and error variables (Kagan et al., 1964, p. 27; Kagan, 1965c, p. 617). The decision time variable was also found to show cross-task generality. Response time on the HVM was as highly associated with errors on the DRT (r's = -.35 and -.38) as was response time on the DRT itself (r's = -.28 and -.33). Palpation time of the HVM was positively correlated with HVM response time (r's = .56 and .55). Children who responded quickly spent little time exploring the standard figure. Furthermore, palpation time predicted errors on both the DRT (r's = -.39 and -.35) and the MFF (r's = -.35 and -.42). For boys, palpation time was a better predictor of HVM errors than HVM response time (r = -.50 versus -.28).

Evidence bearing on the test-retest reliability of the MFF and DRT suggests that individual differences in reflection-impulsivity are relatively stable over time. Yando (1968) tested second grade children for ten consecutive weeks on variations of the MFF in which the number of alternatives was increased by one each week. The number of alternatives ranged from two the first week to twelve the tenth week. The average correlation for response latency throughout the ten week interval was r = .70.

In spite of the variation of the number of stimulus alternatives, Yando's results support those of Kagan, Pearson, and Welch (1966a), who report an average reliability coefficient of r = .[illegible] for latencies over a ten week interval on ten alternative forms of the MFF. In addition, Kagan et al. (1964) report an average latency reliability coefficient of r = .55 for nine consecutive weekly administrations of the DRT. The corresponding error coefficient was r = .58.

Over the longer test-retest interval, MFF reliability decreases considerably. The stability of reflection-impulsivity has been reported to be $\underline{r}$ = .50 for a one year test-retest interval involving parallel forms of the MFF, and $\underline{r}$ = .62 for a one year interval using identical forms of the MFF (Kagan et al., 1964). Over a two and a half year period the parallel form reliability coefficient of the MFF has been found to drop to $\underline{r}$ = .31 (Kagan & Kogan, 1970). Over the same period of time, Messer (1970b) has reported parallel forms reliability coefficients that range from $\underline{r}$ = .25 to $\underline{r}$ = .43.

In total, these results appear to support the conclusion that the improved performance that results from the tendency to delay before responding in situations with many response alternatives, shows intraindividual consistency for a variety of tasks and stability through time.

POSTULATED EXPLANATIONS OF CONCEPTUAL TEMPO

From a research point of view, the most interesting aspect of conceptual tempo is to explain why individuals differ in tempo. However, the surprisingly large number of postulated explanations may be interpreted as an indication of the degree of uncertainty that exists about the dynamics of this construct. Basically, the proposed explanations are centered on three major constructs: anxiety, information processing, and problem solving.

Anxiety

Kagan and Kogan (1970) have postulated two alternative psychological explanations of the disposition toward reflective or impulsive responding: (1) a strong motive to appear competent, and (2) a differential concern for error. Anxiety about one's competence is presumed to be the basic force behind both an impulsive and a reflective strategy, but the source of anxiety is different for each strategy. The source of anxiety for the reflective individual is the possibility of making a mistake in a social context that equates errors with incompetence. The source for the impulsive individual is the possibility of responding too slowly in a social context that equates slow responding with incompetence. The difference depends upon the degree to which an individual performs according to a criterion of accuracy or a criterion of speed.

The second, and more parsimonious, explanation of reflection-impulsivity postulated by Kagan and Kogan (1970) involves only a differential degree of anxiety over error, and omits concern over response latency as a source of anxiety. This explanation produces the simple dynamic that the greater the fear of making a mistake, the more reflective and cautious the performance. Support the more parsimonious explanation has been reported by Messer (1970a). Impulsive and reflective subjects were induced to believe they had either succeeded or failed in their performance on a difficult intellectual task that was administered between two administrations of the MFF. The "success" manipulation resulted in a decrease in MFF response latency for all subjects and an increase in error for impulsive subjects. In contrast, the "failure" manipulation produced an increase in latency for all subjects and a decrease in errors for impulsive subjects. Messer (1970a) concludes that the "failure" manipulation served to arouse anxiety over error and cause subjects to proceed more carefully. The "success" manipulation reduced anxiety and the degree of caution exhibited on the task.

Evidence contrary to the Kagan and Kogan (1970) hypothesis of differential concern fo error comes from an earlier investigation. Kagan (1966c) employed two communications, intellectual threat and adult rejection, to increase the level of anxiety underlying performance on a serial-learning task. It was found that both anxiety conditions produced a greater number of errors than did a control condition. Concerning tempo differences, on both pre-threat and post-threat lists, impulsive children made a greater number of errors of commission than did reflective children. Furthermore, reflective subjects made anxious over possible failure showed a larger error increase than did reflective subjects in the control condition. Apparently, both anxiety and a disposition toward impulsivity lead to the substitution of incorrect for correct elements in a recall task. However, the anxiety main effect across both levels of conceptual tempo is not consonant with the hypothesis that conceptual tempo is a function of a differential degree of anxiety over error.

In still another avoidance of anxiety explanation of conceptual tempo, Kagan has postulated that the impulsive individual is anxious about the possibility of failure and impairs his performance by responding quickly in order to avoid the anxiety that is associated with the long time interval characteristic of reflective responding (Kagan et al., 1964). A reflective individual either is not anxious about failure and, therefore, does not experience anxiety during the time interval necessary for reflection, or is anxious about failure, but is able to cope with it; such that, in either case performance is not impaired by anxiety.

Ward (1968) provides evidence that is contrary to this third anxiety avoidance hypothesis. Several reflection-impulsivity measures were administered in two testing contexts. One context accentuated task feedback and included a prize for overall accurate performance; the other context was a nonevaluative test atmosphere characterized by liberal use of praise and no error feedback. It was assumed the emphasis on accuracy in the evaluative context would produce the postulated anxiety over error in impulsive subjects that occasions an anxiety alleviating increase in response speed, while the nonevaluative context would serve to decrease anxiety over error in impulsive subjects, and cause them to reduce their speed of responding.

Ward found that the response latency and error intercorrelations among tasks within a permissive or evaluative test context were not significantly different from the intercorrelations among tasks across test contexts. Apparently, either the two testing contexts did not generate differential levels of anxiety, or differential anxiety levels were generated, but they do not affect performance in the manner outlined by anxiety-avoidance hypothesis (Kagan et al., 1964). A post-hoc analysis by Ward of the response latencies of subjects following correct and incorrect responses supports the latter interpretation. Consonant with the anxiety avoidance hypothesis, Ward deduced that anxiety in impulsive subjects would increase after an incorrect response and decrease after a correct response and that response latency would similarly increase and decrease. The analysis revealed that both impulsive and reflective subjects showed an increase in response latency following an incorrect response, and this tendency was greater for impulsive than for reflective subjects (80% versus 61%, respectively).

Ward concludes: "Impulsive children were thus more responsive to evaluational cues; but the direction of change was the same for the two groups and was not that predicted by the avoidance of anxiety hypothesis (Ward, 1968, p. 873)." It might also be noted that Ward's results for the post-response analysis are also contrary to the differential concern for error explanation offered by Kagan and Kogan (1970).

Further evidence concerning Kagan's anxiety-avoidance hypothesis comes from Reali and Hall (1970). It was found that the effects of neither success nor failure differentiated reflective from impulsive subjects in terms of either response latencies or consequent expectancy of success. For both impulsive and reflective subjects the expectancy of success was positively correlated with manipulated success feedback, but contrary to Kagan's hypothesis that a possible antecedent of impulsive behavior is the expectation of failure, this expectation did not significantly influence response latency. For both reflective and impulsive subjects, decision times following failure feedback were significantly longer than decision times following success feedback. This finding is consistent with that obtained by Ward (1968). Apparently the degree of anticipated success or failure is not an antecedent of differences in conceptual tempo.

Messer has also investigated the effect of situationally induced anxiety as a possible determinant of individual differences in conceptual tempo (Messer & Kagan, 1969; Messer, 1970a). According to Messer (1970a), anxiety over intellectual performance is the principle dynamic underlying individual differences in conceptual tempo. Messer manipulated anxiety by having subjects either succeed or fail on an intellectual task, after being told that the task was a test "to see how smart" subjects were, and that most subjects "do well" on the task.

For both impulsive and reflective subjects, failure resulted in a significant increase in response latency while success resulted in a significant decrease in latency. Messer argues that the experience of failure induces a general set for accuracy which leads to longer decision times, while success induces a set for speed that results in shorter decision times. Both sets are mediated by anxiety over performance, with failure affecting an increase and success a decrease in the level of anxiety. Messer notes that impulsive subjects who increased their response time reduced their number of errors; thus lending support to the hypothesis that the anxiety induction led to increased task attention, rather than distraction from the task. In sum, Messer's results, which have since been replicated by Weiner and Adams (1974), strongly suggest that anxiety concerning one's intellectual performance is an antecedent of reflective and impulsive behavior.

Information Processing

A recent development in conceptual tempō research is an increasing number of investigations that postulate an information processing explanation of conceptual tempo. These explanations include differences in the speed and efficiency of processing as well as individual differences in the relationship between information processing and perceptual learning.

Tempo of information processing. Kagan and Kogan (1970) postulate individual differences in the tempo of information processing to account for the observation that some people appear to process information eadily; others process slowly, even in situations devoid of negative sanctions for failure. Observed differences in the rate of processing are difficult to validate empirically since differences in a second variable, the quality of processing, may occur conjointly; thus, confounding the rate variable. The fast processor may actually assimilate more information per unit of time, or it may be that he only appears to process faster. He may be processing in a global fashion, matching to a less precise standard; thereby requiring less time to complete the task due to the lower standard of detection.

One investigation that does contribute some rather direct evidence to the question of differences in processing speed is Weiner (1975). Using a backward masking procedure with tachistoscopically presented visual stimuli, Weiner found that reflective subjects had a significantly lower information processing threshold than did impulsive subjects. Given that reflective subjects process information faster, yet take more time to respond than do impulsive subjects, it appears that it is not primarily the tempo, but the quality of information processing that accounts for the latency and error differences of conceptual tempo. Certainly, these results do not support the notion that impulsive subjects respond more quickly because they process information faster than do reflective subjects.

Additional information concerning differences in information processing tempo comes from Kagan's studies of attention in infants (Kagan, 1970, 1971, 1972; Kagan & Rosman, 1964). The generalizability of these results to school age children and adults is undoubtedly limited, but infant behavior does offer the advantage that differences in processing tempo would seem to be minimally, if at all, affected by the anxiety generated by the negative sanctions of public failure noted above, or the internalization of cultural performance standards of either speed or accuracy.

One of the infant behavior variables that may be applicable to the processing tempo construct is the dramatic difference among infants in rates of habituation to visual or auditory stimuli. Visual stimuli, such as representations of human faces, nonsense designs, and novel mobiles, produce differential rates of habituation in infants. Rapid habituation to face representations could be the result of a firmer schema of the face, in that the closer the stimulus-schema match, the more quickly habituation should occur. However, it is difficult to explain similar differences in the rate of habituation to meaningless geometric designs or novel mobiles as being a product of differential familiarity. It is unlikely that any of the infants would have established prior schemata for these novel stimuli; therefore, rapidly habituating infants either established firm schemata for the novel stimuli at a faster rate, or their schemata were less differentiated than those of the slow habituating infants.

Kagan and Kogan (1970) view the differences in rate of habituation in infants as a possible preview of reflective and impulsive behavior. The question raised about the speed and quality of schema development in infants is analogous to the suggestion that impulsive individuals either process faster or have a less precise standard of equivalence. Data from a 27-month longitudinal study conducted by Kagan (1971) suggest that attentional habituation in infancy is related to reflection-impulsivity dispositions at ages 3 and 4 years. At 4 months the children showed a range of habituation rates, as indexed by fixation time to sixteen presentations of four achromatic faces. By 8 months differences in the boys' tempo of play with toys was related to the rate of habituation at 4 months. A pattern of toy play that was typified by many short involvements was shown by rapid habituators, while fewer, but longer involvements with the toys was shown by slow habituators. In addition, boys with a fast play tempo at 8 and 13 months were less attentive to visual stimuli at both those ages, and were relatively vigorous and excitable at 4 months. At 27 months, Reppuci (1968) found positive intercorrelations among a slow tempo of play and decision times on two problem situations that involved response uncertainty. In addition, he noted that slow tempo boys who spent long periods involved in a single activity at 27 months, exhibited a slow tempo at 8 months and a slow rate of habituation at 4 months.

Results obtained by Pederson and Wender (1968) support the possibility that infant behavior can serve as a preview of a disposition toward reflection or impulsivity. Nursery school children 2.5 years of age were evaluated for their duration of attention with particular toys. At 6.5 years of age these children were administered both the verbal and performance scales of the Wechsler Intelligence Scale for Children. Children who exhibited long durations of toy involvement (slow tempo) performed better than children who exhibited short durations of toy involvement (fast tempo) on those tasks that involved response uncertainty (e.g., picture arrangement, mazes). No differences between the groups occurred on the verbal scales. A slow tempo of play at 2.5 years predicted a reflective disposition 4 years later.

While the evidence in support of a preferred processing tempo in infants is limited, and Weiner's (1975) results indicate processing quality may be more important than processing speed, the data from infants does suggest that a consideration of the possible origins of conceptual tempo may have important implications for understanding the dynamics of the construct. Kagan and Kogan (1970) postulate that infant attentional behavior as indexed by fixation time, non-social smiling, duration of involved play, and decision time favor a genetic rather than an experiental interpretation. For example, Kagan (1970) has noted that slow habituating, 4-month-old males tend to be larger, fatter, and smile more frequently than their fast habituating counterparts. For adults, Kagan (1966a) obtained a limited degree of evidence to suggest that reflective responding is associated with a tall-thin body build and impulsive responding is associated with a short-broad build. Further evidence of the genetic interpretation of this construct comes from the finding that body size and frequency of smiling during the first half year show greater similarity between monozygotic than between dizygotic twins. Scarr (1966) found that identical twins ages 6 - 10 years showed evidence of heritability in their tendency to display long or short decision times in a situation involving response uncertainty. In addition, an overall rating of apprehensiveness (which was partially based upon response time) showed an intraclass correlation of .88 for monozygotic twins as opposed to .28 for dizygotic twins.

More direct evidence on the heritability of conceptual tempo comes from Plomin and Willerman (1975). In an investigation of 54 pairs of young twins, it was found that with age partialed out the MFF performance correlations for identical twins was greater than that for fraternal twins for both the response latency ($\underline{r}$ = .77 versus $\underline{r}$ = .56) and error ($\underline{r}$ = .48 versus $\underline{r}$ = .36) variables. Heritability estimates calculated by Plomin and Willerman indicate that over 40% of the response latency variance and 21% of the error variance may be due to genetic factors.

A related explanation of differences in conceptual tempo comes from the finding that lower-class children are more impulsive than middle-class children. This result led Kagan (1967a) to speculate that differences in tempo may be biological in origin. Lower-class children have higher incidences of pre- and peri-natal trauma, anoxia, and toxemia of pregnancy -- all of which increase the risk of subtle damage to brain stem centers and associated inhibition systems. The hyperkinesis that is associated with brain damage in children is presumed to be the consequence of such insult and could be a determinant of impulsivity.

Information processing efficiency. Nuessle (1972) has investigated the relationship between conceptual tempo and information processing efficiency. Efficiency is this context is equated with the ability to eliminate irrelevant hypotheses and is termed focusing behavior. Nuessle reported that two variables were related to focusing behavior: age and conceptual tempo. Ninth-grade subjects were more efficient focusers than were fifth-grade subjects, and reflective subjects, were significantly better at focusing than were impulsive subjects. In addition, he reported that older and reflective subjects had longer latencies following task feedback than did younger and impulsive subjects, and longer latencies following negative feedback were associated with more proficient focusing on the experimental task.

Information ocessing in perceptual learning. Odom, McIntyre, and Neale (1971) used an information processing model to determine the basis of the matching-to-sample behavior of reflective and impulsive subjects. Briefly, they designed training and transfer tasks that facilitated performance in accordance with two hypothetical accounts of perceptual learning. The first, the prototype hypothesis, asserts that improved perception is a consequence of matching a sensory input with stored-memory prototypes; thus cognitive prototypes must be established before matching can improve. The second, the distinctive feature hypothesis (Gibson, 1969) asserts that the detection of dimensions of difference among stimuli is a function of perception, not cognition and memory; thus, it is experience that allows the observer to discover perceptually those features that distinguish among stimulus arrays. Pick (1965) has determined that on matching tasks both prototypic and distinctive feature learning occur, the latter is clearly superior to the former, except for stimuli predisposed to the formation of memory prototypes. In the light of these results Odom et al. predicted and found that reflective subjects employed distinctive feature learning. However, their prediction that impulsive subjects would employ prototypes was not supported. These subjects performed in accord with neither of the postulated methods of perceptual learning. Odom et al. speculate that the discrepancy between the perceptual learning results of the two groups may be a consequence of a difference in the degree and amount of cognitive evaluation that occurred. Impulsive subjects may also have learned distinctive features of the training stimuli, but when confronted with the novel stimuli of the transfer task the typical short latencies of these subjects may not have been sufficient to allow adequate evaluation of relevant and irrelevant task features. Consequently, knowledge of the distinctive features would not facilitate the performance of impulsive subjects. The difficulty outlined by Odom et al. is to demonstrate that impulsive subjects inadequately employ a distinctive feature learning process. In this regard, Zelniker and Oppenheimer (1973) have found that distinctive feature training of impulsive subjects resulted in fewer errors than did prototype training or an equivalent amount of task experience. This result occurred after training on a task that required subjects to identify the single different stimulus from a set of identical stimuli. Comparable training on a matching-to-sample task did not facilitate the performance of the distinctive feature training subjects. These investigators argue that unlike the matching-to-sample task, the differentiation task does not allow subjects to arrive at a subjectively appropriate response without detecting the specific feature that distinguishes between the about-to-be-selected alternative and the standard. Consequently, the differentiation task had the effect of drawing the subject's attention to details distinguishing among the stimuli and resulted in distinctive features learning which, in turn, facilitated performance on subsequent discrimination tasks (including the MFF as Zelniker, Jeffrey, Ault, and Parsons, 1972, as shown.

Also within an information processing framework, Siegel, Kirasic and Kilburg (1973) have found that both visual feature analysis and verbal labelling processes were involved in conceptual tempo. In a subsequent investigation Kilburg and Siegel (1973) have reported that differences in conceptual tempo are related to individual differences in the ability to employ a visual feature analysis and are independent of verbal labelling processes. These investigators employed a recognition memory task which required subjects to identify from each of 20 sets of stimulus pairs the particular stimuli that had been shown to the subjects two weeks earlier. Differences in visual feature analysis were assessed by the levels of relative performance on four sets of stimulus pairs that contained systematically manipulated feature differences. Stimulus Set One consisted of an original stimulus paired with a new and completely different stimulus. In this condition a correct recognition response can be made either on the basis of a global feature analysis and/or on the basis of the verbal name of the stimulus. Set Two paired the original stimulus with one having the same name, but differing from the original in only one minor visual feature. This condition required subjects to conduct a rather complete feature analysis of the original and test stimuli to obtain a correct recognition response. Set Three paired the original stimulus with one having the same name, but differing from the original in several different visual features. This condition also required a feature analysis since the verbal label was held constant, but in this case a global feature analysis would be sufficient to produce a correct recognition response. Set Four consisted of two new stimuli, one completely new stimulus having no verbal or figural relationship to the originally viewed stimulus, the other having the same label as the original stimulus, but having several visual features different from the original. In this condition a correct response can be made only on the basis of the verbal label attached to the stimulus (or a global template of the original), not on the basis of specific visual features. The results obtained indicated that while the set comprising a minute feature change was too difficult for all subjects, reflective subjects performed significantly better than impulsive subjects on the task requiring a general feature analysis. These two groups did not differ on the task requiring only the recall of a verbal label. Kilburg and Siegel conclude that visual feature analysis is the most significant cognitive-perceptual component of reflection impulsivity, and that verbal mediation is not a significant part of this process. These investigators also interpret their results as evidence ...

> "... against the hypothesis that the nature of the search process is different for reflective and impulsive Ss. That is, the differential performance of reflective and impulsive Ss is due to a quantitative difference in the thoroughness of the process of feature analysis rather than to a qualitative or process difference. (p. 418)."

This result is not in agreement with the results of the visual fixation studies. These investigations, cited above, strongly support a qualitative difference. The discrepant results may arise from comparing performance on different tasks that may not be comparable.

Before leaving the topic of perceptual learning strategies and conceptual tempo, it is instructive to consider the nature of tempo tasks in relation to feature and prototype strategies of learning. Pick (1965) has reported that the learning strategy employed is a function of the type of comparisons required by the task. With successive comparisons on a discrimination learning task, prototype learning occurred as much as distinctive-features learning. Pick suggests that in this situation prototype learning makes possible the detection of distinctive-features of the absent standard. With simultaneous comparisons, however, distinctive-features learning predominated almost to the exclusion of prototype learning. As Pick explained, there was no need to memorize the standard in this condition; therefore, prototype learning was not necessary. In relation to conceptual tempo, the MFF requires simultaneous comparisons; thus, one would expect distinctive-features learning to predominate and training in distinctive-features learning to successfully modify conceptual tempo. In contrast, when conceptual tempo is assessed by a tempo task such as the DRT, which requires successive comparisons, one would expect both distinctive-features and prototype learning to occur, ~~and~~, through differential amounts of feature and prototype training, to make possible an assessment of the role of each of these perceptual learning processes in conceptual tempo behavior.

Task Solution Strategies

Another category of independent variables postulated to underlie differences in conceptual tempo are termed task solution strategies. This label includes differences in patterns of observing responses, and differences in the method of achieving a solution.

Although Vurpillot (1968) was testing the hypothesis that syncretism (a lack of coordination between analysis and synthesis) was due to a deficiency of perceptual activity, her results strongly indicate the existence of profound individual differences in the strategies employed to solve perceptual matching tasks. The number and sequence of eye movements were recorded during performance on a task that required children to decide whether a pair of line drawings was the same or different. Vurpillot attempted to determine the amount of information children of different ages retained from a stimulus, the kinds of strategies used to make comparisons, and the rationale for their decisions. The results obtained were as follows: (1) The number of correct responses was directly related to the age of the child and inversely related to the number of objective differences between drawings. (2) Up to age six, the number of fixations was not related to the number of differences between stimuli;

i.e., young children viewed only six or seven of a possible twelve fixation points. After age six, however, the number of fixations was directly related to the number of differences between stimuli. This result suggests that the amount of information collected was adapted to the requirements of the task. (3) Paired comparison data showed that from age five onward, children made more paired comparisons on identical pairs than on different pairs, but from age seven onward, paired comparisons were directly related to the number of actual differences between stimulus pairs.

These results are interpreted by Vurpillot as evidence for the postulation of an age-related succession of stages of comparison task performance. In the first stage, children scan pictures at random and their answers are not related to the information collected. Stage two children define sameness by the existence of a common element and difference by its absence; scanning is limited to part of the stimulus and there is no spatial frame of reference in which the parts of the stimulus are considered. By stage three, the adult criteria of "same" and "different" are employed; i.e., identity is defined as the absence of differences and a difference is relative only to homologous elements of the stimuli. In addition, at this stage comparisons are articulated within a frame of reference, but one that is limited in space and time and includes only those elements than can be scanned and memorized in a few seconds. By stage four, a systematic strategy of scanning appears, as well as a frame of reference that is temporally sufficient to discriminate between stimuli that have already been scanned and those that have not.

Support for Vurpillot's position comes from two investigations, Adams (1972) found age-related strategy differences between reflective and impulsive children on a probability learning task. Not only did reflective and impulsive subjects use different strategies to solve the problem, but also reflective and impulsive subjects used different strategies at age six than they used at age eight. This last result has led Adams to suggest that the processes underlying impulsive and reflective behavior may change with increasing age. Furthermore, using a matrix solution task similar to that used by Bruner, Goodnow, and Austin (1966), McKinney (1973) has reported that reflective children attempted to consider several alternative hypotheses and use a strategy that tested the relevance of conceptual categories rather than specific instances. Impulsive children, in contrast, were less likely to form abstract hypotheses and typically used information in a random trial and error fashion. In terms of strategy labels, reflective children preferred a scanning strategy while impulsive children preferred a focusing strategy. This result also supports Vurpillot's postulated process of comparison task performance.

Another advocate of a stage approach to conceptual tempo is Shine (1971), who found a positive correlation between reflective MFF responding and two measures of Piaget's decentration construct. She suggests that the stage of perceptual decentration attained by the child is indicative of his ability to dissect and compare stimulus figures. Consequently the stage of decentration of the individual is thought to influence his style of processing information by determining the number of alternative hypotheses available for selection. This result is also consonant with Kagan's theoretical discussion of the role of hypothesis generation in conceptual tempo noted above.

Still another approach to solution strategy differences comes from an analysis of MFF search strategies which suggests that the efficiency of the search strategy may be a more important variable in understanding reflection-impulsivity than is response latency. Zelniker et al. (1972) have noted that attempts to modify impulsive behavior by means of response latency modeling (Debus, 1970; Yando & Kagan, 1968) and response inhibition training (Kagan et al., 1966b) have produced increased response latencies, but no corresponding decrease in error scores. They suggest that this failure may indicate that differences in conceptual tempo may be a function of the problem-solving strategies employed rather than the latencies of their employment. If this were the case, then effective search strategy training would be more helpful than response latency training. As noted above, Vurpillot (1968) found that the greater frequency of erroneous "same" responses of young children was a consequence of a limited search of the attributes prior to responding. Zelniker et al. (1972) have noted that Vurpillot's finding is applicable to MFF performance, i.e., if the search for differences is hasty, minor differences among variants are erroneously overlooked. In an attempt to teach subjects a more effective search strategy, Zelniker et al. designed the Differentiating Familiar Figures task (DFF) which employed the MFF stimuli, but required that subjects find the variant that differed from the standard when this variant was located among five variants that were identical to the standard. These investigators reasoned that the search for a difference in such a task would end successfully only when the subject found a difference, and that training on this task might force subjects to develop more extensive search strategies which would tr[illegible] to MFF tasks.

Zelniker et al. found that the DFF changed the search strategy of both reflective and impulsive subjects and this change transferred to subsequent MFF performance to the extent that impulsive subjects significantly reduced their error rate, but did not change their response latency. The strategy change occasioned by the DFF was to reduce the proportion of standard-variant comparisons and increase the proportion of variant-variant comparisons. The decreased number of MFF errors in a constant period of time produced by the DFF experience suggests that comparisons among variants is a more efficient MFF task strategy than is a standard-variant comparison strategy.

Zelniker et al. (1972) also noted that with the longer response latency of reflective subjects accounted for, reflective and impulsive subjects did not differ on the initial MFF task in terms of fixation duration to each stimulus or the proportion of time spent viewing the standard. This result lends support to the results of Drake (1970) who found no significant differences between the eye movements of reflective and impulsive subjects during the first six seconds of exposure to MFF items. These results prompt one to question whether performance differences between reflective and impulsive subjects occur during the extra interval of time that reflective subjects attend to the stimuli, or whether there are differences in the process of attending to stimuli that occur throughout the interval of exposure. One method that might help to answer this question would be to make the response interval constant for reflective and impulsive subjects by requiring all subjects to respond within an amount of time that is typically taken by impulsive subjects to respond. If performance differences between reflective and impulsive subjects persist despite this latency control, then it could be assumed that such differences are not solely a function of a longer period of attending to the stimuli. A limited degree of evidence on this question comes from Ostfeld and Neimark (1967). Using the Conceptual Styles Test (Kagan et al., 1963), these investigators required analytic (reflective) subjects to respond within the time interval taken by global (impulsive) subjects and vice versa. The results indicated that while global subjects showed increased analytic responding as a result of the longer response interval, analytic subjects still responded analytically in spite of the shorter response interval (analytic responding has the latency and error characteristics that are typical of reflective responding while global responding has the characteristics of impulsive responding) (Kagan, et al. 1964). More recently, Zelniker, Cochavi, and Yered (1974) have replicated the Ostfeld and Neimark results.

To conclude this section, it is appropriate to ask: What might be said about the explanations of conceptual tempo in general? Quite simply, that, as yet, there are no satisfactory explanations of the construct. Perhaps this is not surprising, for the questions to be answered by a satisfactory explanation are fundamental ones; such as, Is there such a thing as a cognitive tempo; and if there is, why are there differences in tempo? Several of the proposed explanations of the construct are presently capable of accounting for a part of the variance attributed to tempo, and show the promise of being able to do so. More interesting, however, is that each of the explanations is attempting to relate reflection-impulsivity to one or more established concepts in the discipline. This type of research is most important for conceptual tempo because it is precisely the lack of such a relationship that makes the construct suspect as a parsimonious explanation of cognitive behaviors in humans.

EDUCATIONAL IMPLICATIONS OF CONCEPTUAL TEMPO

The conceptual tempo construct has a number of implications for educational practice. One implication comes under the heading of aptitude-treatment interactions. Are there significant interactions between an individual's position on the reflection-impulsivity dimension and variables of instruction; such as, instructional treatment or the cognitive style of the instructor? Yando and Kagan (1968) have indicated that the cognitive style of the teacher influences the cognitive styles of students. In addition, McKinney (1975) has reported that conceptual tempo has been found to be related to the teacher's perception of the classroom behaviors of children, particularly impulsive boys, who are seen to be more distractible than reflective boys and all girls, regardless of their tempo. A more germane question, however, is, What is the effect of cognitive style on student learning? At present attempts to answer this question are lacking and the implications of conceptual tempo tend to be concerned with peripheral aspects of education.

One educational implication of reflection-impulsivity concerns the modifiability of cognitive style. If reflective and impulsive styles are as modifiable as the literature suggests, then it seems reasonable to include style flexibility as an educational objective. Style flexibility would consist of teaching students to adopt that position on the reflection-impulsivity dimension which best meets specific task requirements. Extreme impulsivity and extreme reflection are both maladaptive for the majority of school tasks, which usually require a task-dependent tradeoff of speed and accuracy. The work of Heider (1971) suggests the very practical implication that direct instruction in information processing strategies or the structuring of tasks to force the use of correct strategies may both be effective methods of modifying impulsive behavior. A second implication of Heider's work derives from her demonstration of a social class difference in the degree of impulsive behavior. This difference may well be of assistance to those investigators seeking explanations of the consistent differences in academic performance between lower- and middle-class students.

An implication for education also comes from Schwebel's (1966) ding that the verbal performance of lower-class boys improves when they are forced to delay their response. Schwebel argues that explicit programs designed to teach impulsive children to delay responding and think through their response before overtly responding, would considerably improve the performance of these children.

In one of the few examinations of the role of conceptual tempo in special education, Gozali (1969) has found that the reflection-impulsivity dimension also applies to educable mentally retarded subjects. Reflective retardates attempted to solve the MFF problems, while impulsive retardates tended to employ a position respons et. However, the extension of conceptual tempo into the area of exceptional behavior may not be a simple application of the conventional tempo measures. Finch, Deardorff and Montgomery (1974) report that neither the latency nor the error variables of the MFF were reliable over a three-month test-retest interval for a sample of emotionally disturbed children.

Given that one cautiously interprets the data collected from children exhibiting exceptional emotional behavior, several investigations involving emotionally disturbed subjects may have some implications for educational practice. Finch, Pezzuti, Montgomery and Kemp (1975) have reported that while samples of reflective and impulsi e emotionally disturbed children that were matched for both chronological and mental age did not differ on a measure of academic achievement, the reflective subjects were found to exceed the impulsive subjects by two grade placements. If one overlooks the questionable practice of mental age matching as a valid means of controlling intelligence (Campbell & Stanley, 1963), these results indicate that conceptual tempo may be an extremely important factor in school success. Despite the limitations on the internal validity and generalizability of the Finch et al. (1974) results, a difference of two grade placements strongly suggests that the relationship between conceptual tempo and grade placement should be further examined.

With regard to educational methodology, Kagan (1967b) suggests that discovery learning methods are more appropriate for reflective than for impulsive children. The impulsive child does not reflect on the validity of his hypotheses and would be expected to cut short the discovery interval with an impulsively derived hypothesis that would probably be incorrect. After encountering a series of such failures in the absence of specific instruction, the impulsive child would be expected to withdraw from such a humiliating situation.

With regard to the relation between conceptual tempo and particular subject areas, Kagan (1965b) has reported that reflective children make fewer errors reading English prose than do impulsive children.[2] Based on their performance on the MFF, 65 male and 65 female, first-grade subjects were assigned to reflective or impulsive groups. Subjects were then asked to identify a word spoken by the investigator by pointing to the correct word in a visual display of five

---

[2]The educational implications of conceptual tempo for particular subject areas have, with the exception of the literature on reading, not been discussed in this paper. The reason for this is that while many studies of this nature are available, most are exceptionally poor from an experimental design point of view. More importantly, however, these studies are generally of the form of a reported correlation between the MFF and a standardized achievement test or teacher-made test in some subject area without any attempt to theoretically explain the relationship between the two measures. For the reader who is interested in this question, extensive discussions of the general educational implications of cognitive style are available in Kagan (1965a) and Kogan (1971), as well as some of the subject area investigations that do not suffer from the limitations noted above; namely, Cathcart and Liedtke (1969), Coop and Sigel (1971).

similar alternatives. Accurate recognition of the spoken words coincided with longer response delays on the MFF. In addition, verbal ability was positively correlated with reading ability, but the relation between a reflective orientation and reading ability remained significant even after the influence of verbal skills had been partialled out ($r = .28$, $p < .05$). Using word errors as the criteria and verbal skills and response time as separate predictors, the multiple correlation was .51 for boy- and .59 for girls. Separate correlations for children high or low on verbal ability revealed that the overall relationship was primarily attributable to high-verbal children. For these children, the correlations between MFF response time and reading errors were -.21 for boys and -.44 for girls, while the corresponding correlations for low-verbal children were -.14 for boys and -.21 for girls. Kagan explains this discrepancy as being a consequence of the minimal reading skills of the low-verbal subjects which caused their delay to be due less to response uncertainty than to conceptual deficit. He notes: "This situation is analogous to asking the authors to write the equation describing the trajectory of Mariner IV. The ensuing delay reflects incompetence, not cautious brooding over a set of alternative answers" (Kagan & Kogan, 1970, p. 1312). One year later these same subjects, in grade two, were asked to read some prose paragraphs. Impulsive children made more errors than did the reflective children, with the most frequent type of error involving word alternatives that were graphemically similar to the spoke word; e.g., "truck" for "trunk". Support for Kagan's results comes from Lesiak (1970) who found that reflective first-grade females scored significantly higher than their impulsive counterparts on tests of word recognition, reading comprehension, and critical reading. In contrast, however, Denney (1974) found conceptual tempo information did not greatly facilitate the identification of good and poor elementary school readers.

The measurement of achievement is another area of educational practice that may be affected by individual differences in conceptual tempo. The similarity of format of the MFF and some types of educational measurement, particularly measurement employing a multiple choice format, such as group administered IQ and achievement tests, suggests that scores may be influenced by individual differences in conceptual tempo.

Finally, a most important educational implication is suggested by the work of Messer (1970b). In a two-year longitudinal study of children passing from grades one through three, Messer found that children who failed a grade were significantly more impulsive than their peers, but very comparable in verbal intelligence. Messer postulates that conceptual tempo differences are the product of differential anxiety over error. From an educational point of view, speculation about the cause of tempo differences seems secondary to the need for an extensive investigation of a possible relationship between conceptual tempo and failure.

CHAPTER 3

EXPERIMENT ONE: INTELLIGENCE AND CONCEPTUAL TEMPO

Notwithstanding the considerable volume of research that has been conducted on conceptual tempo, some aspects of that construct have been neither extensively examined nor examined in relation to the tempo construct as a whole. The operational definition of reflective and impulsive behavior according to the dual criteria of task errors and response latency results in the loss of those subjects who score either below or above both the latency and error medians. To facilitate discussion, the four classifications for this expanded conception of conceptual tempo will be labelled fast-accurate (FA) for subjects scoring below the latency and error medians; fast-inaccurate (FI) for subjects usually labelled "impulsive", who score below the latency and above the error median; slow-accurate (SA) for subjects usually labelled "reflective", who score above the latency median and below the error median; and slow-inaccurate (SI) for subjects who score above both the latency and error median.

Kagan (1965a, p. 617-618) addressed the question of the effect of the loss of FA and SI subjects from conceptual tempo samples by comparing word recognition performance of the tempo sample as a whole, with that obtained following the selection of SA and FI subjects according to the dual criteria of latency plus errors on the MFF. The analysis indicated no significant differences between the correlations of word recognition errors with MFF latency and MFF errors for the sample as a whole and the sample following the exclusion of FA and SI subjects. Consequently, it appears to have been tacitly assumed that not only does the exclusion of FA and SI subjects not limit the internal and external validity of the study, but also, this procedure limits the effects of possible sources of invalidity that would obfuscate the results of conceptual tempo investigations. In Kagan's words:

> "There is, on the one hand, a small group of bright subjects who can have relatively fast response times on easy tasks (like the DRT) but make few errors. These children do not have a fast response time on the MFF because this task is more difficult than the DRT. It is crucial to use tasks that are of optimum difficulty for each age level to guarantee that fast response times typically lead to high error scores. A second anomalous group, also small, contains children whose long response times result from extreme fear. These children may have high error scores, for they are not reflecting upon alternative possibilities during the long delay. They fail to respond quickly because they have no idea what to say and are afraid of offering any answer. It is likely that elimination of children who show both excessively long response times and high error scores will permit us to understand with greater clarity the antecedents of the reflective variable (Kagan, 1964, p. 503)".

The first question that Kagan's explanation begs is: What percentage of the total sample is represented by the "small" groups of subjects that are eliminated from the sample? While the proportion of the total sample represented by these excluded response categories varies from study to study, an examination of several investigations in which the data permitted a calculation of the number of subjects eliminated indicated an average value of 36.18% (see Table 1). From a research point of view, these subjects constitute over one-third of each sample selected for research on this construct. To simply eliminate such a large number of subjects from an investigation, certainly appears to result in a considerable loss of information about the construct being investigated. Furthermore, in that it is FA and SI subjects who seem to contradict the construct of reflection-impulsivity, an examination of their performance may reveal valuable information about conceptual tempo. For both of these reasons, an investigation of conceptual tempo as it applies to all individuals appears to be in order.

A recent and rather extensive consideration of a complete sample of conceptual tempo subjects has cast considerable doubt upon the MFF as a measure of reflection-impulsivity. Block, Block and Harringtc (1974) advance three major arguments against the MFF as a measure of reflection-impulsivity. First, they note a discrepancy between the conceptualization and operationalization of reflection-impulsivity. They argue that while Kagan's early conceptualization of the reflection-impulsivity dimension was defined solely in terms of response latency in situations involving a degree of response uncertainty (Kagan, 1965a, 1965c, 1966a, 1966b), his operationalization of the construct involves two variables, response latency and error, which operate conjointly to identify reflective

TABLE 1

Percentage of Subjects Eliminated from Seventeen Investigations that Employed a Latency and Error, Dual-Median Split, Operational Definition of Reflection-Impulsivity

Investigator/s	Date	Percent Eliminated
Ault	1973	42
Block, Block, & Harrington	1974	39
Cathcart & Leidtke	1973	29
Eska & Black	1971	44
Harrison & Nadelman	1971	48
Kagan	1966b	23
Kagan, Pearson, & Welch	1966a	49
Katz	1971	43
Massari	1975	27
Messer	1970b	30
McKinney	1975	37
Odom, McIntyre, & Neale	1971	28
Reali & Hall	1970	32
Siegelman	1966	44
Weiner & Adams	1974	31
Zelniker, Jeffery, Ault, & Parsons	1972	29
Zelniker & Oppenheimer	1973	40
Combined Total Average		36.18

and impulsive behaviors. Consequently, they argue that it is necessary to unconfound response latency and response accuracy and determine their separate effects upon MFF behavior. Second, Block et al. (1974) cite several observations that strongly challenge the construct validity of the MFF. For example, they note that while early investigations of visual scanning strategies reported significant differences between reflective and impulsive subjects (Siegelman, 1969; Nelson, 1969), more recent investigations have reported that the visual scanning strategies of reflective and impulsive subjects do not differ significantly (Drake, 1968; Zelniker, Jeffery, Ault, & Parsons, 1972; Ault, Crawford, & Jeffery, 1972). Additional examples include: the relative lack of success of the tempo modification procedures that emphasize response latency change in contrast with those that emphasized search strategy instruction and have reduced response errors; the lack of control for regression effects in many of the studies that have reported experimentally induced changes in response latency and/or error; and the reports that reflective and impulsive subjects have shown similar response behaviors on the MFF following a variety of anxiety arousing situations (Messer, 1970a; Reali & Hall, 1970; Ward, 1968). Block et al. (1974) also note that contrary to expectation, the MFF operationalization of reflection-impulsivity is not related to several tasks and situations such as motor inhibition, delay of gratification, and observer-rated impulsivity, even though it is reasonable to expect that such indices should be related to reflection-impulsivity. Finally, Block et al. (1974) using California Child Q set ratings of children in each of the four quadrants resulting from MFF latency and error median-splits, found that while only two of one hundred personality traits were significantly associated with MFF response latency, thirty-two traits were significantly associated with response errors. Analysis of the particular traits involved have led Block et al. to posit that accuracy, not latency, has been the major variable accounting for differences between MFF defined reflective and impulsive behavior. Block et al. suggest that differences in MFF performance may be related to anxiety which detrimentally affects the performance of both slow- and fast-inaccurate subjects, and they conclude that whatever MFF accuracy-inaccuracy represents, it is an invalid index of the broad constructs of reflection and impulsivity. Another investigation that included fast-accurate and slow-inaccurate subjects lends further support to the Block et al. (1974) emphasis on the importance of response errors. Ault (1973) has reported that she found no significant differences in performance on Mosher and Hornsby's (1966) measure of cognitive maturity between reflective and fast-accurate subjects, but she did obtain significant differences between both these groups and impulsive subjects.

It might also be noted that Kagan and Messer (1975) suggested a number of qualifications for the Block et al.

(1974) position; however in a rejoinder, Block, Block, and Harrington (1975) address each suggested qualification then conclude their original conclusions are still valid. Leaving aside the particulars of the debate, the Block et al. (1974) finding, concerning the relative importance of accuracy versus latency, strongly suggests that the determination of the psychological dynamics associated with MFF performance will benefit from the additional information gained from the [illegible] of the conventionally excluded FA and SI subjects.

One of the few studies reported to date that has extensively examined the behavior of subjects in the normally excluded categories was conducted by Eska and Black (1971). The major variable involved in their study was measured intelligence. Unfortunately, the relationship between reflection-impulsivity and measured intelligence is not at all clear. In an early investigation of the tempo construct, measured intelligence was reported to be orthogonal to reflection-impulsivity (Kagan et al., 1964). More recent studies suggest that the relationship between these variables is not orthogonal; for example, Meichenbaum and Goodman (1969) have found that reflective subjects score significantly higher than impulsive subjects on all subtests of the Primary Mental Abilities (PMA) test; namely, verbal meaning, perceptual speed, number facility, and spatial ability. The total battery IQ scores were positively correlated with MFF response time ($\underline{r} = .385$, $\underline{p} < .05$). However, as Meichenbaum and Goodman have noted, the formats of the PMA and MFF are quite similar. Both measures are matching-to-sample tasks, and the perceptual speed subtest is similar to the MFF in that there is no time limit specified. These investigators go on to suggest that conceptual tempo may be an important determinant of performance on nonverbal tests of intelligence. This suggestion appears to have some support in the tempo literature.

In an extensive investigation of the relationship between IQ and conceptual tempo, Eska and Black (1971) have noted the intercorrelations among IQ, MFF latency, and MFF error that have been reported by a number of investigators. These data appear in Table 2, together with the results of several more recent investigations that have been added by the present author. While the nonsignificant latency-IQ correlations of several of the studies listed support the position that response uncertainty and decision times are relatively orthogonal to traditional intelligence test scores, it should be noted that eleven of the twelve studies listed report positive correlations between latency and IQ, and seven of the twelve report that the obtained correlations were significant for either male or female subjects, or both. Eska and Black suggest that this apparent discrepancy can be explained by considering the relationships between specific subscores of the IQ measures used. Eska and Black (1971) used the Otis-Lennon Mental Ability Test and obtained a significant correlation between the total IQ

TABLE 2

Correlations Between MFF Errors, MFF Latencies, and IQ in Selected Studies

STUDY	N Male	N Female	GRADE	Errors - Latency Male	Errors - Latency Female	Errors - IQ Male	Errors - IQ Female	Latency - IQ Male	Latency - IQ Female
Lewis et al. (1968)	23	25	Preschool	-.48*	-.11	-.30	-.60**	.10	.30
Ward (1968)	41	46	Kindergarten	-.02	-.39**	-.09	-.33*	.23	.30
Ward (1968)	41	46	Kindergarten	-.39*	-.26	-.27	-.22	.15	.39**
Kagan (1965b)	65	65	First	-.40*	-.56**	--	--	--	--
Yando & Kagan (1968)	80	80	First	-.53**	-.59**	-.36**	-.33**	.20	.27*
Eska & Black (1971)	50	50	Third	-.69**	-.56**	-.47**	-.35**	.33*	.45**
Kagan et al. (1964)	30	28	Third	-.66**	-.47*	-.53**	-.28	.36*	.22
Kagan et al. (1964)	60	60	Third	-.57**	-.51**	-.47**	-.21	.05	.15
Kagan et al. (1964)	30	25	Fourth	-.65**	-.60**	.10	-.40*	-.13	-.03
Block, Block & Harrington (1974)[1,2]	50	50	Preschool	-.33*		-.39*		.14	
Mumbauer & Miller (1970)[2]	16	16	Preschool	-.48**		-.53**		.52**	
Harrison & Nadelman (1972)[2]	25	25	Preschool	-.25	-.35*	-.30	-.34*	.46*	.00
Massari & Massari (1973)[2,3]	34	39	Preschool	-.69	-.50	-.29	-.35*	.26	.22
Meichenbaum & Goodman (1969)[2]	13	17	Kindergarten	-.64**		-.62**		.39*	
Denney (1973)[2]	32	32	Two & Three	-.39**		-.14		.07	

*$p < .05$
**$p < .01$

[1]This and subsequent investigations that appear below the broken line have been added to the original Eska and Black (1971) table by the present investigator.

[2]Separate data for males and females not given.

[3]The conceptual tempo measure used in this investigation was the Early Childhood Matching Familiar Figures (Banta, 1970).

score and MFF response latency ($r = .33$, $p < .05$ for boys; $r = .45$, $p < .01$ for girls). However, they note that for the verbal subscale of the Otis-Lennon the latency-IQ correlations were not significant ($r = .08$, $p > .05$ for boys; $r = .21$, $p > .05$ for girls). Apparently the value of the total score correlation was primarily a consequence of the significant correlations obtained for both the figural content subscale ($r = .40$, $p < .05$ for boys; $r = .50$, $p < .05$ for girls) and the symbolic content subscale ($r = .42$, $p < .05$ for boys; $r = .26$, $p < .08$ for girls). These results, together with the correlational data summarized in Table 2, lend support to three general conclusions about conceptual tempo. First, MFF response latency appears to be positively correlated with nonverbal measures of intelligence. Second, the consistent reports of a negative correlation between MFF latency and error suggests that fast responding reduces MFF test performance. Third, the observation that fourteen of twenty-three correlations between MFF errors and IQ cited in Table 2 are significant negative correlations, plus the observation that all but one of the reported correlations are negative, suggests that MFF error is inversely related to intelligence.

Eska and Black (1971) also report several results related to the inclusion of SI and FA subjects in their investigation. First, they report a trend for FA and FI subjects to come from a lower SES level than did SA and SI subjects. Second, as noted above, Eska and Black report significant positive correlations between MFF latency and Otis-Lennon total IQ, and significant negative correlations between MFF errors and Otis-Lennon total IQ. Although these results are in agreement with the general conclusions given above, they are worthy of special note because they are obtained from a sample that did not exclude SI and FA subjects. Third, as would be expected from the correlations cited above, SA subjects were found to score significantly higher than FI subjects on four of the interrelated Otis-Lennon measures of intelligence: total IQ, figural content, symbolic content, and mental age. This result is not congruent with the Kagan et al. (1964) position that conceptual tempo performance is orthogonal to intelligence. Reflective subjects are significantly more intelligent than impulsive subjects on the Otis-Lennon measures. In addition, the inclusion of the usually eliminated SI and FA subjects produced data which suggests the relationship between conceptual tempo and intelligence is not a simple linear relationship. The only significant differences in IQ reported for the four tempo conditions were for the diagonally opposite SA and FI cells of the latency X error matrix produced by the dual-median split procedure. Subjects from these two cells differed on both the latency and error dimensions. In short, this result suggests that no significant IQ main effects were found for either the MFF latency (fast vs. slow) or the MFF error (accurate vs. inaccurate) variables. Furthermore, and contrary to a popular belief, the second interaction, comparing the IQ scores of FA and SI subjects, also not significant. For further examination the mean Otis-Lennon total IQ scores for each tempo were: FI = 107.53, SA = 116.87, FA = 113.00, and SI = 113.07. A puzzling aspect of these results is the near identical scores of the FA and SI subjects. Kagan (1965a) has noted that the reflection-impulsivity construct contradicts the commonly accepted practice of equating response speed with intelligence. While the Eska and Black results do not support Kagan's argument that reflective and impulsive subjects do not differ in intelligence, their results very strongly support Kagan's observation that MFF response latency is not inversely related to intelligence. First, their results indicate that SA subjects are more intelligent than FI subjects. Second, they report that SI subjects are not significantly different in intelligence from FA subjects.

The additional information provided by the SI and FA subjects is particularly interesting because it comes from experimental conditions in which the reported significant positive correlation between MFF latency and IQ and the significant negative correlation between MFF error and IQ are placed in opposition to each other. It would appear that the separate significant relationships that response latency and error have with IQ oppose and negate each other in the SI and FA tempo conditions. In addition, the Eska and Black results suggest that despite the observed significant correlations between MFF latency, MFF error and

IQ, neither the latency nor the error variable is associated with a significant difference in IQ when either variable is evaluated in isolation. In other words, with IQ as the dependent variable, the main effects for MFF latency and error are not significant. Only the latency by error interaction is significant, and that occurs only when the two le[illegible] each variable are <u>combined</u> to take full advantage of the underlying negative correlation between latency and error.

Finally, Eska and Black (1971) also report that SA subjects employed the strategy of physically removing the portable response alternatives from their line of sight as each alternative was eliminated from consideration. In contrast, FA subjects demonstrated little of this behavior. It is noteworthy that the time taken to remove stimuli would itself contribute to the separation of SA and FA subjects on the MFF latency dimension. Since few, if any, other conceptual tempo studies have employed portable response alternatives and the manipulation of alternatives takes time, the Eska and Black (1971) results may not be strictly comparable with the results of conceptual tempo investigations employing conventional, non-manipulable response alternatives. In view of the reported observation that subjects in the four tempo conditions differentially took advantage of the opportunity to manipulate response alternatives (fifteen of twenty-one subjects who systematically manipulated alternatives were in the SA category, while only three were in the FA category) the caution about the generalizability of their results seems especially pertinent, particularly when they have used the obtained latencies to describe and discriminate among four categories of conceptual tempo rather than two.

Given the additional information provided by the inclusion of SI and FA subjects, the contradiction of the postulated orthogonal relationship between conceptual tempo and intelligence, and the possibility that the inclusion of portable response alternatives in the conceptual tempo task contributed uninterpreted variance to the results, an attempt was made to partially replicate the Eska and Black (1971) investigation and assess the relationships between response latency, error, and IQ for four rather than two conceptual tempo categories. In accord with the results of Eska and Black (1971) and the summary of conceptual tempo-IQ investigations presented above, it was anticipated that the results would reveal a positive correlation between MFF latency and IQ, and negative correlations between MFF errors and IQ, and MFF latency and MFF errors. In addition, it was anticipated that SA subjects would score higher than FI subjects on the IQ measures and that no other significant IQ differences would occur among the remaining conceptual tempo combinations.

METHOD

Subjects

Letters requesting the permission of parents for their children to participate in a psychological study (see Appendix B) were circulated to the parents of grade 5 students enrolled in two urban elementary schools located in predominantly middle-class residential areas of St. John's, Newfoundland. Of the 198 letters that were returned, 187 approved their child's participation in the investigation. Subject mortality reduced the sample size to a final total of 175 subjects. The loss of twelve subjects occurred for the following reasons: withdrawal from school (one subject); misunderstanding of intelligence test instructions (seven subjects); and experimenter error in the administration of the MFF (four subjects).

Apparatus

Each of the MFF items appeared on interfacing 22 X 28 cm. pages of a coil-bound test booklet, with the standard appearing on one page and the six alternatives on the other. The booklet was placed with its length horizontal on a portable stand, approximately 40 cm. from the eyes of a subject seated at a table. The portable stand supported the test booklet such that the lower page was sloped toward the subject at an angle of 25° from the horizontal plane of the table. The upper page was similarly sloped at an angle of 115°. Response latencies were timed to the nearest second by a stopwatch.

Procedure

Initially, the Canadian Lorge-Thorndike Intelligence Test, Level C Form One, was administered to each of six grade five classes according to the standardized procedure outlined in the test manual. The Canadian Lorge-Thorndike consists of a verbal battery and a nonverbal battery which are combined to yield a full scale IQ score. The verbal battery consists of five subtests: comprehension, sentence completion, arithmetic, semantic similarities, and verbal analogies. The nonverbal battery consists of three subtests: pictorial similarities, numerical seriation, and pictorial analogies. The verbal battery involves 35 minutes of actual testing time, while the nonverbal battery involves 27 minutes. In practice, each battery required approximately one hour to administer, with a fifteen minute recess between batteries. Beginning two days later, each subject was administered the MFF - Elementary Level (Kagan et al., 1964) according to the instructions supplied with the test (see Appendix C). To facilitate scoring, one of the numbers one through six was stenciled below and to the right of each figure. The number one was assigned to the left-most alternative in the top row and numbering proceeded horizontally by rows. Subjects were asked to select from among six similar alternatives the one alternative that matched the standard stimulus presented above, and indicate their choice by verbalizing the number corresponding to the alternative they chose. To insure that all subjects understood the instructions, two initial practice items were provided. While several subjects did not correctly complete the first practice item, this opportunity for remedial instruction was sufficient such that all subjects completed the second practice item in accord with the prescribed procedure. The dependent variables scored were the subject's response latency in seconds to the first alternative selection and the total number of incorrect selections up to a maximum of six errors.

Following the procedure outlined by Kagan (1966a), subjects were classified according to a dual-median split of the response latency and error variables. Subjects who scored above the group latency median and below the group error median were classified as reflective or SA. Subjects who scored below the latency median and above the error median were classified as impulsive or FI. In addition to these typical categories, the two remaining cells of the latency-error matrix were also included in the investigation. Subjects who scored above the group latency median and above the group error median were classified as SI; subjects scoring below both medians were classified as FA.

Design

A two-way factorial, fixed effects model analysis of variance was used to analyze mean differences between conceptual tempo conditions on four dependent variables: chronological age, verbal IQ, nonverbal IQ, and composite IQ. In addition, this design was also used to analyze MFF latency and MFF error to determine if the dual-median split procedure did in fact produce significant latency and error mean differences. The two factors analyzed were sex (male and female) and conceptual tempo (FI, SI, FA, and SA). If the interaction effect was significant, tests on main effects were then replaced by analyses of simple main effects (Winer, 1971, pp. 435-442). Individual comparisons were tested by _t_ tests, Newman-Keuls sequential range tests, or Scheffe multiple comparisons (Winer, 1971, pp. 35, 191, and 198 respectively), depending upon which test was appropriate. A probability level of $\alpha = .05$ was accepted for all tests of significance except the Scheffe multiple comparisons. Due to the extremely conservative nature of the Scheffe, the probability for this test was set at $\alpha = .10$, as recommended by Winer (1971, p. 201).

RESULTS

The latency and error medians for the 175 subjects that completed all phases of the investigation were 115.51 seconds and 8.50 errors. Using the dual-median split procedure, these medians produced the distribution of subjects given in Table 3. The percentage of subjects occurring in the normally excluded FA and SI tempo categories is 27%.

TABLE 3

Number of Observations by Sex and Conceptual Tempo

Condition	Male	Female	Total
	N	N	N
FI	39	20	59
SI	11	13	24
FA	13	10	23
SA	29	40	68
TOTAL	92	83	175

While this value is lower than the average value of 36.18% noted above, it is within the 23% to 49% range of values cited for the investigations that contributed to that average.

The means and standard deviations for each of the four conceptual tempos for the MFF latency and error variables are presented in Table 4. A summary of a sex X tempo, two-way analysis of variance for MFF response latencies is presented in Table 5. This analysis revealed a significant tempo main effect ($F = 72.84$, $p < .000001$). Scheffe multiple comparisons of MFF response latencies indicated the median split of the latency variable produced highly significant differences in response latency between the means of the fast and slow tempo groups (p's $< .001$).[3] Furthermore, SA subjects ($\bar{X} = 200.49$ seconds) took significantly longer than SI subjects ($\bar{X} = 152.38$ seconds) to complete the MFF test ($p < .001$). With regard to MFF errors, a sex X tempo analysis of variance again produced a significant tempo main effect ($F = 105.83$, $p < .000001$) and no significant result for either the sex main effect or the sex X tempo interaction (see Table 6). Scheffe multiple comparisons of means indicate that the error means of all accurate cells produced by the median split are significantly different than the error means of the inaccurate cells (p's $< .001$). Furthermore, this analysis also indicates that SI subjects made an

---

[3]Complete summary statistics for both the main effects analyses of variance and when significance levels warrant the simple effect analyses and post hoc multiple comparisons are presented as consecutive tables in Appendix D.

TABLE 4

Conceptual Tempo Means and Standard Deviations for the MFF Latency and Error Variables

Dependent Variable	Tempo			
	FI	SI	FA	SA
N	59	24	23	69
MFF Latency in Seconds				
$\overline{X}$	86.63	152.38	87.26	200.49
S.D.	19.65	36.80	20.40	65.65
MFF Errors				
$\overline{X}$	13.27	10.83	6.17	4.36
S.D.	3.78	1.46	1.58	2.35

TABLE 5

Summary Analysis of Variance of MFF Response Latencies

	Source	SS	df	MS	F	p
A	Tempo	466765.00	3	155580.00	72.84	<.000001
B	Sex	1778.00	1	1778.00	.83	>.05
C	A x B	3658.00	3	1219.33	.57	>.05
	Error	356738.00	167	2136.16		

TABLE 6

Summary Analysis of Variance of MFF Response Errors

	Source	SS	df	MS	F	p
A	Tempo	2437.08	3	812.36	105.83	<.000001
B	Sex	4.55	1	4.55	.59	>.05
	A x B	35.98	3	11.99	1.56	>.05
	Error	1281.86	167	7.68		

average of 2.44 fewer errors than did FI subjects ($p < .05$), and SA subjects made an average of 1.81 fewer errors than did FA subjects ($p < .10$). Taken together the ar s of the MFF latency and error results indicate that the atency and error dual-median split procedure produced significantly different conceptual tempo g oups. In addition, unanticipated significant differences in both latency and error for groups falling on the same side of the latency or error medians, may be interpreted as being the product of a negative correlation between MFF response latency and errors (Pearson $r = -.60$, $p < .001$).

The correlations among the six dependent variables measured in the investigation: MFF latency and error, Canadian Lorge-Thorndike verbal, nonverbal and composite IQ, and chronological age, are presented in Tables 7 and 8 for the sex and tempo independent variables, respectively. As expected, the negative correlations between MFF latency and error were significant for both les and females, and the correlations among the three measures of intelligence approximated the large positive values cited in the Canadian Lorge-Thorndike test manual. Additionally, significant negative correlations between chronological age and intelligence were obtained for each of the three measures of intelligence. Further investigation of this relationship for each sex indicated that while each of the twelve correlations calculated was negative, the values were significant only for female subjects. Additional investigation of this

TABLE 7

Correlations for Male and Female Subjects Among Six Dependent Variables

	Dependent Variables					
	Chronological Age	MFF Latency	MFF Errors	Verbal IQ	Nonverbal IQ	Composite IQ
Chronological Age						
Male		.17	-.18	-.11	-.09	-.11
Female		-.14	.01	-.30**	-.27**	-.32**
Combined		.02	-.09	-.19*	-.17*	-.22
MFF Latency						
Male			-.62**	.00	.02	-.01
Female			-.57**	-.21	-.10	-.16
Combined			-.60**	-.10	.02	-.06
MFF Errors						
Male				-.13	-.10	-.13
Female				.03	-.17	-.08
Combined				-.06	-.14	-.12
Verbal IQ						
Male					.61**	.88**
Female					.63**	.89**
Combined					.61**	.88**
Nonverbal IQ						
Male						.91**
Female						.91**
Combined						.91**

NOTE: n male = 92; n female = 83

*$p < .05$, two-tail test

**$p < .01$, two-tail test

TABLE 8

Conceptual Tempo Correlations for Six Dependent Variables

Variable and Tempo	Chronological Age	MFF Latency	MFF Errors	Verbal IQ	Nonverbal IQ	Composite IQ
	Dependent Variables					
Chronological Age						
FI		.01	-.14	-.31**	-.27**	-.32**
SI		.03	-.40	-.23	-.05	-.09
FA		.10	-.17	-.12	-.16	-.16
SA		.07	-.02	-.09	-.22	-.18
Combined		.02	-.09	-.19*	-.17*	-.20*
MFF Latency						
FI			-.43**	-.14	-.26*	-.21
SI			-.23	-.12	.16	.04
FA			-.36	-.08	-.31	-.11
SA			-.41**	-.09	.05	-.01
Combined			-.60**	-.10	-.02	-.06
MFF Error						
FI				-.11	-.08	-.11
SI				.12	-.28	-.11
FA				.16	.19	.18
SA				-.17	-.31**	-.28*
Combined				-.06	-.14	-.12
Verbal IQ						
FI					.66**	.91**
SI					.49**	.84**
FA					.57**	.90**
SA					.61**	.87**
Combined					.61**	.88**
Nonverbal IQ						
FI						.92**
SI						.89**
FA						.87**
SA						.92**
Combined						.91**

NOTE: N = (FI = 59, SI = 24, FA = 23, SA = 69) = 175
*$p < .05$, two-tail test
**$p < .05$ two-tail test

relationship suggested that a negative correlation between chronological age and IQ was related to the fact that thirteen students in the sample had grade placements one year lower than was appropriate for their chronological age. Of these students (five male and eight female) all had composite IQ scores that were below the mean for this sample (108.60) and five of the eight female and one of the five male students had composite IQ scores that approached one standard deviation below the test mean. (The mean and standard deviation for the Canadian Lorge-Thorndike are $\overline{X} = 100$, and $S = 16$).

The correlations for the individual tempo groups are presented in Table 8. Again, the correlations among MFF latency and error are negative, but it is noteworthy that these values fail to reach significance for the SA and FA tempo conditions. Also, for each conceptual tempo the correlations between the three measures of intelligence again support the positive values noted in the test manual. With regard to the relationship between chronological age and the three measures of intelligence, only the negative correlations for the FI tempo condition were significant, but again all of the correlations for each of the four conceptual tempos were negative.

With the exception of a significant negative correlation for FI subjects on the nonverbal IQ measure, MFF response latency was not significantly related to the measures of intelligence. Furthermore, with the exception of the correlations for SA subjects on the nonverbal and composite

IQ variables, MFF response errors were also not significantly related to the measures of intelligence.

The means and standard deviations for the chronological age and Canadian Lorge-Thorndike IQ variables are presented in Table 9. A two-way (sex X tempo) analysis of variance for the chronological age variable indicated that both the sex and tempo main effects and the interaction were not significant (see Table 10). In contrast, similar two-way analyses for the IQ variables (see Table 11) indicated the presence of a significant sex X tempo interaction for both the Verbal IQ (F = 3.01, p < .05) and Composite IQ (F = 2.75, p < .05).

Simple effects analyses conducted on the Verbal IQ variable indicated that the variance among tempo means was significant only for female subjects (F = 2.90, p < .04). Post hoc Scheffe multiple comparisons surprisingly failed to indicate the presence of any significant simple contrasts. The smallest probability occurring between verbal IQ means was p = .1487, a comparison of the means for the SI ($\overline{X}$ = 98.23) and FA ($\overline{X}$ = 109.80) tempo conditions. Further simple effects analysis of the Verbal IQ scores revealed a marginally significant sex difference for SI subjects. The Verbal IQ of SI male subjects ($\overline{X}$ = 110.45) was significantly higher than that of SI female subjects ($\overline{X}$ = 98.23, t = 2.12, p < .05).

With regard to the composite IQ scores, one-way simple effects analyses of variance revealed a significant

TABLE 9

Conceptual Tempo Means and Standard Deviations for Chronological Age, Verbal IQ, Nonverbal IQ and Composite IQ

Dependent Variable	Tempo			
	FI	SI	FA	SA
N	59	24	23	69
Chronological Age in Months				
$\overline{X}$	127.95	127.88	128.83	128.10
S	4.69	4.97	3.53	4.71
Verbal IQ				
$\overline{X}$	103.02	103.83	108.52	102.65
S	14.47	14.72	14.42	10.27
Nonverbal IQ				
$\overline{X}$	109.29	111.54	117.39	110.80
S	15.39	17.37	13.14	13.26
Composite IQ				
$\overline{X}$	106.36	107.96	113.13	106.94
S	13.49	13.92	12.15	10.57

TABLE 10

Summary Analysis of Variance of Chronological Age Means

	Source	SS	df	MS	F	r
A	Tempo	11.00	3	3.67	.17	>.05
B	Sex	4.00	1	4.00	.18	>.05
	A x B	62.00	3	20.67	.95	>.05
	Error	3641.00	167	21.80		

TABLE 11

Summary Analysis of Variance of Verbal, Nonverbal, and Composite IQ Means

	Source	SS	df	MS	F	p
Verbal IQ						
A	Tempo	553.00	3	184.33	1.10	>.05
B	Sex	182.00	1	182.00	1.08	>.05
	A x B	1516.00	3	505.33	3.01	<.05
	Error	28032.00	167	167.86		
Nonverbal IQ						
A	Tempo	1137.00	3	379.00	1.76	>.05
B	Sex	199.00	1	199.00	.93	>.05
	A x B	1202.00	3	400.67	1.87	>.05
	Error	35874.00	167	214.81		
Composite IQ						
A	Tempo	785.00	3	261.67	1.73	>.05
B	Sex	0.00	1	0.00	0.00	>.05
	A x B	1247.00	3	415.67	2.75	<.05
	Error	25240.00	167	151.14		

overall tempo difference for female subjects ($\underline{F}$ = 3.36, $\underline{p}$ < .03). Post hoc Scheffe multiple comparisons produced two significant simple contrasts: FA IQ scores ($\overline{X}$ 116.80) were significantly greater than were either SI IQ scores (103.39, $\underline{p}$ < .05) or SA IQ scores ($\overline{X}$ = 106.13, $\underline{p}$ < .10). Simple effects, two-tail $\underline{t}$ tests on the levels of the tempo variable produced no significant sex differences, though the difference for the SI subjects approached significance ($\overline{X}$ male = 113.36 versus $\overline{X}$ female = 103.38, $\underline{t}$ = 1.79, $\underline{p}$ < .087).

In summary, these data indicated that the four conceptual tempos did reflect the latency and error behaviors indicated by their various labels, and in general, there were no differences between sexes or among conceptual tempos in IQ. Specific differences in Composite IQ were, however, found for the SI subjects: SI males were more intelligent than were SI females; and for female subjects: FA females were more intelligent than were either SI or SA females.

DISCUSSION

In general, the results appear to support the feasibility of using the latency versus accuracy dual-median split procedure of identifying mean differences in MFF test behavior. This procedure produced four categories of subjects that did differ significantly from one another in directions that were compatible with the category labels.

Furthermore, while the percentage of subjects classified in the usually excluded FA and SI tempo conditions (27%) was less than the mean value (36%) calculated for the seventeen investigations cited above, the obtained value supports the argument that the exclusion procedure eliminates a substantial part of the sample and it will be argued results in the loss of information that is related to the conceptual tempo construct.

With regard to the relationships among the two MFF variables, latency and error, and the several dependent variables of the Canadian Lorge-Thorndike, the results only partially agree with the Eska and Black (1971) results. First, the relationship between MFF latency and error calculated for a sample including FA and SI subjects does not differ substantially from those earlier investigations cited above that excluded these subjects. The observed correlation ($\underline{r}$ = -.60) is similar to the values noted in the earlier investigations and it agrees with the value for this relationship that was reported by Eska and Black (1971). However, the latency and error scores of these two groups lie on opposite sides of their respective medians and would, when combined, tend to cancel one another and not affect the original relationship obtained for the FI (impulsive) and SA (reflective) tempo conditions. Examination of the mean latency and error scores of the SI and FA tempo groups indicates considerable support for this interpretation. Clearly, the relationship between latency and error on the MFF is more complex than that described by the reflection-impulsivity dimension and investigations of conceptual tempo can only benefit from a redefinition of the construct that includes the FA and SI performance conditions. Second, the correlation between MFF latency and IQ is not significant and it does not support the positive relationship between these variables reported by Eska and Black (1971). The nonsignificant correlation observed between MFF latency and verbal IQ does support the nonsignificant relationship reported by Eska and Black for this variable, but the nonsignificant correlations for the nonverbal and composite IQ variables are compatible with neither the Eska and Black (1971) results nor the predominantly positive, often significant correlations reported by several previous investigations that are summarized in Table 2. Further analysis of this relationship for each of the four tempo conditions indicated that while the latency-IQ relationship was not significant over all tempo conditions, there was a significant negative correlation for the FI tempo condition on the nonverbal IQ variable. This result was not anticipated and inspection of the data does not suggest a reason for it.

A similar relationship was observed between MFF errors and IQ. Over all four tempo conditions combined this relationship was not significant, but for the SA tempo on the nonverbal and composite IQ variables a significant negative correlation was obtained. This result is consonant with the position that MFF performance is positively related to nonverbal intelligence. What is not explained is why this relationship occurs only for SA subjects. Inspection of the magnitudes of the MFF latency and error correlations suggests a possible answer. The average MFF latency-error correlations are higher for fast subjects than they are for slow subjects, r's = -.395 and -.320, respectively. Therefore, MFF errors may be more a function of response speed than a function of intelligence for fast tempo subjects, and more a function of intelligence than a function of response speed for slow tempo subjects. The Canadian Lorge-Thorndike employs a multiple-choice test format with no penalty for guessing. Consequently, it is advantageous for a subject to answer the test items quickly to ensure that all test items are completed. Even if a subject does not know the answers, his score will increase in proportion to the change level of the number of questions completed. Since there is a time limit on each of the subtests of the Canadian Lorge-Thorndike, it seems reasonable to assume that given the difference in conceptual problem-solving speed between fast and slow conceptual tempo subjects, fast subjects would complete more IQ test items within the test time limits than would slow subjects; and thereby, spuriously benefit from a combination of speed and chance. In contrast, if slow subjects did not complete all test items, their IQ would be reduced in proportion to the chance value of the number of items not completed. In short, the Canadian Lorge-Thorndike Intelligence Test may be biased in favor of fast tempo subjects. While it is the case that the difference between the latency-error correlations of the fast and slow subjects is not significant, some evidence in support of the bias hypothesis comes from an analysis of the number of intelligence test items not completed by subjects in the four tempo conditions. For eight of the nine subtests in the verbal and nonverbal batteries, fast subjects completed more IQ test items than did slow subjects. One way analyses of variance performed on the mean numbers of items not completed, indicated that these differences were significant only for the nonverbal test battery; specifically for the pictorial similarities subtest ($F = 3.53$, $df = 3/171$, $p = .016$), the numerical seriation subtest ($F = 4.09$, $df = 3/171$, $p = .008$), and the total score for the nonverbal test battery ($F = 4.01$, $df = 3/171$, $p = .009$). Scheffe multiple comparisons of conceptual tempo means indicated that in the pictorial similarities subtest, SA subjects ($\bar{X} = 2.42$) omitted significantly more items than did FA subjects ($\bar{X} = .70$, $p = .087$); in the numerical seriation subtest, SA subjects ($\bar{X} = 4.93$) omitted significantly more items than did FI subjects ($\bar{X} = 2.76$, $p = .017$); and for the total nonverbal battery, SA subjects ($\bar{X} = 8.35$) omitted significantly more items than did either FI ($\bar{X} = 4.53$, $p = .032$) or FA subjects ($\bar{X} = 3.87$, $p = .086$). Considered in total, these results suggest that the IQ scores of fast subjects were augmented by their response speed. The significant negative correlation between MFF errors and IQ for SA subjects on the nonverbal and composite IQ scores, reflects the observation that on the nonverbal IQ measure (and by definition partly on the composite IQ measure) the relationship between MFF errors and IQ was little, if at all, biased by response speed. This observation of response latency bias in the IQ scores, suggests that the relationships reported between conceptual tempo and intelligence should be examined for this source of bias. In that almost all intelligence tests have specific time limits, it may be that the IQ levels of FI and SA subjects have repeatedly been, respectively, over- and underestimated.

With regard to the intelligence levels of the four tempos reported in Table 9, the results do not support Eska and Black's (1971) observation that reflective subjects were more intelligent than impulsive subjects on all but one (verbal intelligence) of the five Otis-Lennon Mental Ability Test measures of intelligence. In the present investigation, no significant main effect differences in intelligence were observed for either the sex or conceptual tempo variables. The interaction between these variables was significant, but further analysis indicated that the significant results were related to differences among subjects in verbal IQ, the only intelligence variable that did not show significant tempo differences in the Eska and Black investigation. Furthermore, the significant differences in intelligence between conceptual tempo groups observed in the interaction are contrary to those reported by Eska and Black. Specifically, the present results indicate that significant differences in intelligence exist only for SI subjects and for female subjects. Concerning the SI tempo condition, the simple effects analysis of the interaction indicated that the verbal IQ score of SI males was significantly higher than that of SI females. However, given that this difference was a completely unanticipated, marginally significant result that has not been reported in other investigations, it seems prudent to suspect this result may be due to Type I error. Among female subjects, FA tempo subjects were more intelligent than either SI or SA tempo subjects as indexed by the composite IQ variable. However, in that the composite IQ is the arithmetic average of the verbal and nonverbal IQ's, and the verbal IQ measure also indicated significant differences among tempo groups that were similar to composite IQ differences, it seems reasonable to conclude that the observed differences between tempos in intelligence were primarily a function of differences in verbal intelligence. In general, the results indicate that for male subjects the four conceptual tempo conditions do not differ in intelligence, while for female subjects, the differences in intelligence that do exist support the popular notion that fast-accurate performers are more intelligent than slow performers -- even when the latter perform accurately. However, the observation that the IQ scores of fast tempo subjects is inflated by their response speed suggests that the results of this and other investigations of the relationship between intelligence and conceptual tempo should be viewed with suspicion until the effect of the bias has been determined and controlled.

CHAPTER 4

EXPERIMENT TWO: PROBLEM DIFFICULTY AND CONCEPTUAL TEMPO

The second question that this investigation will attempt to answer concerns the nature of the FA and SI tempos and their relationship to the FI and SA tempo categories. It is anticipated that manipulation of the difficulty levels of conceptual tempo tasks will differentially change the latency-error relationships of the four categories of conceptual tempo. The direction and magnitude of these differential changes may provide information about postulated interrelationships among tempo categories and the problem-solving behaviors occurring within these categories.

To date, the only reported investigation of the relationship between problem difficulty and conceptual tempo includes a methodological difficulty that limits the generalizability of its results. Yando and Kagan (1970) manipulated MFF complexity by varying the number of available choice alternatives from two through twelve. A repeated measures design was employed in which each subject was administered one of ten modified MFF tests at weekly intervals, beginning with a two-alternative test and ending with a twelve alternative test. Subjects were classified on the basis of their performance on the standard six-alternative MFF into one of three categories: FI, SA, and non-extreme (above or below <u>both</u> the error and latency medians).

The results revealed significant differences between tempo categories on both the latency and error variables. While all groups showed an increase in response time as the number of alternatives increased, this effect was greatest for SA subjects and least for FI subjects. In contrast, the increase in errors corresponding to the increase in number of alternatives was greatest for FI subjects and least for SA subjects. For both dependent [illegible] non-extreme subjects occupied an intermediate position between the values for the SA and FI response styles. However, this position appears to be due to the pooling of scores from diagonal cells of the latency X error matrix. The non-extreme values are error and latency means calculated for subjects that were not within the dual-median criteria defining FI and SA subjects. These remaining subjects occupied both the FA and SI cells of the matrix, and the calculation of mean latency and error scores may seriously misrepresent the performance of both groups on both variables. An analogous procedure would be to average the latency and error scores of FI and SA subjects. The result would be subjects that respond at a moderate rate of speed and a moderate rate of error. This study strongly emphasizes the point made above concerning the operational definition of conceptual tempo; namely, that each cell created by the dual-median split should be included in conceptual tempo studies as separate levels of the tempo variable and analyzed accordingly.

In a second analysis of their data, Yando and Kagan (1970) compared the performance of subjects who were consistently FI, SA, or non-extreme, across all 10 MFF administrations. The stability of response styles is indicated by the relatively large percentage of subjects who maintained their original response style classification for 10 separate MFF administrations. These percentages were as follows: 57% consistently FI, 54% consistently SA and 64% consistently non-extreme. These subsamples dramatically mirrored the results for the total group. Consistently SA subjects showed no increase in errors across tests, despite the increase in difficulty. These subjects did, however, show increases in response latency that corresponded to increases in task difficulty (e.g., 17 seconds for the 2-variant test versus 58 seconds for the 12-variant test). In contrast, FI subjects showed no significant increase in response latency in response to the increase in task difficulty (e.g., 9 seconds for the 2-variant test versus 12 seconds for the 12-variant test). In short, SA subjects adjusted response latency in accord with problem difficulty; FI subjects did not.

A qualification to this generalization about latency adjusting is that at least a part of the increase in response errors of FI subjects may have been due to the increasing number of alternatives, rather than to increased problem difficulty. Evidence in support of this argument comes from a consideration of the error data of several tempo investigations (Meichenbaum & Goodman, 1969; Odom et al., 1971;

Ridberg, Parke, & Hetherington, 1971). These data indicate that the error rate of FI subjects approximates a chance level of responding. Consequently, if subjects simply guessed answers, the number of errors committed would be a function of the number of alternatives available. Inspection of the Yando and Kagan data indicates that the number of errors committed is relatively proportional to the number of alternatives available. For this reason it is not certain whether the increased number of errors was due to the increased difficulty of processing information from additional alternatives, or simply the reduced chance of guessing correctly. A better test of the difficulty hypothesis would hold constant the number of available response alternatives and manipulate difficulty within that constraint.

Yando and Kagan note that the generality of their results is limited by the confounding of task difficulty with a practice effect. This occurred as a result of the constant order of administration of tasks in which the number of alternatives increased linearly each week. It would be expected that experience gained during the task would reduce the difficulty levels of tasks occurring later in the series.

While the Yando and Kagan (1970) study provides some information about the relationship between problem difficulty and conceptual tempo, the practice of combining the results for FA and SI subjects, the varying number of alternatives affecting the level of chance, and the occurrence of a confounding practice effect -- all suggest that further investigation of this relationship may provide additional information about conceptual tempo. Specifically, if problem difficulty were varied within the context of a conventional six-variant, matching-to-sample, conceptual tempo task, the results would not be biased by a practice effect or the alteration of the level of chance, and the task would more closely approximate the MFF classification task than did the Yando and Kagan (1971) procedure. This alternative method of difficulty manipulation, combined with the inclusion of each of the four tempo classifications in the experimental design, should provide information about the stability of the tempo classifications, and the directions and magnitudes of changes in the error-latency ratios that define the tempo classifications. This information would facilitate understanding of the tempo construct in two ways. First, it would indicate which, if any, of the tempo categories were interrelated. Second, evidence of interrelationships or their absence would facilitate the task of determining the validity of the conceptual tempo construct. The primary concern of an examination of the relationship between conceptual tempo and problem difficulty is the determination of the consequences of increases in problem difficulty for each of the four conceptual tempos defined by a dual-median split. While this relationship has not been reported for FA and SI subjects, the tempo literature does make it possible to suggest probable directions and magnitudes of change for SA and FI subjects, and the possibility of a problem-solving process similarity between SA and FA subjects on one side of the accuracy median, and FI and SI subjects on the other. From these two observations, it is possible to deduce testable consequences for the error and latency scores of FA and SI subjects.

First, consider evidence on the relationship between problem difficulty and conceptual tempo. Yando and Kagan (1970) have reported that for SA subjects, increased levels of problem difficulty were associated with increased latency, but not increased error. In contrast, for FI subjects increased difficulty was associated with increased error, but not increased latency. Non-extreme subjects (FA and SI subjects combined) showed a moderate increase in score on both the latency and error variables with each increase in problem difficulty.

Given that the data for SA and FI subjects is acceptable, what might account for the observed relationship of "non-extreme" subjects? It could be the product of an increase in both errors and latency for both the FA and SI groups. It might also be a product of an increase in errors for one tempo and an increase in latency for the other. While adequate evidence to support a decision between these alternatives is lacking, there is one observation from the tempo literature that may be interpreted as support for the latter position. In one of the few evaluations of the problem-solving strategies of all four tempo categories reported to date, Ault et al. (1972) studied the visual scanning strategies of subjects in each of the four quadrants resulting from bifurcation of the latency and error performance dimensions of the MFF. Data from video recordings of eye movements of the subjects indicated that all children employed a paired-comparison scanning strategy to solve MFF problems. In comparison with FI or SI subjects, the low error rates of SA and FA subjects appear to result from spending a larger proportion of time making systematic "returns", i.e., viewing one stimulus, then another, then returning to view the first stimulus again. In addition to quantitative differences in the number of returns made by high- and low-error-rate subjects, a post hoc analysis revealed qualitative differences in the types of returns employed by these two classes of subjects. An additional variable, extent of returns, was defined as the extent of a series of return fixations between the same two stimuli. This variable indicated that while high-error subjects tended to alternate their gaze back and forth many times between the same two stimuli prior to fixating a different stimulus, low-error subjects made a greater variety of systematic comparisons by alternating their gaze between two stimuli and frequently applying this viewing strategy to <u>various pairs</u> of stimuli. Ault et al. interpret this result as an indication that SA subjects employ a more systematic scanning pattern than do FI and SI subjects. These investigators also note that FA subjects have a higher rate of returns than FI subjects, but have an equivalent average response latency. From this result they conclude that FA subjects also employ a different scanning pattern than do FI subjects. A difficulty with this interpretation is that FA subjects were found to view significantly fewer variants and have a significantly higher "extent of returns" rate than the other three MFF groups. The difficulty arising from this finding is that a non-significant difference between SA and FI subjects on the "extent of returns" dependent variable was interpreted as evidence that the higher percentage of all returns of SA subjects was attributable to a more systematic scanning pattern among various pairs of alternatives, rather than a more diligent application of the process used by FI subjects. It would seem that if this interpretation were extended to FA subjects, their scanning strategy would ironically have to be described as a diligent application of the scanning strategy of FI subjects. While Ault et al. do not speculate about the nature of the scanning pattern of FA subjects, their results lead to the anomalous conclusion that these subjects solve MFF problems by rapidly executing a large number of paired comparisons on a restricted subset of the available alternatives. The anomaly of this result is two-fold. First, the result that FA subjects viewed significantly fewer variants than did all other classes of subjects does not seem consistent with the low rate of error reported for these subjects. Second, the result that the scanning strategy of FA subjects appears to be an extensive application of the strategy used by FI subjects suggests that the low error rates of SA and FA subjects may not be a simple consequence of a greater number of return fixations. Both of these results suggest that FA subjects may employ a visual scanning strategy different from those used by subjects in each of the other MFF performance categories. The fixation of fewer variants and numerous return fixations on the same two stimuli suggest that FA subjects may intensively search only a few of the available alternatives until either feature differences are located within each of the alternatives and the search is transferred to other alternatives, or no feature difference is located in an alternative and a match is reported. Support for this speculation is suggested by the result reported in Ault et al. that FA subjects fixated the standard stimulus a significantly greater number of times than did either SI or FI subjects. A clear implication of the work of Ault et al. (1972) is that the inclusion of FA and SI subjects adds a new dimension to the study of conceptual tempo. Their results suggest to this writer that for the purpose of determining the relationship between latency and accuracy in alternative choice behavior, it may be more helpful to consider individual differences in latency <u>within</u> accuracy classifications rather than <u>between</u> these classifications. On the basis of this observed dissimilarity in the scanning strategies of the accurate and inaccurate tempo categories reported by Ault et al. (1972), and the results of Yando and Kagan (1970) for SA and FI subjects, the following hypotheses were postulated:

(1) For both SA and FA subjects, response latency will increase significantly as a function of problem difficulty.

(2) For both FI and SI subjects, response errors will increase significantly as a function of problem difficulty.

(3) For all conceptual tempo subjects combined, the correlation between response latency and errors will increase directly as a function of problem difficulty.

METHOD

Subjects

Fifty-eight male and forty-six female student volunteers, enrolled in three grade five classes in a middle-class elementary school, participated in the experiment. The average age of the subjects was 129 months, with a standard deviation of 6.45 months. Following an administration of the MFF, subjects were classified into one of four conceptual tempo categories according to the conventional dual-median split procedure. The median values obtained were 116.19 seconds and 9.39 errors. The resulting distribution of subjects is presented in Table 12.

In accord with Ferguson's recommendation (Ferguson, 1971, p. 203), equal cell sizes were obtained by randomly

TABLE 12

Distribution of Problem Difficulty Subjects Produced by the MFF Classification Task

Sex	Conceptual Tempo FI	SI	FA	SA	Total
Male	30	7	8	13	58
Female	17	6	7	16	46
Combined	47	13	15	29	104

selecting from each cell the number of subjects equal to that of the smallest cell. In the present case, thirteen subjects were initially selected from each cell. However, due to the prolonged absence of two subjects in the small SI cell, it was necessary to randomly reduce the remaining cells to a final size of eleven subjects.

Apparatus

The apparatus was the same as that described in Experiment One.

Procedure

Initially, the MFF was administered to each of the 44 subjects. Beginning three days later, each subject was administered a difficulty-ordered matching-to-sample test similar to the MFF. For convenience this test was called the Conceptual Tempo Test (CTT). Three sample items from the CTT are presented in Appendix E. The CTT is a twelve-item, six-alternative, matching-to-sample task with two practice items to assist the subject. Unlike the MFF, the items of the CTT are ordered into three levels of difficulty: high, medium, and low, by means of redundant information in the form of feature differences between the standard and the alternative. At the lowest level of difficulty (LD) each alternative, except the correct alternative has three feature differences between it and the standard figure. In that it is only necessary to identify one feature difference to render an alternative incorrect, the two additional differences are redundant and serve only to increase the probability of the item being detected as being different from the standard by the subject. At the moderate level of difficulty (MD) two feature differences result in one redundant feature and at the highest level of difficulty (HD) no redundant feature differences occur -- as is the case for the MFF items. There are four CTT items at each of the three levels of difficulty. The CTT was administered and scored in accord with the procedure outlined in Experiment One for the MFF.

Design

A two-way factorial, fixed effects model analysis of variance was used to analyze mean differences in response latencies and errors on the CTT. The two factors analyzed were problem difficulty (high, medium, and low difficulty levels) and conceptual tempo (FI, SI, FA, and SA). If the interaction effect was significant, tests on main effects were then replaced by analyses of simple main effects (Winer, 1971, pp. 435-442). Individual comparisons were tested by $\underline{t}$ tests or Newman-Keuls Sequential Range tests, depending upon which tests were appropriate. A probability level of $\alpha = .05$ was accepted for all tests of significance.

RESULTS

Table 13 presents the performance data of the four conceptual tempo categories for the difficulty-ordered CTT.

TABLE 13

Performance Data of Conceptual Tempo Subjects on the Conceptual Tempo Test

Tempos	FI				SI				PA				SA			
Difficulty	LD	MD	HD	Total	LD	MD	HD	Total	LD	MD	HD	Total	LD	MD	HD	Total
CTT Latencies																
$\overline{X}$	30.36	38.[illegible]	39.55	[illegible].45	50.82	69.09	91.89	211.73	31.00	41.89	46.00	118.52	52.58	82.82	92.00	227.64
S	11.07	[illegible]	25.81	[illegible].89	16.96	27.62	62.67	103.89	7.23	15.54	21.10	39.87	11.08	20.61	42.69	65.75
CTT Errors																
$\overline{X}$	2.18	5.18	5.73	13.09	1.55	3.46	4.27	9.27	1.64	5.46	5.82	12.91	1.00	2.09	3.18	6.27
S	1.17	2.04	3.47	3.94	1.21	2.02	3.17	5.04	1.29	2.66	3.19	5.45	1.27	1.38	2.75	3.77

NOTE: The abbreviations "LD", "MD", AND "HD" represent the low, medium and high difficulty levels, respectively.

A two-way analysis of variance (tempo X difficulty) on the mean CTT response latencies revealed that both the tempo (F = 8.68, df = 3/40, $p < .001$) and difficulty (F = 22.47, df = 2/80, $p < .000001$) main effects were significant (see Table 14). Newman-Keuls multiple comparisons of the tempo means revealed that FI and FA subjects take less time to respond to CTT items than do either SI or SA subjects (all p's < .01).[4] No other differences between tempos were significant. Newman-Keuls multiple comparisons of CTT difficulty means indicate that problem difficulty was orthogonal; LD problems took less time than MD problems ($p < .01$) and MD problems took less time than did HD problems ($p < .05$). In short, the latency measures supported the information redundancy distinction between stimuli as a valid index of problem difficulty for the experiment.

A significant interaction was also obtained between the tempo and difficulty variables, thus necessitating the analysis of simple main effects. One-way simple effects analyses of variance and Newman-Keuls multiple comparisons of mean response latency differences among tempos indicated significant tempo differences occurred at all three levels of difficulty. The magnitude of these differences was as follows: LD (F = 11.25, df 3/40, $p < .001$), MD (F = 11.72, df = 3/40, $p < .0001$), and HD (F = 5.21, df = 3.40, $p < .01$).

---

[4]Complete summary statistics for the main effects analysis of variance and, when significance levels warrant, the simple effects analyses and Newman-Keuls multiple comparisons are presented as consecutive tables in Appendix F.

TABLE 14

Tempo X Difficulty Analysis of Variance of Mean CTT Response Latencies

Source	SS	df	MS	F	p
Between Subjects	106216.75	43			
A (Tempo)	41895.13	3	13965.04	8.68	<.001
Subjects Within Groups	64321.81	40	1608.05		
Within Subjects	47798.00	88			
B (Difficulty)	15393.82	2	7696.91	22.47	<.0000001
A X B	5002.90	6	833.82	2.43	<.05
B X Subjects Within Groups	27401.56	80	342.52		

The Newman-Keuls multiple comparisons among means indicated that the pattern of significant differences among means was the same for each level of difficulty; namely, that FI and FA tempo subjects take significantly less time to respond to CTT items than do SI and SA tempo subjects, and that within the fast and slow latency conditions the differences between the accurate and inaccurate subjects is not significant. This interaction is more clearly demonstrated in Figure 5.

Simple effects analyses of variance and appropriate Newman-Keuls multiple comparisons of problem difficulty level latency means for each conceptual tempo were also conducted. These analyses indicated that response latencies varied directly with problem difficulty for FA, SI, and SA subjects ($F = 6.31$, $df = 2/20$, $p < .01$; $F = 6.73$, $df = 2/20$, $p < .01$; and $F = 9.95$, $df = 2/20$, $p < .001$, respectively). In contrast, no significant latency differences were obtained for FI subjects. Newman-Keuls multiple comparisons revealed that for FA subjects LD problems required less time than did either MD or HD problems ($p < .05$, and $p < .01$, respectively). The response latency difference between MD and HD problems was not significant. A similar pattern of differences occurred for both the SI and SA conditions, except that for SI subjects the difference between the response latencies for low and medium difficulty problems was not significant.

Response errors on the CTT are also presented in Table 13. A two-way analysis of variance (tempo x difficulty)

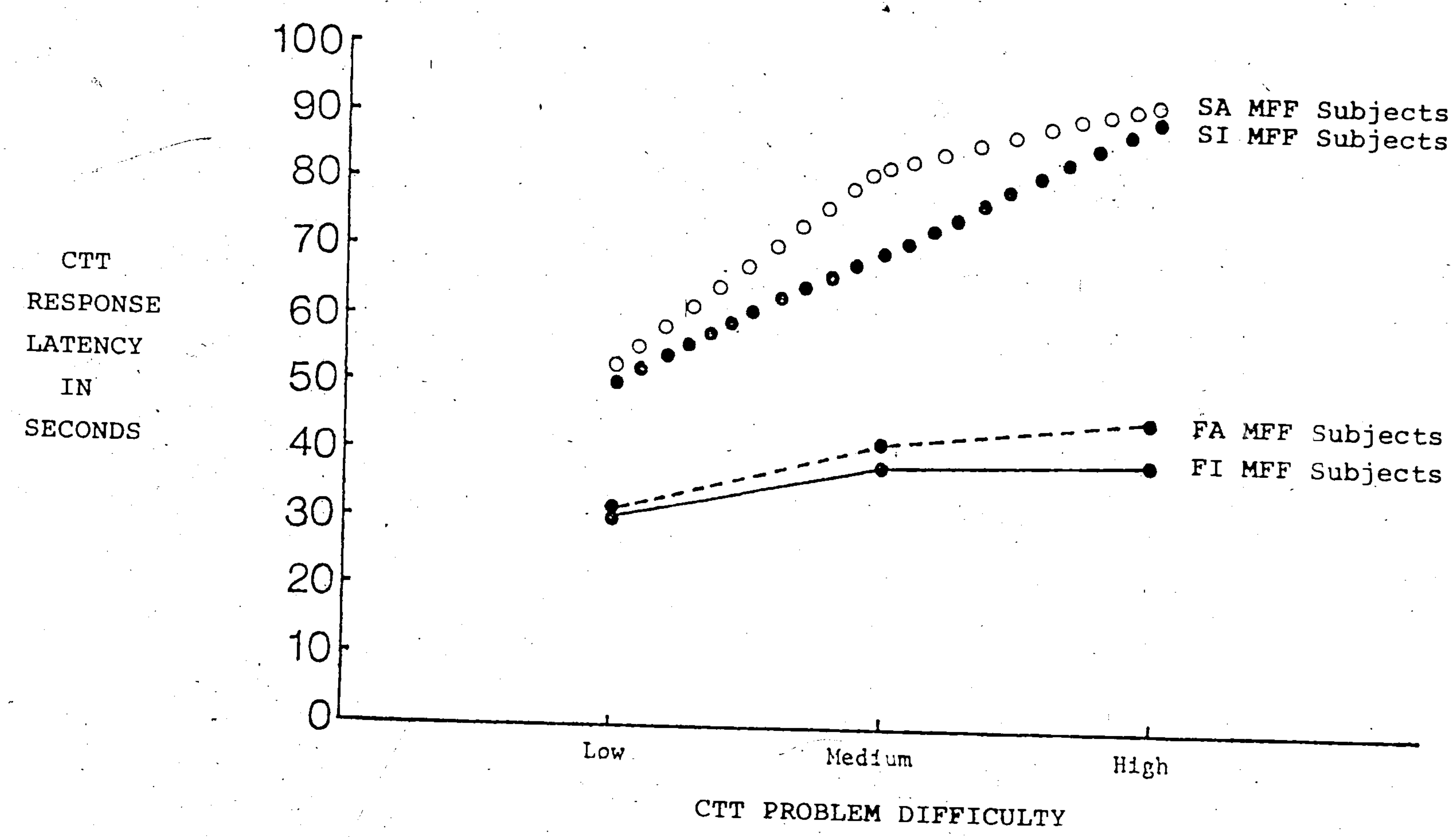

FIGURE 5. Response latency means for four conceptual tempo categories on the difficulty levels of the CTT.

conducted on these data produced significant main effects for the tempo variable ($F = 5.51$, $df = 3/40$, $p < .003$), and the difficulty variable ($F = 27.83$, $df = 3/40$, $p < .0000001$), with no significant interaction (see Table 15).

Newman-Keuls multiple comparisons of classification tempos indicated that FI and FA subjects committed more CTT errors than did SI and SA subjects (p's $< .01$). In addition, SI subjects committed more errors than did SA subjects (p's $< .05$). Figure 6 better illustrates these results.

Newman-Keuls multiple comparisons of CTT error means for the significant problem difficulty main effect indicated that LD problems produced fewer errors than either MD ($p < .01$) or HD ($p < .01$) problems. However, the error difference between MD and HD problems failed to reach significance. Consequently, the redundancy based method of establishing different levels of problem difficulty was only partially valid for the errors variable. It should be noted, however, that while some of the differences between difficulty levels were not significant for the latency and/or error variables, all differences were in the expected direction.

In summary: first, the latency variable and in part the error variable of the CTT support the distinctions made among the three difficulty levels of the CTT. Second, both the latency and error variables of the CTT indicate that the FI and FA conceptual tempo subjects perform differently from the SI and SA tempo subjects on tasks involving different levels of problem difficulty. Third, conceptual tempo inter-

TABLE 15

Tempo X Difficulty Analysis of Variance of Mean CTT Response Errors

Source	SS	df	MS	F	p
Between Subjects	399.48	43			
A (Tempo)	116.75	3	38.92	5.51	<.003
Subjects Within Groups	282.73	40	7.07		
Within Subjects	615.33	88			
B (Difficulty)	242.01	2	121.01	27.83	<.0000001
A X B	25.50	6	4.25	0.98	>.05
B X Subjects Within Groups	347.82	80	4.35		

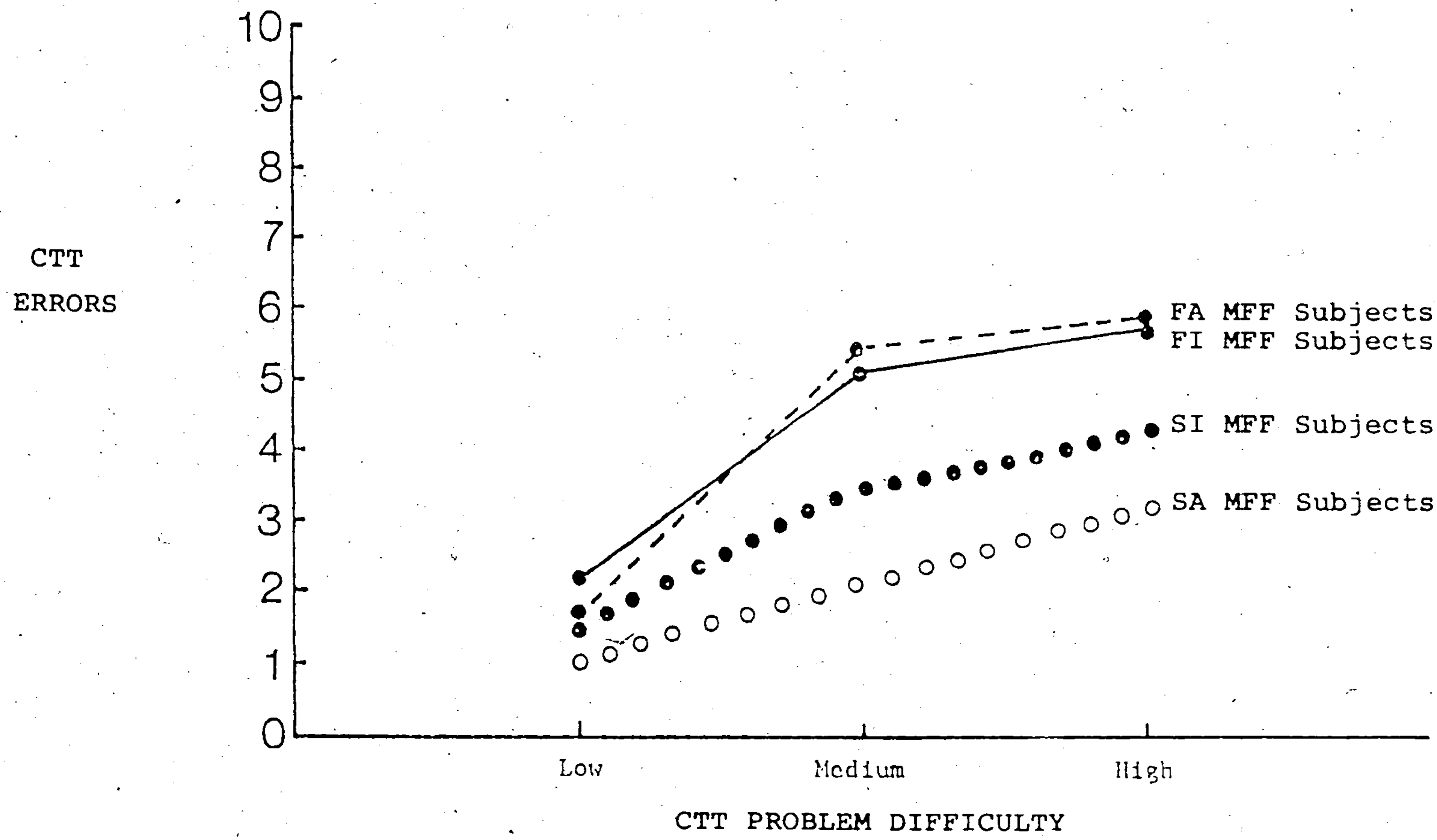

FIGURE 6. Response error means for each of four MFF determined conceptual tempo categories on the difficulty levels of the CTT

acts with problem difficulty to affect response latencies. The effect of difficulty levels on conceptual tempo latency differences was that although the pattern of tempo latencies, FI ≈ FA < SI ≈ SA, remained constant across the difficulty levels of this experiment, the latency scores within tempos, particularly the SI and SA conditions, became increasingly heterogeneous with increasing levels of difficulty. The effect of individual tempos on the levels of problem difficulty was quite varied. Fast-inaccurate subjects did not significantly change their response latencies for any level of problem difficulty. The remaining three tempos did spend significantly less time on LD problems than HD problems, but they did not temporally differentiate between MD and HD level problems and SI subjects did not temporally differentiate between LD and MD level problems. Finally, the two accurate tempo categories, FA and SA, took a significantly shorter period of time to complete LD problems than to complete MD problems or HD problems. For the CTT errors variable, FI and FA subjects made significantly more errors than SI subjects, who, in turn, made significantly more errors than SA subjects. In addition, the problem difficulty main effect indicated that LD problems produced a significantly greater number of errors than MD and HD problems. The difference between the latter two difficulty levels was not significant.

With one exception noted, the foregoing analyses suggest that it is response latency rather than response accuracy which is significantly related to both the response latency and error variables of the CTT. Unfortunately, by definition the conceptual tempo classifications confound the latency and error variables; such that, it is not possible to maintain the traditional classifications and assess the separate effects of MFF latency and errors on CTT performance. Since the data from this experiment indicate that such as assessment may clarify the role of problem difficulty in conceptual tempo, the traditional, conjoint MFF latency and error tempo classifications were abandoned in favor of separate latency and error classifications to determine the independent effects of each variable upon CTT performance. Means and standard deviations for these variables are presented in Table 16 and are summarized graphically in Figures 8 and 9 to better illustrate the pattern of results. Three-way analyses of variance (latency X errors X difficulty) were conducted on the CTT latency and error means (Tables 17 and 18, respectively). The pattern of significant differences is quite similar for both variables; that is, the latency main effects are significant for both the CTT latency (F = 25.64, df = 1/40, $p < .00001$) and error (F = 14.17, df = 1/40, $p < .001$) variables; the difficulty main effects are also significant for both the latency (F = 22.47, df = 2/80, $p <$ .000[illegible]) and error (F = 27.83, df = 2/80, $p < .0000001$) variables; and the main effects for the MFF errors variable are not significant for either of the CTT dependent variables. In addition, the only significant

TABLE 16

Conceptual Tempo Test Latency and Error Results as a Function of Subjects Original MFF Latency and Error Classifications

	MFF Latency Original Classification						MFF Error Original Classification					
	FAST			SLOW			ACCURATE			INACCURATE		
CTT Problem Difficulty	LD	MD	HD	LD	MD	HD	LD	MD	HD	LD	MD	HD
CTT Latencies												
$\overline{X}$	30.69	40.18	42.77	51.82	75.95	91.91	40.59	53.82	65.68	41.91	62.32	69.00
S.	8.92	15.73	22.71	13.70	24.23	51.12	17.06	26.74	52.64	14.09	26.89	39.49
CTT Errors												
$\overline{X}$	1.91	5.32	5.78	1.27	2.77	3.73	1.32	3.77	4.50	1.86	4.32	5.00
S	1.20	2.26	3.18	1.21	1.78	2.88	1.26	2.63	3.13	1.13	2.12	3.25

NOTE: The abbreviations "LD", "MD", and "HD" represent the low, medium, and high CTT difficulty levels, respectively.

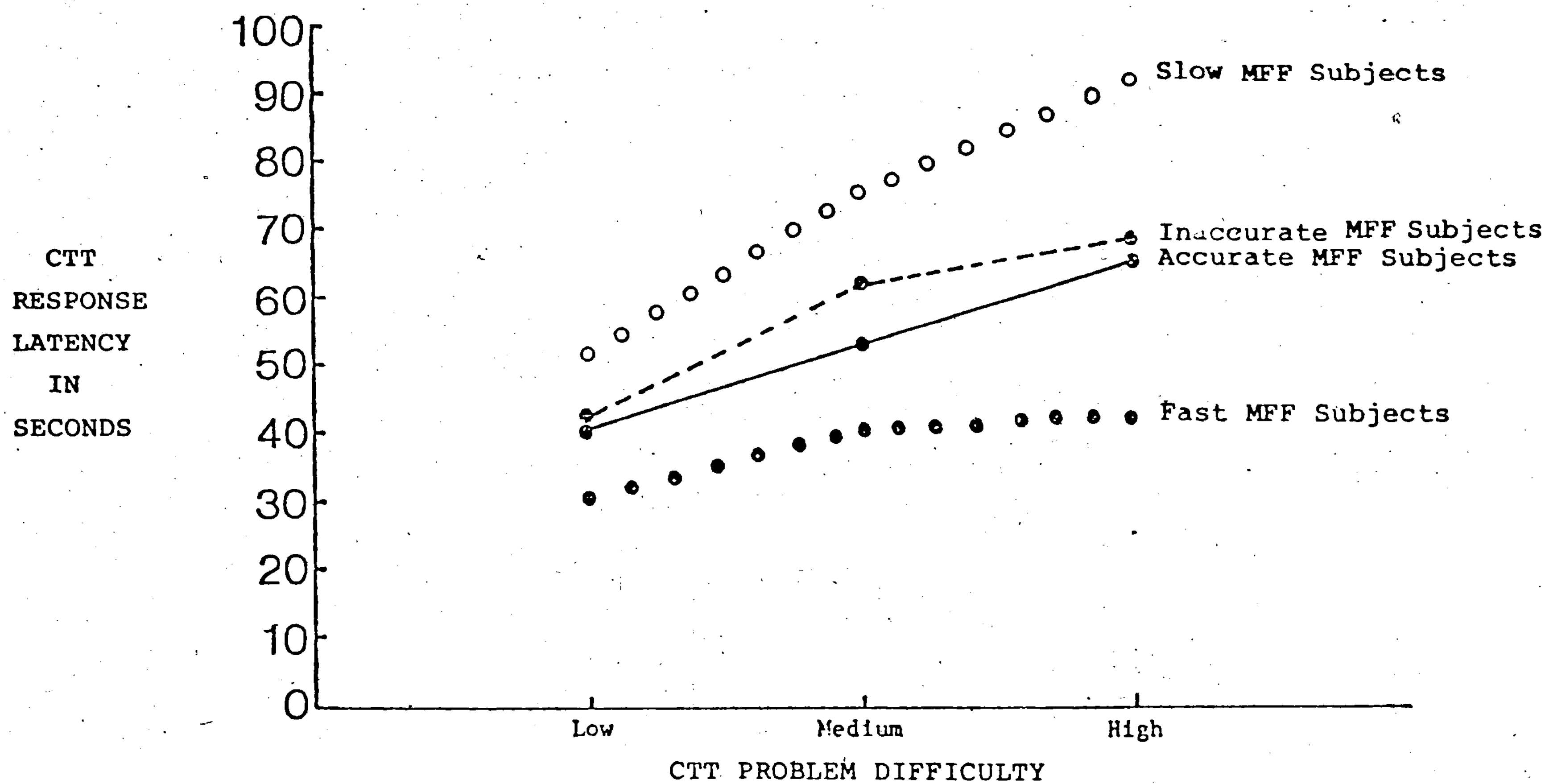

FIGURE 7. Conceptual tempo test latency means for separate MFF latency and error classifications

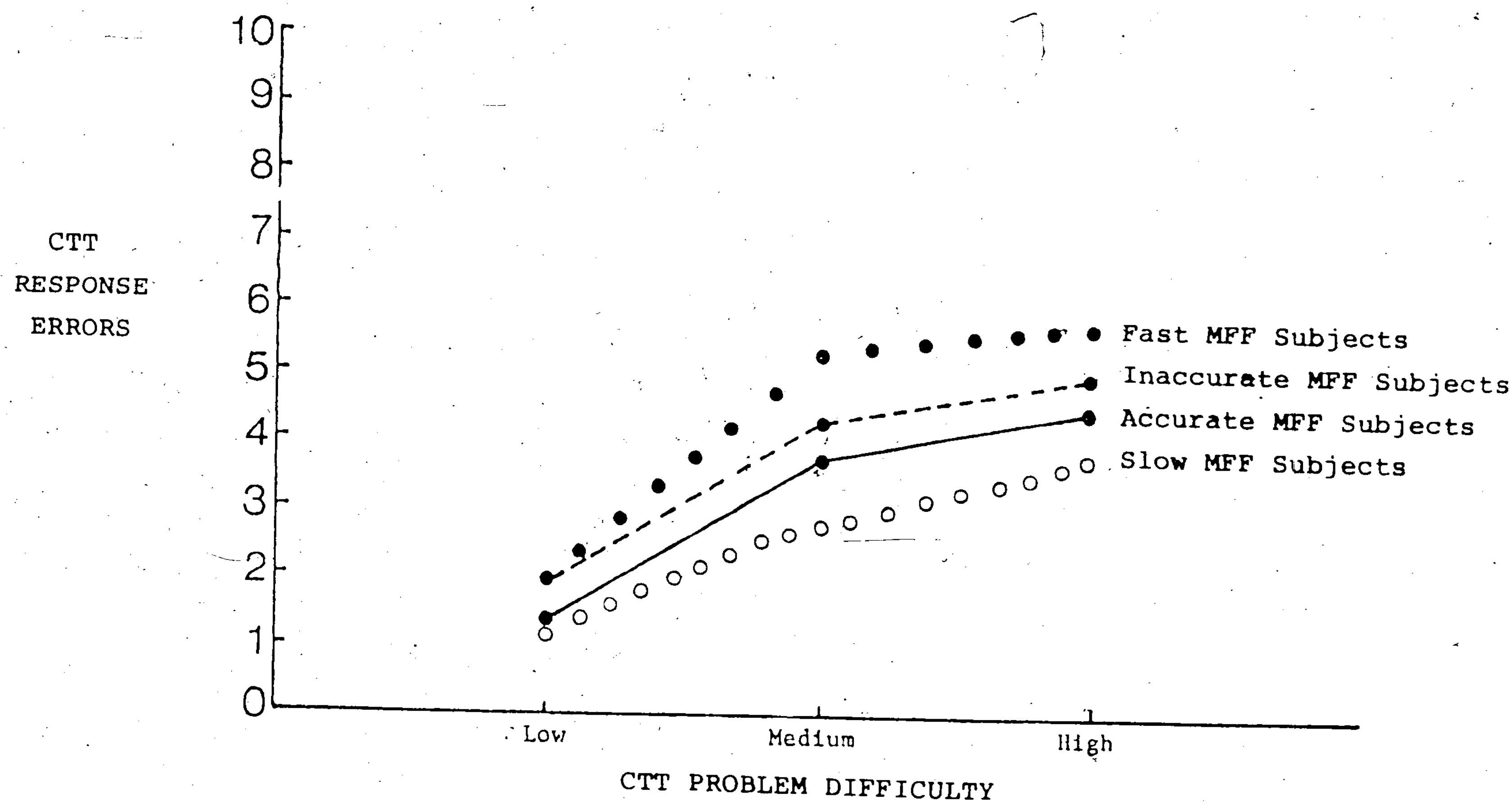

FIGURE 8. Conceptual tempo test error means for separate MFF latency and error classifications

TABLE

Summary Analysis of Variance of Mean Changes in Response Latency for Three Levels of Problem Difficulty

Source	SS	df	MS	F	p
Between Subjects	106216.75	43			
Response Latency	41234.06	1	41234.06	25.64	<.00001
Response Errors	632.63	1	632.63	.39	NS
Latency X Errors	28.31	1	28.31	.02	NS
Subjects Within Groups	64321.75	40	1608.04		
Within Subjects	47798.00	88			
Problem Difficulty	15393.75	2	7696.88	22.47	<.0000001
Latency X Difficulty	4314.94	2	2157.47	6.30	<.01
Errors X Difficulty	302.38	2	151.19	.44	NS
Latency X Errors X Difficulty	385.56	2	192.78	.56	NS
Difficulty X Subjects Within Groups	27401.38	80	342.52		

TABLE 18

Summary Analysis of Variance of Mean Changes in Response Errors for Three Levels of Problem Difficulty

Source	SS	df	MS	F	p
Between Subjects	399.48	43			
Response Latency	100.19	1	100.19	14.17	.001
Response Errors	9.28	1	9.28	1.31	NS
Latency X Errors	7.28	1	7.28	1.03	NS
Subjects Within Groups	282.73	40	7.07		
Within Subjects	615.33	88			
Problem Difficulty	242.02	2	121.01	27.83	.0000001
Latency X Difficulty	21.56	2	10.78	2.48	NS
Errors X Difficulty	.02	2	.01	.00	NS
Latency X Errors X Difficulty	3.92	2	1.96	.45	NS
Difficulty X Subjects Within Groups	347.82	80	4.35		

interaction obtained was the latency X difficulty interaction for the CTT latency variable.

Post hoc Newman-Keuls multiple comparisons of difficulty level means for the CTT error variable indicate that LD problems produced significantly fewer errors than did either MD or HD problems (p's $< .01$). The mean number of errors did not differ significantly between the MD and HD levels. With regard to the latency factor, the data indicate that fast subjects committed a significantly greater number of CTT errors than did slow subjects ($F = 14.17$, $df = 1/40$, $p < .001$).

The significant latency X difficulty interaction obtained for the CTT latency variable necessitates simple effects analyses of variance for both these factors. Beginning with the latency factor, simple effects analyses of variance and Newman-Keuls multiple comparisons of mean CTT latencies indicate the presence of significant differences in response latency on the three difficulty levels of the CTT for both fast ($F = 8.49$, $df = 2/42$, $p < .0009$) and slow $= 15.90$, $df = 2/42$, $p < .00001$) subjects. The Newman-Keuls multiple comparisons indicate that both fast and slow subjects take significantly less time to solve LD than or HD level problems (p's $< .01$). The comparisons also indicate that slow subjects also spend significantly less time on MD problems than they do on HD problems ($p < .05$). This same relationship is not significant for fast subjects.

Finally, independent sample t tests performed on the latency means of fast and slow subjects at each level of CTT difficulty indicated that slow subjects spent significantly more time on the problems at each level of difficulty than did fast subjects (LD $t = 5.93$, $p < 0000006$;[5] MD $t = 5.68$, $p < 000002$; HD $t = 4.03$, $p < .0003$).

In summary, Figure 9 presents a general outline of the results obtained. Analysis of the CTT latency and error scores as separate dependent variables produced the following results. First, the problem difficulty manipulation was only partially successful for both the CTT error and latency variables. In terms of CTT errors, LD problems produced fewer errors than either MD or HD problems, but the error difference between MD and HD problems was not significant, albeit in the right direction. For the CTT latency variable, a significant latency X difficulty interaction necessitated separate analysis of problem difficulty latencies for slow and fast subjects. For fast subjects, the pattern of differences paralleled that obtained for the CTT errors variable; that is, LD problems required less time than either MD or HD problems, while the latter two levels did not differ significantly. In contrast, for slow subjects LD problems required less time than MD problems and in turn MD problems required less time than HD problems. Second, the MFF latency variable was significant for both the CTT error and latency

---

[5] t values expressed are all for $df = 42$, and probability values stated are for two-tail tests of significance.

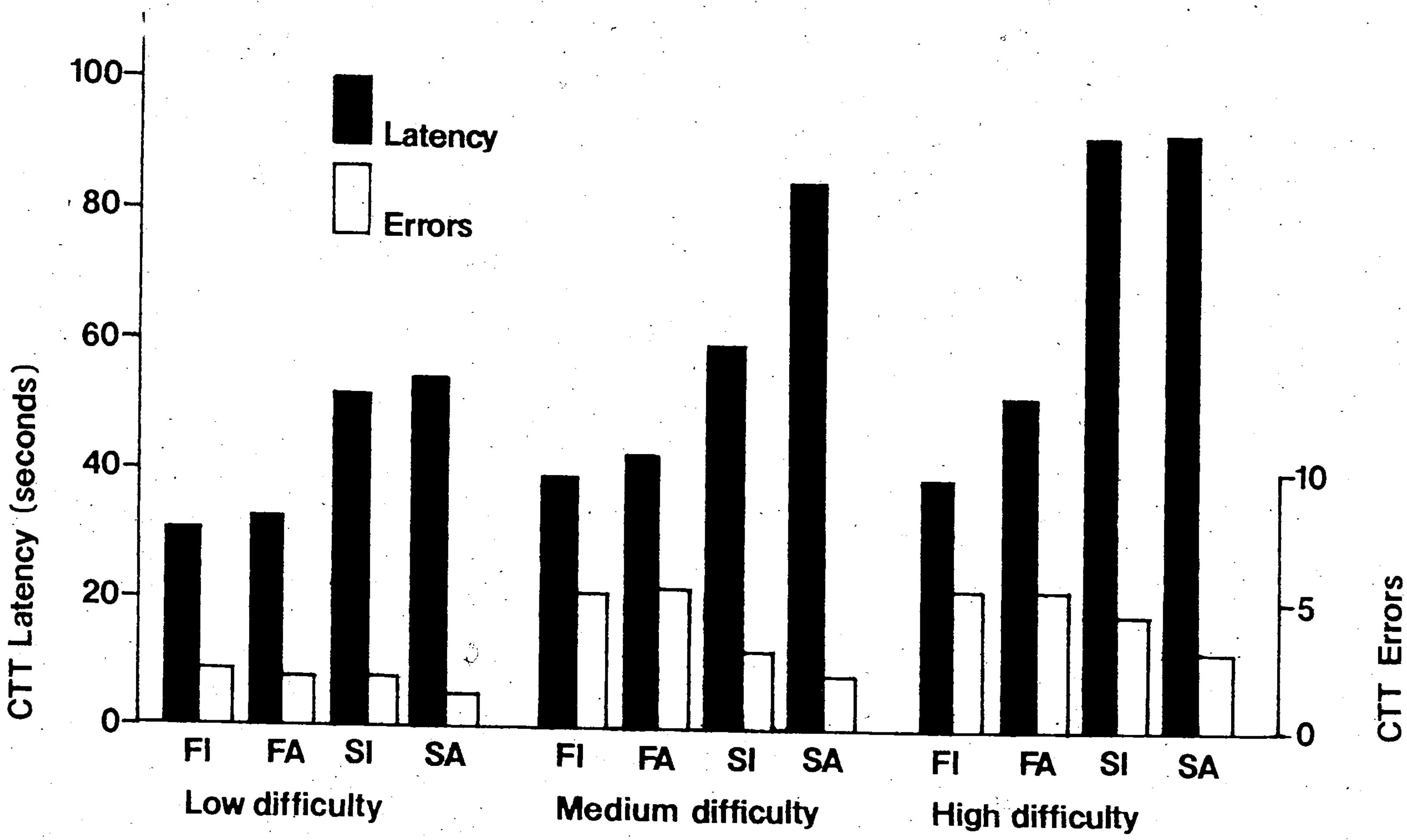

FIGURE 9. Conceptual tempo test response latencies and errors for four conceptual tempos and three levels of problem difficulty.

variables. With regard to CTT errors, a significant main effect indicated that slow subjects made fewer errors than fast subjects at all levels of problem difficulty. For the CTT latency variable, analysis of the significant latency X difficulty interaction revealed that fast subjects consistently took less time than slow subjects at all difficulty levels of the CTT. Third, and finally, MFF errors as a separate independent variable did not significantly account for variance on either the CTT latency or errors variable.

Correlations between the CTT latency and error variables are presented in Table 19. The most noteworthy aspect of these data is the curvilinear relationship of the correlation between CTT latency and error. At all levels of problem difficulty for the latency variable the correlations for the levels of the error variable display a consistent pattern; namely, that while all latency-error correlations are negative and significant, the values for MD problems are consistently higher than those for either LD or HD problems. It is also noteworthy that while the CTT latency intercorrelations for the three levels of difficulty are all exceptionally high, the intercorrelations for the CTT errors variable are quite low. In fact, the correlations between the LD level and both the MD and HD levels failed to be significant (r = .13, and r = .12, respectively). Inspection of the mean error values suggests that the LD task was not sufficiently difficult to reliably discriminate among the four tempo categories. However, despite the apparent

TABLE 19

Conceptual Tempo Test Inter-Correlations

	CTT Latency				CTT Errors			
	LD	MD	HD	Total	LD	MD	HD	Total
CTT Latency								
LD	1.00	0.86**	0.78**	0.88**	-0.44**	-0.64**	-0.31*	-0.59**
MD		1.00	0.88**	0.96**	-0.43**	-0.71**	-0.36*	-0.65**
HD			1.00	0.97**	-0.48**	-0.53**	-0.30*	-0.54**
Total				1.00	-0.48**	-0.64**	-0.34*	-0.61**
CTT Errors								
LD					1.00	0.13	0.12	0.37*
MD						1.00	0.52**	0.81**
HD							1.00	0.88**
Total								1.00

*p < .05 (two-tail)
**p < .01 (two-tail)

simplicity of the task, slow subjects still allotted a significantly greater amount of time for the task than did fast subjects.

Considered in total, separate analyses of the latency and error variables appear to yield a more parsimonious explanation of the relationship between conceptual tempo and problem difficulty than does the conventional, combined analysis. Differences in CTT performance at all levels of difficulty and for both the latency and error variables appear to be associated with individual differences in MFF latency, not MFF errors.

DISCUSSION

The observed lack of importance of the MFF error factor was not at all anticipated. On the contrary, the underlying rationale for the stated hypotheses was that within the confounded contexts of tempos operationally defined by median-split combinations of latency and error, error would be the dominant variable. Consequently, several hypotheses were not supported. Specifically, hypotheses one and two predicted that with increasing problem difficulty, accurate subjects, whether they were slow or fast, would maintain their accuracy by reducing their response speed; while inaccurate subjects, whether slow or fast, would proceed at the same speed, regardless of problem difficulty, and still further reduce their accuracy level. These hypotheses were partially supported for SA and FI tempo subjects. This part of the prediction was based upon and clearly supports the results of Yando and Kagan (1970). Consequently, one would conclude that the confounding effects of practice and the differential probability of guessing correctly were not substantial in their investigation. The hypotheses were not supported by the results for the FA and SI tempo subjects. Fast-accurate subjects responded to increasing difficulty by maintaining their speed and decreasing their accuracy. Slow-inaccurate subjects decreased their speed and maintained their level of accuracy. It is noteworthy that while the CTT latency and error values of the FA and SI subjects are significantly different, they would if combined, approximate mid-point values between the FI and SA tempo subjects and would resemble Yando and Kagan's (1970) "non-extreme" subjects. The tempo results do not support the inference made from the Ault et al. (1972) investigation of the visual scanning patterns of the four conceptual tempos. Accurate subjects do not differ significantly from inaccurate subjects, in spite of the significantly different scanning patterns reported by Ault et al. (1972). It was also noted that in the Ault et al. investigation, the scanning strategy of FA subjects was unusual in that these subjects fixated significantly fewer variants and had a significantly higher "extent of returns" rate, i.e., a series of returns between the same two alternatives. From this it was concluded that FA subjects employ the same scanning strategy as FI subjects. The data from the present investigation lend support to this conclusion. Due to the relative nature of the definition of conceptual tempo, FA subjects became FI subjects on the CTT and SI subjects became SA subjects. It must be noted, however, that the dependent variables in the Ault et al. (1972) investigation are entirely different from those of the present investigation. Therefore, the noted support or lack of it applies only to the inferences drawn by this investigator from the Ault et al. results, not to the results themselves.

The curvilinear nature of the negative corre- between CTT latency and error refutes Hypothesis Three, that this correlation will increase directly with problem difficulty. Lengthy reconsideration of this relationship produced no logical explanations which could be supported by the present data.

In general, the results appear to support the feasibility of using feature difference redundancy as an empirical means of establishing differences in problem difficulty on matching-to-sample tasks. Response latency and error measures taken at each level of difficulty indicated that, in general, problems involving three feature differences were easier to solve than those involving either two differences or one difference. For the latency variable, problems involving two feature differences were easier to solve than those with one feature difference. This result was not significant, however, for the error variable. Analysis of the classification tempo X problem difficulty interaction for the latency variable indicated that while the significance of differences between difficulty levels varies for the different conceptual tempos, the lack of significance between the MD and HD levels is constant for all conceptual tempos. Given this result plus the similar result for the errors variable, one must conclude that the difficulty manipulation for these two levels was not successful. Whether the failure was specific to the stimuli used in this experiment or an instance of a generic inability to discriminate between the two types of stimuli in a matching-to-sample context is not known. Further research on this question is planned.

With regard to the effect of classification tempo upon CTT performance, the results for the latency variable support the initial MFF tempo classification. In terms of response latency, FI and FA subjects were significantly faster than SI and SA subjects. In contrast, the error variable did not support the initial tempo classification. In terms of errors committed, FI and FA subjects made significantly more errors than did SI and SA subjects, but within both the fast and slow categories, accurate subjects did not differ significantly from inaccurate subjects. This result suggests that the error half of the operational definition of conceptual tempo may not be a reliable predictor of errors on matching-to-sample tasks in which the problems vary in difficulty. A better predictor of both response latency and errors on the CTT appears to be MFF response latency. Unfortunately, neither of these conclusions can be made from an analysis in which tempo was an independent variable. Tempo was itself a set of specific combinations of both the latency and error variables; consequently, neither of these variables is examined in isolation. For this reason, a second analysis was performed which included MFF latency and error as separate independent variables along with the problem difficulty variable. The results supported the earlier speculation. The MFF error factor was not significantly related to either the latency or error variable of the CTT, nor was it a part of any significant interaction. In contrast, both the MFF latency and difficulty factors were highly significant and so was the interaction between these factors. At all levels of problem difficulty fast subjects spent significantly less time on CTT problems and made significantly more errors than did slow subjects. With regard to problem difficulty, LD problems took less time and produced fewer errors than MD or HD problems for both fast and slow subjects. In addition, slow subjects spent a significantly smaller amount of time on MD problems than HD problems. This difference was not reflected in the error scores, nor was it displayed by fast subjects.

CHAPTER 5

EXPERIMENT THREE: INSTRUCTION, PERCEIVED ALTERNATIVES AND CONCEPTUAL TEMPO

In spite of the arguments that the conceptual tempo construct describes stable response styles (Kagan et al., 1964; Kagan & Kogan, 1970), a major part of the conceptual tempo research has been concerned with experimental manipulations designed to modify the various tempo behaviors. Several investigators have employed some form of response delay to test the hypothesis that response errors are a consequence of responding too quickly. Response delay manipulations have consistently increased response latencies on conceptual tempo transfer tasks (Briggs, 1966; Briggs & Weinberg, 1973; Debus, 1970; Denney, 1972, 1973; Harcum & Harcum, 1973; Kagan et al., 1964; Kagan et al., 1966b), but only a few of these investigations have consistently reduced response errors (Briggs & Weinberg, 1973 - Experiment 2; Debus, 1970; Denney, 1972; Kagan et al., 1966b).

In contrast to the emphasis upon changing response latency, some investigators have emphasized response accuracy in attempts to modify conceptual tempo. Gauld and Stephens (1967) have found experimental instructions that deliberately discourage guessing under conditions of uncertainty produce a decrement in response errors. Another accuracy emphasis investigation involved a delayed response, incentive procedure which Marks (1967) reported was a successful method of improving response accuracy (Marks, 1968). Impulsive subjects, defined by three self-report inventories of impulsive behavior, were required to indicate on a five-point scale, ranging from "completely certain" to "completely uncertain", the degree of certainty about the correctness of their answer to each of several questions. This procedure increased the number of stimulus cues sampled by subjects and reduced the incidence of premature responding to questions. As predicted, this procedure increased response latencies and reduced errors.

The results from both these investigations suggest that accuracy emphasis procedures are capable of modifying impulsive tempo behavior. Unfortunately, few investigations of this seemingly fruitful approach to modification have been reported.

An extension of the latency-delay and accuracy-emphasis procedures involves response-contingent reinforcement of response latency and/or error rates as a means of modifying conceptual tempos. In one of the earliest modification studies, Briggs (1966) modified both reflective and impulsive response styles by separately manipulating response adequacy feedback for both the speed and accuracy of each response. Subjects were led to believe that positive reinforcement was contingent upon both the speed and accuracy of performance. In fact, reinforcement was contingent upon only the response speed for each item. This deception was possible as a result of the use of stimulus items that were all highly similar but not identical to the standard. Following each response, reinforcement was provided by means of a panel of red and green lights. Reflective training, designed to increase response latency, consisted of the presentation of a green speed and a green accuracy light if the response latency exceeded that of either of the previous two trials. If the subject did not meet this criterion, a green speed and a red accuracy light were presented. In addition, the red light illuminated the words, "Be more careful". Impulsive training, designed to reduce response latency, involved dual reinforcement if response latency decreased below that obtained on either of the two preceding trials. If this criterion was not reached, a green light for accuracy and a red light for speed were presented. In this condition the red light illuminated the words, "Guess sooner". Reflective training resulted in increased response latencies and fewer errors for both reflective and impulsive children, but reflective children showed the longest response latencies and fewest errors both prior to and following training. Impulsive training resulted in decreased response latencies and more errors for both reflective and impulsive children. Furthermore, impulsive children responded faster and committed more errors than did reflective children both prior to and following impulsive training. Apparently it is possible to modify the speed of responding and the error frequency of both reflective and impulsive children by means of response contingent reinforcement.

Weinberg (1969) partially replicated Briggs' (1966) study with the exception that different types of reinforcement were added to the basic response adequacy light signals and the subject was able to view all six alternatives simultaneously rather than sequentially as in Briggs' experiment. The results indicated no significant training main effects on either the latency or error variables. A significant training X tempo interaction was obtained such that impulsive subjects took longer and made fewer errors on the posttest, while reflective subjects reduced their latency and maintained their pretest error rate. Weinberg suggests that the improvement of the impulsive subjects may be due to a practice effect. In addition, he makes the point that the changes for both impulsive and reflective subjects on both variables may be due to a regression effect. In attempting to explain the lack of support for Briggs' (1968) results, Briggs and Weinberg (1973) have noted that the sequential stimulus presentation device used only by Briggs may have forced subjects to adopt a task strategy which facilitated MFF posttest generalizations.

In a post-hoc analysis of the Kagan et al. (1964) data, Ward (1968) found evidence to suggest the possible importance of the role of reinforcement in modifying impulsive response styles. A comparison of response latencies following correct and incorrect responses revealed that 73% of the subjects chose more slowly after errors than after correct responses ($Z = 4.23$, $p < .0001$). Furthermore, the increase in response latency following an incorrect response was demonstrated more by impulsive than by reflective subjects (74% and 63%, respectively). These results suggest that the latencies associated with both reflective and impulsive response styles can be modified by reinforcement in the form of response adequacy feedback. However, the value of such a result is questionable when the administration format of the reflection-impulsivity measures is taken into consideration. On each of these measures, the subject is required to select alternatives until he selects the correct one, up to a maximum of six errors, following which he is given the correct answer. With such a format, Ward's hypothesis would lead one to expect that the latency of impulsive subjects would increase as a consequence of committing errors, and the latency of reflective subjects would remain constant or decrease as a consequence of making correct responses. Such changes may well occur, but the point worth noting is that the standard administration format includes the differential reinforcement advocated by Ward, yet the tests still result in significant latency differences between tempos. It is these differences that should have been ameliorated by differential reinforcement.

In addition to the matching-to-sample tasks used to assess the effects of reinforcement on conceptual tempo, performance on a discrimination learning task has been found to differ for reflective and impulsive subjects as a function of the type and schedule of verbal reinforcement. In a probability learning situation, Schack and Massari (1971) found support for Kagan's argument that response latency may be a direct function of one's anxiety about response accuracy (Kagan & Kogan, 1970). Massari and Schack (1972) extended this finding to a discrimination learning task by having reflective and impulsive children perform a two-choice discrimination task under either a verbal reinforcement condition (70% of the responses correct and positively reinforced with the word "right" and 30% incorrect and punished with the word "wrong") or a verbal punishment condition (70% of the responses "incorrect" and punished and 30% of the responses "correct" and positively reinforced). For both impulsive and reflective subjects the punishment condition resulted in a significa reduction in the number of errors while the error rate for the rewarded condition was not significantly changed. Massari and Shack (1972) contend that punishment increased the subjects' concern for accurate responding.

An unusual approach to tempo modification is that of Campbell, Douglas, and Morgenstern (1971) who have indicated that drug therapy methods of treating hyperactive children may have implications for the modification of impulsive conceptual behavior. These investigators have noted that hyperactive children manifest the behavioral trait of extreme distractibility, short attention span, and excessive physical activity that is similar to that reported by Kagan et al. (1964) for impulsive children. To determine the relationship between hyperactivity and conceptual tempo, Campbell et al. (1971) administered the MFF to 19 hyperactive children and 19 nonhyperactive children who served as controls. Hyperactive subjects were found to be significantly more impulsive than normal subjects on both the latency and error measures of the MFF. Following initial testing, hyperactive subjects were administered the energizer drug methylphenidate and at a different period of time a placebo. The MFF was administered to subjects under both the drug and placebo conditions in a double-blind, drug-placebo design in which each subject served as his own control. The differences between the drug and the placebo conditions were significant for both response time and number of errors. Response time increased and errors decreased under the influence of the drug.

Still another approach to conceptual tempo modification involves direct task strategy instruction. While such instruction can be used with several aspects of tempo performance, it has generally been concerned with attending behavior during conceptual tempo tasks. In a notable advance in tempo research, Nelson (1968) suggested that attention deployment strategy training may be the key to effecting both longer response times and fewer errors in impulsive subjects. Reflective and impulsive subjects were trained to employ a reflective solution strategy that was based on Nelson's observations of the attention deployment of reflective subjects during an MFF administration. Experimental subjects were instructed to scan the arrays extensively, spend less time viewing the standard and spend more time viewing the alternatives. Control subjects spent an equivalent amount of time solving the training problems and received an equivalent degree of social reinforcement, but were not given any strategy instructions. Following training, impulsive boys showed a marked increase in response time and a decrease in errors when contrasted with the untrained controls. The reflective boys showed similar effects, but the magnitude of the difference was not as large as those obtained from the impulsive boys (a possible ceiling effect).

Another approach to conceptual tempo modification is observational learning of modeled behaviors. The independent variables that have been modeled in an observational learning context are basically those reviewed above; namely, response latency, response accuracy, differential reinforcement, and task strategy instruction. It should be noted, however, that the efficiency of the observational learning approaches to tempo modification is a direct function of the particular independent variable(s) selected for modeling, and it is the identification and understanding of these variables that is of primary importance for conceptual tempo research. Toward this end, some of the observational learning investigations have provided comparisons of the relative effects of a few of the postulated modification variables.

In an early investigation Debus (1968) exposed subjects to one of several response latency models. In general, it was observed that exposure to a reflective model increased the response latencies of all subjects, but as was often the case for the response delay manipulations noted above, the increased response latencies were not accompanied by significant changes in the error scores.

Evidence suggesting the possibility of modifying conceptual tempo through modeling in a normal educational setting comes from Yando and Kagan (1968). Through the course of a school year, elementary students showed a significant MFF latency change in a direction that was consonant with their particular teachers' tempos. A limitation of these results from applied settings is that it is not known which specific behaviors were exhibited by the teachers.

Ridberg, Park, and Hetherington (1971) have demonstrated that both impulsive and reflective behavior styles can be modified through the observation of film-mediated models. These investigators noted that in Debus' (1968) study, "... the effects of reinforcement, model articulation of response strategies, or the nonverbal performance cues (i.e., longer decision time) were confounded, making it impossible to assess which aspects of the modeling process was most critical (sic. p. 370)." To determine the importance of each of these variables, the experimental design of Ridberg et al. included response latency modeling, task strategy verbalization and task strategy demonstration as independent instruction factors for both reflective and impulsive subjects. In brief, the method was as follows: Impulsive and reflective fourth-grade boys viewed one of four films that illustrated the "correct" method of solving MFF problems. Impulsive boys viewed only reflective models and reflective boys viewed only impulsive models. The four film conditions were variations of two basic procedures which showed a model making either fast, impulsive or slow, reflective responses. This latency modeling was augmented by one of three task strategy explanations: a verbal explanation, a visual explanation, or both combined. The reflective verbal explanation stressed: (a) responding slowly, (b) avoiding choosing the first alternative that appears correct without checking the remaining stimuli, and (c) checking back and forth between the standard and each variant. The impulsive verbal explanation stressed: (a) responding quickly, (b) picking the first stimulus that appears correct, and (c) checking only a few stimuli with the standard before responding. For the visual strategy demonstration, the reflective model outlined his visual scanning pattern for the task by pointing with his finger to the standard, each of the alternatives, and then back and forth between particular alternatives and the standard. The impulsive model pointed to the standard and only a few of the alternatives before responding.

The results indicated that both the response latency and error rate of impulsive and reflective subjects could be modified by film-mediated, response latency models. Impulsive subjects showed a significant decrease in the number of errors and a significant increase in response latency following exposure to the reflective model. Reflective subjects exposed to an impulsive model demonstrated an expected increase in response errors and paradoxically an unexpected increase in response latency. Ridberg et al. posit that this increase occurred as a consequence of conflict and indecision occasioned by the choice between the successful behavior of the model (the success rate was experimentally manipulated to equal that of the reflective model) and the subject's own previously successful style. The conflict and indecision may have both lengthened decision times and interfered with the usually effective solution strategy of the reflective subjects.

The results for the task strategy explanation and/or demonstration revealed a significant interaction with measured intelligence. Subjects scoring below a mean IQ of 115 were most affected by the combined visual and verbal strategy explanation, while subjects scoring above the mean were affected by either the visual or the verbal treatments, but not both.

In general, the success of the modeling treatments suggests that conceptual tempo may be modified through observational learning. In addition, the work of Ridberg et al. (1971) indicates that the research in this area has progressed to the point of comparing the effects of different instructional variables within an observational learning paradigm.

Further advances in the direction of comparing the effects of several proposed methods of tempo modification come from Heider (1971) and Egeland (1974). In a comparison of three proposed methods of modifying impulsive conceptual behavior, Heider (1969) found that some methods of tempo modification interacted with social class, and that individual differences in cognitive strategy intervene between a subject's level of motivation and the tempo of his performance on a decoding task. Differences in the nature and pattern of both errors and response latencies between lower- and middle-class subjects suggested that the fast tempo and inaccuracy of the lower-class subjects resulted from strategies of information processing which were inappropriate the serial processing required by some of the decoding items of her study and by most conceptual tasks.

To test her hypothesis, Heider (1971) compared the relative effectiveness of three proposed methods of modifying an impulsive tempo: enforced response delay, increased anxiety over errors, and task strategy instruction. In the first experiment, subjects completed the MFF after receiving one of the following four treatments designed to modify MFF response latency and/or response errors: (1) Control treatment (standard MFF instructions), (2) Forced delay treatment (standard instructions plus the inclusion of a time clock placed in front of the subject, and the instruction to delay each response at least until the bell sounded), (3) Increased motivation treatment (standard instructions plus the incentive that if "few enough mistakes" were made the subject would be allowed to play with some attractive toys after the test), and (4) Task strategy instruction treatment (standard instructions plus two types of task strategy instructions given prior to testing: first, to look back and forth between the standard and the alternatives, and second, to be certain of the right answer before responding by identifying the way each of the variants differ from the standard -- both strategies were observed in Drake's (1970) study of the eye movements of reflective subjects. In part two of the experiment, Heider used a verbal task that required subjects to make a sentence out of five words supplied by the experimenter. The four experimental treatments were similar to those used with the visual MFF task.

The results obtained by Heider are as follows: First, lower-class subjects were significantly more impulsive than were middle-class subjects on both the visual and verbal tasks. Second, none of the treatments had a significant effect on the middle-class subjects. Heider speculated that this result may be due to middle-class subjects already possessing an adequate task tempo, sufficient motivation to avoid error, and appropriate task strategies; or it could be due to a task difficulty ceiling effect which applied only to middle-class subjects. Third, for lower-class subjects only, the task strategy treatment produced both a significant increase in response latency and a significant decrease in errors for both the visual and verbal tasks. On the visual task, the motivation treatment produced a significant increase in response latency, but the latency increase was not associated with a corresponding decrease in errors. On the verbal task, the enforced delay treatment produced a significant decrease in the mean number of errors, but this decrease was smaller than that produced by the task strategy treatment. Heider speculates that the effectiveness of enforced delay on the verbal task and its ineffectiveness on the visual task: "... may be due to the fact that forming a sentence is a more familiar and more easily comprehended task than finding small visual differences in figures; thus, subjects may be more likely to discover the 'correct' task strategy themselves during an enforced delay in the sentence task than in the MFF (1971, p. 1279)".

A more recent comparison of tempo modification procedures has been reported by Egeland (1974). Egeland has compared visual scanning strategy instruction with response-delay instruction on both an immediate and delayed posttest. The scanning strategy instruction taught subjects to apply the following rules on matching-to-sample tasks: (1) View the standard and <u>all</u> alternatives. (2) Break the alternatives into component parts. (3) Compare the same components across all alternatives. (4) Check the standard to determine the correct form of the component parts.

(5) Successively eliminate each non-matching alternative until only the correct matching stimulus remains. In contrast, the response-delay instruction consisted of asking subjects to take their time, think about their answers, and avoid making mistakes. In addition to this instruction, both the scanning and response delay experimental groups completed a number of tasks designed to acquaint them with matching-to-sample tasks and improve their information processing efficiency. Specifically, the first part of this instruction involved geometric design matching-to-sample tasks, following which subjects were asked to correct each alternative that varied from the standard by drawing in the corrections and verbally noting the change that was required. The remaining parts of the instruction included a matching-to-sample task with nonsense syllable alternatives, a matching-to-sample task with geometric design alternatives that were selected from memory, a design reproduction memory task, and a task that required the verbal description of a design from memory. A control group did not receive this general information processing instruction. In contrast to an uninstructed control group, both the response delay and scanning instruction treatment groups showed significant latency increases and error decreases on both the immediate and delayed posttests. Egeland also found that the scanning instruction treatment was more durable than was the response delay treatment. While both treatment groups showed approximately equal latency and error scores on the immediate

posttest, the response-delay subjects showed an increase in errors on the delayed posttest that was significantly greater than the still stable error rate of the scanning group.

In general, the research suggests that there are several methods of modifying conceptual tempo. Most frequently the modification treatments have produced a change in response latency, but have not changed the number of errors. While these results do constitute changes in conceptual tempo due to the conjoint latency plus error definition of the construct, the change in latency appears to be independent of the cognitive process of matching stimuli. Less frequently have the modification treatments produced change on both the latency and error variables. It is interesting to note that the treatments that have effected a joint change are those that have concentrated upon the variables involved in the conceptual process of matching, rather than upon the latency of the response. These investigations suggest that the role of latency in the definition of conceptual tempo may be overestimated. The relative ineffectiveness of latency-based versus accuracy- and strategy-based tempo modification treatments lends support to the suggestion that response latency may be a by-product of the conceptual process employed to solve the task. Further support for this suggestion comes from Egeland's (1974) finding that response delay instruction was as effective as scanning strategy instruction in modifying both the response latency and errors of impulsive subjects. The unusual effectiveness of the response delay treatment is explained by Egeland as being a consequence of the general information processing instruction that was given to both the response delay and the scanning strategy treatment groups. Evidently the general information processing instructions added to the latency delay treatment an element that overcame the usual difficulty of the latency treatments in modifying error scores. Unfortunately, the general information processing instruction was confounded with both the response-delay and scanning strategy instruction groups in order to ascertain if extensive modification training was capable of producing a large and durable degree of tempo modification. As a consequence the relative contribution of the general information processing instruction can not be assessed, but as Egeland (1974) has noted such an assessment is now necessary.

One aspect of information processing that may have contributed to the latency <u>and</u> error modifications reported by Egeland (1974), and possibly other investigations that included some form of task related information processing instruction (Heider, 1971; Nelson, 1968; Ridberg et al., 1971), is the subject's knowledge of the types of task alternatives that constitute critical alternatives. A second aspect is that since full tempo modification has come to mean changes in both latency and error an examination of information processing variables of conceptual tempo may benefit from the inclusion of the often excluded FA and SI tempo categories. Taken together these aspects suggest an examination of the role of alternatives in tempo modification in relation to four rather than two conceptual tempo categories.

In the theoretical definition of conceptual tempo, Kagan has noted that the conceptual tempo construct describes stable individual differences in the degree to which an individual reflects upon alternative classifications of a stimulus in situations in which several alternatives are available simultaneously. A theoretical position that may have implications for this definition, has been elaborated by Olson (1970, 1972, 1974). Consistent with the feature detection approach to perception advocated by Gibson (1969), Olson has proposed that the cognitive process is a perceptual task of identifying features that will serve to differentiate an event from a set of alternatives. Extending this position, Olson (1970) has introduced the concept of media-specific performatory acts which confront the individual with the alternatives that result in his acquisition of information about his environment, or in Olson's words; "... that provides the occasions for the radical elaboration of the perceptual world (Olson, 1970, p. 201)." To clarify this position, it is necessary to consider Olson's definitions of the terms "feature," "information," "performatory act" and "media." Garner (1966) has noted that what one perceives in a stimulus is a function of the set of alternatives perceived or inferred by an individual; that is, the contrast set. A single stimulus is meaningless without reference to a set of stimuli, because the attributes which define it cannot be specified without knowing what the alternatives are. For example, a single stimulus, two dots, arranged horizontally, would be perceived as a horizontal line if the context of alternatives were vertical and oblique arrays of dots. However, the same stimulus would be perceived as "two" if the set of alternatives were arrays of one and three dots. Consequently, a feature detected by an individual is a function of the set of alternatives he perceives.

Information is defined by Olson (1970) as: "... the ability to reduce uncertainty; that is, to specify alternatives (p. 191)." For example, if one is able to identify single and triple dot arrays as alternatives to a double dot array, he may then be certain that the double dot stimulus is "two" rather than any of the infinite number of things an array of two dots could represent in relation to different alternatives. In this case the one and three dot arrays provide the information that the relevant attribute of the two dot stimulus is number. From this point of view, the accumulation and revision of information that occurs with development is a process of perceiving events in s of increasingly larger sets of alternatives, that is, on the basis of more, different, and less obvious features.

A perf matory act is a sequential set of performance decisions p formance requires a continuous set of decisions from the initial decision, how to begin, to the final decision, how to terminate, and for all points of continuation between these points. Each decision requires information, that is, the ability to specify the alternatives at each decision point and select that which is appropriate for the performance.

Media refer to domains of performatory activity. The domains outlined by Olson are cultural media which are those that have evolved within and are transmitted by the culture, such as: drawing, speaking, counting and making. In addition, two other media defined by Olson are locomotion and grasping. While he does not elaborate on the origins of these media, he does note that early childhood perception appears to be attuned primarily to features which are invariant in the performatory acts of locomotion and grasping. Consequently, a part of most of the information we have about the world is a function of our performatory attempts at walking and grasping.

Given these definitions of his terminology, Olson's theory of cognitive development is related to conceptual tempo through the common importance of alternatives in both theories. Within the context of studying perceived alternatives, Olson (1970) has recorded eye fixations on a matching-to-sample task similar to those used to define conceptual tempo. His results are as follows. First, Olson found that visual search of the stimuli was a function of the alternatives among which the viewer either knew or expected he would have to choose, not the stimulus per se. As long as subjects assumed that general criteria such as shape and color would facilitate their choice, their visual search was brief and general. However, when the information value of certain critical features was determined, the visual search became precise and consistent. Second, Olson found that:

> Some children looked at a stimulus briefly because they immediately know what to look for...; others searched briefly because they did not know what to look for.... The longest searches were conducted by older subjects who appeared to know something was wrong, but were unable to isolate it at first (p. 141).

While Olson has not presented the error and latency data required to classify these subjects into conceptual tempo categories, his description suggests that the performances he describes could be interpreted as FA, FI, SA, and, if some of his subjects who noticed something was wrong were unable to identify it, SI subjects.

Third, a partial test of Olson's hypothesis about the role of alternatives in perception comes from four subjects who were shown the alternative stimuli prior to viewing the standard stimulus. While Olson notes the limitation of conclusions drawn from such a small sample, the results do indicate a radically abbreviated search of the standard. These subjects made less than half the number of fixations made by their age peers, and all four subjects viewed the point of variation critical to choosing between the alternatives.

These results are admittedly sketchy as a consequence of not being particular to the tempo construct. However, the critical point for this investigation is that Olson's study is an investigation of the role of alternatives in perception, and it is the generation and evaluation of alternatives that is the basis of conceptual tempo. Consequently, these results raise new questions about the role of alternatives in conceptual tempo. Specifically, can conceptual tempos be modified by altering the subject's knowledge of task alternatives? What effect would such an alteration have upon response latencies and response errors for each of the four latency-accuracy combinations that comprise the tempo construct? If it is the case that individual differences in response latency and accuracy are determined by the number and nature of perceived response alternatives, then it would seem that acquainting all subjects with the alternatives critical to the task, would alter individual differences on both dependent variables. However, such alteration would be anticipated with such a degree of specific task instruction. A more important question is, will instruction in the alternatives specific to one task, transfer to tasks with similar, but not identical alternatives. In short, will instruction in the <u>type</u> of alternatives to expect (minor feature differences) alter general conceptual tempo task performance.

Before stating hypotheses for this question, it will be helpful if Olson's position on instruction is briefly considered. He has argued that the execution of performatory acts is the means for encountering new alternatives and the need for further information. Such acts lead to the internalization of information about alternatives that occur in each medium, but this information, once achieved is not specific to a medium. It is general perceptual information. This role of activity or experience may on some occasions be replaced by instruction. The sole purpose of instruction in this context is to increase the likelihood that the individual will perceive the critical alternatives and receive information (reinforcement) about the correct choice among those alternatives. Olson has identified three methods of instruction that can be employed to increase perception of critical alternatives: educational toys, language, and modeling. The last of these is not relevant to the proposed investigation. An educational toy involves a rearrangement of the environment to increase the probability of encountering the critical choice points. In manipulating an educational toy one executes performatory acts; thereby encountering new alternatives. Language is a more powerful means of instruction. It can be used to indicate what the alternatives are and how to choose among them. Language does this by directing one's attention to the critical alternatives and the correct choice. Each of these methods have particular weaknesses and neither can guarantee perception of the instructed alternatives. Consequently, the probability of a child's perceiving the instructed alternatives is increased if both methods of instruction are employed.

With regard to specific instructional hypotheses, it is anticipated that following initial tempo classification, instruction designed to facilitate the perception of critical alternatives will have the following effects on performance on a subsequent conceptual tempo transfer task:

(1) For all subjects combined, there will be a significant decrease in both response latency and response errors.

(2) For SA subjects there will be a significant decrease in response latency.

(3) For SI subjects there will be a significant decrease in response latency and response error.

(4) For FI subjects there will be a significanc decrease in response error.

Each of the hypotheses listed above is based upon the visual fixation results of Olson (1970). These data indicated that short response latencies and correct responses were exhibited by subjects whose visual fixation records indicated that they were aware of the critical alternatives among which a choice response was to be made.

METHOD

Subjects

Ninety-three male and ninety-five female student volunteers, enrolled in grades four and five of two urban, middle-class elementary schools, participated in the experiment. The average age of all subjects was 122.94 months, with a standard deviation of 9.52 months. Following an administration of the MFF (Kagan et al., 1964) subjects were classified into one of four conceptual tempo categories according to the conventional dual-median split procedure. The median values were 120.50 seconds and 8.02 errors. The resulting distribution of subjects is presented in Table 20. Twenty subjects were randomly selected from each of the four tempo categories. Ten of these were randomly assigned to an experimental group, and ten to a control group.

Apparatus

The apparatus was the same as that described in Experiments One and Two.

Procedure

Initially, the MFF was administered to each subject. Following the determination of tempo classification, experimental subjects were exposed to two methods of instruction. Both methods were designed to assist subjects to perceive the type of feature difference that defines the alternatives of conceptual tempo tasks like the MFF. The two methods of instruction were language and the educational toy as defined by Olson (1970). The simultaneous use of both methods was employed to increase the possibility of effecting a successful instruction treatment. The educational toy consisted of

TABLE 20

Distribution of Alternative Instruction Subjects Produced by the MFF Classification Task

	Conceptual Tempo				
Sex	FI	SI	FA	SA	Total
Male	35	14	13	31	93
Female	24	13	12	46	95
Total	59	27	25	77	188

a set of transparencies of each of the standard figures in a ten-item, matching-to-sample, conceptual tempo task (see Appendix G for a sample item). The language aspect of instruction consisted of the experimenter's verbal interventions to direct the subject's attention to the critical alternatives when these were not identified by the subject during his manipulation of the educational toys. Similar to the procedure used for the MFF, each item of the instruction task was presented to the subject to solve. Following each response, the subject was given the appropriate transparency of the standard figure and asked to check to see if his answer was correct. Upon placing the transparent standard over the selected alternative, the subject was asked if the two figures were the same. If the figures were the same the experimenter acknowledged this and asked the subject to check each of the remaining stimuli in turn and identify how it differed from the standard. If the figure was different the subject was asked to identify the discrepancy, then continue selecting alternatives until he identified the correct alternative and the discrepancy present in each incorrect alternative. The motion of placing the transparency over an incorrect alternative had the effect of making the discrepancy stand out such that most subjects quickly identified the correct alternative and each of the discrepancies, and, incidentally, often expressed surprise at the "sudden appearance" of feature differences. If a subject was unable to identify a discrepancy, the experimenter employed verbal instruction by verbally directing the subject to attend to the appropriate part of the stimulus and note the discrepancy. Instruction was complete when each child identified the matching stimulus and each discrepancy of the alternatives for all ten items. Control condition subjects were also administered the ten-item matching-to-sample task. However, the administration procedure employed was the conventional MFF procedure, wh[illegible]bjects selected up to six incorrect alternatives and w[illegible]ormed when their choices were correct, but, like the [illegible]al MFF administration procedure, subjects did not receive instruction about feature discrepancies. Following either the experimental or control procedures, all subjects completed a conceptual tempo transfer test that was designed to approximate the MFF test.

RESULTS

Preliminary analyses of variance and appropriate post hoc comparisons were conducted for sex and tempo classification factors on the chronological age, MFF latency and MFF error variables. These and all subsequent simple effects analyses and post hoc comparisons analyses, which are summarized in Appendix H, indicate that significant mean differences occurred only for the tempo factor on the MFF latency and error variables. Subsequent multiple comparisons indicate the presence of highly significant latency differences between fast and slow subjects and highly significant error differences between accurate and inaccurate subjects; thus supporting the tempo classification procedure. In addition, the lack of significant latency or error differences for the sex factor prompted the combination of male and female subjects for all subsequent analyses.

With regard to the analysis of performance on the conceptual tempo transfer test, a summary of response latency and error means and standard deviations is presented in Table 21. In addition, the mean values are presented graphically in Figure 10 to facilitate comparisons. Summary two X four way (instruction X tempo) analyses of variance were conducted for both the response latency and response error variables. These results, presented in Table 22, indicate that the instruction main effect was not significant for the latency variable ($F = .73$, df = 1/72, $p = .73$), but that it was significant for the error variable ($F = 4.57$, df = 1/72, $p = .036$). The tempo main effect was significant for both the latency variable ($F = 7.59$, df = 3/72, $p = .00018$) and the error variable ($F = 6.94$, df = 3/72, $p = .0003$), and the instruction by tempo interaction was also significant for both the latency and error variables ($F = 2.75$, df = 3/72, $p = .048$; and $F = 4.52$, df = 3/72, $p = .0058$), respectively. The significant interactions necessitated further analysis of simple main effects.

One way simple effects analyses of variance of the response latency and error means of experimental subjects on the transfer task are presented in Table 23. These data

TABLE 21

Conceptual Tempo Transfer Task Performance Summary

Condition		Tempo FI	SI	FA	SA	Total
Response Latency						
Experimental	N	10	10	10	10	40
	$\bar{X}$	178.90	265.30	191.50	258.00	223.43
	S	53.34	193.70	101.07	111.33	131.27
Control	N	10	10	10	10	40
	$\bar{X}$	87.90	204.00	175.20	385.50	213.15
	S	47.30	98.90	91.18	198.27	163.23
Combined	N	20	20	20	20	80
	$\bar{X}$	133.40	243.65	183.35	321.75	218.29
	S	67.91	156.81	96.60	172.96	148.19
Response Errors						
Experimental	N	10	10	10	10	40
	$\bar{X}$	8.60	7.30	9.00	6.30	7.80
	S	3.07	5.71	4.56	5.76	5.02
Control	N	10	10	10	10	40
	$\bar{X}$	17.80	10.90	7.50	5.10	10.33
	S	4.28	6.30	5.46	4.13	7.01
Combined	N	20	20	20	20	80
	$\bar{X}$	13.20	9.10	8.25	5.70	9.06
	S	5.92	6.28	5.09	5.05	6.22

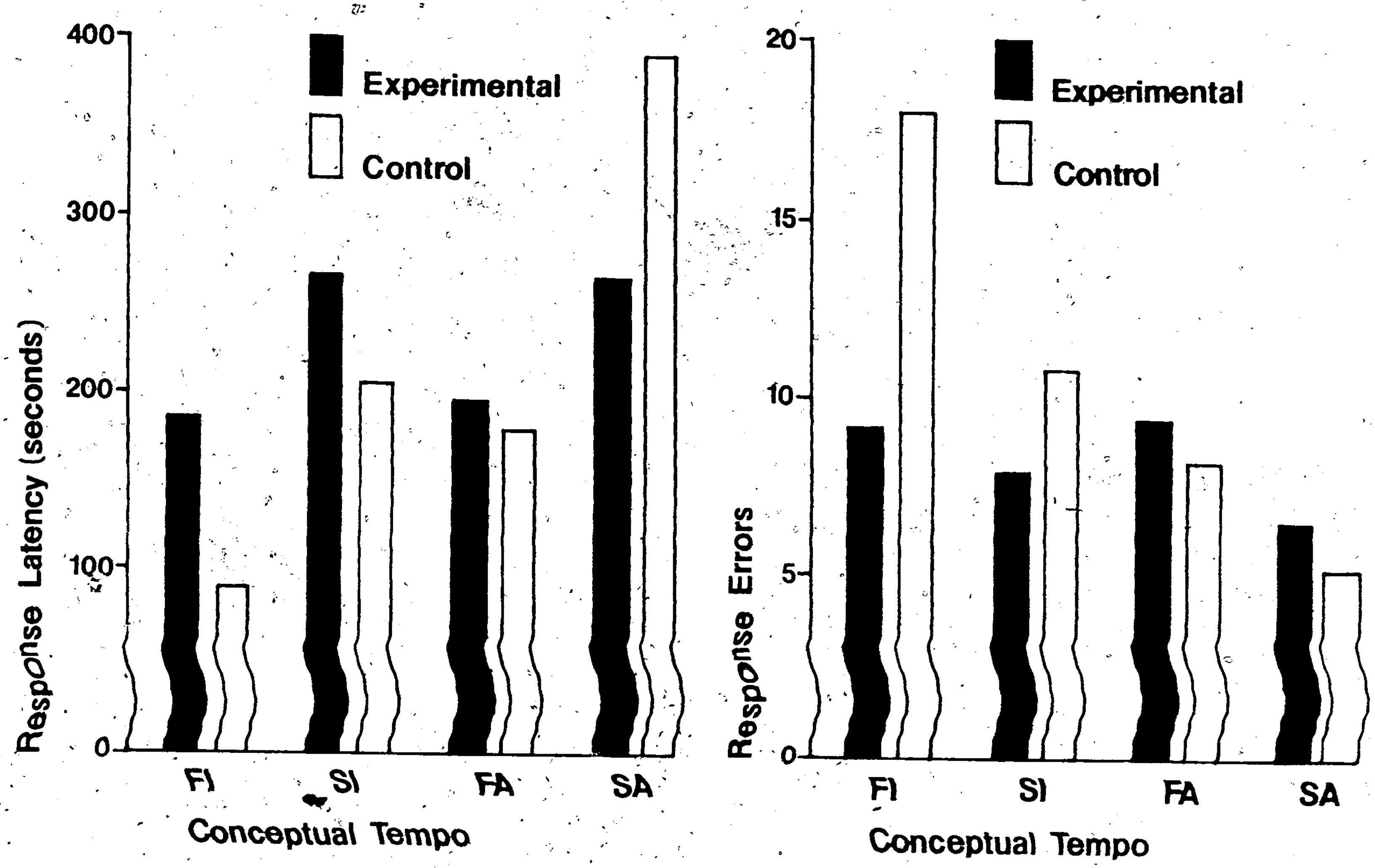

FIGURE 10. Conceptual tempo transfer task response latency and error means of experimental and control condition subjects.

TABLE 22

Instruction X Tempo ANOVA of Response Latency and Error Means on the Conceptual Tempo Transfer Task

Source	Transfer Task Latency				
	SS	df	MS	F	p
A (Instruction)	2116.00	1	2116.00	.12	.73
B (Tempo)	387979.00	3	129326.00	7.59	.00018
A X B	140692.00	3	46897.30	2.75	.048
Error	1226140.00	72	17029.80		

Source	Transfer Task Errors				
	SS	df	MS	F	p
A (Instruction)	127.52	1	127.52	4.57	.036
(Tempo)	581.74	3	193.91	6.94	.0003
A X B	387.94	3	126.31	4.52	.0058
Error	2010.51	72	27.92		

TABLE 23

Simple Effects ANOVAs of Response Latency and Error Means of Experimental Subjects on the Transfer Task

Source	Transfer Task Latency				
	SS	df	MS	F	p
Tempo	59506.00	3	19835.33	1.13	.348
Error	629720.00	36	17492.22		

Source	Transfer Task Error				
	SS	df	MS	F	p
Tempo	45.80	3	15.27	0.57	.637
Error	960.60	36	26.68		

indicate that for experimental subjects there are no significant differences among the four tempo conditions for either the response latency variable ($F = 1.13$, $df = 3/36$, $p = .35$) or the response error variable ($F = .57$, $df = 3/36$, $p = .64$). A similar analysis of response latency means of control subjects is presented in Table 24. For control subjects, the tempo factor is associated with significantly different response latencies ($F = 9.44$, $df = 3/36$, $p = .0001$). Scheffe multiple comparisons of individual tempo means indicate that SA subjects take significantly more time to complete the transfer task than do FI subjects ($p < .0001$), FA subjects ($p < .001$), and SI subjects ($p < .05$). Table 25 summarizes a similar analysis for the errors variable. The simple effects analysis of variance reveals the presence of significant differences among the error means of the four conceptual tempo classifications for the control group subjects ($F = 10.46$, $df = 3/36$, $p < .0001$). Subsequent Scheffe multiple comparisons among individual means reveals that FI subjects made significantly more transfer task errors than did SI subjects ($p < .10$), FA subjects ($p < .01$), or SA subjects ($p < .001$). Considering the results for both the experimental and control groups, it appears that the critical alternative instruction treatment served to eliminate the differences between several conceptual tempo classifications that are observed for the control subjects.

A summary table of simple effects analyses of the instruction factor is presented in Table 26. These analyses

TABLE 24

Simple Effects ANOVA and Scheffe Multiple Comparisons of Response Latency Means of Control Subjects on the Transfer Task

Analysis of Variance

Source	*SS*	*df*	*MS*	*F*	*p*
Tempo	469160.00	3	156386.63	9.44	.0001
Error	596424.00	36	16567.33		

Scheffe Multiple Comparisons

Tempo	$\bar{X}$ (Seconds)	FI 87.90	SI 204.00	FA 175.20	SA 385.50
FI	87.90	0	116.10	87.30	297.60****
SI	204.00		0	28.80	[illegible]1.50**
FA	175.20			0	210.30***
SA	385.50				0

*p < .10
**p < .05
***p < .01
****p < .001

TABLE 25

Simple Effects ANOVA and Scheffe Multiple Comparisons of Response Error Means of Control Subjects on the Transfer Task

Analysis of Variance

Source	SS	df	MS	F	p
Tempo	914.87	3	304.96	10.46	.0001
Error	1049.91	36	29.16		

Scheffe Multiple Comparisons

Tempo		FI	SI	FA	SA
	$\bar{X}$	17.80	10.90	7.50	5.10
FI	17.80	0	6.90*	10.30***	12.70****
SI	10.90		0	3.40	5.80
FA	7.50			0	2.40
SA	5.10				0

*$p < .10$
**$p < .05$
***$p < .01$
****$p < .001$

TABLE 26

Simple Effects Analysis *t* Tests of the Instruction Treatment for Four Conceptual Tempos on the Response Latency and Error Variables

Variable	Tempo	Instruction $\bar{X}$	No Instruction $\bar{X}$	Instruction S	No Instruction S	*df*	*t*	*p* (one-tail)
Response Latency								
	FI	178.90	87.90	53.34	47.30	18	3.83	<.01
	SI	265.30	204.00	193.70	98.90	18	0.85	>.05
	FA	191.50	175.20	101.07	91.18	18	0.36	>.05
	SA	258.00	385.50	111.33	198.27	18	-1.68	>.05
Response Error								
	FI	8.60	17.80	3.07	4.28	18	-5.24	<.0001
	SI	7.30	10.90	5.71	6.30	18	-1.27	>.05
	FA	9.00	7.50	4.56	5.46	18	0.63	>.05
	SA	6.30	5.10	5.76	4.13	18	0.51	>.05

demonstrate that the instruction treatment changed the conceptual tempo behavior of only the FI subjects. For these subjects critical alternative instruction produced both a significant increase in response latency (t two-tail = 3.83, df = 18, $p < .01$) and a significant decrease in response errors (t one-tail = 5.24, df = 18, $p < .0001$). In addition, two other differences approached significance. First, SI subjects that received instruction made fewer errors than did control subjects (t one-tail = -1.27, df = 18, $p < .11$). Second, SA subjects that received instruction took less time to complete the transfer task than did their control group counterparts (t one-tail = -1.68, df = 18, $p < .06$).

DISCUSSION

In general, the results appear to support the feasibility of employing critical alternative instruction as an empirical method of modifying impulsive responding.

With regard to the stated hypotheses, the results were as follows: Hypothesis One was only partially supported. For all experimental subjects a significant decrease did occur for the error variable but not for the latency variable. Hypothesis Two was not supported. The predicted significant reduction in response latency did not occur for SA experimental subjects. However, as was noted above a decrease that approached significance ($p < .06$) was observed. Hypothesis Three was not supported. For SI subjects in the experimental condition, a significant decrease occurred for neither the latency nor the error variable. Finally, Hypothesis Four was partially supported in that there was a significant decrease in the response errors of FI experimental subjects, as well as an unanticipated significant increase in response latency.

Taken together, the results noted above suggest that Olson's theory of cognitive development (Olson, 1970, 1972) does have implications for the conceptual tempo construct. One implication concerns the role of alternatives. Olson's distinction between what he calls "perceived alternatives" and what might be called extant alternatives may explain a considerable portion of the variance attributed to conceptual tempo. From pupillometric observations of subjects completing a task somewhat similar to a conceptual tempo task, Olson (1970) concluded that the visual search of the stimuli was a function of the alternatives among which the viewer either knew or expected he would have to choose, not the stimuli per se. As long as subjects assumed that general criteria such as shape and color would facilitate their choice, their visual search was brief and general. However, when the information value of certain critical features was determined, the visual search became precise and consistent. This conclusion appears to be supported by the improved performance of FI subjects following instruction designed to acquaint them with the type of alternative critical to successful performance. In addition, this instruction was also associated with reductions in the latency of SA subjects and the error rate of SI subjects that approached significance. These performance differences for the experimental group had the effect of making the group sufficiently homogeneous that the original tempo classifications were not supported by significant latency or error differences on the transfer task. In contrast, for the control group several significant latency and error differences on the transfer task supported the original tempo classification. In short, critical alternative instruction reduced the variance attribut[illegible] to conceptual tempo differences. A noteworthy, but moot point is whether the instruction in this, and indeed in Olson's (1970) investigation, served to teach subjects to perceive critical alternatives, or inform subjects that already perceived feature differences are, in fact, critical alternatives. The surprise expressed by many subjects during their use of the transparency as an educational toy suggests that at least some subjects did not perceive the feature differences critical to the task. Further research is obviously necessary.

A second implication of Olson's theory is that instruction is an empirical means of altering conceptual tempo. Having noted that the purpose of instruction was to increase the likelihood that subjects would perceive the critical alternatives, it appears that the combination of two methods of instruction outlined by Olson, educational toys and language, did "...provide the occasions for the radical elaboration of the perceptual world (Olson, 1970, p. 201)." Unfortunately, the two methods were purposely confounded to improve the effectiveness of the instruction treatment; therefore, the relative contribution of each could not be assessed. It should be noted, though, that the procedure followed employed the language method only when the method involving the educational toy failed -- which it seldom did. Consequently, there is reason to believe that the method of instruction that was primarily responsible for the observed performance changes was the educational toy. Again, further research is necessary.

The final implication of Olson's theory concerns the construct validity of conceptual tempo. If the results noted above are replicated such that one's conceptual tempo can be modified to a point that original tempo classifications do not reliably produce appropriate significant differences, then, it would call into question the theoretical definition of conceptual po as: stable individual differences in the degree to which one reflects upon alternative classifications of a stimulus or alternative solution hypotheses. Certainly on multi-alternative tasks there will be latency and error differences among subjects and a negative correlation between latency and error, as well as significant tempo differences produced by the practice of splitting latency and error scores at their respective medians. However, in accord with the definition of the tempo construct, one would expect conceptual tempo subjects to reliably maintain their relative position and not be greatly affected by attempts to modify their tempo behavior. Clearly this expectation was not met in the present investigation. The fact that instruction designed to inform subjects about the type of feature differences that constituted critical alternatives, improved performance on the transfer task sufficiently to eliminate performance distinctions among the initial tempo classifications, suggests that a major part of the variance attributed to conceptual tempo may be due to subjects not being familiar with the type of feature differences used to define the alternatives. Once informed, a significant number of these subjects cease to behave in accord with their tempo classification label; thus, the notion of stable individual differences in conceptual tempo may not be warranted for many subjects classified by the MFF. This observation suggests that either the conceptual tempo construct is in error or the operational definition of the construct is at least partially inadequate.

The results from the instruction manipulation strongly suggest that at least the operational definition of the construct may contain a source of error that hinders examination of the construct. The apparent error is that in spite of the two practice items on the MFF that are included to acquaint subjects with the requirements of the task, some subjects, particularly those that are likely to be classified as FI subjects, do not know what to look for, while other subjects apparently do. There appears to be two levels of uncertainty operating. At the first level, subjects are not aware of the type of minor feature differences that constitute critical differences. At the second level, subjects are aware of the type of differences, but are uncertain about particular differences within a set of problems. The confusion of the two levels of uncertainty appears to confound performance results and make the investigation of the tempo construct more difficult. Possibly an improvement in the operational definition of the construct would be to construct practice items for the conceptual tempo measures that include task specific instruction by means of the educational toy method of instruction noted above. Given this instruction, a researcher could be fairly certain that for the operational definition of conceptual tempo, subjects were faced with the same set of alternatives. Given this condition, one may find that tempo classifications are more reliable and amenable to research.

CHAPTER 6

GENERAL CONCLUSIONS AND IMPLICATIONS

To conclude this investigation of conceptual tempo an attempt will be made to summarize the major results of the three investigations and integrate them with one another and with current research. In addition, the chapter will include general conclusions about conceptual tempo and the implications of this research for conceptual tempo research and educational practice.

Experiment One examined the relationship between conceptual tempo and intelligence. This examination was prompted by a paucity of information about the FA and SI conceptual tempo categories that have typically been excluded from conceptual tempo investigations. To date, only one investigation of conceptual tempo and intelligence has included FA and SI subjects (Eska & Black, 1971). While the results of this study are in accord with those reported for investigations that excluded FA and SI subjects, an attempt was made to replicate the Eska and Black (1971) investigation for two reasons. First, the Eska and Black results are presently the only reported source of information about the less popular FA and SI tempo categories and intelligence. Second, the MFF used to operationally define conceptual tempo groups in the Eska and Black (1971) investigation differed from the standard MFF, in that the former involved portable

MFF alternatives. Eska and Black note that subjects in the various tempo categories differentially spent time manipulating and arranging the portable alternatives. Given that it would take time to manipulate the alternatives, and in that time is a major part of the definition of conceptual tempo, it appeared worthwhile to reexamine the relationship between intelligence and all four categories of conceptual tempo as defined by a standard MFF with nonmanipulable alternatives.

The results obtained from the present investigation only partially support the results reported by Eska and Black (1971). However, since the Eska and Black results are generally consonant with those reported in the tabulated summary of results for two category conceptual tempo-IQ relationships (see Table 2), it was assumed that the results of the present investigation are atypical and following the presentation of a summary of similarities and differences between the results of the two investigations, the discussion will focus upon possible reasons for the discrepancies.

Results from Experiment One that are in accord with the results reported by Eska and Black (1971) are a significant negative correlation between MFF latency and error scores, and a nonsignificant correlation between MFF latency and verbal IQ. In contrast, results that are not in accord include: nonsignificant correlations between MFF latency and either nonverbal IQ or total IQ, a negative correlation between MFF errors and IQ that was significant only for SA subjects on the nonverbal and total IQ variable, no significant differences in IQ among the four conceptual tempo categories, and a significant sex X tempo interaction, such that for females, FA subjects had significantly higher nonverbal and total IQ scores than did either SI or SA female subjects.

These four major discrepancies between the two studies prompted a reexamination of the operational definitions of conceptual tempo and intelligence. As noted, the conceptual tempo measures differed in terms of the portability of the MFF alternatives, but the Eska and Black results were generally in agreement with the tabulated summary of investigations of the relationship between intelligence and two category definitions of conceptual tempo. The results for Experiment One did not coincide with the general summary. It seemed reasonable to conclude that the discrepancy was due to some aspect of Experiment One, rather than the portable alternatives used by Eska and Black (1971). A second operational difference between the two studies is different measures of intelligence. Again, Otis-Lennon Mental Ability Test scores used by Eska and Black produced correlations that were generally in accord with previous two tempo category investigations; the Canadian Lorge-Thorndike Intelligence Test scores used in Experiment One were not. Consequently, the Canadian Lorge-Thorndike results were further analyzed for a possible explanation of the discrepancy between this and the previous investigations.

A review of the administration procedures of the Canadian Lorge-Thorndike suggested that the test was at least in part a speed test and that it would to some extent be biased in favor of fast responding subjects. The format of the Canadian Lorge-Thorndike is multiple choice, with no penalty for guessing. Consequently, with a fixed time limit and fixed probability of guessing correctly, the more questions completed, the higher the IQ score. Subsequent analysis of the number of Canadian Lorge-Thorndike items completed by fast and slow subjects revealed that on eight of the nine subtests, fast subjects completed more items than did slow subjects. Further analysis indicated that the difference was greatest for the nonverbal battery (F 3,171 = 4.01, $p < .009$). Scheffe multiple comparisons determined that SA subjects omitted significantly more items than did either FI ($p < .033$) or FA ($p < .087$) subjects. Apparently the nonverbal IQ scores and to some extent by reason of the additive way the total IQ is derived, the total IQ scores of fast subjects were augmented by their response speed.

Application of this IQ score bias hypothesis to the four major discrepancies between the Experiment One results and those of Eska and Black (1971), suggests that the discrepancies may have been due to the unanticipated interaction between conceptual tempo and the operational definition of intelligence used in Experiment One, the Canadian Lorge-Thorndike Intelligence Test.

The first discrepancy, the failure to find a significant positive correlation between MFF latency and either nonverbal or total IQ, appears to be explained by the observation that on the Lorge-Thorndike response latencies for the nonverbal IQ and, by virtue of the fifty percent contribution that the nonverbal IQ makes toward the total IQ, the total IQ -- both are negatively correlated with IQ. If, as the majority of studies have indicated, there is a positive correlation between MFF response latency and intelligence, and there is a negative correlation on this particular test, then it is not surprising that the obtained correlation was not significant.

The second discrepancy, the failure to find a significant negative correlation between MFF errors and total IQ may also be explained by an hypothesized speed bias of the Canadian Lorge-Thorndike. If the test favors fast responders such that their speed contributes to their IQ as well as their total number of MFF errors, then one would ultimately expect a positive correlation between MFF errors and the IQ score. Consequently the nonsignificant correlation observed in Experiment One is again not surprising. Furthermore, the observed exception to the results for all tempos combined, the significant negative correlation between MFF errors and nonverbal and total IQ for SA subjects, may also be consistent with the notion of a speed bias. Since it has been noted above that SA subjects completed significantly fewer IQ test items than did FA and FI subjects, it follows that the IQ scores of SA subjects would minimize the spurious effect of response speed upon the IQ scores. With this effect reduced for subjects in the slow-accurate cell, a less confc nded measure of intelligence may have been obtained. Such a measure should yield the significant negativ relation between IQ and MFF errors that was observe in the tabular summary presented above -- and, inteed, that would be anticipated from our common knowledge of the positive correlations between intelligence and performance on a variety of cognitive tasks.

The third exception may also be explained in terms of an hypothesized response speed bias. Contrary to the Eska and Black (1971) findings, in Experiment One SA subjects were not found to have significantly higher scores than FI subjects on any of the IQ measures. But, if response speed spuriously increased the IQ scores of fast responding subjects it would be anticipated that the previously reported difference between SA and FI subjects would be reduced, possibly below the level of significance.

Finally the fourth discrepancy, the significant sex X tempo interaction produced by FA female subjects that had significantly higher nonverbal and total IQ scores than did their SA and SI counterparts; this discrepancy would also be anticipated as a consequence of response speed augmenting the IQ scores of FA subjects and conversely depressing the IQ scores of SA and SI subjects.

Additional evidence that supports the suggestion of a speed bias in the IQ measure comes from two sources. First, as noted in Table 2, Denney (1973) used the standard Lorge-Thorndike to determine the relationship between reflection-impulsivity and IQ. The results obtained are very similar to those obtained in Experiment One with the Canadian Lorge-Thorndike. This consistency reduces the probability that either of the two sets of results was a consequence of atypical samples. It increases the probability that the atypical results obtained were related to the test format of the Lorge-Thorndike. The second piece of evidence related to a possible speed bias comes from reviews of the intelligence tests used in this and the Eska and Black (1971) investigations (Buros, 1972). In reviewing the Lorge-Thorndike Intelligence Tests, Multi-Level Edition, Tittle (1972) has noted that while the test manual does not provide information about the effect of time on the distribution of scores, McComas (1967) has reported that the tests were too highly speeded to calculate internal consistency reliability coefficients for a sample of black students in grades seven through twelve. In contrast, a review of the Otis-Lennon Mental Ability Test indicated that an evaluation of the speededness of the test revealed that for an untimed administration of the test, the gain was less than two IQ points at the elementary level (Milholland, 1972). If one can infer from this indirect evidence that the Canadian Lorge-Thorndike Intelligence Test and the Otis-Lennon Mental

Ability Test differ significantly in terms of speededness, and speed is central to the conceptual tempo construct, then speededness may explain the discrepancies between the conceptual tempo-IQ relationships observed in the present investigation and those observed by Eska and Black (1971). It is also possible that a speed-bias hypothesis may at least partly explain the large amount of variation found among the previous investigations of the conceptual tempo-IQ relationship that were summarized in Table 2.

What is necessary is a specific investigation of the speed component of intelligence measures as a possible moderator variable that influences the conceptual tempo-IQ relationship. If test speededness differentially affects the scores of fast and slow tempo students as a consequence of the chance probability of the number of questions attempted, the implications for the measurement of individual differences in general, and education and psychology in particular, are worth considering. It may well be that slow tempo persons will not do as well as fast tempo persons on a variety of important measures that can influence one's life; namely, intelligence tests, standardized achievement tests and classroom achievement tests. The speed-bias hypothesis suggests the difference may be a function of conceptual tempo rather than cognitive ability.

Experiment Two investigated the relationship between problem difficulty and four conceptual tempo classifications. This investigation was prompted by a lack of information about the role of problem difficulty in conceptual tempo research, particularly the effect of problem difficulty variations upon the performance of four rather than two conceptual tempo categories. It was postulated that increased levels of problem difficulty would result in inaccurate subjects maintaining their initial response latencies and increasing their rate of errors, while accurate subjects would increase their response latencies and maintain their initial error rate. In addition, it was predicted that the negative correlation between response latency and error would increase directly with problem difficulty. The results obtained did not support any of these hypotheses. Increased problem difficulty resulted in fast subjects minimally increasing their response latencies and substantially increasing their response errors; slow subjects minimally increased their response errors and substantially increased their response latencies. In addition, the magnitudes of the observed negative correlations between response latency and error were curvilinear. While all values were significant, those obtained for medium difficulty problems were substantially larger than were the approximately equal values observed at the low and high difficulty levels.

In that the major hypotheses were not supported, the results obtained were compared with those from several related investigations. The results obtained in the present investigation fully support those reported by Yando and

Kagan (1970); i.e., with increased problem difficulty SA (reflective) subjects increase their response latency and maintain their error rate; FI (impulsive) subjects maintain their response latency and increase their error rate; and nonextreme (FA and SI subjects combined) moderately increase both their response latency and error rates. This confirmation suggests that two of the limitations of the Yando and Kagan (1970) investigation, the practice effect and the reduced probability of guessing correctly, did not substantially alter their reported results.

The third limitation of the Yando and Kagan study, the practice of combining the FA and SI tempo categories into a nonextreme category, appears to have resulted in a loss of information about these tempos in particular and conceptual tempo in general. In particular, the present results indicate that with increasing problem difficulty the moderate latency and error increases of the nonextreme subjects is an artifact of averaging the quite different latency and error increases of SI and FA subjects. The SI subjects substantially increase their response latencies and minimally increase their error rate; while FA subjects substantially increase their error rate and minimally increase their response latencies. As problem difficulty increases FA subjects increasingly approximate the behavior of FI subjects and the behavior of SI subjects comes to resemble that of SA subjects. In general, this information suggests that for both the theoretical and operational definitions of conceptual tempo, response latency may be considerably more important than response errors.

The suggestion that latency may be more important than errors is contrary to many of the stated and implied opinions expressed above in the review of the conceptual tempo literature. For this reason a second analysis of the data was performed. For the second analysis the conjoint, conceptual tempo independent variable of the first analysis was separated into its MFF latency and error components and analyzed as two independent variables. The results indicated that while response latency and problem difficulty were both highly significant variables, response error was not significant for any aspect of CTT performance.

Subject to replication, the observed importance of latency and insignificance of errors appears to have implications for the current debate about the relative importance of these two variables for the theoretical and operational definitions of conceptual tempo. To greatly simplify this long and complex debate, Block, Block, and Harrington (1974) argue that the current practice of operationally defining conceptual tempo with conjoint latency and error measures has the effect of confounding both measures and admitting spurious variance that reduces the construct validity of the MFF and admits alternative explanations that are not consonant with a conventional conceptualization of reflection-impulsivity. To note just one aspect of this well reasoned criticism, Block et al. (1974) note that as well as confounding the two variables, the addition of the error variable to the operationalization of the reflection-impulsivity construct had the effect of admitting variance to the measure that was not related to the construct. Separate analyses of the response latency and error variables of the MFF demonstrated that contrary to the assumed importance of the latency variable, it was MFF error, not latency that accounted for substantial amounts of variance on a set of personality measures, and these characteristics are not related to the expressed conceptualization of reflection-impulsivity (Block et al., 1974).

Kagan and Messer (1975) reply to this criticism by noting that while they have found that response latency is not as important in the operationalization of reflection-impulsivity as they had originally supposed, it was still an important variable in that the latency and error variables combined explained more variance than did the errors variable above. They note that the discrepant results of the Block et al. (1974) investigation were a consequence of the selection of preschool subjects for their sample. Kagan and Messer (1975) present evidence to indicate that response latency may not be a valid measure of reflection-impulsivity for preschool children. They note that the longer response times of preschool children are not always associated with fewer errors; therefore, it is unlikely that they are reflecting over alternative hypotheses and their behavior may well be subject to alternative explanations. In a rejoinder to these arguments Block, Block, and Harrington (1975) present evidence in support of their original conclusions.

This debate is in itself complex, but it appears even more complex when it is considered in relation to the major result of the present study; specifically, that for the determination of conceptual tempos, response latency is the important variable and response accuracy is trivial. Consideration of these results in the larger context of the debate suggests at least three alternative explanations. First, the result noted may be an atypical consequence of the redundancy method used to describe the difficulty levels of the CTT. For example, it is conceivable that the inclusion of two redundant feature differences for low-difficulty-level problems may have permitted subjects to employ comparison strategies that were related more to response latency than to errors.

A second explanation might suggest that the results are attributable to the CTT being a member of a narrow class of cognitive tasks. In this regard, Block et al. (1975) note:

> The finding that MFF latency scores have significant, if not high, correlations with other latency scores derived from analogous tasks only testifies to a generality of response latency within a rather narrow class of cognitive tasks and is not evidence per se for an interpretation of response latency as an index of reflection-impulsivity more broadly conceived (p. 615).

However, if the latency correlations are a reflection of the narrow similarity of the cognitive tasks, then it seems reasonable to expect that this narrow similarity would produce significant error correlations.

The absence of error correlations prompts a third explanation. Kagan and Messer (1975) argue that the discrepancy between their results and those of Block et al. (1974) was due to the latter's use of preschool subjects. Kagan and Messer note that for preschool age children, response latency is not necessarily a reflection of cognitive activity related to the conceptual tempo construct. They further argue that response latency is a valid index of conceptual tempo for school-age children and adults, but that the conjoint use of response latency and response accuracy is a better index of conceptual tempo than is either variable alone. In contrast to both the Block et al. (1974) and the Kagan and Messer (1975) positions, the results of the present investigation indicate that rather than accuracy, it is response latency alone that is the central index of reliable differences in conceptual tempo. Considered together, these results may be interpreted as a possible indication of an age-related shift in the role of both the response latency and error variables as determinants of conceptual tempo. In accord with the Block et al. data, accuracy, not latency, may be the best index of behavior on conceptual tempo tasks for very young children. With increased age, response latency may increasingly become an important index of tempo behavior to a point that, as Kagan's studies indicate, response latency and accuracy may be used conjointly to better account for conceptual tempo variance than does either variable alone. It may also be the case that with further increases in age, response latency becomes increasingly important as a determinant of conceptual tempo behavior, while response accuracy declines in its ability to account for tempo variance.

The postulation of an age-related change in conceptual tempo behavior is admittedly speculative, but there are three observations that suggest it may be worthy of further investigation. First, some similarities and differences among the three positions. In both the Block et al. (1974) and the present investigation the MFF latency and error variables were separately analyzed. In contrast, Kagan and his colleagues typically do not analyze their variables separately because they theoretically define reflection-impulsivity as the conjoint product of both variables. Another variable, the age of subjects, also reveals an interesting pattern of similarity and difference. The Block et al. (1974) subjects were of preschool age. In contrast, Kagan and Messer (1975) note that subject samples from which their conclusions are drawn typically range in age from six to twelve years. Subjects in the current study had an average age of ten years, nine months; thus, their ages approximate those of the oldest subjects referred to by Kagan and Messer (1975).

Given the similarities and differences noted above it appears possible that the relative importance of response latency and error in conceptual tempo behavior does change with age, but the change is obscured in each of the three investigations. In the Block et al. (1974) investigation and the present investigation the change would be obscured by the use of subjects of approximately the same age, albeit the age levels between the investigations differed considerably. Similarly, while Kagan's investigations involved children of different ages, any developmental change in the significance of the latency and error variables would be obscured by the analysis of the conjointly defined tempo categories. This analysis does not assess the independent contributions of the latency and error variables.

Another observation that lends support to the possibility of a developmental change in conceptual tempo behavior is that the seven-year age span of subjects in the three investigations is first a lengthy period of time in terms of child development. Second, the particular ages involved, four through eleven years, include the period four through seven years of age that has been identified by several investigators as a period of reliable cognitive behavior change. Studies of transposition (Kuenne, 1946) reversal and nonreversal learning (Kendler & Kendler, 1962) and the acquired equivalence of cues (Jeffrey, 1953) have all supported the observation that there is a mediational deficiency in young children (Reese, 1962). While the critical period for the transition to mediational responding varies for different tasks, the gradual transitions for the behaviors noted above occur approximately between the ages of four and seven years. In each case, the transition is marked by a major change in task performance. From these changes it is inferred that while the tasks remain the same the cognitive behaviors associated with the task change drastically. Given that such changes occur for the types of cognitive behavior noted, such a change may also occur for conceptual tempo behavior.

A final observation that may be interpreted as support for a possible developmental change in conceptual tempo behavior is that as noted above, several investigators have reported that with increasing age conceptual tempo latencies increase and errors decrease. In other words, performance does change with age. However, does this change reflect an alteration in the amount of variance than can be accounted for by the latency and error variables?

This explanation of the results of the present study appears to warrant additional thought and possibly an empirical investigation. If, however, there is any merit in the idea of developmental change in the relative importance of the conceptual tempo variables, the idea should assist the investigation of conceptual tempo by reconciling some of the contradictory results reported by tempo investigators. The idea would also have implications for the educational process. It would alert educators to a change in the cognitive behavior of young children that would have several implications for instruction.

Experiment Three examined the effect of critical alternative instruction upon conceptual tempo behavior. In general, this method of instruction modified the conceptual tempo behavior of experimental subjects sufficiently that the original tempo classifications were not supported by significant latency or error differences on the conceptual tempo transfer task. In contrast for the control subjects several significant latency and error differences on the transfer task supported the original tempo classifications. Specifically, critical alternative instruction had the effect of significantly increasing the response latency and reducing the response errors of FI subjects. Two other effects that approached significance were an increase in the response speed of SA subjects and an increase in the accuracy of SI subjects. If these results can be replicated, there are several implications of these observations for conceptual tempo research and educational practice.

One implication for conceptual tempo research is that critical alternative instruction can modify both response latencies and errors that define conceptual tempos. This observation adds alternative instruction to the list of techniques that have been found to successfully modify conceptual tempo behaviors. This observation also lends support to the suggestion that tempo modification per se reduces the construct validity of conceptual tempo. The theoretical definition of conceptual tempo as stable individual differences in the degree to which one reflects upon alternative classifications of a stimulus or alternative solution hypotheses, is not consistent with the observation that instruction can render insignificant the response latency and error differences that define the four conceptual tempo categories. If the results of the present investigation are reliable, then either the conceptual tempo construct is invalid or the operational definition of the construct, the MFF, is at least partially inadequate. While there is not sufficient evidence in this or the previous two experiments to address the major question of the construct validity of conceptual tempo, there is some evidence that bears upon the validity of the MFF as an operational definition of conceptual tempo. The ability of the instruction treatment to change the behaviors of FI subjects in directions consonant with good task performance suggests that at best some of these subjects did not know what to look for on the MFF. The success of SA subjects suggests they did know what to look for on MFF tasks. Consequently, the MFF appears to be measuring two different types of uncertainty and it may be these types of uncertainty that underlie the two major conceptual tempo categories, FI and SA (or as the singular importance of the latency variable in Experiment Two attests, simply fast and slow tempo categories). Examination of the MFF reveals that the two practice items include feature differences that are much more pronounced than are those of the test items. Therefore, it is possible that some subjects do approximate those noted by Olson (1970), who respond rapidly because they don't know what to look for, while others respond slowly because they do know what to look for. To the extent that the MFF admits two levels of uncertainty, performance on the task is the confounded product of two variables: the ability to understand conceptual tempo instructions, and the ability to solve conceptual tempo problems. The conceptual tempo construct is operationally defined as the ability to solve conceptual tempo problems. Therefore, if this possible confounding source of variance was removed from conceptual tempo measures by the use of instruction techniques such as those used in the present investigation, it should have the effect of refining individual differences attributed to conceptual tempo and facilitate the task of testing the construct validity of this variable. If conceptual tempo is presently confounded by individual differences in understanding task instructions, and if this possible artifact can be removed, then it may be that variance presently attributable to conceptual tempo may be better explained by such psychological variables as intelligence, practice, anxiety, motivation, etc. and there may be no need to postulate a conceptual tempo construct.

REFERENCES

Adams, W.V. Strategy differences between reflective and impulsive children. Child Development, 1972, 43, 1076-1080.

Armentrout, J. Parental child-rearing attitudes and pre-adolescent's problem behaviors. Journal of Consulting and Clinical Psychology, 1971, 37, 278-285.

Ault, R. Problem-solving strategies of reflective, impulsive, fast-accurate, and slow-accurate children. Child Development, 1973, 44, 259-266.

Ault, R.L., Crawford, D.E., & Jeffery, W.E. Visual scanning strategies of reflective, impulsive, fast-accurate, and slow-inaccurate children on the Matching Familiar Figures test. Child Development, 1972, 43, 1412-1417.

Banta, T.J. Tests for the evaluation of early childhood education: The Cincinnati Autonomy Test Battery (CATB). In J. Hellmuth (Ed.), Cognitive Studies (Vol. 1). New York: Bruhner/Mazel, 1970.

Berman, P.W., & Villwock, M.A. Response latency: Errors and subsequent change of response on retest. Journal of Educational Psychology, 1971, 62 (6), 474-481.

Berzonsky, M.D. Reflectivity, internality, and animistic thinking. Child Development, 1974, 45, 785-789.

Blishen, B.R. A socioeconomic index for occupations in Canada. Canadian Review of Anthropology and Sociology, 1967, 4, 41-53.

Block, J., Block, J.H., & Harrington, D.M. Some misgivings about the matching familiar figures test as a measure of reflection-impulsivity. Developmental Psychology, 1974, 10 (5), 611-632.

Block, J., Block, J.H., & Harrington, D.M. Comment on the Kagan-Messer reply. Developmental Psychology, 1975, 11 (2), 249-252.

Briggs, C.H. An experimental study of reflection-impulsivity in children. Unpublished doctoral dissertation. University of Minnesota, 1966.

Briggs, C.H., & Weinberg, R.A. Effects of reinforcement in training children's conceptual tempos. Journal of Educational Psychology, 1973, 65 (3), 383-394.

Bruner, J.S., Goodnow, J.J., & Austin, G.A. A Study of Thinking. New York: John Wiley, 1966.

Buros, O.K. (Ed.), The Seventh Mental Measurements Yearbook. New Jersey: Gryphon Press, 1972.

Campbell, D.R. A study of the relationship between discrimination response styles and the orienting response. Unpublished doctoral dissertation, University of Alberta, 1968.

Campbell, S.B., Douglas, V.I., & Morgenstern, G. Cognitive styles in hyperactive children and the effect of methylphenidate. Journal of Child Psychology and Psychiatry and Applied Disciplines, 1971, 12, 55-67.

Campbell, D.T., & Stanley, J.T. Experimental and quasi-experimental designs for research. Chicago: Rand McNally, 1966.

Cathcart, W.G., & Leidtke, W. Reflectiveness/impulsiveness and mathematics achievement. The Arithmetic Teacher, 1969, 16, 563-567.

Cathcart, W.G., & Leidtke, W. Role of conceptual tempo in concept formation. The Alberta Journal of Educational Research, 1973, 19 (3), 216-223.

Coop, R.H., & Sigel, I.E. Cognitive style: Implications for learning and instruction. Psychology in Schools, 1971, 8 (2), 152-161.

Coyle, P.J. Differences in reflection-impulsivity as a function of race, sex, and socio-economic class. Unpublished doctoral dissertation, George Peabody College for Teachers, 1966.

Debus, R.L. Effects of brief observation of model behavior on conceptual tempo of impulsive children. Developmental Psychology, 1970, 2 (1), 22-32.

Denney, D.R. Modeling effects upon conceptual style and cognitive tempo. Child Development, 1972, 43 (1), 105-119.

Denney, D. Reflection and impulsivity as determinants of conceptual strategy. Child Development, 1973, 44, 614-623.

Denney, D.R. Relationship of three cognitive style dimensions to elementary reading abilities. Journal of Educational Psychology, 1974, 66 (5), 702-709.

Draguns, J.G., & Multari, G. Recognition of perceptually ambiguous stimuli in grade school children. Child Development, 1961, 32, 541-550.

Drake, D.M. Perceptual correlates of impulsive and reflective behavior. Unpublished doctoral dissertation, Harvard University, 1968.

Drake, D.M. Perceptual correlates of impulsive and reflective behavior. Developmental Psychology, 1970, 2 (2), 202-214.

Egeland, B. Training impulsive children in the use of more efficient scanning techniques. Child Development, 1974, 45 (1), 165-171.

Eska, B., & Black, K.N. Conceptual tempo in young grade-school children. Child Development, 1971, 42, 505-516.

Ferguson, G.A. Statistical analysis in psychology and education. Toronto: McGraw-Hill, 1971.

Finch, A.J., Deardorff, P.A., & Montgomery, L.E. Reflection-impulsivity: Reliability of the matching familiar figures test with emotionally disturbed children. Psychological Reports, 1974, 35, 1133-1134.

Finch, A.J., Nelson, III, W.M., Montgomery, L.E., & Stein, A.B. Reflection-impulsivity and locus of control in emotionally disturbed children. The Journal of Genetic Psychology, 1974, 125, 273-275.

Finch, A.J., Jr., Pezzuti, K.A., Montgomery, L.E., & Kemp, S.R. Reflection-impulsivity and academic attainment in emotionally disturbed children. Journal of Abnormal Child Psychology, 1974, 2, 71-74.

Fuqua, R.W., Bartsch, T.W., & Phye, G.D. An investigation of the relationship between cognitive tempo and creat-ivity in preschool-age children. Child Development, 1975, 46 (3), 779-782.

Garner, J., Percey, L., & Lawson, T. Sex differences in behavioral impulsivity, intellectual impulsivity, and attainment in young children. Journal of Child Psychology and Psychiatry, 1971, 12, 261-271.

Garner, W.R. To perceive is to know. American Psychologist, 1966, 21, 11-19.

Gauld, A., & Stephenson, G.M. Some experiments relating to Bartlett's theory of remembering. British Journal of Psychology, 1967, 58, 39-49.

Gibson, E.J. Principles of perceptual learning and development. New York: Appleton Century Crofts, 1969.

Gozali, J. Impulsivity-reflectivity as problem-solving styles among educable mentally retarded children. American Journal of Mental Deficiency, 1969, 73, 864-867.

Grim, P.F. A sustained attention comparison of children and adults using reaction time set and GSR. Journal of Experimental Child Psychology, 1967, 5, 26-39.

Hagen, J.W. Strategies for remembering. In S. Farnham-Diggory (Ed.), Information processing in children. New York: Academic Press, 1972.

Harcum, P.M., & Harcum, E.R. Tempo modification of visual perception of EMR children. Perceptual and Motor Skills, 1973, 37, 179-188.

Harrison, A., & Nadelman, L. Conceptual tempo and inhibition of movement in black preschool children. Child Development, 1972, 43 (2), 657-668.

Heider, E.R. Style and effectiveness of children's verbal communications within and between social classes. Unpublished doctoral dissertation, Harvard University, 1969. (Abstract)

Heider, E.R. Information processing and the modification of an "impulsive conceptual tempo." Child Development, 1971, 42 (3), 1276-1281.

Hemry, F.M. Effect of reinforcement conditions on a discrimination learning task for impulsive versus reflective children. Child Development, 1973, 44, 657-660.

Hess, R.D., & Shipman, V.C. Early experience and the socialization of cognitive modes in children. Child Development, 1965, 36, 369-386.

Jeffrey, W.E. The effects of verbal and nonverbal responses in mediating an instrumental act. Journal of Experimental Psychology, 1953, 45, 327-333.

Kagan, J. Developmental studies in reflection-analysis. In A.H. Kidd & J.L. Riviori (Eds.), Perceptual and conceptual development in the child. New York: International Universities Press, 1964.

Kagan, J. Impulsive and reflective children: Significance of conceptual tempo. In J.D. Krumboltz (Ed.), Learning and the educational process. Chicago, Rand McNally, 1965, 133-161. (a)

Kagan, J. Individual differences in the resolution of response uncertainty. Journal of Personality and Social Psychology, 1965, 2 (2), 154-160. (b)

Kagan, J. Reflection-impulsivity and reading ability in primary grade children. Child Development, 1965, 39, 609-628. (c)

Kagan, J. Body build and conceptual impulsivity in children. Journal of Personality, 1966, 34, 118-128. (a)

Kagan, J. A developmental approach to conceptual growth. In Klausmeier, H.G., & Harris, C.W. (Eds.), Analysis of Concept Learning. New York: Academic Press, 1966, 97-115. (b)

Kagan, J. Reflection-impulsivity: The generality and dynamics of conceptual tempo. Journal of Abnormal Psychology, 1966, 71, 17-24. (c)

Kagan, J. Biological aspects of inhibition systems. American Journal of Diseases of Children, 1967, 114, 507-512. (a)

Kagan, J. Personality and the learning process. In J. Kagan (Ed.), Creativity and Learning. Boston: Houghton, Mifflin Co., 1967, 153-163. (b)

Kagan, J. The determinants of attention in the infant. American Scientist, 1970, 58, 298-306.

Kagan, J. Change and continuity in infancy. Toronto: John Wiley, 1971.

Kagan, J. Do infants think? Scientific American, 1972, 226 (3), 74-82.

Kagan, J., & Kogan, N. Individual variation in cognitive processes. In P. Mussen (Ed.), Carmichael's manual of child psychology, Vol. 1, New York, Wiley, 1970, 1273-1365.

Kagan, J., & Messer, S.B. A reply to "Some Misgivings about the Matching Familiar Figures Test as a Measure of Reflection-Impulsivity." Developmental Psychology, 1975, 11 (2), 244-248.

Kagan, J., Moss, H.A., & Sigel, I.E. Psychological significance of styles of conceptualization. Monographs of the Society for Research in Child Development, 1963, 28 (2, Whole No. 86), 73-112.

Kagan, J., Pearson, L., & Welch, L. Conceptual impulsivity and inductive reasoning. Child Development, 1966, 37, 583-594. (a)

Kagan, J., Pearson, L., & Welch, L. Modifiability of an impulsive tempo. Journal of Educational Psychology, 1966, 57, 359-365. (b)

Kagan, J., & Rosman, B.L. Cardiac and respiratory correlates of attention and an analytic attitude. Journal of Experimental Child Psychology, 1964, 1, 50-63.

Kagan, J., Rosman, B.L., Day, D., Albert, J., & Phillips, W. Information processing in the child: Significance of analytic and reflective attitudes. Psychological Monographs, 1964, 78, (Whole No. 578).

Karp, S.A., & Konstadt, N.L. Manual for the Children's Embedded Figures Test. Brooklyn, N.Y. Cognitive Tests, 1963.

Katz, J.M. Reflection-impulsivity and color-form sorting. Child Development, 1971, 42, 745-754.

Kendler, H.H., & Kendler, T.S. Vertical and horizontal processes in problem-solving. Psychological Review, 1962, 69, 1-16.

Kilburg, R.R., & Siegel, A.W. Differential feature analysis in the recognition memory of reflective and impulsive children. Memory and Cognition, 1973, 1 (4), 413-419.

Kogan, N. Educational implications of cognitive style. In G.S. Lesser, (Ed.), Psychological and Educational Practice. Glenview: Scott Foresman, 1971, 242-292.

Kuenne, M.K. Experimental investigation of the relation of language to transposition behavior in young children. Journal of Experimental Psychology, 1946, 36, 471-490.

Lee, L.C., Kagan, J., & Rabson, A. Influence of a preference for analytic categorization upon concept acquisition. Child Development, 1963, 34, 433-442.

Lesiak, J.F. The relationship of the reflection-impulsivity dimension and the reading ability of elementary school children at two grade levels. Unpublished doctoral dissertation, Ohio State University, 1970. (Abstract)

Lewis, M., Rausch, M., Goldberg, S., & Dodd, C. Error, response time and IQ: Sex differences in cognitive style of preschool children. Perceptual and Motor Skills, 1968, 26, 563-568.

Luria, A.R. The directive function of speech in development. Word, 1959, 15, 341-352.

Luria, A.R. The role of speech in the regulation of normal and abnormal behavior. New York: Liveright, 1961.

Maccoby, E.E. Sex differences in intellectual functioning. In E.E. Maccoby (Ed.), The development of sex differences. Stanford, Cal.: Stanford University Press, 1966.

Mann, L. Differences between reflective and impulsive children in tempo and quality of decision making. Child Development, 1973, 44, 274-279.

Marks, E. Some situational correlates of recognition response level. Journal of Personality and Social Psychology, 1967, 6, 102-106.

Marks, E. Personality factors in the performance of a perceptual recognition task under competing incentives. Journal of Personality and Social Psychology, 1968, 8, 69-77.

Massari, D.J. The relation of reflection-impulsivity to field dependence-independence and internal-external control in children. Journal of Genetic Psychology, 1975, 126, 61-68.

Massari, D.J., & Massari, J.A. Sex differences in the relation of cognitive style and intellectual functioning in disadvantaged preschool children. Journal of Genetic Psychology, 1973, 122, 175-181.

Massari, D.J., & Schack, M.L. Discrimination learning by reflective and impulsive children as a function of reinforcement schedule. Developmental Psychology, 1972, 6 (1), 183.

Meichenbaum, D., & Goodman, J. Reflection-impulsivity and verbal control of motor behavior. Child Development, 1969, 40, 785-797.

Miechenbaum, D.H., & Goodman, J. Training impulsive children to talk to themselves: A means of developing self-control. Journal of Abnormal Psychology, 1971, 77, 115-126.

Messer, S. The effect of anxiety over intellectual performance on reflection-impulsivity in children. Child Development, 1970, 41, 723-735. (a)

Messer, S. Reflection-impulsivity: Stability and school failure. Journal of Educational Psychology, 1970, 61, 487-490. (b)

Messer, S., & Kagan, J. Changes in reflection-impulsivity following situationally induced anxiety. Proceedings of the 77th Annual Convention of the American Psychological Association, 1969, 4 (1), 331-332.

Milholland, J. Otis-Lennon Mental Abilities Test Review. In O.K. Buros (Ed.), The Seventh Mental Measurements Yearbook. New Jersey: Gryphon Press, 1972, 690-691.

Montgomery, L.E., & Finch, A.J. Reflection-impulsivity and locus of conflict in emotionally disturbed children. Journal of Genetic Psychology, 1975, 126, 89-92.

Mosher, F.A., & Hornsby, J.R. On asking questions. In J. Bruner, R.R. Olver, P.M. Greenfield, et al., (Eds.), Studies in Cognitive Growth. New York: Wiley, 1966, 86-102.

Mumbauer, C.C., & Miller, J.O. Socioeconomic background and cognitive functioning in preschool children. Child Development, 1970, 41, 471-480.

McComas, W.C. Structure and function of the Lorge-Thorndike Intelligence Tests when used with Negro school children. Unpublished master's thesis, Marshall University, 1967.

McKinney, J.D. Problem-solving strategies in impulsive and reflective second graders. Developmental Psychology, 1973, 8 (1), 145.

McKinney, J.D. Teacher perceptions of classroom behavior of reflective and impulsive children. Psychology in the Schools, 1975, 12 (3), 348-353.

Nelson, T.F. The effects of training in attention development on observing behavior in reflective and impulsive children. Unpublished doctoral dissertation, University of Minnesota, 1968. (Abstract)

Nuessle, W. Reflectivity as an influence on focusing behavior of children. Journal of Experimental Child Psychology, 1972, 14, 265-276.

Odom, R.D., McIntyre, C.W., & Neale, G.S. The influence of cognitive style on perceptual learning. Child Development, 1971, 42 (3), 883-891.

Olson, D.R. Cognitive development: The child's acquisition of diagonality. New York: Academic Press, 1970.

Olson, D.R. On a theory of instruction: Why different forms of instruction result in similar knowledge. Interchange, 1972, 3, 9-24.

Olson, D.R. Mass media versus schoolmen: The role of the means of instruction in the attainment of educational goals. Interchange, 1974, 5 (2), 11-17.

Ostfeld, B.M., & Neimark, E.D. Effect of response time restriction upon cognitive style scores. Proceedings of the 75th Annual Convention of the American Psychological Association, 1967, 2, 169-170.

Pederson, F.A., & Wender, P.H. Early social correlates of cognitive functioning in six-year-old boys. Child Development, 1968, 39, 185-194.

Pick, A.D. Improvement of visual and tactual form discrimination. Journal of Experimental Psychology, 1965, 69, 331-339.

Plomin, R., & Willerman, L. A co-twin control study and a twin study of reflection-impulsivity in children. Journal of Educational Psychology, 1975, 67 (4), 537-543.

Reali, N., & Hall, V. Effect of success and failure on the reflective and impulsive child. Developmental Psychology, 1970, 3 (3), 392-402.

Reese, H.W. Verbal mediation as a function of age level. Psychological Bulletin, 1962, 59, 502-509.

Reppucci, N.D. Individual differences in the consideration of information among two-year-old children. Developmental Psychology, 1970, 2 (2), 240-246.

Ridberg, E.H., Parke, R.D., & Hetherington, E.M. Modification of impulsive and reflective cognitive styles through observation of film-mediated models. Developmental Psychology, 1971, 3 (3), 369-37

Rotter, J.B. Generalized expectancies for internal versus external control of reinforcement. Psychological Monographs, 1966, 80 (1), Whole No. 609.

Scarr, S. Genetic factors in activity motivation. Child Develop 1966, 37, 663-673.

Schack, M., & Massari, D.J. The effect of conceptual tempo and reinforcement conditions on probability learning. Paper presented at the biennial meeting of the Society for Research in Child Development, Minneapolis, Minnesota, April 1971.

Schliefer, M., & Douglas, V.I. Moral judgements, behavior and cognitive style in young children. Canadian Journal of Behavioral Science, 1973, 5 (2), 133-144.

Schwebel, A.I. Effects of impulsivity on performance of verbal tasks in middle- and lower-class children.

American Journal of Ortho-psychiatry, 1966, 36 (1), 13-21.

Shine, D.W. Cognitive impulsivity and Piaget's theory of perceptual decentration. Dissertation Abstract International, 1971, 32 (4-B), 2385-2386.

Siegel, A.W., Kirasic, K.C., & Kilburg, R.R. Recognition memory in impulsive and reflective preschool children. Child Development, 1973, 44, 651-656.

Siegelman, E.Y. Observing behavior in impulsive and reflective children. Unpublished doctoral dissertation, University of Minnesota, 1966.

Siegelman, E. Reflective and impulsive observing behavior. Child Development, 1969, 40, 1213-1222.

Sigel, I.E. When do we know what a child knows? Human Development, 1974, 17 (3), 201-217.

Souch, S. A cross-sectional study of reflection-impulsivity. Unpublished doctoral dissertation, University of Alberta, 1970.

Souch, S.G., & LeFrancois, G.R. Conceptual tempo and elementary school children. In H.W. Zingle & E.E. Fox (Eds.), The elementary school counsellor in the decade ahead. Toronto: Holt, Rinehart & Winston, 1972.

Stevens, J.H. Reflectivity and impulsivity in disadvantaged preschool children. Paper presented at the meeting of the Southeastern Psychological Association, Atlanta, Georgia, April 1962.

Tittle, C.K. Lorge-Thorndike Intelligence Test Review. In O.K. Buros, The Seventh Mental Measurements Yearbook. New Jersey: Gryphon Press, 1972, 684-686.

Vurpillot, E. The development of scanning strategies and their relation to visual differentiation. Journal of Experimental Child Psychology, 1968, 6, 632-650.

Vygotsky, L.S. Thought and Language. New York: Wiley, 1962.

Wallach, M.A., & Caron, A.J. Attribute criteriality and sex-linked conservatism as determinants of psychological similarity. Journal of Abnormal and Social Psychology, 1959, 59, 43-50.

Ward, W.C. Reflection-impulsivity in kindergarten children. Child Development, 1968, 39, 867-874.

Weinberg, R. A. The effects of different types of reinforcement in training a reflective conceptual tempo. Unpublished doctoral dissertation, University of Minnesota, 1969. (Abstract)

Weiner, A.S. Visual information processing speed in reflective and impulsive children. Child Development, 1975, 46, 998-1000.

Weiner, A.S., & Adams, W.V. The effect of failure and frustration on reflective and impulsive children. Journal of Experimental Child Psychology, 1974, 17, 353-359.

Weiner, A.S., & Berzonsky, M.D. Development of selective attention in reflective and impulsive children. Child Development, 1975, 46 (2), 545-549.

Winer, B.J. Statistical principles in experimental design. Toronto: McGraw-Hill, 1971.

Witkin, H.A., Dyk, R.B., Faterson, H.F., Goodenough, R.D., & Karp, S.A. Psychological Differentiation. New York: Wiley, 1962.

Yando, R., & Kagan, J. The effect of teacher tempo on the child. Child Development, 1968, 39, 27-34.

Yando, R.M., & Kagan, J. The effect of task complexity on reflection-impulsivity. Cognitive Psychology, 1970, 1, 192-220.

Zelniker, T., Cochavi, D., & Yered, J. The relationship between speed of performance and cognitive style: The effect of imposed modification of response latency. Child Development, 1974, 45, 779-784.

Zelniker, T., Jeffrey, W.E., Ault, R., & Parsons, J. Analysis and modification of search strategies of impulsive and reflective children on the Matching Familiar Figures test. Child Development, 1972, 43 (2), 321-335.

Zelniker, T., & Oppenheimer, L. Modification of information processing of impulsive children. Child Development, 1973, 44, 445-450.

Zucker, J.S., & Stricker, G. Impulsivity-reflectivity in preschool headstart and middleclass children. Journal of Learning Disabilities, 1968, 1, 578-583.

APPENDICES

APPENDIX A

CORRELATES OF REFLECTION-IMPULSIVITY

CORRELATES OF REFLECTION-IMPULSIVITY

Another part of the research on conceptual tempo has been concerned with the determination of relationships between the postulated conceptual tempo construct and other psychological constructs. Examination of this literature indicated that while a summary of this part of the tempo research was not essential to the development of the three experiments outlined above, the review provided information that will facilitate one's understanding of the construct and its place in psychology; consequently, a summary of this research is presented to complete the review of conceptual tempo. A question that may serve as a focus for this summary is: Is conceptual tempo an anomaly that is unique to a few tasks such as those described above, or is it a construct that is applicable to a wider class of human behaviors? The evidence bearing on this question is necessarily of a correlational nature and it comprises the bulk of the research done on conceptual tempo to date. The postulated correlates of conceptual tempo that have been investigated are: chronological age, sex, motor activity, socioeconomic status, hypothesis generation and evaluation, discrimination learning, inductive reasoning, cognitive style, attention, moral judgement, creativity, and measured intelligence. The intelligence relationship was examined above; therefore, it will not be included in this review.

Chronological Age

Kagan (1966b) has evaluated the developmental course of reflection-impulsivity with a cross-sectional study of children aged six to ten years. Performance on the MFF, DRT, HVM, and VA tasks revealed consistently negative correlations between the response latency and error variables (coefficients ranged between $r = -.30$ and $r = -.60$). With increased age, there were significant decreases in errors and significant increases in response latencies on the MFF, DRT, and HVM. Corresponding data from the VA task indicated that with increased age there is an increase in response latency and a reduction of errors in labelling the figural component, but a decrease in response latency and an increase in labelling errors for background components (Kagan, 1966b). This result is interpreted as evidence suggesting that the disposition to reflect over alternative solution hypotheses grows stronger as the child matures.

Further evidence in support of a linear increase in reflection with age comes from Katz (1971). Katz found that the mean age of impulsive subjects was significantly lower than that of reflective subjects. In addition, he found that age [illegible]lated negatively with MFF errors ($r = -.51$, $p < .$[illegible]) [illegible]ositively with response latency ($r = .21$, $p < .05$)

In [illegible] the results of Kagan (1966b), and Katz (1971), Sc[illegible] [illegible]orted that "... no positive linear relationship w[illegible] [illegible]und between [illegible]ge and reflectivity for either male or female subjects (p. 39)." However, comparison of the relationship between response latency and age with that between response errors and age, admits the alternative explanation that increases in response latency with increased age were confounded with an inverse relation between age and task difficulty. With increased age conceptual tempo problems become less difficult such that they require less time and produce fewer errors. Support for this inverse relationship is found in the error-age data which shows that the number of errors was negatively correlated with age. While Souch's results may be explained by the postulation of an inverse relation between age and task difficulty, his study prompts a reconsideration of the results of both Kagan (1966b) and Katz (1971). Of particular importance is clarification of the several relationships that exist among the variables: age, task difficulty, response latency and response errors. It would appear that until one can quantify levels of task difficulty and control this variable at various age levels, estimates of the relationship between age and conceptual tempo are of questionable validity.

An alternative explanation of the age-related change in conceptual tempo is offered by Draguns and Multari (1961). They have indicated that a corresponding characteristic of the developmental change toward increased reflection is the demonstration of a general disposition to be more cautious with age; i.e., to become increasingly concerned with avoiding a mistake. These investigators showed ambiguous pictures to children in grades 1, 3, 5, and 7, and gradually added clues to decrease the ambiguity of the stimuli. The younger children offered guesses early, whereas older children proceeded cautiously and inhibited hypotheses until they were more certain of the accuracy of their responses. As would be expected the error rate of the younger children was considerably higher than that of older children.

Sex

While sex differences in conceptual tempo have seldom been the major subject of an investigation, the inclusion by Kagan and Kogan (1970) of Maccoby's hypothetical explanation of sex differences in intellectual performance under the reflection-impulsivity rubric provides an enticing proposition that should promote specific research on this question. Briefly, Maccoby (1966) postulates that sex differences in intellectual performance are curvilinearly related to a personality dimension of inhibition-impulsiveness. The positions occupied by males and females on this dimension are presumed to be different (see Figure 1). Generally, boys must become more inhibited and girls less inhibited to increase their intellectual performance. Kagan and Kogan (1970) interpret Maccoby's hypothesis as an indication that sex differences in intellectual performance may be a consequence of differences in attitude toward error, rather than differences in decoding, memory capacity, or hypothesis generation. Boys are more willing to tolerate the risk of

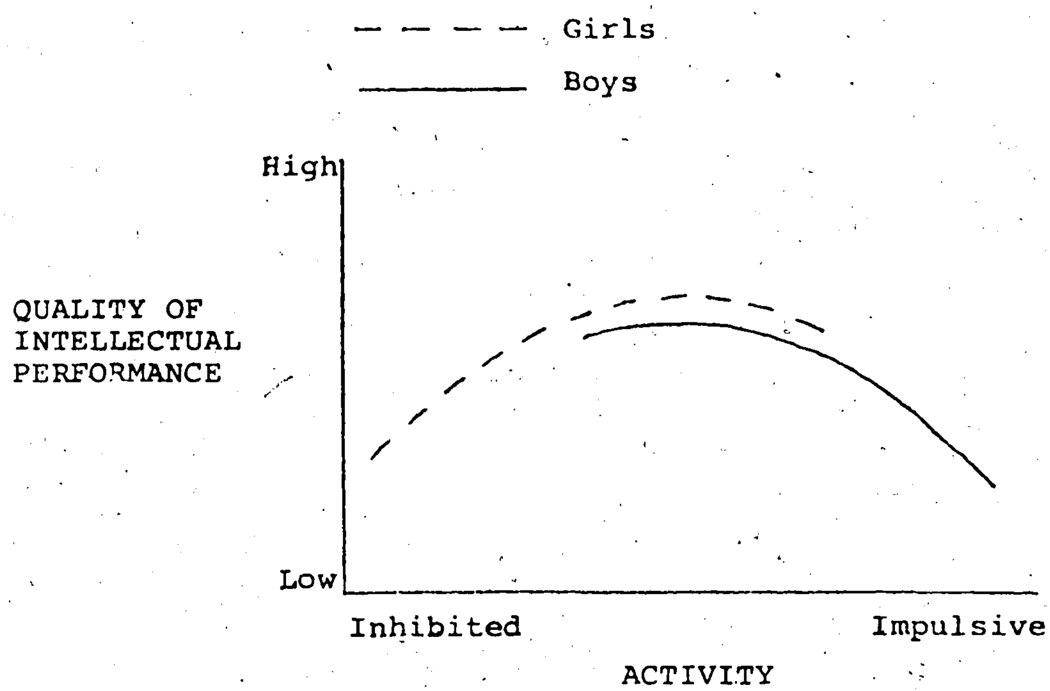

FIG. 1 Relative positions of boys and girls on an hypothesized personality dimension running from inhibited to impulsive, which is curvilinearly related to the quality of intelligent performance (Maccoby, 1966).

error than are girls (Wallach & Caron, 1959); thus, sex differences in intellectual performance may be related to personal cautiousness.

Evidence that is consonant with the Maccoby hypothesis comes from Cathcart and Leidtke (1973). In a sample of seven- and eight-year-old subjects, males were found to be significantly more impulsive than were females. However, these investigators suggest that reflectiveness may be a function of maturity. The sex difference obtained may be related to the more rapid rate of maturation of females at this age level.

An early study that focused upon sex differences in reflection-impulsivity (Lewis, Rausch, Goldberg, & Dodd, 1968) found no sex difference for either the error or latency variables. It was found, however, that errors were more strongly related to IQ in girls than in boys, and to response speed in boys than in girls, a result that is consonant with the Maccoby hypothesis. More recently, Massari and Massari (1973) have replicated the Lewis et al. (1968) results with a sample of disadvantaged preschool children. Massari and Massari argue that despite the absence of overall sex differences for the latency and error variables, sex differences in the patterns of correlations among measures of intellectual ability and conceptual tempo indicate that the conceptual tempo measures are not functionally equivalent for both sexes; that is, the same behaviors have different "psychological meanings" for the two sexes.

In an extensive investigation of sex differences in impulsive behavior, Garner, Percy, and Lawson (1971) evaluated the Maccoby hypothesis in relation to two types of impulsivity: behavioral impulsivity, defined as gross changes in activity in a classroom setting, and intellectual impulsivity, defined as one of the tempo tasks used by Kagan et al. (1964) which required subjects to identify one of six pictures which differed slightly from five identical pictures. Using four subtests of the Wechsler Intelligence Scale for Children (WISC) as a measure of intellectual performance, Garner et al. found no support for Maccoby's argument that the relationship between behavioral impulsivity and intellectual performance is curvilinear. Support was obtained for her argument that behaviorally, boys are more impulsive than girls. With regard to intellectual impulsivity, no support was obtained for any of the deductions of Maccoby's hypothesis, but as Garner et al. note: "... the lack of support might well be due to intellectual impulsivity being a variable that is unrelated to impulsivity of the kind referred to by Maccoby (p. 268)."

Motor Activity

Evidence that individual differences in conceptual tempo occur for motor behavior as well as cognitive behavior comes from Harrison and Nadelman (1972). Preschool children were compared in terms of their performance on two measures of motor inhibition, the Draw a Line Slowly Test and Walk

Slowly Test; one measure of intelligence, the Peabody Picture Vocabulary Test; and one measure of conceptual tempo, the MFF. Correlations among these variables indicated that MFF response latency scores were positively and significantly correlated with response latencies on both motor inhibition measures, and positively, but insignificantly related to IQ. Error scores on the MFF were not related to the motor inhibition tasks when these were administered without task speed instructions, but were negatively and significantly related when subjects were instructed to complete the tasks as slowly as possible. The latter relationship also held when the difference between the scores of the no-speed instruction and slow-speed instruction administrations was used as a dependent variable. A second analysis was conducted for those subjects classified as reflective or impulsive according to the dichotomous classification of MFF latency and error scores. These subjects were then classified as inhibitors or non-inhibitors, according to whether the child was able to reduce his response latency on the motor inhibition tasks by half when instructed to proceed slowly. The resulting matrix revealed that 10 of 14 reflective children attained the reduced level of inhibition, while 9 of 12 impulsive children did not ($\chi^2 = 3.87$, $p < .05$). It is of interest to note that the correlation between motor task latencies for the normal speed and slow speed conditions ($r = .70$, $p < .01$) indicates that the normally slow responding subjects were best able to inhibit motor movement when instructed to do so. These findings suggest the existence of a general disposition to respond with a similar tempo to both cognitive and motor tasks.

Meichenbaum and Goodman (1969, 1971) have examined the possibility that motor behavior is related to conceptual tempo through the medium of speech-for-self. Based on the common observation that children often talk to themselves, Luria (1959, 1961) and Vygotsky (1962) have proposed that speech-for-self serves to orient and direct children's behavior. A proposed sequence of development of this function involves three stages. The child under two years of age cannot use speech to direct his behavior. During the second stage, speech-for-self regulates behavior to a limited degree. A child's speech has a motor component which helps initiate motor behavior, but will not inhibit it, regardless of the semantic content of the speech. At this stage speech has an impulsive function. For example, despite the inhibiting semantic content of the verbalization, "don't push", the child at this stage will push. During the third stage the semantic content of the child's speech becomes dominant and directs behavior.

Meichenbaum and Goodman (1969) used both a finger tapping task and a motor depression task to assess the relationship between conceptual tempo and the extent to which the semantic content of a child's verbalization controls his behavior. Specifically, it was hypothesized that children who failed to demonstrate the ability to verbally control their behavior would respond impulsively on the MFF; while those subjects who demonstrated such an ability would respond reflectively on this measure. These investigators found that while the tapping behavior of reflective and impulsive subjects did not differ significantly under a variety of overt self-instructions, the motor depression behavior did. Only 40 percent of the impulsive subjects reached the criterion of 90 percent correct responding to the cues initiating the verbal commands, "push" or "don't push". In contrast, 95 percent of the reflective subjects met this criterion. In addition, analysis of kymograph responses revealed that the magnitude of the errors committed by the impulsive subjects was significantly greater than that of reflective subjects. The greater number and magnitude of errors committed by impulsive subjects indicates that an impulsive conceptual tempo may be related to Luria's suggestion that for some children self-speech has only an impulsive initiating function, rather than a directive or inhibiting function.

Conceptual tempo has also been found to be related to interpersonal speech. Kagan (1965a) has reported that reflective and impulsive children have been found to differ in an interview situation requiring them to answer an adult questioner. The average delay between the termination of an interviewer's question, that was designed to evoke response uncertainty, and the initiation of the subject's response was computed. Correlations of this measure with response time on the MFF were $r = .30$ for boys and $r = .38$

for girls (p's < .05).

Socioeconomic Status

The relationship between socioeconomic status (SES) and reflection-impulsivity has been investigated both within and between Negro and Caucasian racial groups. The results of these studies suggest that within both cultures, impulsive and reflective responding tends to be associated with lower- and middle-class socioeconomic status respectively; while the differences between races for this variable suggests that Negro subjects tend to be more reflective than Caucasian subjects.

Hess and Shipman (1965) report that Negro children from a lower-class background were significantly more impulsive than were those from a middle-class background, and the same result was true for samples of Negro mothers from both social classes.

Coyle (1966) found significant differences in conceptual tempo between Negro and Caucasian subjects, and between SES levels within both racial groups. Negro children showed longer MFF latencies and made fewer errors than did their Caucasian counterparts. In addition, within both racial groups extreme lower-class children were significantly more impulsive than were middle-class children.

Schwebel (1966) has postulated that part of the inferior language competence of lower-class children is attributable to impulsive responding. Lower- and middle-class Caucasian boys were compared in terms of response latency and errors on four verbal tasks: describing pictures, recalling events of the day, completing sentences, and grouping objects and explaining such groupings. Each of the four tasks was administered under both free and forced latency conditions. Schwebel found that, in general, middle-class subjects were superior to lower-class subjects in language competence. Middle-class children described more ideas and events, used longer and better developed sentences, gave more accurate and complete accounts, and grouped objects more effectively than did lower-class subjects. The lower-class subjects were handicapped by a tendency toward impulsivity. They responded faster and made more errors on each of the four tasks than did the middle-class subjects. The difference between free and forced latency conditions was significant only for lower-class subjects whose performance improved under the forced latency condition. Schwebel contends that the improvement was a consequence of forcing these children to stop and think before responding. Lower-class children were typically so anxious to get started that they often replied before the experimenter finished the instructions. These children appeared to not listen to the directions and respond without considering the problem stimuli. These behaviors were not generally characteristic of the middle-class subjects. Further to Schwebel's contention, Berman and Villwock (1971) have noted that instruction reading time for a discrimination task was positively correlated with response latency on the task ($\underline{r}$ = .55, $\underline{p}$ < .01) and negatively correlated with task errors ($\underline{r}$ = .47, $\underline{p}$ < .05). This observation suggests that part of the latency and error variance that discriminates reflective from impulsive subjects may be due to differential understanding of the instructions.

Zucker and Stricker (1968) have investigated differences in conceptual tempo between lower-class, Negro, and middle-class, Caucasian, preschool children. In accord with previous studies of social class differences on this dimension, lower-class children responded faster and made more errors on the MFF than did middle-class children. Although any generalizations that are based on this study are suspect due to the confounding of the race and social class variables, it is interesting to note that these results support social class differences in conceptual tempo even when the social class variable is placed in opposition to the racial difference reported by Coyle (1966).

Campbell (1968) has reported a significant difference between SES levels and reflection-impulsivity. Sixty-one percent of the students tested from a school situated in the lowest SES area of a city were classified as impulsive subjects. In contrast, only eleven percent were classified as reflective subjects.

Further support for this SES difference comes from the investigation of Souch and LeFrancois (1972), who employed the Canadian Occupational Scale (Blishen, 1967) to identify significantly different SES levels for two elementary schools.

These investigators found that impulsive children were significantly overrepresented in the low SES school, and reflective children were significantly overrepresented in the high SES school.

Hypotheses Generation and Evaluation

In Kagan's postulated theoretical explanation of conceptual tempo, it was noted that of the six processes involved in problem solving, the two most germane to conceptual tempo are the generation and evaluation of hypotheses. In an attempt to test deductions following from this postulation, Kagan has investigated both processes in relation to the measures of conceptual tempo.

Kagan (1965b) has shown that conceptual tempo generalized to tasks which required the subject to generate his own alternative hypotheses. Tachistoscopic presentations of inkline drawings depicting incongruous scenes were observed by second- and third-grade children. The drawings were exposed for increasingly longer intervals. Response latency from the initial exposure to the first significant verbalization of a recognition hypothesis was recorded and found to be positively correlated with response latency on the MFF ($r = .40$, $p < .01$). This result suggests that the individual differences in conceptual tempo are consistent for tasks which require the subject to generate his own alternative hypotheses and tasks in which the alternatives are supplied. It was also found that verbal skills displayed a moderately positive relation with tachistoscopic recognition time ($\underline{r}$ = .33 for boys; $\underline{r}$ = .20 for girls). Kagan notes that this result is somewhat paradoxical. It is reasonable to expect that an extensive vocabulary would lead to rapid conceptualization of the ambiguous stimulus and a rapid response; whereas an inadequate vocabulary might be expected to inhibit conceptualization and delay the response. On the contrary, children of low verbal ability responded rapidly while those of average and high verbal ability responded more slowly. At this point Kagan goes beyond the data to speculate in terms of his proposed theoretical explanation:

> "Since response latency in this situation is regarded as a partial index of degree of response uncertainty, it is suggested that the verbally proficient children generated more response possibilities and, consequently required more time to select a final interpretation (p. 157)."

While this speculation supports Kagan's position, a more direct investigation of hypothesis generation in relation to response uncertainty is needed before any meaningful generalizations can be made regarding the relationship between hypothesis generation and conceptual tempo.

Concerning hypothesis evaluation, Kagan, Pearson, and Welch (1966a) found that MFF response latency is positively correlated with the amount of time taken by a subject to subjectively evaluate his performance on a battery of matching-to-sample and inductive reasoning tests. An interesting aside is that for boys, longer decision times during self-evaluation were predictive of more accurate evaluations of performance.

However, in a specific investigation of the hypothesis that reflection-impulsivity is related to caution in decision-making situations, Mann (1973) found that while reflective subjects took significantly longer to decide than did impulsive subjects, the quality of performance on several decision-making tasks did not differ. Evidently, the analogue to MFF error did not generalize to these decision-making tasks.

Denny (1973) has investigated the relationship between conceptual tempo and the type of hypotheses employed by children as indexed by their questions. Mosher and Hornsby (1966) have demonstrated that between the ages of six and eleven years, the type of questions asked by children changes. Specifically, using a game similar to the parlour game, Twenty Questions, these investigators have noted a shift from hypothesis-seeking questions which test a specific self-sufficient hypothesis having no relationship with previous questions (e.g., "Is it the saw?"); to constraint-seeking questions, which are more general in that they relate to previous questions and are attempts to eliminate a number of alternative hypotheses with a single question (e.g., "Is it a tool?"). Denny's results indicated that reflective subjects used a significantly greater number of constraint-seeking questions than did impulsive subjects. In addition, instructions to adopt either a reflective or impulsive tempo indicated that children who were initially reflective showed greater responsiveness to both reflective and impulsive instructions than did children who were initially impulsive.

In relation to the instructed tempo changes and the types of questions asked, impulsive instructions resulted in a significant decrease in constraint-seeking questions, while reflective instructions did not appreciably increase the use of this strategy.

McKinney (1973) has also noted a similar difference in the hypothesis testing strategies of impulsive and reflective children. On a problem-solving task, reflective subjects employed more efficient hypothesis testing strategies than did impulsive subjects. Specifically, reflective subjects tended to generate several alternative hypotheses and employ a focusing strategy that tested the significance of broad conceptual categories rather than specific stimulus instances. Impulsive subjects attempted to solve the problem in a random, trial-and-error manner, apparently without the aid of any abstract hypothesis.

Discrimination Learning

Hemry (1973) has found that conceptual tempo is related to discrimination learning. Specifically, he reported that under six different reinforcement conditions the discrimination learning performance of reflective subjects exceeded that of impulsive subjects. This result is not surprising if one considers discrimination learning is a major requirement of the MFF. What is surprising, however, is the absence in the conceptual tempo literature of the application of discrimination learning theory to conceptual tempo. It would appear that both constructs might benefit from such an application.

If it is tenable that discrimination learning is an essential part of one's ability to correctly attribute life to animate objects, then further evidence on the relationship between conceptual tempo and discrimination learning comes from Berzonsky (1974). This investigation has indicated that conceptual tempo is a significant process variable affecting the development of animistic thinking in children. In terms of Piaget's postulation of the four invariant stages involved in the ontogenetic evolution of conceptions of life, reflective children were significantly more animistic than were impulsive children of the same age.

Inductive Reasoning

Additional evidence of the generality of conceptual tempo comes from Kagan, Pearson, and Welch (1966a) who found that inductive reasoning is influenced by conceptual tempo. Reflective and impulsive children were given two tests of inductive reasoning; for example, on one test, the child was given three attributes of an object, and was asked to guess what the object was. On both tests impulsive children had significantly shorter response latencies and made significantly more errors than did reflective children.

Cognitive Style

Another area of conceptual tempo research is that concerned with determining the relationships between reflection-impulsivity and other postulated dimensions of cognitive style; such as, field-dependence-independence (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962), and locus of control (Rotter, 1966). In general, the evidence bearing on these relationships is contradictory; therefore, it is necessary to briefly review some of these contradictory results to explain the current status of this area of investigation.

In the initial investigation of reflection-impulsivity (Kagan et al., 1964) it was concluded that the data, "... indicate no strong relation between field-independence and reflection-impulsivity (p. 35)" -- though it should be noted that Kagan et al., do report a significant negative correlation between analytic responding and Embedded Figures Test (EFT) (Witkin et al., 1962) errors. Since that time, several investigations have yielded contrary evidence. Mumbauer and Miller (1970) have found that for a sample of preschool children, performance on the MFF was positively correlated with performance on a conventional measure of field-dependence-independence, the Children's Embedded Figures Test (EFT) (Karp & Konstadt, 1963), for both the latency ($\underline{r}$ = .56) and error ($\underline{r}$ = .43) variables. In addition, significant negative correlations between response latency and error were reported for both measures. These results replicate the significant MFF-CEFT correlations reported by

Stevens (1967), and lend support to his argument that the two tests measure the same response dimension. Still further support for this argument comes from Massari and Massari (1973) for a sample of preschool children measured with the Early Childhood Matching Familiar Figures Test (EC-MFF) and the Early Childhood Embedded Figures Test (EC-EFT) -- both developed by Banta (1970). Errors on the EC-MFF and accuracy on the EC-EFT were significantly correlated for both males ($r = -.45$, $p < .01$) and females ($r = -.46$, $p < .01$); and so were response latencies on the two measures (r's = .39 and .46, p's < .01 for males and females, respectively. However, while the correlations between latency and error were negative and significant for both sexes on the EC-MFF (r's = -.69 and -.50, p's < .01) for males and females, respectively) this relationship was positive and not significant for the EC-EFT. This result is at variance with that reported above for the Mumbauer and Miller (1970) investigation. It seems likely that this difference may be due to the different measures used to test both conceptual tempo and field-dependence-independence. Finally on this subject, Massari (1975), using samples of first and third grade children has reported that for both male and female subjects, reflective subjects were more field-independent than were impulsive subjects ($F = 4.79$, $df = 1/72$, $p < .05$). Taken together, these results suggest that the MFF and EFT do in part measure the same dimension. But, to infer from this that conceptual temp is related to field-dependence-independence seems premature. Until a similar relationship is demonstrated with the original measure of field-dependence-independence, the Rod and Frame Test (Witkin et al., 1962), the Kagan et al. (1964) position noted above cannot be dismissed.

With regard to Rotter's locus of control construct, i.e., the degree to which one believes he is responsible for or causes events (internal control) which affect him rather than attributing these events to fate or chance (external control), this dimension has not been found to be significantly related to conceptual tempo in emotionally disturbed children (Finch, Nelson III, Montgomery, & Stein, 1974) or inner city black children (Massari, 1975). However, for a similar construct, Montgomery and Finch (1975) have shown that cognitive style is related to the locus of conflict in interpersonal relations in emotionally disturbed children. The locus of conflict (Armentrout, 1971) is concerned with the child's mode of impulse modulation. In some children impulses are internalized and the resulting conflict is between impulses and their inhibitions. In other children the impulses are freely vented or externalized and the conflict is between the behavior of the child and the reactions of others affected by the behavior. Montgomery and Finch found that children with an impulsive cognitive style were significantly more external in their locus of conflict, while reflective children were significantly more internal in their locus of conflict.

Attention

Several studies have indicated that the duration and pattern of attention distribution during task performance is related to the reflection-impulsivity dimension. Both Siegelman (1966, 1969) and Nelson (1968) have administered the MFF in an apparatus that required subjects to press manipulada to view the standard stimulus and each of the alternatives. The resulting instrumental responses indicated that in contrast to impulsive subjects, reflective subjects had a longer average duration of viewing both the standard and its variants, and tended to view most of the alternative stimuli prior to responding. Impulsive subjects typically responded after viewing only one or two of the alternatives. In addition, both investigators found that reflective subjects spent proportionately less time attending to the standard stimulus and proportionally more time looking at the alternatives than did impulsive subjects.

Siegelman (1969) has clearly demonstrated that the observing behavior of reflective and impulsive subjects differs during MFF performance. She found that impulsive subjects spent proportionately more time viewing the standard stimulus, the most observed alternative, and the finally chosen alternative, than did reflective subjects. Furthermore, impulsive subjects ignored two and one-half times as many alternatives per item as did reflective subjects (2.83 vs 1.11, $p < .001$). Siegelman's results indicate that the observing behavior of reflective and impulsive subjects differed not only quantitatively, as indicated by differences in total observing response time, but also qualitatively, as indicated by differences in patterns of attention deployment. Impulsive subjects limited their attention to the standard and a few alternatives, and largely ignored the rest of the array. Reflective subjects, on the other hand, viewed a significantly greater number of stimuli in the array, and distributed their attention homogeneously among all members of the array. Reflective subjects also allotted proportionately less time to the standard than did impulsive subjects. Taken together, these differences suggest that different search strategies are used by reflective and impulsive subjects. Reflective subjects appear to search for differences between alternatives, then check these against the standard. In contrast, impulsive subjects appear to make quick global comparisons between the standard and a few of the alternatives, then select that alternative that does not appear to differ from the standard, regardless of whether the two do not actually differ, or an existing difference was not noticed. Indeed, as the literature review for Experiment Three suggested, these subjects may not know what type of alternatives to look for.

These apparent differences in observing strategies have led Siegelman to suggest that long response times may be a necessary but not sufficient condition for reflective responding. In terms of response style modification, Siegelman's results suggest that training in attention deployment strategies may be a more effective modification treatment than response delay manipulation. The critical difference between reflective and impulsive responding may not be the length of the response interval; rather, it may be the activity that takes place _during_ that interval.

In the most extensive investigation of the role of attention in reflection-impulsivity reported to date, Drake (1968, 1970) used a Mackworth eye marker camera to record the number, latency, and distribution of eye fixations to parts of the MFF stimuli in a sample of eighteen third-grade children and sixteen college students. She found that reflective and impulsive subjects showed different patterns of visual behavior both within and between age groups. Concerning attention given to the standard stimuli for the first six seconds of the MFF task, reflective children and impulsive adults attended to the standard considerably longer than did either impulsive children or reflective adults. By the last four seconds of the task, attention to the standard did not differ significantly among the four groups. Concerning the distribution of attention among the variants of the standard, prior to responding reflective subjects fixated each variant longer, scanned more variants, covered more details in each variant, and made a greater number of homologous comparisons than did impulsive subjects of the same age. Concerning age differences, the adults covered larger areas of the stimulus field and had higher fixation densities per unit area of the stimuli than did the children, for both total performance and any constant interval of time. In general, impulsive children differed from reflective adults; and both these groups differed from reflective children and impulsive adults, who had nearly identical mean response times and performed similarly on all qualitative measures of task behavior when age-related differences in response time were accounted for. Apparently reflective subjects attend more carefully to stimuli before they respond than do impulsive subjects, and this molar attending behavior is congruent with their response times and error scores.

According to Drake, her results indicate that approaches to the MFF task differ as functions of both conceptual tempo and age. Reflective subjects gathered more information about the stimuli and gathered that information more carefully prior to responding than did impulsive subjects. Impulsive subjects were prepared to risk a decision on a limited amount of stimulus information and were less concerned with evaluation of that information. Furthermore, the age comparisons for constant units of time indicated that the efficiency, relevance, and/or speed of execution of some parts of the problem-solving process increased with age.

Drake (1970) has postulated that three different general task strategies may account for the subjects' tempo and age differences. The impulsive child appeared to be intent on quickly finding the variant that was the <u>same</u> as the standard:

> "He made very few detailed comparisons across figures..., and accepted as 'correct' a variant for which he, during a relatively brief period of global scanning, did not notice a difference from the standard, regardless of whether or not other variants did, or might if similarly scanned, look equally the same. There was no felt need to look at all the variants before offering an answer... (Drake, 1970, p. 211)."

The similar results for reflective children and impulsive adults suggest that they employed a more complex strategy. They seemed to recode the experimenter's directions into either one or both of two rules. The first rule directs the subject to search for differences between the standard and the variants, and select a variant if differences between it and the standard cannot be found. The second, and more effective rule, directs the subject to search for differences between the standard and the variants and systematically eliminate deviant variants until only one variant remains, i.e., the matching variant. Since the results indicated that neither reflective children nor impulsive adults always viewed all the variants, it appears that many of these subjects employed the first rather than the second rule. Reflective adults, however, appeared to precisely apply only the second rule, and inhibit responding until the search for differences in all variants was completed.

Drake has also noted that additional support for these postulated strategy differences comes from a comparison of her results with those obtained by Siegelman (1966). When presented with four alternative stimuli, reflective children view an average of 3.30 alternatives while the corresponding figure for impulsive children was 3.20 (Drake, 1970). When six alternatives were presented these averages were 4.89 for reflective children, but only 3.17 for impulsive children (Siegelman, 1966). Apparently, the viewing behavior of impulsive children was not related to the number of alternative stimuli. Drake argues that this result is consonant with the different task strategies postulated for impulsive and reflective children. If an impulsive child is hurriedly searching for a variant that globally represents the standard, then he may never need to scan more than a few variants to find a "match" regardless of the number of alternatives available. In contrast, if a reflective child seeks to identify discrepant stimulus attributes in the variants until he has systematically eliminated all but the matching stimulus, then the number of variants scanned would be a monotonically increasing function of the number of available alternatives. Undoubtedly, this postulated explanation has pointed implications for further research.

Another approach to the attention question is that of Zelniker, Jeffrey, Ault, and Parsons (1972). These investigators tested the hypothesis suggested by Kagan et al. (1963) that poor MFF performance might be a function of an inability to sustain attention for long periods of time, thus resulting in a shortened search for attribute differences prior to responding. Zelniker et al. employed an independent measure of attention span outlined by Grim (1967). This measure tests reaction time with a variable interval between a ready signal and stimulus onset. It was found that when preparatory intervals did not exceed the average MFF response latency of impulsive subjects (18 seconds) there was no significant difference between the reaction times of impulsive and reflective subjects. However, when the preparatory intervals exceeded the average latency of impulsive subjects, the reaction times of these subjects were significantly slower than were those of reflective subjects.

Still another approach that accounts for individual differences in conceptual tempo is one employing the joint constructs of selective attention and incidental learning. Using a task that included measures of central and incidental learning, Weiner and Berzonsky (1975) noted that beginning in the sixth grade reflective subjects displayed more central learning and less incidental learning than did impulsive subjects. Apparently, at this stage of development reflective subjects were beginning to employ a selective strategy of focusing attention upon relevant attributes that were critical for central learning and ignoring irrelevant attributes that contributed to incidental learning. Impulsive subjects, in contrast, demonstrated an equal amount of central and incidental learning which suggested that no strategy of selective attention deployment was occurring. Weiner and Berzonsky have attempted to explain this discrepancy in terms of a two-stage model of selective attention proposed by Hagen (1972). The first stage requires the identification of both relevant and incidental cues. The second stage involves focusing upon the relevant cues and ignoring the incidental cues. Weiner and Berzonsky suggest that impulsive children have trouble attending selectively due to a problem in stage one with distinguishing relevant from irrelevant cues. As a result, impulsive children attempt to remember all cues. This non-selective strategy produces equivalent degrees of central and incidental learning, but the level of central learning is significantly less than that of reflective subjects.

The result that individual differences in attention paralleled differences in reflection-impulsivity is the first hint toward an empirical explanation of the dynamics of reflection-impulsivity in terms other than the dual criteria of response latency and error. However, as is the case with any set of correlates, shifting attention from one correlate to the other does not explain the individual differences that underlie the correlates. In this case the logical question that arises is, what is the cause of the individual differences in attention that result in response latency and error differences? What is encouraging about the attention results is that they provide another and possibly a more useful index of the individual differences that result in behavior presently classified as impulsive and reflective.

Moral Judgement and Creativity

In addition to the better established relationships noted above, there are two unreplicated investigations that indicate that conceptual tempo is related to such diverse behaviors as moral judgement and creativity. Schliefer and Douglas (1973) have reported that conceptual tempo is related to the moral maturity of children. For both preschool and first-grade samples, immature moral judgements were associated with an impulsive conceptual tempo. This result is consonant with the argument that a major difference between tempos is the number of alternatives considered prior to responding. In a moral development context, the lower level judgement of morality in terms of a single criterion, consequence, generally conforms with the single hypothesis response of the impulsive child. Similarly, the higher level moral judgement in terms of two criteria, consequence and intention, is in agreement with the reflective child's postulated tendency to consider several alternatives prior to responding.

Another novel relationship that has recently been demonstrated is between conceptual tempo and creativity. Fuqua, Bartsch, and Phye (1975) have found that reflective subjects score significantly higher than do impulsive subjects on the picture completion task of The Torrance Tests of Creative Thinking. This result is of course subject to replication, but if it proves to be a reliable observation it will be interesting in that it contradicts a popular conception of creative individuals as rather rapid-thinking, free-wheeling individuals.

In general, the answer to the question with which the discussion of this review began, would be that reflection-impulsivity is definitely related to established constructs in psychology and is not specific to the four tasks used to operationalize the postulated construct.

APPENDIX B

LETTERS OF PERMISSION

MEMORIAL UNIVERSITY OF NEWFOUNDLAND
St. John's, Newfoundland, Canada A1C 5S7

Department of Educational Psychology
Guidance and Counselling

Telex: 016-4101
Telephone: (709) 753-1200

February 26, 1975

Dear Parent,

I would like to request permission to ask your child to participate in an educational research study. The experiment is concerned with conceptual tempo, the rate at which one makes intellectual decisions. The purpose of the study is to examine the validity of conceptual tempo, and test the efficacy of a proposed method of instruction that is designed to improve the student's ability to make accurate intellectual decisions. The study will involve four or five experimental tasks administered to grade five students during the months of March and April 1975. The total time required will be approximately two hours. Information gathered from the study will be made available to the school principal so that it may be used to benefit participants in the study. In addition, a copy of the final results will be made available to you at the school when the study is completed.

Thank you for your attention.

Sincerely yours,

Bryan Hartmann

Bryan Hartmann
Assistant Professor

☐ Permission Granted

☐ Permission Refused

Signature ______________________________

MEMORIAL UNIVERSITY OF NEWFOUNDLAND
St. John's, Newfoundland, Canada A1C 5S7

Department of Educational Psychology
Guidance and Counselling

Telex: 016-4101
Telephone: (709) 753-1200

April 4, 1975

Dear Parent:

I would like to request permission to ask your child to participate in an educational psychology research study. The research is concerned with attempting to determine a method of instruction that will improve a student's ability to select a correct answer from a set of alternative answers.

The study will be conducted at the school during school hours and will consist of two individual sessions of approximately ten minutes duration. Information from the study will be made available to Mr. Lee so that it may be used to benefit participants in the study. In addition, a copy of the final results will be made available to you at the school when the study is completed.

Thank you for your attention.

Sincerely yours,

B. D. Hartmann

B. D. Hartmann
Assistant Professor

Student's Name ______________________

☐ Permission Granted

☐ Permission Refused

Parent's Signature ______________________

APPENDIX C

MFF INSTRUCTIONS AND A SAMPLE TEST ITEM

DIRECTIONS FOR MATCHING FAMILIAR FIGURES

"I am going to show you a picture of something you know and then some pictures that look like it. You will have to tell me the number of the picture on this bottom page (point) that is just like the picture on this top page (point). Now, let's do some for practice." Experimenter shows practice items and helps the child to find the correct answer. "Now we are going to do some that are a little bit harder. You will see a picture on top and six pictures on the bottom. Find the one picture below that is just like the picture on top and tell me what number it is."

The experimenter will record latency to first response to the half-second, total number of errors for each item and the order in which the errors are made. If the subject is correct, experimenter will praise. If wrong, experimenter will say, No, that is not the right one. Find the one that is just like the top one." Continue to code responses (not times) until child makes a maximum of six errors or gets the item correct. If incorrect, experimenter will tell the child the correct number.

It is necessary to have a stand to place the test booklet on so that both the stimulus and the alternatives are clearly visible to the subject at the same time. The two pages should be practically at right angles to one another. Note: It is desirable to enclose each page in clear plastic in order to keep the pages clean.

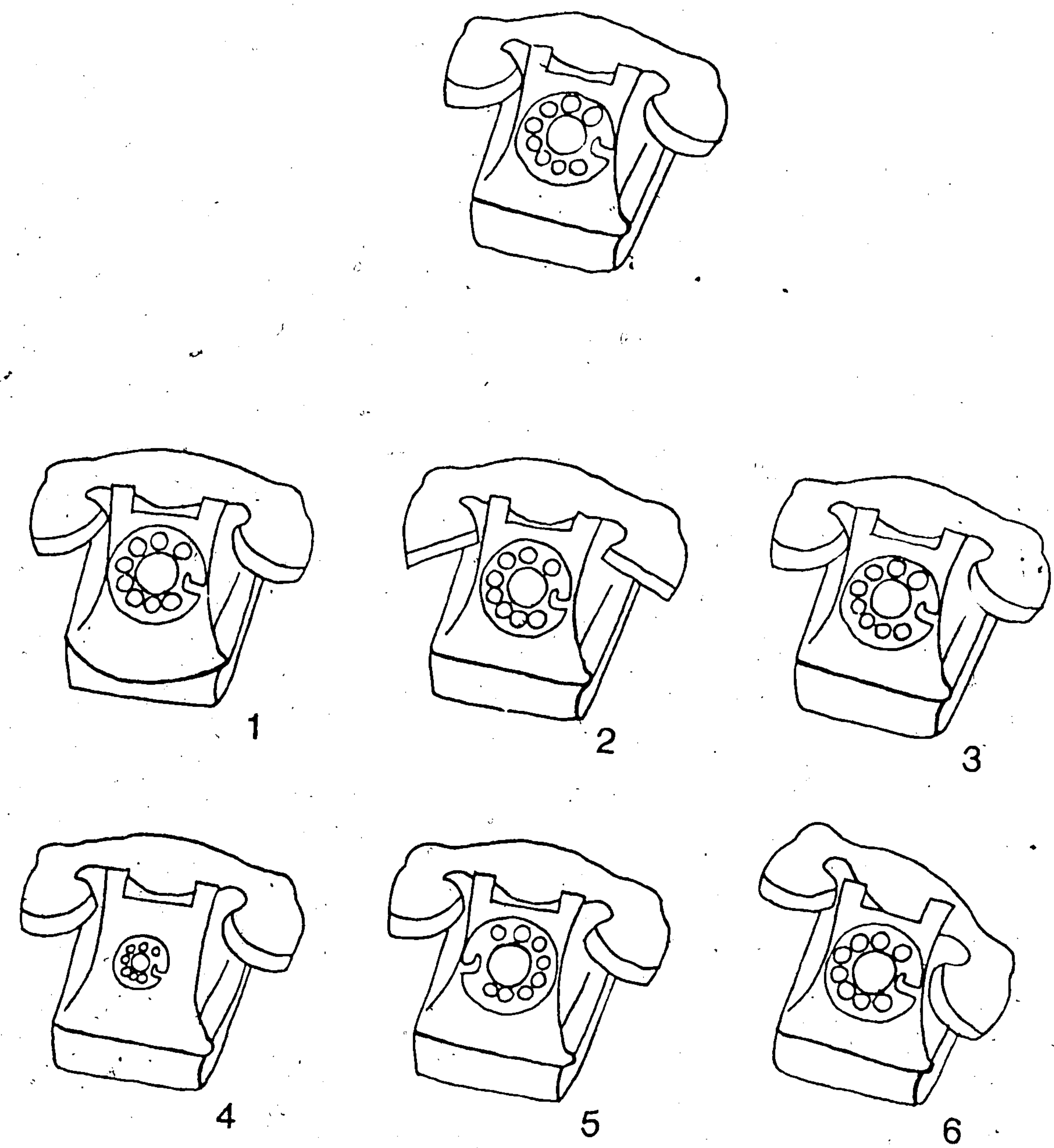

FIG. 1. Sample Test Item from the MFF

APPENDIX D

SIMPLE EFFECTS ANOVAS AND POST HOC COMPARISONS FOR EXPERIMENT ONE

TABLE 1

Scheffe Multiple Comparisons of MFF

Response Latencies

Tempo		FI	SI	FA	SA
	Mean	86.63	152.38	87.26	200.49
FI	86.63		-65.75****	-.63	-113.86****
SI	152.38			65.12****	-48.11****
FA	87.26				-113.23****
SA	200.49				

* $p < .10$

** $p < .05$

*** $p < .01$

**** $p < .001$

TABLE 2

Scheffe Multiple Comparisons of MFF

Response Errors

Tempo		Tempo FI	SI	FA	SA
	$\bar{X}$	13.27	10.83	6.17	4.36
FI	13.27		2.44**	7.10****	8.91****
SI	10.83			4.66****	6.47****
FA	6.17				1.81*
SA	4.36				

* $p < .10$

** $p < .05$

*** $p < .01$

**** $p < .001$

TABLE 3

Simple Effects Analysis of Variance of Verbal IQ

Means of Male Subjects

Source	SS	df	MS	F	p
Tempo	939.31	3	313.10	1.61	.19
Error	17137.69	88	194.75		

TABLE 4

Simple Effects Analysis of Variance and Scheffe Multiple Comparisons of Composite IQ Means of Female Subjects

Analysis of Variance

Source	SS	df	MS	F	p
Tempo	1200.13	3	400.04	2.90	.040
Error	10892.94	79	137.89		

Scheffe Multiple Comparisons

Tempo		FI	SI	FA	SA
	$\bar{X}$	106.45	98.23	109.80	100.73
FI	106.45	0	-8.22	3.35	-5.73
SI	98.23		0	11.57	2.49
FA	109.80			0	-9.08
SA	100.73				0

* $p < .10$

** $p < .05$

*** $p < .01$

TABLE 5

Simple Effects Analysis of Variance of Composite IQ Means of Male Subjects

Source	SS	df	MS	F	p
Tempo	820.00	3	273.33	1.56	.20
Error	15413.00	88	175.15		

TABLE 6

Simple Effects Analysis of Variance and Scheffe Multiple Comparisons of Composite IQ Means of Female Subjects

Analysis of Variance

Source	SS	df	MS	F	p
Tempo	1254.94	3	418.31	3.36	.023
Error	10892.84	79	137.89		

Scheffe Multiple Comparisons

Tempo		FI	SI	FA	SA
	$\overline{X}$	109.80	103.38	116.80	106.13
FI	109.80	0	6.42	7.00	3.68
SI	103.38		0	13.42**	2.74
FA	116.80			0	-10.68*
SA	106.13				0

* $p < .10$

** $p < .05$

*** $p < .01$

APPENDIX E

SAMPLE ITEMS FROM THE CTT

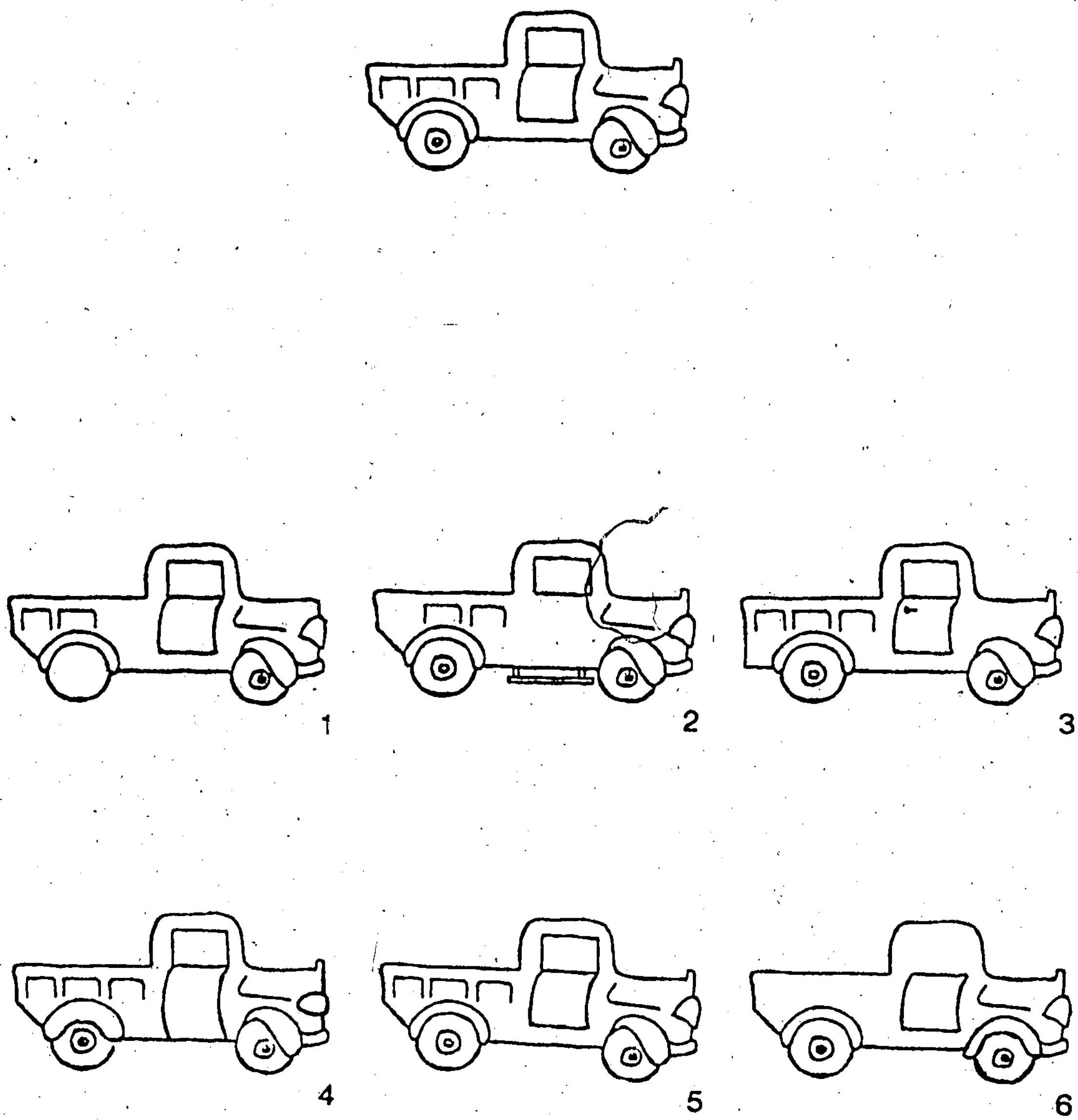

FIG. 1. Low Difficulty CTT Test Item

(Three Feature Differences)

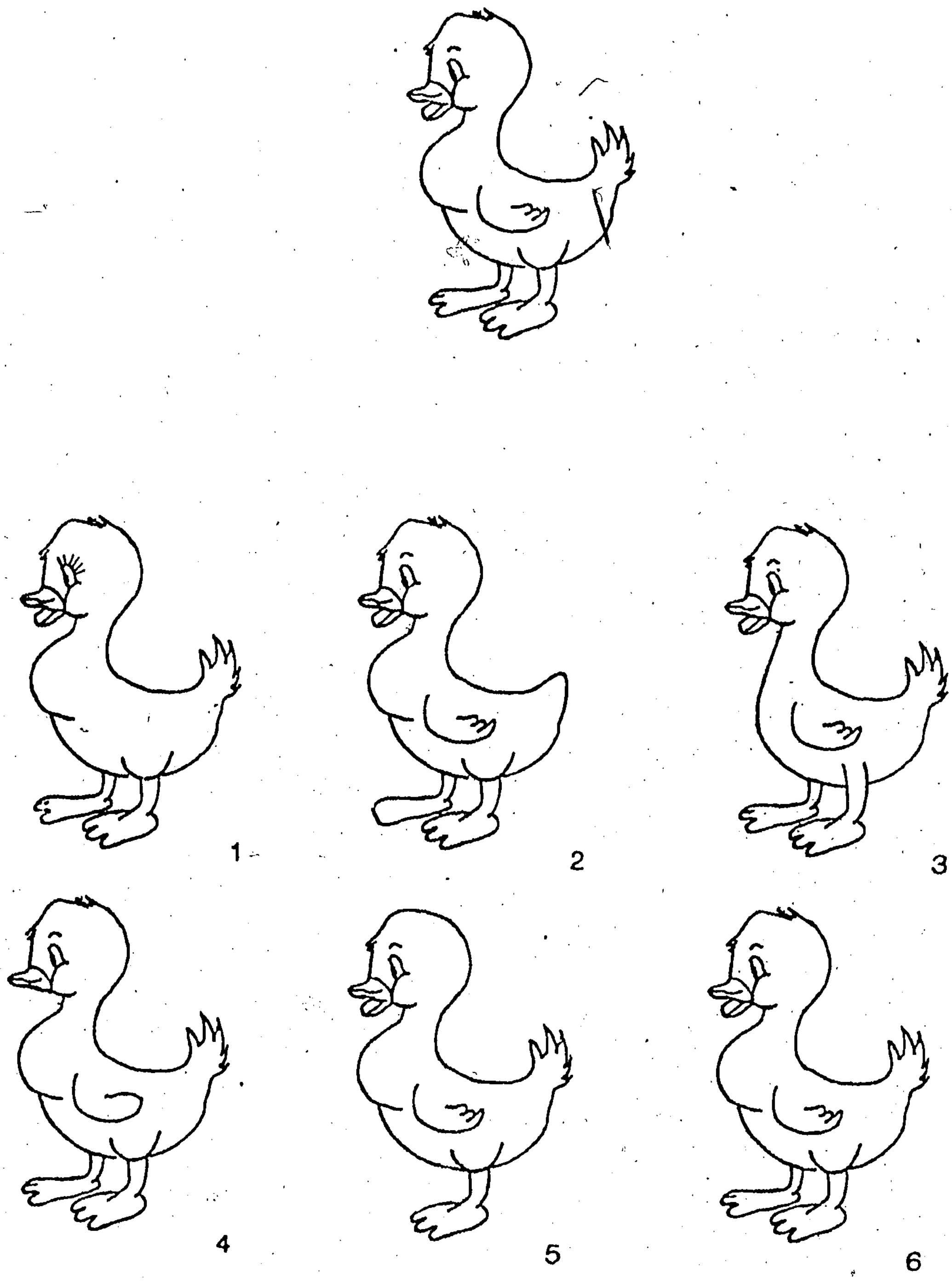

FIG. 2. Medium Difficulty CTT Test Item

(two feature differences)

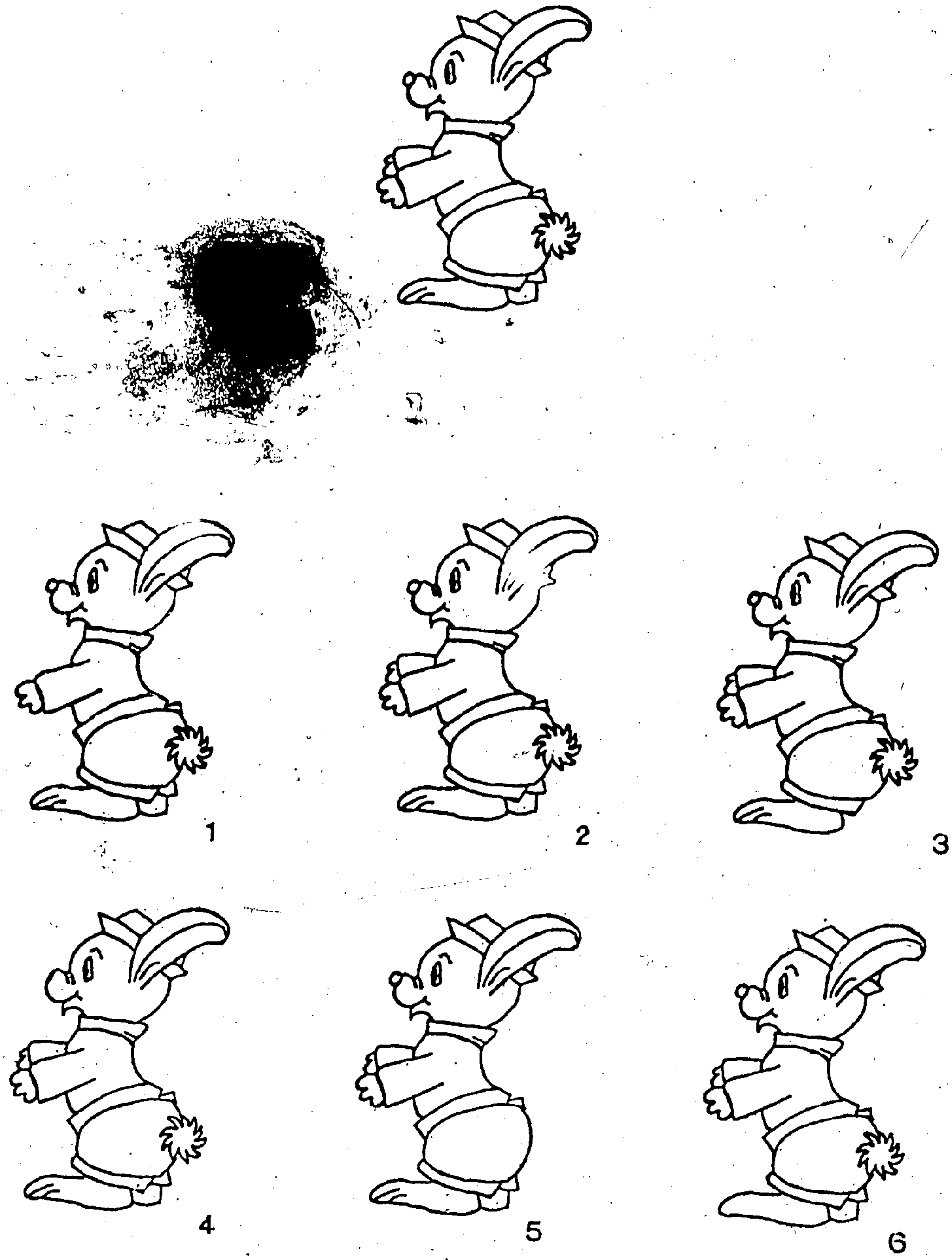

FIG. 3. High Difficulty CTT Test Item

(One Feature Difference)

APPENDIX F

SIMPLE EFFECTS ANOVAS AND POST HOC COMPARISONS FOR EXPERIMENT TWO

TABLE 1

Newman-Keuls Multiple Comparisons of

The CTT Latency Means of Four

Conceptual Tempo Conditions

TEMPO		FI	FA	SI	SA
	$\bar{X}$	108.45	118.82	211.73	227.64
FI	108.45	0	10.37	103.28**	119.19**
FA	118.82		0	92.91**	108.82**
SI	211.73			0	15.91
SA	227.64				0

Note. The Multiplier = MS error/n = 1608.05/11 = 12.09

*$p < .05$

**$p < .01$

TABLE 2

Newman-Keuls Multiple Comparisons of CTT Latency Means for Three Levels of Problem Difficulty

DIFFICULTY		LD	MD	HD
	$\bar{X}$	41.25	58.07	67.34
LD	41.25	0	16.82**	26.09**
MD	58.07		0	9.27*
HD	67.34			0

Note. The Multiplier = MS error/n = 342.52/44 = 2.78

*p < .05

**p < .01

TABLE 3

Simple Effects ANOVA and Newman-Keuls Multiple Comparisons of Conceptual Tempo Response Latencies for Low Difficulty CTT Problems

Analysis of Variance

Source	SS	df	MS	F	p
Tempo	3938.38	3	1646.13	11.25	.0001
Error	5853.88	40	146.35		

Newman-Keuls Multiple Comparisons

Tempo		FI	FA	SI	SA
	$\bar{X}$	30.36	31.00	50.82	52.82
FI	30.36	0	.64	20.46**	22.46**
FA	31.00		0	19.82**	21.82**
SI	50.82			0	2.00
SA	52.82				0

Note. The Multiplier is MS error/n = 146.35/11 = 3.65

* $p < .05$

** $p < .01$

TABLE 4

Simple Effects ANOVA and Newman-Keuls

Multiple Comparisons of Conceptual

Tempo Response Latencies for

Medium Difficulty CTT Problems

Analysis of Variance

Source	SS	df	MS	F	p
Tempo	15171.75	3	5057.25	11.72	.0001
Error	17261.06	40	431.53		

Newman-Keuls Multiple Comparisons

Tempo		FI	FA	SI	SA
	$\overline{X}$	38.55	41.82	69.09	82.82
FI	38.55	0	3.27	30.54**	44.27**
FA	41.82		0	27.27**	41.00**
SI	69.09			0	13.73
SA	82.82				0

Note. The Multiplier is MS error/N = 431.53/n = 6.26

* $p < .10$

** $p < .05$

TABLE 5

Simple Effects ANOVA and Newman-Keuls Multiple Comparisons of Con[illegible]al Tempo Response Latencies for High Difficulty CTT Problems

Analysis of Variance

Source	SS	df	MS	F	p
Tempo	26787.50	3	8929.16	5.21	.01
Error	68608.44	40	1715.21		

Newman-Keuls Multiple Comparisons

Tempo	$\overline{X}$	FI	FA	SI	SA
		39.55	46.00	91.82	92.00
FI	39.55	0	6.45	52.27*	52.45*
FA	46.00		0	45.82*	46.00*
SI	91.82			0	.18
SA	92.00				0

Note. The Multiplier MS error/n = 1715.21/n = 12.49

* $p < .05$

** $p < .01$

TABLE 6

Simple Effects ANOVA of Mean Difficulty Level

Response Latencies of FI Subjects

Source	SS	df	MS	F	p
Between People	8632.25	10	863.22		
Within People	2786.00	22	126.64		
Treatments	558.25	2	279.12	2.51	.11
Residual	2227.75	20	111.39		

TABLE 7

Simple Effects ANOVA and Newman-Keuls Multiple Comparisons of Mean Difficulty Level Response Latencies of FA Subjects

Analysis of Variance

Source	SS	df	MS	F	p
Between People	5299.21	10	529.92		
Within People	3406.67	22	154.85		
Treatments	1318.24	2	659.12	6.31	.01
Residual	2088.43	20	104.42		

Newman-Keuls Multiple Comparisons

Difficulty		LD	MD	HD
	$\bar{X}$	31.00	41.81	46.00
LD	31.00	0	10.81*	15.00**
MD	41.81		0	4.19
HD	46.00			0

Note. The Multiplier = MS residual/n = 104.42/11 = 3.08

* $p < .05$

** $p \leq .01$

TABLE 8

Simple Effects ANOVA and Newman-Keuls Multiple Comparisons of Mean Difficulty Level Response Latencies of SI Subjects

Analysis of Variance

Source	SS	df	MS	F	p
Between People	35980.06	10	3598.01		
Within People	23078.00	22	1049.00		
Treatments	9281.88	2	4640.94	6.73	.01
Residual	13796.13	20	689.81		

Newman-Keuls Multiple Comparisons

Difficulty		LD	MD	HD
	X̄	50.82	69.09	91.82
LD	50.82	0	18.27	41.00**
MD	69.09		0	22.73
HD	91.82			0

Note. The Multiplier = MS Residual/n = $\sqrt{689.81/11}$ = 7.92

* $p < .05$

** $p < .01$

TABLE 9

Simple Effects ANOVA and Newman-Keuls Multiple Comparisons of Mean Difficulty Level Response Latencies of SA Subjects

Analysis of Variance

Source	SS	df	MS	F	p
Between People	14410.19	10	1441.02		
Within People	18527.38	22	842.15		
Treatments	9238.25	2	4619.13	9.95	.001
Residual	9289.13	20	464.46		

Newman-Keuls Multiple Comparisons

Difficulty		LD	MD	HD
	$\overline{X}$	52.82	82.82	92.00
LD	52.82	0	30.00**	39.18**
MD	82.82		0	9.18
HD	92.00			0

Note. The Multiplier = MS Residual/n = 464.46/11 = 6.50

* $p < .05$

** $p < .01$

TABLE 10

Newman-Keuls Multiple Comparisons of CTT Error Means for Four Conceptual Tempos

Tempo		SA	SI	FA	FI
	$\overline{X}$	6.27	9.27	12.91	13.09
SA	6.27	0	3.00*	6.64**	6.82**
SI	9.27		0	3.64**	3.82**
FA	12.91			0	.18
FI	13.09				0

Note. The Multiplier = MS subjects within groups/n = 7.07/n = .80

* $p < .05$

** $p < .01$

TABLE 11

Newman-Keuls Multiple Comparisons of CTT Error Means for Three Levels of Problem Difficulty

Difficulty		LD	MD	HD	
	$\bar{X}$	1.59	4.05	4.75	r
LD	1.59	-	2.46**	3.16**	3
MD	4.05		-	.70	2
HD	4.75			-	

Note. The Multiplier = MS Residual/n = 4.348/44 = .32

* $p < .05$

** $p < .01$

TABLE 12

Newman-Keuls Multiple Comparisons of CTT

Error Means for Three Levels of

Problem Difficulty

Difficulty		LD	MD	HD
	$\bar{X}$	1.59	4.04	4.75
LD	1.59	0	2.45**	3.16**
MD	4.04		0	.71
HD	4.75			0

Note. The Multiplier = MS error/n = 4.35/44 = .30

* $p < .05$

** $p < .01$

TABLE 13

Simple Effects ANOVA and Newman-Keuls Multiple Comparisons of Response Latencies of Slow Subjects for Three Levels of Problem Difficulty

Source	SS	df	MS	F	p
Between People	5084.25	21	2421.63		
Within People	41605.38	44	945.58		
Treatments	17925.56	2	8962.78	15.90	.00001
Residual	23679.81	42	5[illegible]3.80		
Total	92459.63	65			

Newman-Keuls Multiple Comparisons

Difficulty		LD	MD	HD
	$\overline{X}$	51.82	75.95	91.91
LD	51.82	0	24.13**	40.09**
MD	75.95		0	15.96*
HD	91.91			0

Note. The Multiplier = MS error/n = 563.80/22 = 5.06

* $p < .05$

** $p < .01$

TABLE 14

Simple Effects ANOVA and Newman-Keuls Multiple Comparisons

of Response Latencies of Fast Subjects for

Three Levels of Problem Difficulty

Source	SS	df	MS	F	p
Between People	14128.38	21	672.[illegible]		
Within People	6192.69	44	140[illegible]		
Treatments	1783.13	2	891.56	8.49	.0008
Residual	4409.56	42	104.99		
Total	20321.06	65			

Newman-Keuls Multiple Comparisons

Difficulty		LD	MD	HD
	$\bar{X}$	30.68	40.18	42.77
LD	30.68	0	9.50**	12.09**
MD	40.18		0	2.59
HD	42.77			0

Note. The Multiplier = MS error/n = 104.99/22 = 2.18

* $p < .05$

** $p < .01$

APPENDIX G

A SAMPLE ITEM FROM THE CONCEPTUAL TEMPO ALTERNATIVE INSTRUCTION TASK

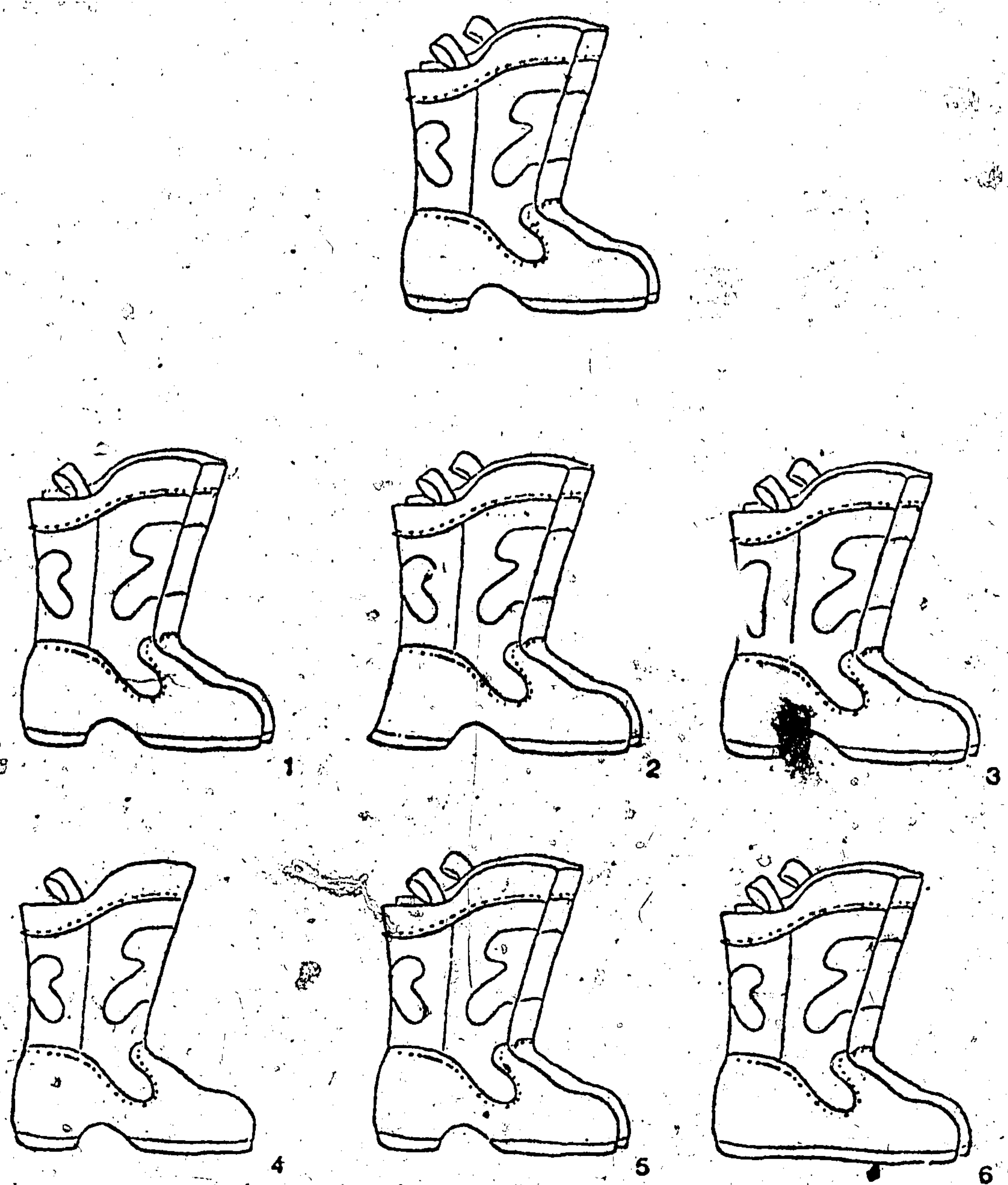

FIG. 2. Sample Item from the Conceptual Tempo Alternative Instruction Task

APPENDIX H

PRELIMINARY ANALYSES, AND SELECTED SIMPLE EFFECTS ANOVAS AND POST HOC COMPARISONS FOR EXPERIMENT THREE

TABLE 1

Chronological Age Means and Standard Deviations

of Alternative Instruction Subjects

Sex		TEMPO FI	SI	FA	SA	Total
	N	35	14	13	31	93
Male	$\bar{X}$	121.06	122.86	123.85	126.90	123.67
	S	6.32	6.27	5.35	5.20	10.83
	N	24	13	12	46	95
Female	$\bar{X}$	121.38	121.62	123.83	122.44	122.23
	S	10.05	7.25	7.40	7.35	7.97
	N	59	27	25	77	188
Total	$\bar{X}$	121.22	122.24	123.84	124.67	122.94
	S	7.97	6.66	6.28	11.98	9.52

TABLE 2

Analysis of Variance of Mean Chronological Ages (Months) of Alternative Instruction Subjects

Source	SS	df	MS	F	p
A. Tempo	420.00	3	140.00	1.54	.20
B. Sex	69.00	1	69.00	.76	.38
A x B	214.00	3	71.33	.79	.50
Error	16315.00	180	90.64		

TABLE 3

MFF Response Latency Means and Standard Deviations

of Alternative Instruction Subjects

Sex		FI	SI	FA	SA	Total
		TEMPO				
Male	N	35	14	13	31	93
	$\overline{X}$	78.03	156.07	98.23	208.67	135.25
	S	23.83	51.68	19.56	63.30	68.72
Female	N	24	13	12	46	95
	$\overline{X}$	82.21	146.15	95.75	210.13	133.56
	S	19.41	34.22	14.49	63.40	52.61
Total	N	59	27	25	77	188
	$\overline{X}$	80.12	151.11	96.99	209.40	134.41
	S	22.06	43.61	17.00	62.95	73.53

TABLE 4

Analysis of Variance and Scheffe Multiple Comparisons of MFF Response Latency Means

Analysis of Variance					
Source	SS	df	MS	F	p
A. Tempo	605529.00	3	201843.00	94.43	.000001
B. Sex	106.00	1	106.00	.05	.82
A x B	986.00	3	328.67	.15	.93
Error	384764.00	180	2137.58		

Scheffe Multiple Comparisons					
Tempo		FI	SI	FA	SA
	$\bar{X}$	80.12	151.11	96.99	209.40
FI	80.12	0	-70.99****	-16.87	-129.29****
SI	151.11		0	54.12****	-58.29****
FA	96.99			0	-112.41****
SA	209.40				0

* p < .10

** p < .05

*** p < .01

**** p < .001

TABLE 5

MFF Response Error Means and Standard Deviations

of Alternative Instruction Subjects

Sex		TEMPO FI	SI	FA	SA	Total
Male	N	35	14	13	31	93
	$\overline{X}$	14.40	11.29	6.08	4.81	9.14
	S	3.95	3.12	1.94	2.10	3.61
Female	N	24	13	12	46	95
	$\overline{X}$	13.17	11.15	6.83	4.20	8.84
	S	3.09	1.86	1.59	2.36	3.01
Total	N	59	27	25	77	188
	$\overline{X}$	13.78	11.22	6.46	4.50	8.65
	S	3.65	2.55	1.78	2.27	5.00

TABLE 6

Analysis of Variance and Scheffe

Multiple Comparisons of MFF

Response Error Means

Analysis of Variance

Source	SS	df	MS	F	p
A. Tempo	3074.14	3	1024.71	134.15	.000001
B. Sex	3.44	1	3.44	.45	.50
A x B	18.52	3	6.17	.81	.49
Error	1374.[illegible]7	180	7.64		

Scheffe Multiple Comparisons

Tempo		FI	SI	FA	SA
$\overline{X}$		13.78	11.22	6.46	4.50
FI	13.78	0.00	2.56***	7.33****	9.28****
SI	11.22		0.00	4.76****	6.72****
FA	6.46			0.00	1.95**
SA	4.50				0.00

* $p < .10$

** $p < .05$

*** $p < .01$

**** $p < .001$