THE EFFECT OF REWARD ON
COGNITIVE TEMPO

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Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF PHILOSOPHY
December, 1984

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CHAPTER I

INTRODUCTION

A detrimental effect of reward upon task performance and intrinsic interest has been well documented (see Lepper and Greene, 1978, for reviews and models). Reward has undermined the performance of children and adults on tasks that involve creative thinking and problem solving. Nevertheless, some individuals appear to be immune to the negative effects of rewards. Subject characteristics such as developmental level, ability, and personality factors as well as task characteristics seem to play a role in the maintenance of good performance under reward conditions (Fabes, 1983; Fabes, Moran, & McCullers, 1981; Moran, McCullers, & Fabes, 1984).

Perhaps one characteristic, individual differences in cognitive tempo, may help to explain why some subjects are able to resist the detrimental effect of reward. Cognitive tempo reflects the relationship between response latency and errors. Cognitive tempo thus should affect performance in tasks offering the possibility of a speed-accuracy trade-off.

There is a clear relationship between cognitive tempo, developmental level, cognitive ability, and task characteristics. Cognitive tempo follows a normal sequence of development from impulsive to reflective, and then to efficient stages (Salkind & Nelson, 1980; Salkind & Wright, 1977). Longitudinal studies (Kagan, 1965a) have indicated that individual differences remain constant across stages. Impulsive children respond more quickly than non-impulsive children at the same developmental level even when it is a level of maximum reflectivity. Error rates are indicative of intellectual ability in that fast accurate and reflective subjects are generally more capable than impulsive or slow inaccurate ones (Block, Block, & Harrington, 1974). Task characteristics are crucial; cognitive tempo effects are limited to intellectual tasks with response uncertainty (selection among several viable responses) and a negative relationship between speed and accuracy (Kagan, 1966b; Kagan & Messer, 1975). Thus the subject's age, ability, and the task's difficulty level are linked to the cognitive tempo construct.

There is considerable evidence to suggest that reward may affect response latency and that latency may affect errors. Some studies have shown that subjects respond more quickly under reward (Fabes, McCullers & Moran, in press; Greene and Lepper, 1974; Sarafino, 1981; Weiner, 1980). Others have found that the effects of reward upon errors and response latency were related to age and ability of the subjects (Buse & McCullers, 1982; Moran, et al., 1984). It is important to note that none of these studies were designed to directly investigate reward's effect upon response latency as a dependent measure. Time measures were germane either to the instrument or the experimental design. Evidence of impulsivity was extrapolated from the numbers and quality of responses during timed sessions.

In order to clarify the effect of reward upon response latency, that variable must be measured directly under reward and nonreward conditions. Two other important variables: developmental level and intellectual ability, which are known to be related to reward effects as well as cognitive tempo must be controlled. Then, the effect of reward upon response latency could be evaluated.

Kagan's (1965c) Matching Familiar Figures (MFF) test is the most widely accepted measure of cognitive tempo. The MFF administered to children at different developmental levels would provide data on individual differences in cognitive tempo and ability. A second administration under reward or nonreward conditions would reveal the effect of reward on response latency relative to individual differences in cognitive tempo.

The central purpose of the present research was to begin to assess the role of cognitive tempo as a factor in the relationship between response latency and reward effects. If reward affects response latency and latency affects the tendency to make errors, cognitive tempo could help to explain individual differences in reward effects.

CHAPTER II

LITERATURE REVIEW

This chapter begins with a review of the literature on the relationship between cognitive tempo and reward effects. Discussion of the cognitive tempo construct, definition, and measurement is presented first followed by theoretical considerations and research data. Research findings on the effects of rewards on performance and interest are reviewed next along with the theory and models regarding reward effects and response latency. The next section evaluates the relationship between MFF studies and reward studies. Lastly, the present research is described in terms of the problem, theory, pilot work, theoretical predictions, and methodology as well as research design rationale.

Cognitive Tempo

Definition and Measurement

The cognitive tempo construct (Kagan, Rosman, Day, Albert, & Phillips, 1964) reflects individual differences in response style. In the face of response uncertainty on tasks that allow speed to be sacrificed for accuracy and vice versa, some children tend to respond relatively fast but are error prone while other subjects respond more slowly but more accurately.

A subject's cognitive tempo may be classified as impulsive (fast inaccurate), reflective (slow accurate), fast accurate, or slow inaccurate.

Using response latency and total errors as the dependent variables, fast accurate subjects are those who score below the mean on both latency and errors. Reflective subjects are those who sacrifice speed for accuracy and so score above the mean on latency but below the mean on errors. Impulsive subjects conversely, sacrifice accuracy for speed and score above the mean in errors, but below the mean on latency. Slow inaccurate subjects score above the mean on both latency and errors. In the general population, it is expected that approximately 15 percent of the individuals will be fast accurate, 35% reflective, 35% impulsive, and 15% slow inaccurate (Wright & Vliestra, 1977).

Theoretical discussions of the construct and experimental evidence have suggested that cognitive tempo is the result of an interaction between intellectual ability and personality orientation (Wright & Vliestra, 1977). Individual differences in cognitive tempo have been observed on a variety of tasks involving response uncertainty and a speed-accuracy trade-off and in some aspects of social decision making, such as toy choice (Messer, 1970). An individual's cognitive tempo, as measured by MFF scores, appears to be stable over time and across tasks (Kagan, 1965b). However, the MFF scores of preschool children lack stability; so with preschoolers the use of appropriate developmental control group is advisable (Ault, Mitchell, & Hartman, 1976; Messer, 1970).

Instrument Development

Kagan's (1965c) Matching Familiar Figures (MFF), Form F, the Elementary MFF, has emerged as the primary measure of reflection-impulsivity. This test is a match-to-standard task in which the subject views a familiar line-drawing figure and selects among an array of six similar figures the one that exactly matches the standard. Originally the test was designed to be used in the fall of the academic year (Form F) with retesting again in the spring (Form S). Since both forms of the MFF had the same number of items and choices, they could be used in pre- and post-test intervention studies. However, Egeland and Weinberg (1976) found that Form S was significantly more difficult than Form F, and Form S has not been distributed since 1978.

The MFF Form F has become the Elementary MFF to be used with children aged five-twelve years. Salkind (1978) constructed normative data by contacting 350 potential sources gleaned from published and unpublished reports. The final data pool consisted of 2,846 administrations from 97 individual researchers who described their subjects as normal, middle-class children between the ages of four and one half to twelve and one half years.

The MFF20 (Cairns & Cammuck, 1978) has 20 items for subjects 9-11 years of age that include most the MFF Form F items; the MFF20 has two practice items and every item has six alternatives for matching. The main advantages of the Elementary MFF over the MFF20 are normative data, a wider age range, and greater use; all factors which facilitate comparisons across studies.

An adolescent/adult version of the MFF is also available, but without norms, and consists of two practice items each with six alternatives and twelve scored test items each with eight alternatives. Banilvy and Gilliland (1980) developed an alternate form.

Work With Preschool Children. MFF Form K was developed for use with younger subjects because Form F was considered too difficult for kindergarten children (Egeland & Weinberg, 1976). Form K has two practice and 12 test items, but each array has only four, not six, alternatives. Wright's (1971) Kansas Reflective-Impulsive Scale for Preschoolers (KRISP) provides two compa-rable A and B forms, each with five practice and 10 scored items. Of the 10 test items, four have four-choice alternatives, four have five, and two have six. Norms for both forms were developed for ages two-six years (Wright, 1978). Salkind and Schlecter (1982) tested the feasi-bility of using the KRISP and MFF Form F as analogous measures of cogni-tive tempo in kindergarteners. After correction for chance agreement, only 30% of the judgments coincided. Thus, the interchangeability of the MFF and KRISP in test-retest studies does not appear to be warranted.

With so many measures of cognitive tempo available, each with differences in format and difficulty level, it is virtually impossible to make precise comparisons across studies. Some 200 studies have been reported since the first studies of cognitive tempo in 1964. Reviews of this literature have been published by Kagan and Kogan (1970), Block et al., (1974), Messer (1976), Wright and Vliestra (1977) and Zelniker and Jeffrey (1976).

Criticisms of the MFF have ranged from concern about the reliability of the instrument (Cairns and Cammock, 1978) and methodological problems (Ault et al., 1976) to misgivings about the cognitive tempo construct (Block et al., 1974) and doubt of its psychometric credibility (Egeland & Weinberg, 1976). While there is considerable evidence that cognitive tempo may be undeveloped or at least not measurable in preschool children (Kagan & Messer, 1975; Egeland & Weinberg, 1976), researchers continue to investigate the phenomenon across age groups. A more consistent use of one instrument, the MFF Form F, has emerged in recent years. Margolis, Leonard, Brannigan, and Heverly (1980) supported its construct validity for kindergarten subjects, further extending the appropriate age range of this instrument.

Developmental Differences. Cognitive tempo follows a normal sequence from impulsive to reflective, and finally to efficient stages (Salkind & Nelson, 1980). Young children (e.g., age eight years and younger) respond impulsively, as if they were not thinking. As children mature they become more reflective, increasing their response latency and reducing errors. The negative correlation between latency and errors is strongest at age 10 years. Older children, at ages 11 and 12 years, exhibit efficiency by reducing the latency of their responses while maintaining the same low error rate of the reflective stage.

The majority of MFF studies used sample median splits to classify impulsive and reflective subjects usually about 70 percent of the sample. The remaining subjects, fast accurate and slow inaccurates, representing ability groups more than cognitive tempo groups are eliminated from further consideration. Salkind and Wright (1977) proposed an integrative use of latency and error standard scores to calculate impulsivity and efficiency scores which are continuous and allow inclusion and comparisons of all subjects, including the fast accurate and slow inaccurate responders.

The MFF norms show similar developmental trends for both males and females (Salkind & Nelson, 1980). The means reported by Salkind (1978) show a sex difference at the impulsive (third grade) level. At that age level males are more impulsive, have higher error score and faster response latency than females. Error and latency scores for males and females are virtually the same at the reflective (fifth grade) and efficient (seventh grade) age levels.

Theoretical Considerations

Kagan and Kogan (1970) indicated that the dynamics of impulsivity and reflectivity were such that the impulsive child focuses on quickness of response and needs immediate feedback while the reflective child is concerned about errors and needs to be as correct as possible on the first attempt. Kagan (1965a, 1966a, 1966b) in a series of similar studies noted that, placed between trials, the threat of failure and possibly not getting a prize had a greater effect on impulsive third and fourth graders than reflective subjects causing impulsive subjects to have a greater increase in intrusion errors (Kagan, 1966a) and errors of commission, not omission. (Kagan, 1965a) on a serial learning task. The more impulsive the child, the greater the increase in errors following the threat. Under more stressful failure conditions, Messer (1970) found that both reflective and impulsive subjects slowed their speed of responding and reduced errors. Moderate threat or anxiety appears to strengthen a child's tendency to respond according to his/her cognitive style, but extreme stress can alter response style with impulsive children more likely to be affected by the threat and to shift in the direction of reflectivity.

Classic drive theory (Hull, 1943; Spence, 1956) treats anxiety as drive (D). Any factor that increases anxiety will increase drive. Drive serves to energize available responses (D X H). Therefore, classic drive theory would predict that an increase in anxiety would result in faster responses from all subjects. Similarly, rewards and other incentives would function as incentive motivation (K), and would combine with available drive leading to faster responses. Any accompanying effect upon error rates would depend upon the presence or absence and relative strength of inaccurate and accurate response tendencies. In the case of younger and less capable children, the relative strengths of incorrect response tendencies should be greater than correct response tendencies. Thus, with these subjects, any increase in anxiety (D) or reward (K) would have the same effect of driving out high habit response tendencies, resulting in faster response times and greater numbers of errors. For more reflective and more capable subjects the faster responses under anxiety or reward would lead to an increase in errors, but, for efficient subjects, accurate responses are a strong habit and a reduction in response latency would increase efficiency of performance.

Kagan and Kogan (1970) propose a differential effect of anxiety for impulsive and reflective children due to their different orientations and sources of anxiety. For reflectives, anxiety serves as an inhibitor of fast inaccurate responses, but for impulsives, anxiety serves as drive. While they acknowledge that impulsive children may have different reinforcement histories than those of reflective children (i.e., they were praised for quick responses while reflective children were praised for inhibition of such responses in favor of accuracy), and may therefore have different relative strengths of habit for fast and slow responses; they prefer an interpretation that considers the source or focus of the anxiety over performance. Impulsive subjects are concerned about speed of response and reflective subjects are concerned about errors. The impulsive child focuses on quickness of response and needs immediate feedback while the reflective child is concerned about errors and needs to be as correct as possible on the first attempt. Therefore, they predict that an increase in anxiety affects children differently depending upon their cognitive tempo orientation. Impulsive children respond more impulsively and reflective children respond more reflectively because of the relative differences in their concern over speed of response and accuracy.

Messer (1970) suggests yet another interpretation of anxiety and cognitive tempo. He found that concern about performance induced caution causing both reflective and impulsive subjects to perform more carefully. This cognitive-dynamic formulation based on concern over intellectual performance predicts longer response latencies under stressful conditions. Whether or not this increase results in greater accuracy may depend upon anxiety's potential for distracting the subject from the task. He found that impulsives who increased response times following threat also reduced MFF errors and reflectives who increased response times made about the same number of errors due to a "floor effect". Using rewards Ward (1968) found slower responses for all subjects following failure errors and faster responses for all subjects following correct choices. The tendency to choose more carefully following errors was significant for impulsive subjects but no different from chance for the reflectives.

Cognitive Tempo Findings

Conceptual Styles

Kagan, Moss, and Sigel (1963) developed the Conceptual Styles Test (CST) to measure individual and developmental differences in information processing. Children selected from three familiar objects the two that went together and told why that pair was chosen. Most responses were based upon relational criteria or common function. For example, a watch and a ruler may be paired because both measure something. Analytic responses were based on similarity of objective attributes. For example, they both have numbers. Inferential responses were based upon language conventions or classifications and were rare. For example, they are inanimate objects.

Children who tended to give more analytic responses were also found to have longer response latencies (Kagan et al., 1964). Also, subjects instructed to respond more slowly gave more analytic responses on the CST and had fewer errors on three other visual tasks. Subjects instructed to respond more quickly gave more global and incorrect answers. Ostfeld and Neimark (1967) and Zelniker, Cochavi, and Yered (1974) replicated the findings with subjects instructed to slow down, but were unable to verify the decrease in analytic responses from speeded subjects. Analytic responding increased with age and intellectual ability, and so was considered an indication of a more mature information processing style (Kagan et al., 1964).

Two cognitive orientations contributed to the production of analytic responses: a tendency to reflect upon simultaneously available alternatives and a tendency to consider component parts of a visual array (Kagan et al., 1964). The MFF was developed to measure those tendencies without requiring memory by presenting the standard and variants simultaneously. Though Kagan et al. (1964) demonstrated a conceptual and operational correlation between the CST and MFF, several replications have not (Block, et al., 1974; Denney, 1972; Wyne, Coop, & Brookhouse, 1970). However, these studies and relationships they suggested will be considered further in relation to reward studies to be discussed in the section that follows on reward and response latency.

Cognitive Abilities

Cognitive style should have some relationship to cognitive ability. The relationship between cognitive tempo and intellectual ability has presented questions concerning the validity of Kagan's conceptualization of the construct and its primary measure, the MFF. The relationship between cognitive tempo and IQ raises the question of whether cognitive tempo is an expression of cognitive style or simply another measure of cognitive ability. Kagan (1966b), Kagan and Kogan (1970), and Kagan and Messer (1975) contended that cognitive tempo reflects an interaction of ability and personality measured by both errors and latency. Messer (1976) tabulated the IQ and MFF correlations from 23 studies in which a specific numerical value was reported. The median correlation between MFF latency and IQ scores was .14 for boys, .22 for girls, and for MFF errors and IQ it was .295 for boys and .335 for girls. Also, the correlation was stronger for preschoolers than for elementary school age children. When the format of the IQ test was non-verbal and multiple choice, the correlation between MFF and IQ was higher because of the similar test format for both instruments and the similarly restricted range for errors.

According to Block et al. (1974) the relationship between MFF errors and intelligence is consistent, appreciable, and negative, usually in the negative mid-.40's indicating the brighter children made fewer errors and are reflective or fast accurate not impulsive. Since the cognitive tempo construct is operationally defined as MFF scores with a negative correlation between errors and latency in the mid-.40's, errors and IQ bear the same relationship to response latency. Given the early work by Kagan and his associates that stressed latency alone, the Block, et al. criticism was powerful. In reply, Kagan and Messer (1975) stressed the importance of considering older children, not preschoolers, because the cognitive tempo construct does not appear to be measurable until age six. Kagan and Messer also stressed the importance of considering the various sources of anxiety that mediate performance: anxiety over ability can lead to impulsivity, but anxiety over making an error can lead to reflectivity. In view of the points made by Block, et al., both critics and defenders of the cognitive tempo construct have emphasized the importance of estimating the relative contribution of errors and latency to tempo scores.

Task Factors

Bush and Dweck (1975) found that reflective nine-year-olds modified their conceptual style to match task characteristics. On speeded tasks of increasing difficulty reflective children were more accurate and faster than were impulsive subjects. Brodzinsky (1982) found that for children tested at ages four and six and retested two years later, reflectivity facilitated operational thought, but reflective children were not necessarily more competent. Bartis and Ford (1977) reported a significant positive relationship between a reflective tempo and the ability to conserve numbers and amounts in a kindergarten sample. Such evidence of flexibility in both cognitive tempo and cognitive style supported the notion that reflectivity was representative of a more mature developmental or higher intellectual level.

Borkowski, Peck, Reid, and Kurtz (1983) found that reflective children had higher metamemory scores. Metamemory skills, introspective knowledge of the memory system, facilitate the development and transfer of strategy training. Again, reflective children have the advantage and task characteristics may increase that advantage. When the task requires strategy development, conservation, perspective taking, memory training, or flexibility of style, reflective subjects have performed better than their impulsive age mates.

Social-Personality Measures. Kagan (1965a, 1966b) and others (Messer, 1976; Wright & Vliestra, 1977) have cautioned that the impulsive and reflective categories describe cognitive style and are not intended to be interpreted as general behavior or personality descriptors. However, numerous investigators have linked cognitive tempo to social settings and personality variables.

Teacher Ratings. Teacher appraisals of student characteristics and achievement have been found to favor reflective preschoolers (Herman, 1981) and elementary pupils (Rosenfeld, Houltz, & Steffero, 1977). Teacher ratings and reflectivity were positively correlated with preschool measures predictive of school success but unrelated to problem solving skills or creativity. Because of the nature of the teacher-pupil relationship, teacher ratings include a mixture of elements related to ability and achievement plus personality characteristics of conflict or compatability.

Toy Choice. Eska and Black's (1971) study of cognitive tempo used

third graders, retaining fast accurates and slow inaccurates as subjects, and a toy choice task. A task analogous to the MFF was used to measure cognitive tempo. A lack of response style stability in the toy choice task was attributed to its relative lack of appeal and the children's preference for the cognitive tempo task. Actually the toys presented (a sheriff's badge, a "Teacher's Pet" monster, a notebook, a skeleton, a flying saucer, a "jumping" dog, and a blackboard) had such variation that the selection process was probably quite easy. Kagan (1965a) emphasized that the cognitive tempo construct applies only in situations with response uncertainty: several alternatives are presented simultaneously and it is not immediately obvious which alternative is correct. The cognitive tempo construct would not apply to situations in which the solution is not presented or where only one alternative is viable (e.g., What is the cube root of 1331?). The basic assumption is that response times will be decision times in situations that present some challenge for the subject. In the Eska and Black (1971) study, the toy choice offered only a minimal challenge to the children. Mann (1973) offered six-and eight-year-olds a toy choice with a high degree of uncertainty (Kagan & Messer, 1975). Boys selected among five match box toy cars and girls selected among plastic bracelets. The similarity of the choices, rank ordering and a final choice between the toys ranked third and fourth, made the toy choice task especially challenging.
Reflective children took longer and were more consistent in their choices than were impulsives.

Locus of Control. According to Messer's 1976 review, the possibility of a relationship between cognitive tempo and locus of control was supported by three studies, but refuted by three others. The expectation was that reflectives would be internally controlled and impulsives externally controlled. Interpretation of the results of these studies is complicated by the fact that location on the external-internal control scale is also related to minority ethnic status, low income, and failure experiences. Messer was unable to support the notion that the superior performance on academic and intellectual tasks by children with internal control was due to greater reflectivity. The relatively greater number of success experiences of reflectives, and not their longer latencies may have determined their perceived locus of control and cognitive tempo orientation.

Reward and Response Latency

Investigations of the effects of reward upon performance and interest have not included measures of cognitive tempo. Time factors (response latency) when included have been a part of experimental procedures required by standardized instruments, or used as measures of motivation and interest. In the case of motivational studies, subsequent interest has been measured by the time spent on the task during a free-choice period. If reward effects interacted with individual differences in cognitive tempo and those differences were normally distributed within the sample, the differential effects would have been cancelled.

Theoretical Considerations

There are several interesting parallels between the effects of rewards and an impulsive cognitive tempo. In some tasks both reward and impulsive responding have resulted in a poorer quality of performance. Moreover, both reward and impulsivity have had a detrimental effect upon task performance when the subject was required to discover a solution strategy or to demonstrate other forms of creative thinking. Reward and impulsivity have had either no effect or a facilitating effect upon the performance of tasks which relied upon well-learned responses, tests of speed and accuracy, short-term memory, and efficiency. Developmentally less mature performance has been reported in several reward studies and impulsive responding has been identified as developmentally less mature. Attention factors appear to be implicated in both reward effects and changes in response latencies. Reward may cause the subject's attention to be divided between the task itself and the reward, particularly if the subject looks at and thinks about the reward. Though response latencies increase under those circumstances, accuracy, especially in complex tasks, is undermined.

The McGraw Model. McGraw (1978) provided a model predicting a detrimental effect of reward upon tasks that are attractive and heuristic (i.e., appealing tasks that require creative or insightful discovery of a solution strategy) and a facilitation effect upon tasks that are unattractive and/or algorithmic (i.e., initially unappealing tasks or ones that can be successfully completed by using a well known strategy). Heuristic tasks require some thinking and if the task is attractive the subject should be motivated to spend time on it.

Though the McGraw model does not make differential predictions as a function of age or ability, the algorithmic-heuristic dimension logically should vary with the developmental level and capability of the subject.

Tasks that an adult finds algorithmic, such as, tying shoes or adding a column of numbers, may be heuristic to a young child. In fact, the solution strategy may be beyond the child's comprehension and response latency or task attractiveness could have no bearing on accuracy. An older, more capable child may be able to discover the strategy by responding more slowly (longer response latency) and the more mature subject may use a learned response more efficiently with decreased latency. In this sense the facilitating effect of reward upon the performance of an algorithmic task parallels the increase in efficiency in cognitive tempo by subjects able to decrease response latency without increasing errors.

Regression Hypothesis. Several studies have detected a regression in performance under reward conditions. That is, performance quality under reward resembled that normally expected of nonrewarded subjects at an earlier age (Fabes, et al., 1981; Moran, et al., 1984).

Denney (1973) and Wright and Vliestra (1977) reviewing MFF training studies, have proposed that reward may elicit responses that were learned earlier, habits that are stronger and more established, according to White's (1965) temporal stacking model. First learned behaviors with high habit levels would be most likely to be evoked under reward conditions if reward heightened motivation or drive.

Standardized tasks with developmental norms lend themselves well to the measurement of regression in performance. When the subject's performance under reward resembles what would normally be expected of a younger child, one behavior in service of that regression could be impulsive responding. The subject may be performing incorrectly as a younger child would perform because of responding quickly as a younger child would do. Either the child performs quickly and appears to be performing less maturely, or the child performs immaturely and therefore responds more quickly and less accurately.

In his review of the literature that was limited to modification studies Denney (1973) specifically suggested that in MFF training reward interacts with developmental level to elicit earlier, more impulsive responses rather than facilitating a reflective discovery of an improved strategy. These findings would be consistent with the notion that reward produces a developmental regression applied to cognitive tempo, this would be especially detrimental to the performance of impulsive subjects and those who are at a stage of transition in cognitive tempo development. Mandell (1974) reported regression on impulsivity measures with Porteus mazes and Holtzman ink blots due to a treatment variable of stress and distraction caused by noise. When the introduction of reward was the treatment variable (Fabes, et al., in press) evidence of regression was again evidenced on Holtzman ink blots. It is possible that both noise and reward produce a similar stress which leads to impulsive and immature performance on cognitive tasks. Adults hypnotically regressed to age five performed as children ages five to 10 years typically do, impulsively (Parrish, Lundy, & Leibowitz, 1968). Kagan and Kogan (1970) suggested that regression merely creates a set to respond impulsively and that errors and immature responses are the result of a developmental regression in cognitive tempo.

MFF norms, experimental evidence, and the construct presented by Kagan indicate that developmental regression in cognitive tempo is behaviorally defined as impulsive responding. White's (1965) temporal stacking model, traditional S-R learning theory, particularly. The Hull-Spence theory (Hull, 1943; Spence 1956) and research findings suggest that in terms of cognitive tempo reward would induce regression in performance by energizing the early learned and therefore strongest responses that are fast and inaccurate, impulsive.

Attention and Effort. A reflective cognitive tempo indicates that the subject is able to carefully consider several alternate responses in order to avoid errors. The longer response associated with reflectivity provides opportunity for greater attention to the task than that afforded an impulsive subject. Shifts in attention and effort away from the task at hand would disturb the negative relationship between response latency and error rate. Janet Spence (1970) proposed that the inferior performance of rewarded subjects is due to a distraction of attention away from the task stimuli. If the subject's attention to the task was distracted by reward, (i.e. to look at the reward, think about using it, etc.) response latency would increase without a corresponding reduction in errors. The net result would be a decline in performance, but impulsivity would be contraindicated by the long response latency. In fact, the response may have been an impulsive one offered after a period when the child's attention wandered in order to give the appearance of having been on task.

Most of the increase in the selective allocation of attention develops in children between the ages of seven and 11 years (Ruble & Nahamura, 1972). This is also the developmental period of increasing reflectivity. Prior to age seven a child's attention is directed toward the most obvious stimuli present, and attention-getting features of the environment can control a child's responses. The introduction of material reward provides an alternative focus for the child's attention. Thus, the subject would be involved in two rather effortful activities: completing the task and considering the reward. If that were the case, increased latency would not accompany enhanced performance because the time was spent off task (Hasher & Zacks, 1979). Older children, 11 and 12 years of age would be less susceptible to this detrimental effect of reward because they have developed more skill in the selective allocation of attention.

Attribution Models. The offer of an extrinsic incentive for completing a task produces lower levels of intrinsic interest in the task as well as lower levels of performance. Deci (1975) proposed that the subject attributes to the reward qualities of controlling behavior and that sense of external control undermines intrinsic motivation. If impulsive subjects are more externally controlled than reflective subjects, the attribution model may have different effects depending upon the subject's cognitive tempo orientation with reflective subjects being more likely to retain their internal controls in the face of rewards.

The introduction of reward can also cause subjects to consider a task less interesting or actually boring or to consider as work a task that was play (Lepper & Greene, 1978). When the subject attributes such negative characteristics to a task, the time spent on the task is likely to decline. Loss of interest, enjoyment, and persistence on a task, especially a challenging task, can lead to impulsive responses and poor performance. A reduction in response latency times could be an indication of a loss of intrinsic interest.

Reward and Response Latency Findings

Reward Manipulation

Studies in which reward manipulation was variable have reported response latency effects, usually in a post hoc analysis. Buse and McCullers (1982) found that reward increased latency and was related to improved performance in third and sixth grade children. The reward was contingent upon accuracy of responses. In the Fabes et al., (in press) study of reward effects on ink blot perception, a task in which accuracy and efficiency are not important factors, reward decreased latency and the quality of performance resembled that of much younger subjects. Fabes et al. (1981) reported that reward and control groups did not differ in time to completion on tasks in three heuristic subscales of the Weschler Adult Intelligience Scale. Thus, reward has been known to increase, decrease, or have no effect upon response latency. The influence of other variables might explain reward's differing effects. Task requirements would appear to determine the relationship between latency and performance. The subject's ability and developmental level as well as the subject's normal tendency to respond slowly or quickly could affect the relationship between response latency and performance. If, for example, reward decreases response latency on a task that requires careful attention, a bright, mature, reflective child might maintain quality performance (no increase in errors) under reward conditions, while a less capable, younger, impulsive child could not. In this case, the effect would be to make the reflective child appear efficient, and the impulsive child more impulsive. On the other hand, if reward increased response latency, then the reflective child would appear less efficient while the impulsive child would appear more reflective.

In measuring the effect of reward on subsequent interest Greene and Lepper (1974) noted that reward influenced the quantity and quality of immediate performance. Preschool children who expected a reward for drawing pictures tended to draw more pictures ($p < .06$) than subjects who did not expect a reward in the same period of time. Also, the pictures were of lower quality due to a lack of detail ($p < .01$). Moreover, the quality and quantity of the drawings were negatively related, ($r = -.43$, $p < .01$; Lepper, Greene, & Nisbitt, 1973). Since all of the sessions were six minutes long, the children who produced more drawings with less detail (lower quality) could be said to have demonstrated an impulsive tempo. Impulsive responding following reward could also be extrapolated from Sarafino's (1981) study in which rewarded subjects gave more riddle endings and Weiner's (1980) work in which subjects under reward attempted more anagrams.

MFF Training. Most of the studies which have combined MFF administration and reward in the procedures were investigations of the trainability of cognitive tempo. Usually the training protocol included specific instructions plus reward manipulations designed to increase reflectivity either by increasing response latency, decreasing errors or both. Four strategies have been used: error contingent reinforcement. (Errickson, 1980; Errickson, Wyne, & Routh, 1973; Scher, 1971), reinforcement of increased latency (Briggs & Weinberg, 1973; Weinberg, 1968), reinforcement of strategies associated with improved performance (Eastman & Rasbury, 1981; Heider, 1971) and reinforcement of modeling (Debus, 1970).

Training studies have generally shown that response latency was more readily modified than was error rate which required strategy training. Subjects who extended response latency under training conditions of reward plus instructions rarely decreased errors. However, in some studies, a successful strategy for reducing errors was discovered and used by some subjects carefully instructed in that particular strategy. More importantly, that same effect occurred naturally under standard procedures.

Given time to reflect, think, and discover the strategy through independent cognitive processing, some subjects will exhibit a more reflective style. Training studies have also shown that impulsive subjects are more likely to be influenced by treatment, but reflective subjects respond to task characteristics and are more likely to discover and use a successful solution strategy on their own unaided by training and reward. Denney (1973) proposed that more mature subjects might resist reward's distraction and elicitation of immature responses, but that younger subjects would be highly susceptible. He concluded that natural experience with the task would result in reflection and discovery. Briggs and Weinberg (1973), considering the relative superiority of the control condition over the tangible reinforcement condition, suggested that knowledge of performance or feedback from the experimenter and experience with the task itself were more effective in training than the additional incentive of a highly valued prize. Morgan (1984) reviewed the effect of reward on motivation and performance quality and quantity. His conclusion was that the recipient's perception of the reward is crucial. Rewards used as symbols of success have positive effects, but reward instrumentality has negative outcomes. In training sessions rewards are used instrumentally and that use of rewards may off-set the positive effects of feedback and experience. Morgan further found evidence of faster responding under reward and speculated that faster performance lowered the quality of performance which undermined enjoyment and a sense of success.

There seems to be little to recommend the use of rewards in MFF administration when researchers who have used that procedure consider its impact neutral or negative especially for reflective or mature subjects. The fact that the use of rewards was fairly ineffective in training studies suggests that cognitive tempo is either not trainable or negatively affected by reward.

Conceptual Styles

The relationship between cognitive tempo and conceptual style is relevant to this review because reward effects have been reported on tasks that have been linked to CST performance: ink blot responses, WISC subscales, and the ability to break a mental set in problem solving. These findings suggest a link between reward effects and factors which the MFF measures directly: response latency and accuracy.

Inkblot Responses. Analytic, reflective children gave more mature responses to inkblots (Kagan et al., 1963). Response latency and response quality were positively related. Fabes (1983) and Fabes, et al. (in press) found that under reward inkblot responses were given more quickly and that the responses were developmentally less mature. The link between these two findings would be that reward encourages impulsivity (faster responses and lower quality performance) on inkblot responses.

WISC Subscales. Kagan, et al. (1964) found that performance on the WISC verbal subscales were unrelated to performance on the CST, but perceptual organization scores were positively related to analytic performance on the CST. Moran, et al. (1984) reported that performance on verbal subscales was unaffected by reward, but perceptual organization was undermined by reward. Again, there is a potential link in that reward may affect perceptual organization processes and thereby intefere with reflective, analytic thinking.

Mental Set Breaking. Analytic conceptualizations' on the CST require the breaking of a mental set to make novel relational responses (Kagan et al., 1964). McGraw and McCullers (1979) reported that reward and nonreward subjects performed similarly on nine set formation problems, but rewarded subjects were less likely to break set and solve the tenth (set breaker) problem correctly. Reward may discourage analytic thinking and/or encourage mechanical thought in complex tasks.

Cognitive Abilities

The relationship between reward, cognitive tempo, and cognitive ability may be strongest for younger, high ability subjects and those in a transition or discovery stage. Generally, reflective children are brighter than their peers. They are more likely to be conservers and, along with fast accurate subjects, they score lower on errors, and MFF error scores reflect IQ scores. Also, reflective cognitive tempo is developmentally more mature and reflective subjects and brighter subjects are less likely to be affected by reward in MFF training studies. The stability of MFF error scores has been explained by their positive relationship to IQ scores and the stability of IQ scores. However, reward has been associated with IQ score variations in error rates (Fabes et al., 1981; Moran et al., 1984). The brighter, younger children make fewer errors and therefore have a greater margin for error increase than their more impulsive peers who are closer to maximum error rates. Thus, the negative effect of reward can be observed in the brighter, younger children. This was verified experimentally in rewarded WISC subscale performance (Moran, 1979) and CST scores (Kagan et al., 1963). Also, reward may disrupt the good performance of subjects capable of discovering and using a successful strategy, but has little impact on the less capable. This effect was demonstrated in MFF training studies and in the water jar problem solutions of rewarded subjects (McGraw & McCullers, 1979).

Social-Personality Measures

Teacher Ratings. A teacher's opinion of a pupil has been influenced by reward. Condry and Chambers (1978) have noted that as subject matter became more abstract the use of rewards increased and undermined the teaching learning process. Teachers evaluated rewarded learners as: more concerned about product than process, answer oriented, beginning to guess earlier, obtaining less information before answering, making more guesses, making inefficient and incomplete use of information, making more errors, making less use of resources, and rarely using a planned strategy. The teacher comments about guessing, errors, and making use of information and strategy are the qualities used to describe impulsive students. From the perspective of a teacher who uses rewards, the performance of a rewarded pupil is the performance of an impulsive child.

Thus, reward induces teacher evaluations indicative of impulsivity which should have low value in an education setting. If indeed reward elicits impulsive responding and teachers value reflectivity, the use of rewards to motivate learning is a questionable practice for it sets up a vicious cycle of product orientation, impulsive behavior, and poor personal relationships.

Locus of Control. Condry and Chambers (1978) proposed that one reason rewards had a detrimental effect on the learning process is that they tend to undermine a child's sense of self control. The specific effects of that phenomenon are: lower standards, attention to the rewarder's wishes, inadequate development of basic skills, lower sense of adequacy, and lower interest in returning to the task. Those same characteristics are typical of impulsive responders. If indeed impulsive children are more externally controlled and reflective children are more internally controlled as Kagan (1965a), Messer (1970), and Condry and Chambers (1978) have predicted, impulsive youngsters should be more strongly influenced by the use of reward. In terms of the learning process, impulsive children would experience the detrimental effects listed above. In terms of cognitive tempo, their external orientation would be heightened which would increase their need for immediate feed-back and so they would respond quickly. On the MFF faster responses increase errors and so there would be a detrimental effect upon performance.

Social Perceptions. Heider (1958) presented another view of reward's controlling influence in that reward, praise, and punishment are means of altering perceptions of behavior. Reward and praise, according to Heider, cause a child to feel that the behavior and the child have been positively received. This positive acceptance would strengthen behavior. Wapner and Alper (1952) verified their predicitons that decision time before an audience would decrease when the subject felt accepted by the audience. In an individual testing situation the experimenter is the child's audience and, if the reward is perceived as an indication that the experimenter approves of the child's performance and accepts the child, response latencies would be expected to decrease under reward conditions.

The reward literature and discussions of the antecedants of cognitive tempo show a relationship between external control and impulsivity. Reward tends to heighten perceptions of external control which leads to impulsive responding and impulsive children tend to be more suceptible to the influence of reward. Reflective subjects, on the other hand respond slowly and carefully, exercising internal controls, and are less influenced by reward's implications of external approval which leads to fast responses either for feedback or due to confidence from acceptance. Reflective subjects, being generally more cautious, may consider the possibility that reward is an indication that the experimenter disapproves of previous performance and is trying to manipulate behavior. In that case, the reflective child would perform even more carefully and slowly.

Reward Studies and MFF Findings

When reward studies and MFF findings are viewed together, a pattern emerges. Reward can alter response latency which can affect performance quality. Closer inspection suggests that reward effects interact with individual differences in cognitive tempo or other individual differences associated with cognitive tempo orientation. Generally, reflective subjects are more: mature, internally controlled capable of breaking a mental set, positively rated by teachers, competent, intelligent, and less rigid than impulsive subjects. These same characteristics are found in subjects who are relatively immune to reward effects. Cognitive tempo may be the variable that explains individual differences in the effects of rewards.

Task factors also play a role in both cognitive tempo measurement and the detrimental effects of reward. Measurable differences in cognitive tempo, specifically response latency, and reward effects on performance quality are more likely to be observed on tasks that are: non-verbal, optiminally challenging to the subject's ability and developmental level, intellectual rather than social in nature, and involve problem solving through strategy building. The reason that such tasks are influenced by reward and cognitive tempo may be the negative relationship between speed and accuracy in the completion of those tasks.

CHAPTER III

PRECEDURE

The Present Research

The Problem

The present study tested the effect of reward on response latency relative to individual differences in age or developmental level, ability, and cognitive tempo classification. Refinements in the measurement of cognitive tempo, particularly Salkind and Wright's (1977) integrated model, made it possible to use continuous measures that include all subjects. Fast accurate and slow inaccurate as well as impulsive and reflective children were retrained to investigate differences in impulsivity and efficiency. The usual classifications and measurement of latency and errors on the MFF were extended to include all four classifications.

Age or Development Level

Most reward studies have used tasks with optimum challenge and interest for the subjects. Tasks which the children had mastered and performed efficiently were usually excluded. The present study offered a direct comparison of reward effects on MFF performance which requires complex strategy development by younger subjects, but which older subjects can perform relatively easily through the use of established strategy.

This study sought to test the different effects of reward on performance of the same task by subjects at different developmental levels relative to the requirements of the task.

In other reward studies the question of developmental differences was approached in a post hoc analysis often across different tasks. These post hoc hypotheses were tested in this study by direct measurement of reward's effect upon cognitive tempo for children at three distinct developmental levels: impulsive, reflective, and efficient. Since the MFF has a measureable potential for impulsive, reflective, or efficient performance, the pattern of reward effects relative to age or developmental level was tested. In that manner, the present study sought to answer the question of how reward affects performance on a task as a function of developmental level from impulsivity (third graders), to reflectivity (fifth graders), to efficiency (seventh graders).

Cognitive Abilities

Individual differences in ability could cancel reward effects if reward enhances the performance of the more capable subjects and undermines the performance of the less capable or vice versa. MFF error scores have a well documented relationship to IQ and other ability measures. Children with fewer errors, the fast accurate and reflective children, are usually brighter while the impulsive and slow accurate children have lower I Q scores. Reward studies (Fabes et al., 1981; Moran, 1979; Moran et al., 1984) have shown that cognitive ability interacts with reward. MFF training studies (Denney, 1973) have shown that subjects with lower error scores are less influenced by training that includes rewards. One aim of the present study was to examine the effect of reward as a function of individual differences in ability.

Cognitive Tempo

The main goal of the present study was to assess the relationship between reward and cognitive tempo to determine whether reward has a consistent effect with all subjects or varies in effect with cognitive tempo. Because of a possible interaction of reward with cognitive tempo or ability it is important to include a wide range of baseline error and latency scores in each treatment group. Most cognitive tempo studies compared reflective and impulsive subjects, excluding the fast accurate and slow inaccurate responders. Questions about the effect of reward on fast accurate subjects may be of special interest because of the effect of reward upon the performance of WISC subscales (Moran, 1979) that were power tests of speed with accuracy. Fast accurate subjects should do well on such tasks unless reward caused them to respond more slowly, sacrificing speed, or more quickly, sacrificing accuracy. By retaining subjects in all four categories of cognitive tempo: impulsive, reflective, fast accurate, slow inaccurate; the potential interaction of reward effects and individual differences in cognitive tempo could be assessed in terms of both latency and accuracy of response, impulsivity and efficiency.

Pilot Studies

Study I: Preschoolers

The original study was to include a broad range of developmental ages, particularly preschoolers. The KRISP, not the MFF test, is the appropriate instrument for that age group and there is some doubt as to the reliability of cognitive tempo at that young age. The first pilot study was conducted to determine the measurability of a reward effect on the cognitive tempo of preschoolers.

The KRISP was administered to 19 children between the ages of three years-nine months and six years-three months. A test-retest design was used with Form A administered first to all subjects under standard conditions followed by Form B one month later first to the control, nonreward group and then to the reward group. The children selected their own reward from an array of inexpensive, small toys.

Both the reward and control groups had an increase in response latency and a reduction in errors from test to retest as reported by Wright (1976). However, the reward group's latency increase was much smaller than that of the control group. Within group variability was high and none of the differences was significant. A measurable reward effect would have been most unlikely. From age two years-five months to six years-five months the KRISP norms (Wright, 1978) show an increase in response latency of less than one second. If preschoolers regressed in their performance under reward conditions, that regression would not be measurable in terms of response latency.

The KRISP normative evaluation reported low test-retest correlations (r = .46 - .78) and error-latency correlations that are unacceptably low (r = -.16 - -.32). These factors plus the high variability in preschool children led to the conclusion that it is difficult to obtain valid and reliable measures of cognitive tempo for that population and therefore reward effects may not be detected.

The MFF might have produced more useable results, and if it were appropriate for preschoolers, comparisions across age groups would be facilitated. The second preschool pilot study involved administering the MFF Form F to four-year-olds in a test-retest design with nonreward and reward conditions for the retesting comparisons.

The children enjoyed taking the test and expressed feelings of success, but their latencies were brief, about five seconds, almost the minimum time required to look and point. Errors were high and correct answers were due to random chance probability. Again, a measurable reward effect was virtually impossible.

Study II: Norm Comparision

The Elementary MFF Form F was administered to a small sample of six-, eight-, ten-, and twelve-year-olds to refine procedures and verify similarity to norms. College freshmen were included to test age boundaries and compare scores. Also, data from this study would be considered in selecting age groups for the larger study.

Initial testing of three males and three females at each age level yielded results that did not conform to the norms. The sample size was then doubled and the data reflected normal scores reported by Salkind (1978). College student performance was similiar to that of 12-year-olds, suggesting a ceiling effect on maximum quality of performance. The task was definitely enjoyable and challenging. Children and college students recommended participation to their friends. Though MFF norms are limited to ages four and one-half to twelve and one-half, the task required concentration at all age levels including college freshmen.

Study III: Sibling Data

Most of the testing in Study II was conducted in the child's home. Since the task was fun and challenging, siblings wanted to participate. Thus, the pilot study unexpectedly included sibling pairs. It appeared from the experience of the examiner that siblings were performing similarly. The similarity of scores, however, was not noticeable until raw scores were converted to standard scores which correct age and sex differences. Viewing the standard scores the similarity was striking.

To test for a sibling relationship in cognitive tempo, the correlation of sibling standard scores was compared with the correlation of matched nonsibling pairs. Because the result was striking and approached significance, the sample was expanded to 30 sibling and nonsibling, but the strength of the correlations declined (r = .20 for latency and r = .30 for errors) and were virtually the same for nonsiblings.

Study IV: Reward Effects

Some studies have obtained measurable reward effects by comparing the scores of a nonreward group with those of a similar group completing the same task under reward conditions. Study IV was conducted to determine the plausibility of measuring reward's effect on cognitive tempo with that design.

A nonrandom reward group consisting of six males and six females in each age level: four, six, eight, ten, twelve, and eighteen years were tested. At the beginning of each individual testing session, the subject was given a stack of Hallmark Ambassador stickers and told to select one to keep for participating in the project. Because some of the older males seemed unappreciative of the stickers, the alternative of a one dollar bill was added.

The MFF scores of the reward subjects in Study IV were compared to the norms and the scores of nonreward subjects in Study I, Study II, and Study III. The scores of the rewarded 18 year olds were compared to norms for 12 year olds because of their similar performance in Study II.

There was essentially no reliable measurement of reward effect. Only four of the 72 t tests were significant, probably due to chance. High variability was evident and the need for blocking and using continuous scores rather than nominal groupings as reflective, impulsive, fast accurate, or slow inaccurate was clear. For the entire sample approximately 66 percent of the subjects were reflective and about 25 percent were fast accurate, the two types of cognitive tempo representing high ability and reported as least modifiable. The absence of impulsive subjects and the possibility of an age by tempo interaction with reward effects indicated a need for more controls through matching and a larger sample.

Study V: Reward Selection

The first source of information about appropriate rewards for elementary school age children was their mothers and teachers. In a telephone survey the following items were suggested: shoe laces, sticker packets, stuffed animals, candy, and money for video games. Decorative stickers were selected because there was more parent and teacher approval of that choice than any other and because they offered a selection process similar to the MFF task if six alternative packets were presented.

The second source of information about appropriate rewards was the children themselves. The Hallmark company provided the experimenter with 11 sticker packets considered to be best sellers. That final array was limited to six, the number of alternatives presented on MFF items. Also there was some question as a result of pilot work that stickers might not appeal to older boys and the age levels for the major study: third, fifth, and seventh graders included older children. In addition, one dollar bills and Susan B. Anthony one-dollar coins had been popular in other studies. It was important to know if children valued the stickers selling for about one dollar, the dollar coin, and the dollar bill equally.

Five boys and five girls in each of the three age groups: third, fifth, and seventh grades; were asked to rank the 11 packets and select one among three choices: the preferred sticker packet, a one dollar bill, or a Susan B. Anthony one dollar coin. The coin was chosen by over half of the children. Their comment was that it was a collector's item and they were coin collectors. Girls showed a strong preference for stickers over the dollar bill, but boys, especially older boys preferred the monetary reward (Kukura, 1984).

The Present Study

Rationale

If individual differences in cognitive tempo interact with reward effects and such differences are evenly distributed in the population, there would be a canceling of effects within the reward group. For example, reward might cause reflective subjects to perform more impulsively and impulsive subjects to perform more reflectively. Since each group represents about 35 percent of the population, the effect of reward upon one cognitive tempo group might be canceled by rewards effect upon another cognitive tempo group.

If individual differences in reward effects interact with cognitive tempo and ability levels there would be similar cancelling effects. One half of the reward group, fast accurate and reflective children are probably less suceptible to reward effects. The other, less capable children, slow inaccurate and impulsive, are more likely to be affected by reward. Reward's effect on the total group would be lessened by the resilience of the subjects with higher ability.

If reward influences response latency, the children's developmental levels relative to the task at hand could also yield cancelling effects. For example, the performance of subjects in the reflective stage in which the solution strategy is slowly and carefully discovered would be disrupted by quickened responses under reward. On the other hand, the performance of subjects in the efficiency stage in which the task can be performed with both speed and accuracy would be enhanced by decreased response latency.

Basic knowledge of reward's effect upon response latency would provide insight into reward's relationship to cognitive tempo. If reward increases latency for reflective and slow inaccurate subjects, but speeds others, reinforcement of habit is in evidence. If reward has the opposite effect it may be functioning as an inhibitor. If all subjects slow their responses under reward, but do not decrease errors, reward may be distracting their attention and concentration from the task. If reward decreases latency and increases errors or shows no change in errors, the regression hypothesis is supported.

Design

The present study was designed to control the measurement of several possible reward effects on cognitive tempo. Baseline data on cognitive tempo provided information on individual differences in both cognitive tempo, (latency and error rates), and ability, (error rates). Matched assignment to nonreward and reward groups for retesting provided comparisons of learning effects and reward effects on various different cognitive tempo orientations including all four categories: reflective, impulsive, fast accurate, and slow inaccurate at each age level.

The reward was non-contingent, given for participation only with no emphasis on speed or accuracy or strategy to allow its natural effect to occur. This control made the present study different from training studies and facilitated the measurement of reward's effect on either drive or inhibition.

Performance was measured on one task, the elementary MFF for three distinct age groups: third graders who perform the task impulsively, fifth graders who perform the task reflectively, and seventh graders who perform the task efficiently. This aspect of the design made it possible to note developmental regression from distinct stages and to view reward's influence at each stage in task performance.

Predictions

• It was expected that reward would have the general effect of decreasing response latency. This effect was expected to be particularly detrimental to the performance of fifth graders who under normal conditions would carefully discover and use a thorough strategy. For older subjects (fast accurate) the decrease in response latency would not yield more incorrect answers, but errors would have stabalized and greater efficiency might ensue. Conversely the less capable, younger impulsive, and slow inaccurate children would increase their error rates (if possible) when their responses were speeded by reward.

Subjects

The 92 girls included in this study were enrolled in the public schools of Enid, Oklahoma during the 1983-84 academic year. The subjects were in the third (n = 22), fifth (n = 32), and seventh (n = 38) grades and were predominantly white and middle class. Females only were tested for this study because of an apparent sex difference in preferences for the stickers as a reward. (See pilot studies IV and V.)

Instrument

Kagan's (1965) Matching Familiar Figures (MFF), Form F, was used as the primary measure of cognitive tempo. The test is a match-to-standard perceptual recognition task. The subject's task is to identify the one figure among six variants that exactly matches a standard presented simultaneously with the variants. The test consists of two practice items: mug and ruler, and twelve test items: house, scissors, phone, bear, tree, leaf, cat, dress, giraffe, lamp, boat, and cowboy.

Method

All subjects were tested twice on the MFF Form F. Prior to the first, baseline, administration, the children were told that they would be taking the test two times. The purpose of this information was to reduce the tendency reported by Messer (1970) of subjects to think that retesting was required because of poor performance on the initial testing.

Both testing situations took place in an area adjacent to the child's classroom. The time period between the first (baseline) and second (experimental) administration of the MFF was one month for the seventh graders to two months for the third and fifth graders. Each child participated individually. The examiner was a white, female graduate student experienced in administering the MFF to children ages four to 18.

Baseline Session

All subjects were tested initially under standard conditions and instructions. A digital wrist watch with a stop-watch feature was kept out of the child's view behind the test materials and used to take time measurements unobtrusively in an effort to reduce concern over speed of response and obtain a more natural measure of cognitive tempo (Quay, Popkin, Weld, & McLeskey, 1978). Most of the girls seemed unaware of being timed. If the subjects inquired about timing, they were told that times were being recorded, but that they could work as slowly or as quickly as they liked.

Scoring Procedure

The time elapsed until the subject's first choice was recorded as response latency. If the first response was correct, the subject was told so and continued to the next item. If the subject's response was incorrect, the subject was asked to continue until the correct match was selected. Incorrect responses were recorded as errors with a maximum possible of five errors per item or a maximum total of 60 errors possible.

Matching Prodedure

Subjects were matched within each grade level: third, fifth, and seventh, by mean latency and total error scores from the baseline MFF testing session. The Statistical Analysis System (SAS) computer program, graph procedure PLOT (SAS Institute Inc., 1982) was used to give equal consideration to both variables. Subjects were matched by their proximity on the graph. One member of each pair was randomly assigned to either the nonreward or to the reward treatment group for the experimental session.

Experimental Session

Subjects were retested individually on MFF Form F in a room adjacent to the child's classroom one to two months following the baseline session. For the nonreward group, the procedure was the same as had been used in the baseline session. All subjects in the nonreward group were retested before those in the reward group to avoid possible communication leading to an expectation of reward. Retesting was completed within two days.

Children assigned to the reward group were told that they would be matching the same pictures again, but that this time they would receive a prize. A one dollar bill and a stack of six packages of Hallmark self-adhesive stickers were placed in front of the child. Each package contained four sheets of stickers and retailed for $.95 to $1.09. The experimenter said, "You may have one dollar or one package of stickers, whichever you like, it is yours to keep. You may look at the sticker packages and pick the one you like best." The experimenter recorded the child's reward choice and the time she took to make the selection.

The six packets most often chosen by girls in a pilot study were offered in the present study. The monetary reward offered was a one dollar bill. The process of selecting one of six sticker packets for a reward seemed to involve perceptual skills and decision making similar to those required for MFF. Girls, because of their preference for stickers were expected to approach the sticker selection task with a more positive attitude than boys.

After the subject selected a reward, the MFF was then readministered exactly as in the baseline session. The reward remained near the child or in the child's possession during testing. To help minimize communication about the rewards, children in the reward group were asked to refrain from discussing the reward with other children.

Measures

The dependent measures, mean latency of response and total errors, were taken within a 3 Grades (3, 5, or 7) x 2 Treatments (nonreward or reward) x 4 cognitive tempos (reflective, impulsive, fast accurate, or slow inaccurate) repeated measures (MFF testing in two sessions) design. Thus, reward effects could be assessed within subjects by comparing baseline session scores with experimental session scores, and between subjects by comparing matched pairs of subjects assigned to nonreward or reward conditions in the experimental session. The interaction of reward effects with individual differences in age, ability, and cognitive tempo could be assessed by the degree and direction of the change in latency and error scores of rewarded subjects relative to the changes in the same scores for nonreward subjects by grade and baseline session cognitive tempo classification.

Chapter IV

RESULTS

The results are presented in the same sequence as the data were collected. That is, the results of the baseline session are presented first, comparisons of the matched groups next, followed by results for the experimental session. Comparisons of groups within sessions are followed by between-sessions comparisons. The chapter concludes with data on reward choices and reward-choice latencies. Means are followed by their standard deviations placed within parentheses. analyzed via the Statistical Analysis System (SAS) computer program (SAS Institute Inc., 1982). Raw data for each subject are provided in Appendix A.

Baseline Session

Mean response latency for the entire sample (n = 92) was 19.11 (8.32) seconds with no significant differences by grade level with General Linear Models Procedure and Scheffe's Test Analysis. The mean total error score for the entire sample was 5.69 (4.59) errors. Means for the third (n = 22), fifth (n = 32), and seventh graders (n = 38) were 7.86 (5.59), 5.66 (3.51), and 4.47 (4.40) respectively. Error differences by grade level were significant $F(2,89) = 4.06$, $p < .02$ using General Linear Models Analysis because of unequal cell sizes. Scheffe's Test showed mean errors to be significantly different for all but the fifth and seventh grades. The Statistical Analysis is presented in Appendix B.

At all three grade levels the mean latency means were greater than those reported in the norms and total error means were lower than those in the normative data. The sample, like those in the pilot work, appeared to be more accuratethan the subjects that were included in the studies which contributed data for the MFF norms. See Table I for comparisons of sample and normative means and medians.

Cognitive Tempo Classes

The Pearson Product-Moment correlation between errors and latency in seconds was calculated to determine if the acceptable standard ($r = -.43$) was met because, by definition, speed and accuracy must be negatively correlated in measures of cognitive tempo. The correlation between errors and latency was $r = -.56$, $p < .0001$, well within the required level. Separate correlations at each grade level showed stronger relationships for the third and fifth graders, $r = -.65$, $p < .0009$ and $r = -.78$, $p < .0001$ respectively. Correlation for the seventh graders was $r = -.47$, $p < .002$. These correlations conform to the expected stages of cognitive tempo development from the norms. That is, the strongest negative relationships between errors and latency occurred at age 10, = $r = -.58$ for females at the fifth grade level, and weakest at age 12, $r = -.48$ for females at the seventh grade level. The norms reported a negative correlation of $r = -.51$ for third grade females. Even though latencies did not vary by age in the sample and latencies were longer and errors fewer in the sample population, the developmental sequence of MFF skills was evident in the sample data.

In most studies sample median splits have been used to classify

TABLE I

SAMPLE BASELINE AND NORMATIVE DATA ON LATENCY, ERRORS, AND COGNITIVE TEMPO CLASSIFICATION

	GRADE 3 N = 22	GRADE 5 N = 32	GRADE 7 N = 38
BASELINE			
Mean Latency in seconds	18.46	18.74	19.80
Median Latency in seconds	19.30	24.45	22.50
Mean Number of Errors	7.86	5.66	4.47
Median Number of Errors	10.00	6.00	10.50
NORMATIVE			
Mean Latency in seconds	14.17	17.16	12.37
Median Latency in seconds	11.21	13.67	10.68
Mean Number of Errors	11.66	7.33	8.05
Median Number of Errors	12.25	6.68	7.66

	REFLECTIVE		IMPULSIVE		FAST ACCURATE		SLOW INACCURATE	
BASELINE	N	Percent	N	Percent	N	Percent	N	Percent
Medians	23	25	25	27	41	44		
Means	33	36	31	33	22	24	6	6
NORMATIVE								
Medians	49	53	12	13	21	23	10	11
Means	55	60	15	16	17	18	5	5

subjects as reflective (above the median on latency and below the median on errors) impulsive (below the median for latency and above the median for errors) fast accurate (below both medians) and slow inaccurate (above both medians). Some studies use sample means instead of medians and some have used the normative data to classify subjects. The use of sample means produced a cognitive tempo classifiction distribution similiar to that usually reported in MFF studies. See the Cognitive Tempo classifications listed in Table I for the percentage distribution for each of the four groups by sample baseline means and medians and normative means and medians. Since cognitive tempo classification by sample median splits conformed to theoretical expectations that classification system was used for further data analysis.

Results of the Matching Procedure

The matching procedure resulted in nonreward groups and reward groups that were highly comparable. See Table II for Baseline Session latency and error means for comparisons. To the extent that error scores measure cognitive ability, the reward and nonreward groups were well matched. Because of unequal cell sizes and significant differences in error scores by grade level, separate t tests were conducted for the total sample and each grade level to compare the treatment groups.

The t test procedure yielded no significant differences between the reward and control groups on the two baseline measures. The mean baseline latency scores for the reward and control groups across all three grade levels differed by only 0.9 seconds. The baseline error means for the two groups were virtually the same.

TABLE II

MEAN RESPONSE LATENCY SCORES (AND STANDARD DEVIATIONS) IN SECONDS AND TOTAL ERROR SCORES BASELINE AND EXPERIMENTAL SESSIONS FOR REWARD AND NONREWARD GROUPS

		LATENCY IN SECONDS				NUMBER OF ERRORS			
		BASELINE SESSION		EXPERIMENTAL SESSION		BASELINE SESSION		EXPERIMENTAL SESSION	
Nonreward	N	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Grade 3	11	19.18	(7.22)	17.00	(6.53)	8.09	(4.71)	6.36	(4.03)
Grade 5	16	19.11	(8.23)	18.79	(11.21)	5.81	(3.42)	5.68	(4.48)
Grade 7	19	20.20	(8.80)	19.31	(8.90)	4.26	(3.58)	2.84	(4.15)
Reflective	17	27.38	(6.27)	25.67	(9.26)	2.52	(1.87)	2.11	(2.75)
Impulsive	16	13.24	(4.03)	13.15	(6.69)	10.12	(4.03)	7.81	(4.83)
Fast Accurate	10	15.12	(3.05)	14.88	(4.21)	4.00	(1.63)	4.10	(2.87)
Slow Inaccurate	3	24.03	(5.15)	19.70	(7.36)	6.00	(-0-)	4.33	(5.85)
TOTAL	46	19.58	(8.09)	18.58	(9.16)	5.71	(4.31)	4.67	(4.43)
Reward									
Grade 3	11	17.73	(7.74)	19.31	(11.69)	7.63	(5.73)	6.81	(5.23)
Grade 5	16	18.36	(9.70)	19.19	(7.68)	5.50	(3.70)	3.18	(2.71)
Grade 7	19	19.40	(8.46)	22.45	(7.23)	4.68	(5.18)	2.52	(4.36)
Reflective	16	27.56	(6.57)	26.88	(8.67)	2.18	(1.75)	1.56	(2.03)
Impulsive	15	11.83	(3.54	16.23	(7.52)	10.93	(4.75)	7.06	(5.31)
Fast Accurate	12	13.77	(2.60)	17.28	(5.36)	3.33	(1.61)	1.83	(2.16)
Slow Inaccurate	3	24.56	(5.77)	21.70	(2.86)	7.33	(1.52)	7.00	(4.35)
TOTAL	46	18.64	(8.59)	20.56	(8.57)	5.67	(4.89)	3.78	(4.38)

Further *t* tests showed no significant differences between the reward and control groups at any of the three grade levels on either baseline latency or error scores. For the separate grades the mean baseline error difference between the control and treatment groups ranged from 0.3 to 0.4 errors. The corresponding baseline latency error range was from 0.5 to 1.4 seconds. Thus, the total sample and the three grade level control and treatment groups were very closely matched.

Reward Choice

The choice of a one dollar bill or one of the six sticker packets was analyzed in terms of grade level, cognitive tempo classification and MFF latency scores during both baseline and experimental sessions. Response latencies were further analyzed in terms of whether the subject's reward choice was a simple, dollar versus sticker packet, decision or a more complex, one among six sticker packets, choice.

Reward Preference

The stickers were chosen more often than the dollar bill. The ratio was about 2 to 1 and constant across grade levels. See Table III for totals, frequencies, and percentages by reward choice and grade level.

Reward Choice Latency

The mean reward choice latency for all rewarded subjects was 33.65 (36.30) seconds. Since the decision to select the monetary reward may have been more rapid and sure than a selection among similar stickers which had a greater degree of response uncertainty, separate calculations

Table III

REWARD CHOICE: DOLLAR OR STICKERS BY GRADE

REWARD CHOICE

GRADE (FREQUENCY / PERCENT / ROW PCT / COL PCT)	.	DOLLAR	STICKERS	TOTAL
3	11 . . .	3 6.52 27.27 20.00	8 17.39 72.73 25.81	11 23.91
5	16 . . .	5 10.87 31.25 33.33	11 23.91 68.75 35.48	16 34.78
7	19 . . .	7 15.22 36.84 46.67	12 26.09 63.16 38.71	19 41.30
TOTAL	. .	15 32.61	31 67.39	46 100.00

were conducted according to the subject's reward choice. For the 15 subjects choosing the monetary reward, the mean reward choice latency was 26.49 (20.62) seconds. For the 31 girls selecting stickers and then choosing among the stickers, the mean latency for reward choice was 37.11 (41.71) seconds. Sticker choice response latencies were longer than the decision to select the dollar bill for both third and seventh graders. However, for fifth graders, the most reflective age level, the decision to accept the dollar instead of the stickers had the longer response latency mean. See Table IV for means and standard deviations of reward choice latencies by grade level, reward choice, and cognitive tempo classification. Since sorting through six sticker packets would consume some time, even if the subject only glanced at each one, the time differences may be reflecting that exercise. Also some subjects who eventually selected the dollar bill examined the stickers fairly carefully, but none examined the money.

Relationship to MFF Latency Scores

The relationship between Baseline Session and Experimental Session MFF latency scores and reward choice latency scores was analyzed by Pearson Product-Moment correlations by grade level and reward choice. None of the correlations were significant. The correlation between MFF latency during the experimental session and reward choice latency approached significance (r = .24, p <.09) and when the two latency measures were converted to standard scores minimal significance was achieved (r = .28, p <.05).

Separate analysis by reward choice, dollar or stickers, did not

TABLE IV

REWARD CHOICE LATENCIES (AND STANDARD DEVIATIONS) IN SECONDS BY GRADE LEVEL AND COGNITIVE TEMPO CLASSIFICATION

AGE LEVEL	N	CHOICE	LATENCY IN SECONDS
Grade 3	11		42.38 (57.79)
		3 Dollar	25.53 (22.72)
		8 Stickers	48.70 (66.76)
Grade 5	16		30.50 (18.89)
		5 Dollar	42.70 (20.22)
		11 Stickers	24.95 (16.23)
Grade 7	19		31.25 (32.86)
		7 Dollar	15.32 (13.53)
		12 Stickers	40.54 (37.57)
Reflectives	16		40.43 (55.08)
		4 Dollar	10.95 (12.38)
		12 Stickers	19.57 (15.62)
Impulsives	15		27.31 (27.32)
		4 Dollar	25.47 (31.58)
		11 Stickers	27.98 (27.27)
Fast Accurates	12		30.31 (11.40)
		4 Dollar	31.05 (12.18)
		8 Stickers	29.95 (11.84)
Slow Inaccurates	3		42.50 (10.05)
		3 Dollar	42.50 (10.05)
		0 Stickers	
TOTAL	46		33.65 (36.30)
		15 Dollar	26.49 (20.62)
		31 Stickers	37.11 (41.71)

yield any significant correlations. Since the reward choice latency had such high variability, it was unlikely that such calculations would be meaningful especially in view of the small number of subjects choosing the dollar.

Relationship to Cognitive Tempo Classification

Subjects classified as reflective by the MFF sample means from the baseline session took an average of 40.43 (55.08) seconds to make their reward selection. The mean reward choice latency for the three slow inaccurate subjects in the reward group was 42.50 (10.05) seconds. Fast accurate subjects averaged 30.31 (11.40) seconds in making the decision and impulsive subjects had the shortest reward choice latency mean 27.31 (27.32) seconds. Even though reward choice latency had high variability, cognitive tempo classification seemed to be related to reward choice latency.

Experimental Session

Nonreward Group

Means and standard deviations of latency and error scores for the nonreward group during the experimental session (standard retesting condition) are presented in Table II. The negative correlation between latency and error scores ($\underline{r} = -.60$, $\underline{p} < .001$) retained the acceptable level. This negative relationship was also significant at two of the three grade levels: fifth ($\underline{r} = -.70$, $\underline{p} < .002$) and seventh ($\underline{r} = -.61$, $\underline{p} < .005$). For the third graders, the relationship was at the required level ($\underline{r} = -.45$) but not significant ($\underline{p} < .16$).

Test-retest comparisons, baseline session versus experimental session scores, for the nonreward group revealed the expected learning effect of a decline in errors for subjects at the third and seventh grade levels, an average reduction of about two errors. However, for the fifth grade control group, the reduction was only two-tenths of an error. For subjects assigned to the nonreward condition there was an unexpected nonsignificant trend of a decrease in response latency scores on retesting for all three grade levels (see Figure I).

Reward Group

The mean average latency score of the rewarded subjects was 20.56 (8.57) seconds. The mean for error frequency of rewarded subjects was 3.78 (4.38). The negative correlation of latency and error scores under reward was at the acceptable level ($\underline{r} = -.50$, $\underline{p} < .0004$). The negative relationship was significant at the third and fifth grade levels, but not for seventh graders. For third graders mean latency was 19.31 (11.69) seconds and the total error mean was 6.81 (5.23); ($\underline{r} = -0.60$, $\underline{p} < .05$). For fifth grade girls the average mean latency of response was 19.19 (7.68) seconds and the mean frequency of errors was 3.18 (2.71) ($\underline{r} = -0.58$, $\underline{p} < .01$). For seventh graders the mean latency averaged 22.45 (7.23) seconds and the mean for total errors was 2.52 (4.36). The correlation between errors and latency was negative but slightly below the generally accepted standard ($\underline{r} = -.39$) and not significant ($\underline{p} < .09$). However this weakened negative correlation between errors and latency for the reward group was not due to the expected increase in efficiency for the more mature subjects, seventh graders, under reward. Test-retest comparisons for the reward group showed the expected decline in errors

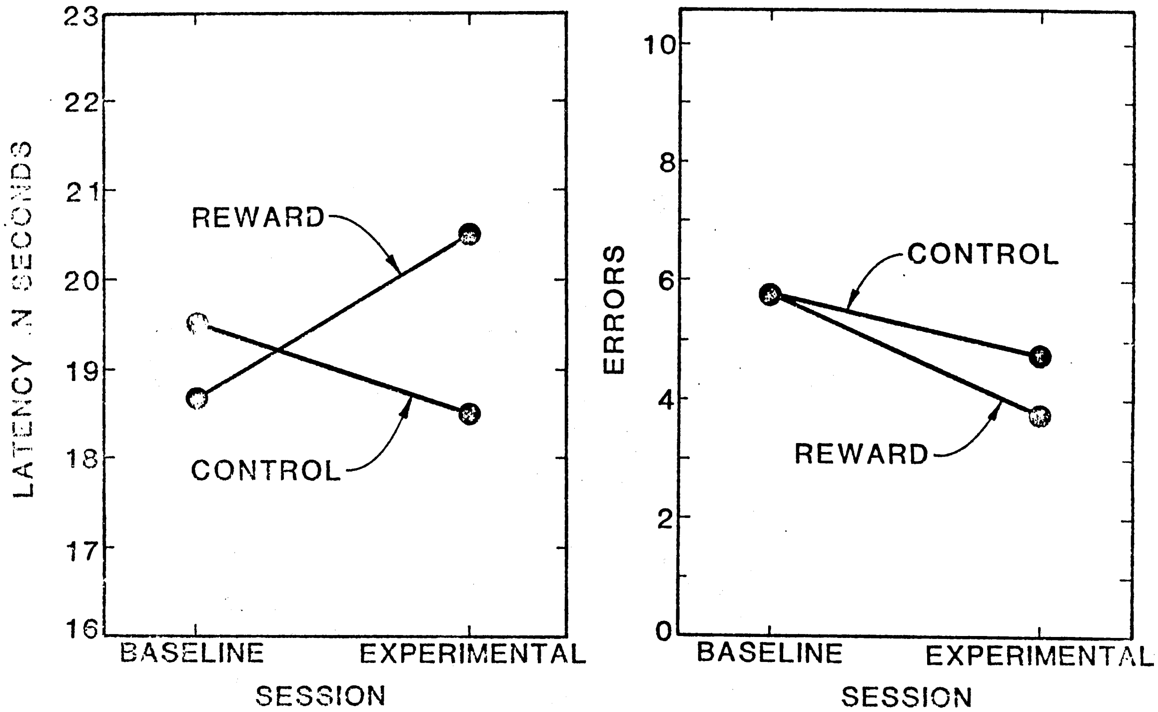

Figure 1. Treatment Effects - Mean Latency Scores in Seconds and Mean Error Scores for Baseline and Experimental Sessions Reward and Non-Reward Groups

and an unexpected increase in mean response latency at each grade level.

Assessment of Reward Effects

Analysis

The dependent measures, mean latency of response and frequency of errors, were analyzed separately in a 3 Grades (3, 5, and 7) x 2 Treatments (reward/nonreward) x 4 Cognitive Tempos (fast, accurate, impulsive, reflective, slow inaccurate) design. Independent measures were grade, treatment, baseline latency, baseline errors and nominal cognitive tempo classification. From the dependent measures of experimental session scores on latency and errors, standard scores were calculated using sample, not normative, means. Following Salkind and Wright's (1977) model impulsivity and efficiency scores were derived from the standard scores. Thus latency and error scores were also analyzed in combination as integrated scores of impulsivity and efficiency and separately as raw scores and standard scores.

The variables of greatest interest were the change in latency and error scores from baseline testing to experimental testing within subjects and within matched pairs. The degree and direction of that change for the member of the pair assigned to the nonreward group was compared with the change in scores for the other member of the pair who was assigned to the reward condition for the experimental session. That comparison of change scores was further considered by grade level and cognitive tempo classification.

Between Groups

Comparisons of group means for latency and error scores under reward and nonreward conditions during the experimental session showed no significant differences. Test-retest means show a tendency toward a reduction in errors indicative of a learning effect regardless of treatment condition in the experimental session.

Separate analysis by grade levels showed no significant differences in the group means for rewarded and nonreward groups. The error means for the fifth grade girls approached significance, t (15) = 1.90, p <.06, due to a lack of learning effect in the control group, not a reward effect.

Paired Differences

For each subject the difference between baseline and experimental session MFF scores for latency and error were calculated. A paired t-test evaluated the differences between baseline to experimental session score changes for matched pairs under reward and nonreward conditions. That analysis of the differences between reward and nonreward subjects with similar cognitive tempo scores revealed two significant reward effects.

Response latency increased significantly under reward, t (45) = -2.08, p <.04. Separate analysis by grade level showed the same significant effect for seventh graders, t (18) = -2.13, p <.04. For third and fifth graders the trend of longer latency scores for rewarded subjects was not significant.

Since the error reduction for rewarded subjects was not significant and the reward effect of increased latency was significant, reward appeared to have a detrimental effect of increased latency without reduced error rates. For the seventh graders, a facilitating effect of increased efficiency under reward was expected, but their performance shift was the greatest of all three age levels. Thus, reward increased latency of response and the effect was greatest where it was least expected, among the older children.

Cognitive Tempo Classification

Reward had a differential effect upon subjects in the four cognitive tempo classes: impulsive, reflective, fast accurate, and slow inaccurate. As has been the case in most studies, reflective children were immune to reward effects. For the impulsive subjects the reward effect of increased latency was significant (t [14] = -2.25 p <.04) for matched pair differences comparisons. Fast accurate subjects also increased latency under reward, but the difference was not significant.

There was a pattern of increased response latency under reward for subjects who normally responded quickly, the impulsive and fast accurate children. Retest latency scores were stable for impulsives and fast accurates or lower for reflectives and slow inaccurates for control subjects in all four quadrants. Latency scores for reflective children were virtually the same for reward and control subjects, with a slight decline on retest. The small number of slow inaccurate subjects included in this study also fit the pattern. Their longer than average baseline latency scores decreased in testing for both rewarded subjects and the controls (see Figure 2).

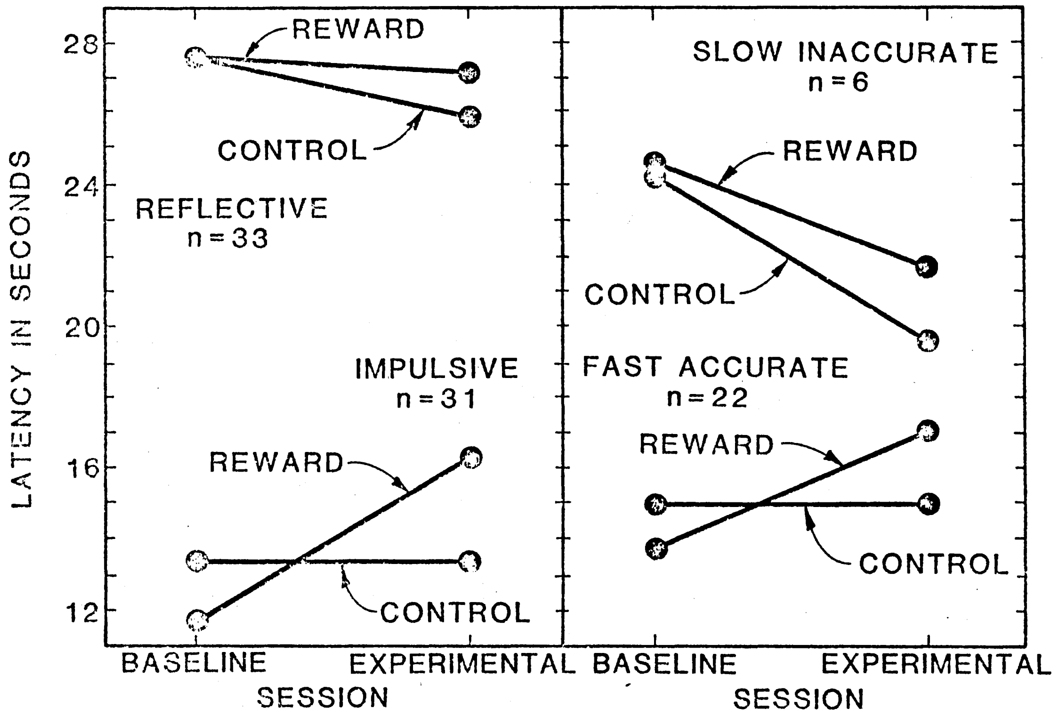

Figure 2. Treatment Effects by Cognitive Tempo Classification-Latency Means in Seconds for Reward and Non-Reward Groups

Error rates for baseline to experimental session were stable or slightly decreased for all conditions and tempos, except for the impulsive subjects. Their error rates in both the control and reward conditions had a large decrease upon retesting and the greater decrease occurred under reward. Thus, the impulsive subjects were the only ones to improve performance under reward. However, the difference between the rewarded and nonreward subjects was not significant, suggesting a natural learning effect for impulsive subjects which reward neither facilitated no hindered (see Figure 3).

Impulsivity and Efficiency

The expected increase in efficiency by more mature and brighter subjects was not found. There was no significant change in efficiency scores from first to second testing and regardless of condition in the experimental session.

Impulsivity scores showed significant main effects for treatment and cognitive tempo classification. Impulsivity scores decreased for rewarded subjects and increased for the nonreward condition (F [1,91] = 5.14, p <0.02, Scheffe's Test of Means, A = 0.05). Impulsivity scores decreased for impulsive subjects and increased for reflectives in both conditions but the differences were greater for rewarded subjects (F [3,91) = 5.35, p <.002) suggesting that retesting alone and retesting plus reward can inhibit normal response latency.

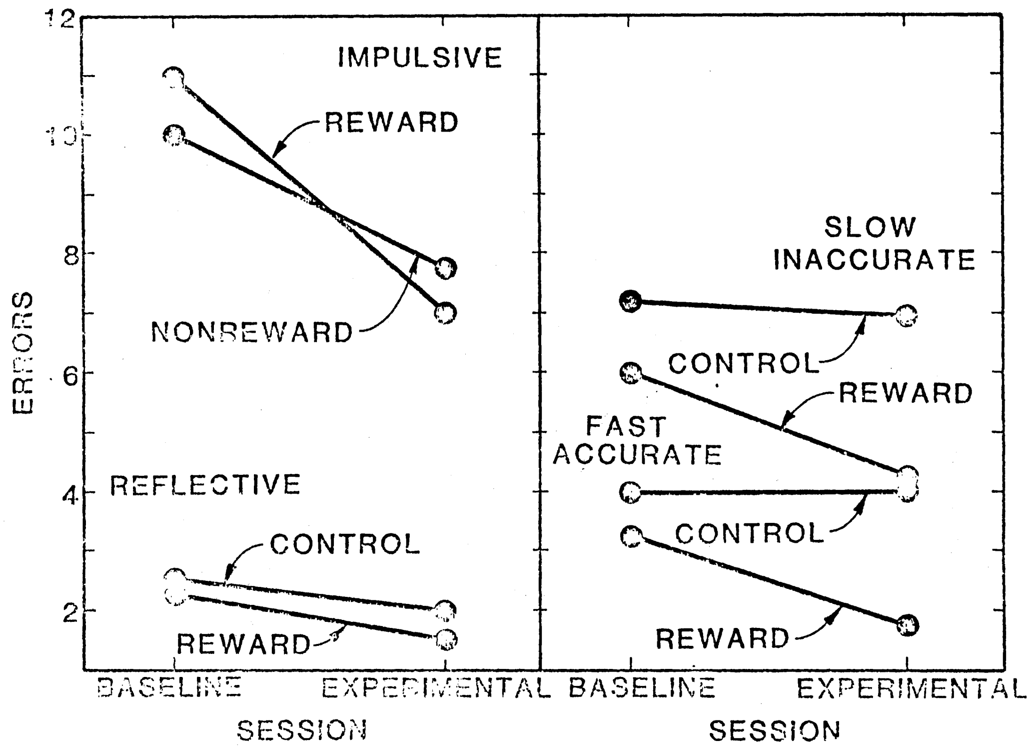

Figure 3. Treatment Effects by Cognitive Tempo Classification-Error Means for Reward and Non-Reward Groups

CHAPTER V

DISCUSSION

Individual Differences in Reward Effects

In the present study the effect of reward was hidden in comparisons of reward and nonreward group means and in the change in scores within subjects from the baseline to the experimental session for matched pairs in the two groups. Reward effects were not detected until cognitive tempo classification as well as treatment condition were the independent variables. As suggested in the introduction, individual differences in cognitive tempo, particularly response latency, can account for individual differences in the effect of reward upon performance quality. Impulsive subjects significantly slowed their responses and tended to decrease errors in the reward condition. Fast accurate subjects also slowed their responses and decreased errors but to a lesser degree, resulting in a nonsignificant decrease in their efficiency scores. Reflective subjects were virtually unaffected by reward and the sample of slow inaccurate responders was too small to consider. However, both groups of slow responders showed a slight trend toward decreased response latency and little change in errors. As proposed reward effects were masked in group data because of the fairly even distribution of individual differences in cognitive tempo in the sample population.

Thus, in this study there was a significant facilitation effect of reward upon the performance of impulsive subjects and a non-significant detrimental effect of reward upon the fast accurate. These effects would have remained undetected unless subjects were classified by cognitive tempo orientation from baseline measures. It should be noted that the sample population for this study was highly reflective and included an unusually large number of fast accurate subjects. Had the number and proportion of fast accurate subjects been smaller and all subjects more impulsive, the overall effect would have appeared to be one of increased response latency under the reward condition. The detrimental effect of reward, decreased efficiency, in fast accurate subjects would have been hidde by the stronger effect on a greater number of impulsive subjects. This finding may account for the strong negative effect of reward upon the performance of power tests (speed with accuracy) by high ability subjects (Moran, 1978). In the WISC subscales that the Moran study selected, fast accurate subjects would have an advantage resulting in better quality performance and the greatest potential for decline should reward increase response latency with little or no change in error rates. Though relatively little is known about fast accurate subjects due to their small numbers and traditional exclusion from studies of reflectivity-impulsivity, fast accurate may be synonomous with high ability.

Reward had virtually no effect upon the MFF performance of the reflective subjects replicating the findings of cognitive tempo studies that used rewards to train subjects (Denney, 1973) or to create anxiety over errors (Kagan, 1966a; Messer, 1970; Ward, 1968). This finding may help to account for the lack of a reward effect in some studies because of the population characteristics, (reflective), and task characteristics, (interesting and challenging enough to retain reflectivity), that counteracted reward effects. However, if the task required reflectivity for optimum performance, but appeared to require only an impulsive response as may be the case with inkblots (Fabes et al., in press; Kagan et al., 1963) or breaking a mental set (Kagan et al., 1964; McGraw & McCullers, 1979) the effect of reward upon the performance of the reflective subjects could have been sufficiently detrimental to off-set the positive effect of reward upon the performance of the impulsive subjects.

Thus, individual differences in the effect of reward upon task performance due to differences in cognitive tempo may be heightened by task demands. Fast accurate subjects perform well on power tests. If their response latency is slowed by reward, their performance declines. Impulsive subjects, on the contrary, have higher error rates and due to generally lower ability level may not be capable of performing well on such power tests even if reward does tend to increase their response latency. However, if the task is less difficult and does not demand both speed and accuracy, increased response latency under reward could improve the performance of impulsive and possibly the fast accurate subjects as well. In order to affect the performance of reflective subjects the reward must be linked with a task that is especially sensitive to decreases in response latencies such as a task that appears to demand impulsive responses while actually requiring rather thoughtful consideration. Under most conditions, though, reflective subjects alter their response style to match task demands.

Reward Choice Latency

The relationship between MFF response latency and reward choice latency was also dependent upon cognitive tempo classification. The correlation between the two raw scores was marginal. However, the mean reward choice latency scores for each cognitive tempo classification group were different, further supporting the importance of considering baseline cognitive tempo measures and the canceling effects of opposite styles.

In the present study as in the Messer (1965) study, there was a high degree of response uncertainty in the reward choice decision so that response latency indicates the degree to which the subject evaluates the selection. Simple, straight forward, easy, or obvious decisions do not require such evaluation as was the case in the Eska and Black (1971) study. The finding of a significant relationship between MFF response latency and reward choice latency support the contention by Kagan and Messer (1975) that the measurement of that cognitive tempo generally and particularly response latency in toy selection is dependent upon a high degree of response uncertainty is the task at hand. The relationship between MFF latency and reward choice latency in the present study may have been further enhanced by the similarity of task demands: selecting one match among six figures and selecting one sticker packet among six designs. Both tasks require visual evaluation and association of familiar figures. However, the decision between the dollar bill and a sticker packet, while maintaining response uncertainty, did not retain task similarity for none of the subjects examined the dollar bill.

Theoretical Explanations

Regression Hypothesis

Because there were no significant differences by grade level on baseline response latency measures it was impossible to detect regression in performance due to reward effects. In order to detect regression either a more sensitive measure, a wider age range, or a sample more like the norms is needed. There were significant differences by grade level in total errors on baseline testing. However, the learning effect of reduced errors on retesting was powerful and could mask regression effects. Given the difficulty of measuring cognitive tempo in preschoolers and the similarity in MFF performance by subjects ages 12 years and older, a broader age range in subjects is unlikely and therefore the question of regression in cognitive tempo development under reward may remain unanswered.

The McGraw Model

The McGraw Model predicts a facilitation effect of reward on the performance of all tasks except those that are initially attractive and heuristic. The contention in this study was that the same task, the MFF, would vary along the algorithmic-heuristic dimension with the developmental level of the subject. Baseline MFF measures failed to support that contention. There was very little difference in latency scores for subjects in the impulsive, reflective, and efficient stages and error totals were significantly different only for the younger, developmentally impulsive subjects.

The data do suggest the possibility that the MFF task varied in attractiveness and along the algorithmic-heuristic dimension from test to retest, especially for impulsive subjects. Pilot work and the baseline session provided definite evidence that the MFF task is attractive. Many of the children said that it was fun and smiled as they worked; none complained. The experimental session, however, was an exact repeat of the baseline session making the task less novel and therefore less attractive and less heuristic, characteristics which, according to the McGraw Model, are essential for a detrimental effect of reward. Subjects remembered or asked how many errors they made on the first administration and strove to do better. Since reflectives are more concerned about errors, the opportunity to take the test again may have had some appeal for them. Impulsive subjects, on the other hand, may have considered the opportunity an unattractive one and being more externally controlled, were more influenced by reward, and having more margin for change in both response latency and error scores, improved their performance in the reward condition.

Drive Theory and Anxiety

The findings do not support the classic drive theory prediction that reward increases drive resulting in faster responses. Nor was there support for Kagan and Kogan's (1970) prediction of a differential effect that would cause impulsive subjects to respond more impulsively and reflective subjects to respond more reflectively. In fact, the opposite effect was found. Impulsive subjects significantly slowed their responses under reward and fast accurate showed a nonsignificant trend in the same direction.

The role and degree of anxiety may be crucial because drive theory treats anxiety as drive and an increase in anxiety would lead to an increase in drive resulting in a decrease in response latency, the same observable effect as would result from an increase in motivation due to reward. Kagan and Kogan's prediction is based upon differential sources of anxiety; errors for reflectives and response latency for impulsives.

Messer (1970) found that retesting per se produced anxiety which led to increased response latency, especially in impulsives. That finding was not replicated in the present study because for the impulsive and fast accurate subjects in the control group performance during the experimental session was no different from their performance during the baseline session in terms of response latency with a learning effect of reduced errors in the impulsive control group. There were two plausable reasons for this finding. The Messer study involved a more difficult task and in the present study subjects were informed of the retesting procedure prior to the first MFF administration.

The rewarded impulsive subjects in the present study replicated Messer's finding of more cautious performance under anxiety conditions and fast accurate subjects showed a similar trend. However, the reflective subjects did not perform more carefully under reward; they very slightly decreased their response latency. Thus, there is only partial support for Messer's cognitive-dynamic explanation, but that support is extended to suggest that fast accurate subjects may do likewise. There is the further possibility that reward plus retesting may offer a minor inhibitor of normal response tendencies, not anxiety over performance. Reflective subjects having already mastered such inhibition of impulsive response, are least affected, while impulsive children who have not developed such internal controls respond significantly to the introduction of reward. It is unfortunate, however, that the fast accurate subjects, by inhibiting their fast, but correct, responses lose efficiency. It is also possible that the reward given unconditionally during a prearranged retesting session served to relax the subjects' normal cognitive tempo orientation and fast responders slowed their rate of response and slower responders felt it was safe to work faster. There is however little theoretical or experimental support for the notion of relaxed performance under reward and differential effects due to contingencies.

Implications

Time measures and specifically response latency measures as well as performance quality measures would enhance the measurement and understanding of reward's effect upon performance and motivation and the relationship between performance, motivation, and time on task. Theoretical explanations of the processes that underlie reward's effect on performance quality and motivation could gain specificity if the effect on response latency was documented. Individual differences in the effect of reward relative to the subject's age or developmental level, cognitive abilities, and task requirements may be clarified by the intervening variable of response time.

The MFF is easily administered and scored to facilitate the inclusion of cognitive tempo orientation as a dependent variable. Matching subjects on cognitive tempo as well as (or including) cognitive ability would provide a tighter control of that variable. Due to the differential effects of reward relative to the subject's cognitive tempo and the distribution of those individual differences in the general population, baseline measurement of cognitive tempo orientation is highly desirable.

Within classrooms the general use of rewards with all children regardless of cognitive tempo differences may be counter productive. The value of reward would be limited to only one group of children, the impulsive responders, and certain tasks, those with a speed-accuracy trade-off. Rewards would be wasted and possibly detrimental for reflective and fast accurate subjects. Given the mixtures of cognitive tempo within a given classroom, singling out one group for reward would be unkind and unmanageable. Rewards could serve to keep class members on schedule by slowing the fast responders and speeding the slow responders. In light of the behavior and self-concept problems when some children finish their work before others, such use of reward might be tempting. However the use of rewards would be at greatest cost to the more gifted students, the fast accurates, and wasted on reflective subjects who tend to perform well on a variety of tasks by adapting their style to task requirements.

The role of individual differences, specifically cognitive tempo, in reward's effect upon performance seems to be a complex one. However, it is worthy of pursuit for potential results are costly in terms of research measures and classroom teaching. Predicting reward effects and evaluating their impact on the learning process could be more successful when cognitive tempo is considered.

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APPENDIX

APPENDIX A

RAW DATA

GRADE=3

OBS	GRADE	TREATMENT	MATCH	BASELINE LATENCY IN	BASELINE ERRORS	TEMPOS	EXPERIMENTAL LATENCY IN	EXPERIMENTAL ERRORS	REWARD CHOICE LATENCY	REWARD CHOICE
1	3	REWARD	12	26.1	1	REFLECTIVE	49.5	1	25.8	STICKERS
2	3	REWARD	1	8.6	18	IMPULSIVE	10.5	7	7.3	STICKERS
3	3	CONTROL	11	24.0	3	REFLECTIVE	27.2	4	.	.
4	3	REWARD	3	6.2	13	IMPULSIVE	10.5	17	20.8	STICKERS
5	3	REWARD	9	30.6	9	SLOW INACCURATE	19.9	12	51.6	DOLLAR
6	3	CONTROL	10	27.0	5	REFLECTIVE	18.1	11	.	.
7	3	REWARD	7	13.6	4	FAST ACCURATE	20.0	1	37.7	STICKERS
8	3	CONTROL	3	8.5	13	IMPULSIVE	11.8	12	.	
9	3	CONTROL	5	16.6	7	FAST ACCURATE	14.3	6	.	.
10	3	REWARD	11	24.9	3	REFLECTIVE	19.3	7	31.4	STICKERS
11	3	REWARD	5	14.9	3	FAST ACCURATE	18.0	2	23.1	STICKERS
12	3	REWARD	10	24.2	4	REFLECTIVE	28.6	2	212.4	STICKERS
13	3	REWARD	4	15.9	8	IMPULSIVE	17.2	8	15.1	DOLLAR
14	3	CONTROL	6	18.5	5	REFLECTIVE	21.5	0	.	.
15	3	REWARD	6	17.4	5	FAST ACCURATE	12.2	6	31.1	STICKERS
16	3	CONTROL	4	17.4	10	IMPULSIVE	8.8	5	.	.
17	3	CONTROL	7	14.6	4	FAST ACCURATE	8.7	10	.	.
18	3	REWARD	2	12.7	16	IMPULSIVE	6.8	12	9.9	DOLLAR
19	3	CONTROL	12	32.4	1	REFLECTIVE	25.5	2	.	.
20	3	CONTROL	1	11.4	19	IMPULSIVE	19.8	11	.	.
21	3	CONTROL	9	25.5	6	REFLECTIVE	20.5	4	.	.
22	3	CONTROL	2	15.1	16	IMPULSIVE	10.8	5	.	.

GRADE=5

OBS	GRADE	TREATMENT	MATCH	BASELINE LATENCY IN	BASELINE ERRORS	TEMPOS	EXPERIMENTAL LATENCY IN	EXPERIMENTAL ERRORS	REWARD CHOICE LATENCY	REWARD CHOICE
23	5	REWARD	14	11.5	11	IMPULSIVE	13.8	3	22.2	STICKERS
24	5	REWARD	15	16.0	10	IMPULSIVE	17.6	3	16.2	STICKERS
25	5	CONTROL	23	12.7	4	FAST ACCURATE	13.8	5	.	.
26	5	REWARD	19	24.5	5	REFLECTIVE	12.9	5	9.6	STICKERS
27	5	REWARD	18	17.4	8	IMPULSIVE	19.9	9	31.4	STICKERS
28	5	CONTROL	15	17.3	10	IMPULSIVE	12.7	6	.	.
29	5	CONTROL	22	13.3	5	FAST ACCURATE	20.3	2	.	.
30	5	REWARD	24	20.7	3	REFLECTIVE	20.8	3	22.1	STICKERS
31	5	CONTROL	14	11.2	10	IMPULSIVE	8.2	15	.	.
32	5	CONTROL	28	40.4	0	REFLECTIVE	43.2	0	.	.
33	5	CONTROL	24	25.5	4	REFLECTIVE	25.1	2	.	.
34	5	CONTROL	27	32.0	2	REFLECTIVE	44.1	1	.	.
35	5	CONTROL	25	18.4	3	FAST ACCURATE	19.1	2	.	
36	5	CONTROL	20	19.0	6	SLOW INACCURATE	23.7	2	.	.
37	5	REWARD	23	13.9	4	FAST ACCURATE	21.8	0	38.6	DOLLAR
38	5	CONTROL	16	16.2	9	IMPULSIVE	15.6	5	.	.
39	5	CONTROL	13	11.6	12	IMPULSIVE	6.1	10	.	.
40	5	CONTROL	17	12.8	8	IMPULSIVE	6.0	9	.	.
41	5	REWARD	16	13.7	8	IMPULSIVE	28.7	0	72.4	DOLLAR
42	5	REWARD	20	19.1	6	SLOW INACCURATE	20.2	4	44.2	DOLLAR
43	5	REWARD	22	11.7	5	FAST ACCURATE	15.1	3	42.7	DOLLAR
44	5	REWARD	26	21.0	0	REFLECTIVE	23.7	0	6.6	STICKERS
45	5	REWARD	27	39.2	0	REFLECTIVE	27.2	3	50.9	STICKERS
46	5	CONTROL	21	11.4	6	IMPULSIVE	19.5	12	.	.
47	5	CONTROL	18	16.4	7	IMPULSIVE	15.2	6	.	.
48	5	REWARD	17	11.7	8	IMPULSIVE	16.6	1	55.7	STICKERS
49	5	REWARD	21	12.7	6	IMPULSIVE	10.6	5	25.6	STICKERS
50	5	REWARD	25	11.8	3	FAST ACCURATE	10.6	4	15.6	DOLLAR
51	5	CONTROL	19	23.8	6	SLOW INACCURATE	11.2	11	.	.
52	5	REWARD	28	41.7	0	REFLECTIVE	38.2	0	26.8	STICKERS
53	5	REWARD	13	7.2	11	IMPULSIVE	9.4	8	7.4	STICKERS
54	5	CONTROL	26	23.9	1	REFLECTIVE	16.9	3	.	.

GRADE=7

OBS	GRADE	TREATMENT	MATCH	BASELINE LATENCY IN SECONDS	BASELINE ERRORS	TEMPOS	EXPERIMENTAL LATENCY IN SECONDS	EXPERIMENTAL ERRORS	CHOICE LATENCY IN SECONDS	REWARD CHOICE
55	7	CONTROL	31	19.7	13	IMPULSIVE	30.3	4	.	.
56	7	REWARD	36	15.1	0	FAST ACCURATE	22.1	0	27.3	DOLLAR
57	7	REWARD	42	27.3	4	REFLECTIVE	18.4	1	27.0	STICKERS
58	7	REWARD	29	24.0	7	SLOW INACCURATE	25.0	5	31.7	DOLLAR
59	7	REWARD	31	15.8	15	IMPULSIVE	25.7	10	98.8	STICKERS
60	7	REWARD	33	11.3	5	IMPULSIVE	32.2	2	11.3	STICKERS
61	7	CONTROL	34	16.2	5	IMPULSIVE	15.7	3	.	.
62	7	CONTROL	40	9.2	6	IMPULSIVE	12.4	4	.	.
63	7	CONTROL	46	28.2	1	REFLECTIVE	29.0	1	.	.
64	7	CONTROL	39	24.5	2	REFLECTIVE	24.6	3	.	.
65	7	CONTROL	45	24.0	1	REFLECTIVE	25.7	0	.	.
66	7	CONTROL	33	13 5	5	IMPULSIVE	15.3	0	.	.
67	7	REWARD	43	34.1	3	REFLECTIVE	29.5	0	6.4	DOLLAR
68	7	CONTROL	38	18.1	2	FAST ACCURATE	21.4	1	.	.
69	7	REWARD	46	29.7	1	REFLECTIVE	26.0	0	0.6	DOLLAR
70	7	REWARD	34	11.5	3	FAST ACCURATE	11.9	0	47.9	STICKERS
71	7	REWARD	37	14.0	2	FAST ACCURATE	24.3	0	17.8	STICKERS
72	7	REWARD	30	9.5	21	IMPULSIVE	11.2	17	4.5	DOLLAR
73	7	CONTROL	42	29.3	6	SLOW INACCURATE	24.2	0	.	.
74	7	REWARD	44	22.8	2	REFLECTIVE	30.5	0	132.6	STICKERS
75	7	REWARD	47	35.2	0	REFLECTIVE	29 6	0	7.1	DOLLAR
76	7	REWARD	45	23.7	1	REFLECTIVE	32.3	1	26.6	STICKERS
77	7	CONTROL	32	8.8	6	FAST ACCURATE	11.1	7	.	.
78	7	REWARD	40	9.9	6	FAST ACCURATE	11.1	5	43.1	STICKERS
79	7	CONTROL	29	25.9	4	REFLECTIVE	16.9	0	.	.
80	7	CONTROL	35	14.2	3	FAST ACCURATE	12.0	2	.	.
81	7	REWARD	38	19.1	3	FAST ACCURATE	14.8	1	21.7	STICKERS
82	7	REWARD	35	12.4	2	FAST ACCURATE	25.5	0	17.2	STICKERS
83	7	CONTROL	43	30.9	1	REFLECTIVE	30.8	0	.	.
84	7	CONTROL	44	21.7	3	REFLECTIVE	12.7	4	.	.
85	7	CONTROL	36	16.0	2	FAST ACCURATE	12.2	3	.	.
86	7	REWARD	32	7.3	6	IMPULSIVE	12.8	4	11.1	STICKERS
87	7	CONTROL	41	20.2	4	REFLECTIVE	16.0	1	.	.
88	7	CONTROL	47	41.0	0	REFLECTIVE	38.6	0	.	.
89	7	REWARD	41	21.0	4	REFLECTIVE	20.0	1	31.4	STICKERS
90	7	REWARD	39	24.9	4	REFLECTIVE	23.7	1	29.7	DOLLAR
91	7	CONTROL	30	4.0	13	IMPULSIVE	2.2	18	.	.
92	7	CONTROL	37	18.5	4	FAST ACCURATE	15.9	3	.	.

APPENDIX B

STATISTICAL ANALYSIS

BASELINE LATENCY AND ERROR SCORES

GRADE 3

VARIABLE	N	MEAN	STD DEV	SUM	MINIMUM	MAXIMUM
LATENCY	22	18.45909091 *seconds*	7.34254783	406.10000000	6.20000000	32.40000000
ERROR	22	7.86363636	5.59162175	173.00000000	1.00000000	19.00000000

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 22

	LATENCY	ERROR
LATENCY BASELINE LATENCY	1.00000 0.0000	-0.65684 0.0009
ERROR BASELINE ERRORS	-0.65684 0.0009	1.00000 0.0000

GRADE 5

VARIABLE	N	MEAN	STD DEV	SUM	MINIMUM	MAXIMUM
LATENCY	32	18.74062500 *seconds*	8.86398510	599.70000000	7.20000000	41.70000000
ERROR	32	5.65625000	3.51594869	181.00000000	0	12.00000000

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 32

	LATENCY	ERROR
LATENCY BASELINE LATENCY	1.00000 0.0000	-0.70825 0.0001
ERROR BASELINE ERRORS	-0.70825 0.0001	1.00000 0.0000

SAS

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: BASELINE ERRORS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	22	1398.53897516	63.56995342	8.45	0.0001	0.729364	48.1493
ERROR	69	518.93928571	7.52085921		ROOT MSE		PERROR MEAN
CORRECTED TOTAL	91	1917.47826087			2.74241850		5.69565217

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TR	1	0.04347826	0.01	0.9396	1	0.02609792	0.00	0.9532
GRADE	2	160.19491757	10.65	0.0001	2	65.49810624	4.35	0.0166
TR*GRADE	2	3.55834590	0.24	0.7900	2	13.45004888	0.89	0.4136
TEMPOS	3	1159.62202784	51.40	0.0001	3	1202.64057893	53.30	0.0001
TR*TEMPOS	3	11.21457410	0.50	0.6894	3	9.13932307	0.41	0.7531
GRADE*TEMPOS	6	52.24400731	1.16	0.3390	6	51.50848193	1.14	0.3479
TR*GRADE*TEMPOS	5	11.66162418	0.31	0.9050	5	11.66162418	0.31	0.9050

SCHEFFE'S TEST
NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
BUT GENERALLY HAS A HIGHER TYPE II ERROR RATE THAN TUKEY'S
FOR ALL PAIRWISE COMPARISONS.

ALPHA=0.05 CONFIDENCE=0.95 DF=69 MSE=7.52086
CRITICAL VALUE OF T=1.76908

COMPARISONS SIGNIFICANT AT THE 0.05 LEVEL ARE INDICATED BY '***'

GRADE COMPARISON	SIMULTANEOUS LOWER CONFIDENCE LIMIT	DIFFERENCE BETWEEN MEANS	SIMULTANEOUS UPPER CONFIDENCE LIMIT	
3 - 5	0.3072	2.2074	4.1076	***
3 - 7	1.5519	3.3900	5.2281	***
5 - 3	-4.1076	-2.2074	-0.3072	***
5 - 7	-0.4636	1.1826	2.8287	
7 - 3	-5.2281	-3.3900	-1.5519	***
7 - 5	-2.8287	-1.1826	0.4636	

LATENCY AND ERROR SCORES

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
TREATMENT=CONTROL TEST=BASELINE									
LATENCY	46	19.58260870	8.09543916	4.00000000	41.00000000	1.19360739	900.80000000	65.53613527	41.340
ERRORS	46	5.71739130	4.31361176	0.00000000	19.00000000	0.63600736	263.00000000	18.60724638	75.447
TREATMENT=CONTROL TEST=RETEST									
LATENCY	46	18.58043478	9.16569982	2.20000000	44.10000000	1.35140871	854.70000000	84.01005314	49.330
ERRORS	46	4.67391304	4.43748852	0.00000000	18.00000000	0.65427199	215.00000000	19.69130435	94.942
TREATMENT=REWARD TEST=BASELINE									
LATENCY	46	18.64130435	8.59476782	6.20000000	41.70000000	1.26722938	857.50000000	73.87003382	46.106
ERRORS	46	5.67391304	4.89922601	0.00000000	21.00000000	0.72235147	261.00000000	24.00241546	86.347
TREATMENT=REWARD TEST=RETEST									
LATENCY	46	20.56956522	8.57603559	6.80000000	49.50000000	1.26446746	946.20000000	73.54838647	41.693
ERRORS	46	3.78260870	4.38133944	0.00000000	17.00000000	0.64599326	174.00000000	19.19613527	115.829
GRADE=3 TREATMENT=1 TEST=BASELINE									
LATENCY	11	19.18181818	7.22216286	8.50000000	32.40000000	2.17756403	211.00000000	52.15963636	37.651
ERRORS	11	8.09090909	5.71759644	1.00000000	19.00000000	1.72392019	89.00000000	32.69090909	70.667
GRADE=3 TREATMENT=1 TEST=RETEST									
LATENCY	11	17.00000000	6.53253396	8.70000000	27.20000000	1.96963310	187.00000000	42.67400000	38.427
ERRORS	11	6.36363636	4.03169263	0.00000000	12.00000000	1.21560107	70.00000000	16 25454545	63.355
GRADE=3 TREATMENT=2 TEST=BASELINE									
LATENCY	11	17.73636364	7.74006108	6.20000000	30.60000000	2.33371622	195.10000000	59.90854545	43.640
ERRORS	11	7.63636364	5.73188847	1.00000000	18.00000000	1.72822940	84.00000000	32.85454545	75.060
GRADE=3 TREATMENT=2 TEST=RETEST									
LATENCY	11	19.31818182	11.69194750	6.80000000	49.50000000	3.52525481	212.50000000	136.70163636	60.523
ERRORS	11	6.81818182	5.23102632	1.00000000	17.00000000	1.57721378	75.00000000	27.36363636	76.722
GRADE=5 TREATMENT=1 TEST=BASELINE									
LATENCY	16	19.11875000	8.23757398	11.20000000	40.40000000	2.05939349	305.90000000	67.85762500	43.086
ERRORS	16	5.81250000	3.42965013	0.00000000	12.00000000	0.85741253	93.00000000	11.76250000	59.005
GRADE=5 TREATMENT=1 TEST=RETEST									
LATENCY	16	18.79375000	11.21382889	6.00000000	44.10000000	2.80345722	300.70000000	125.74995833	59.668
ERRORS	16	5.68750000	4.48283764	0.00000000	15.00000000	1.12070941	91.00000000	20.09583333	78.819
GRADE=5 TREATMENT=2 TEST=BASELINE									
LATENCY	16	18.36250000	9.70648409	7.20000000	41.70000000	2.42662102	293.80000000	94.21583333	52.860
ERRORS	16	5.50000000	3.70585123	0.00000000	11.00000000	0.92646281	88.00000000	13.73333333	67.379
GRADE=5 TREATMENT=2 TEST=RETEST									
LATENCY	16	19.19375000	7.68222787	9.40000000	38.20000000	1.92055697	307.10000000	59.01662500	40.025
ERRORS	16	3.18750000	2.71339271	0.00000000	9.00000000	0.67834818	51.00000000	7.36250000	85.126
GRADE=7 TREATMENT=1 TEST=BASELINE									
LATENCY	19	20.20526316	8.80999897	4.00000000	41.00000000	2.02115238	383.90000000	77.61608187	43.602
ERRORS	19	4.26315789	3.58766568	0.00000000	13.00000000	0.82306695	81.00000000	12.87134503	84.155
GRADE=7 TREATMENT=1 TEST=RETEST									
LATENCY	19	19.31578947	8.90999833	2.20000000	38.60000000	2.04409380	367.00000000	79.38807018	46.128
ERRORS	19	2.84210526	4.15348793	0.00000000	18.00000000	0.95287548	54.00000000	17.25146199	146.141
GRADE=7 TREATMENT=2 TEST=BASELINE									
LATENCY	19	19.40000000	8.46771647	7.30000000	35.20000000	1.94262739	368.60000000	71.70222222	43.648
ERRORS	19	4.68421053	5.18601358	0.00000000	21.00000000	1.18975311	89.00000000	26.89473684	110.713
GRADE=7 TREATMENT=2 TEST=RETEST									
LATENCY	19	22.45263158	7.23620284	11.10000000	32.30000000	1.66009879	426.60000000	52.36263158	32.229
ERRORS	19	2.52631579	4.36359206	0.00000000	17.00000000	1.00107667	48.00000000	19.04093567	172.726

CONTROL AND REWARD GROUP COMPARISONS
GRADE=3

TTEST PROCEDURE

VARIABLE: LATENCY BASELINE LATENCY

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
CONTROL	11	19.18181818	7.22216286	2.17756403	8.50000000	32.40000000	UNEQUAL	0.4529	19.9	0.6556
REWARD	11	17.73636364	7.74006108	2.33371622	6.20000000	30.60000000	EQUAL	0.4529	20.0	0.6555

FOR HO: VARIANCES ARE EQUAL, F'= 1.15 WITH 10 AND 10 DF PROB > F'= 0.8309

VARIABLE: ERROR BASELINE ERRORS

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
CONTROL	11	8.09090909	5.71759644	1.72392019	1.00000000	19.00000000	UNEQUAL	0.1862	20.0	0.8542
REWARD	11	7.63636364	5.73188847	1.72822940	1.00000000	18.00000000	EQUAL	0.1862	20.0	0.8542

FOR HO: VARIANCES ARE EQUAL, F'= 1.01 WITH 10 AND 10 DF PROB > F'= 0.9939

VARIABLE: LATENCY RETEST LATENCY

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
CONTROL	11	17.00000000	6.53253396	1.96963310	8.70000000	27.20000000	UNEQUAL	-0.5741	15.7	0.5741
REWARD	11	19.31818182	11.69194750	3.52525481	6.80000000	49.50000000	EQUAL	-0.5741	20.0	0.5723

FOR HO: VARIANCES ARE EQUAL, F'= 3.20 WITH 10 AND 10 DF PROB > F'= 0.0802

VARIABLE: ERROR RETEST ERRORS

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
CONTROL	11	6.36363636	4.03169263	1.21560107	0.00000000	12.00000000	UNEQUAL	-0.2283	18.8	0.8219
REWARD	11	6.81818182	5.23102632	1.57721378	1.00000000	17.00000000	EQUAL	-0.2283	20.0	0.8218

FOR HO: VARIANCES ARE EQUAL, F'= 1.68 WITH 10 AND 10 DF PROB > F'= 0.4244

GRADE=5

VARIABLE: LATENCY BASELINE LATENCY

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
CONTROL	16	19.11875000	8.23757398	2.05939349	11.20000000	40.40000000	UNEQUAL	0.2376	29.2	0.8138
REWARD	16	18.36250000	9.70648409	2.42662102	7.20000000	41.70000000	EQUAL	0.2376	30.0	0.8138

FOR HO: VARIANCES ARE EQUAL, F'= 1.39 WITH 15 AND 15 DF PROB > F'= 0.5329

VARIABLE: ERROR BASELINE ERRORS

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
CONTROL	16	5.81250000	3.42965013	0.85741253	0	12.00000000	UNEQUAL	0.2476	29.8	0.8062
REWARD	16	5.50000000	3.70585123	0.92646281	0	11.00000000	EQUAL	0.2476	30.0	0.8062

FOR HO: VARIANCES ARE EQUAL, F'= 1.17 WITH 15 AND 15 DF PROB > F'= 0.7681

VARIABLE: LATENCY RETEST LATENCY

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
CONTROL	16	18.79375000	11.21382889	2.80345722	6.00000000	44.10000000	UNEQUAL	-0.1177	26.5	0.9072
REWARD	16	19.19375000	7.68222787	1.92055697	9.40000000	38.20000000	EQUAL	-0.1177	30.0	0.9071

FOR HO: VARIANCES ARE EQUAL, F'= 2.13 WITH 15 AND 15 DF PROB > F'= 0.1543

VARIABLE: ERROR RETEST ERRORS

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
CONTROL	16	5.68750000	4.48283764	1.12070941	0	15.00000000	UNEQUAL	1.9084	24.7	0.0680
REWARD	16	3.18750000	2.71339271	0.67834818	0	9.00000000	EQUAL	1.9084	30.0	0.0660

FOR HO: VARIANCES ARE EQUAL, F'= 2.73 WITH 15 AND 15 DF PROB > F'= 0.0608

GRADE=7

VARIABLE: LATENCY BASELINE LATENCY

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
CONTROL	19	20.20526316	8.80999897	2.02115238	4.00000000	41.00000000	UNEQUAL	0.2872	35.9	0.7756
REWARD	19	19.40000000	8.46771647	1.94262739	7.30000000	35.20000000	EQUAL	0.2872	36.0	0.7756

FOR HO: VARIANCES ARE EQUAL, F'= 1.08 WITH 18 AND 18 DF PROB > F'= 0.8683

VARIABLE: ERROR BASELINE ERRORS

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
CONTROL	19	4.26315789	3.58766568	0.82306695	0	13.00000000	UNEQUAL	-0.2910	32.0	0.7729
REWARD	19	4.68421053	5.18601358	1.18975311	0	21.00000000	EQUAL	-0.2910	36.0	0.7727

FOR HO: VARIANCES ARE EQUAL, F'= 2.09 WITH 18 AND 18 DF PROB > F'= 0.1273

VARIABLE: LATENCY RETEST LATENCY

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
CONTROL	19	19.31578947	8.90999833	2.04409380	2.20000000	38.60000000	UNEQUAL	-1.1912	34.5	0.2417
REWARD	19	22.45263158	7.23620284	1.66009879	11.10000000	32.30000000	EQUAL	-1.1912	36.0	0.2414

FOR HO: VARIANCES ARE EQUAL, F'= 1.52 WITH 18 AND 18 DF PROB > F'= 0.3856

VARIABLE: ERROR RETEST ERRORS

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
CONTROL	19	2.84210526	4.15348793	0.95287548	0	18.00000000	UNEQUAL	0.2285	35.9	0.8206
REWARD	19	2.52631579	4.36359206	1.00107667	0	17.00000000	EQUAL	0.2285	36.0	0.8206

FOR HO: VARIANCES ARE EQUAL, F'= 1.10 WITH 18 AND 18 DF PROB > F'= 0.8365

VARIABLE: LATENCY BASELINE LATENCY

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
1	46	19.58260870	8.09543916	1.19360739	4.00000000	41.00000000	UNEQUAL	0.5407	89.7	0.5900
2	46	18.64130435	8.59476782	1.26722938	6.20000000	41.70000000	EQUAL	0.5407	90.0	0.5900

FOR HO: VARIANCES ARE EQUAL, F'= 1.13 WITH 45 AND 45 DF PROB > F'= 0.6898

VARIABLE: ERROR BASELINE ERRORS

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
1	46	5.71739130	4.31361176	0.63600736	0	19.00000000	UNEQUAL	0.0452	88.6	0.9641
2	46	5.67391304	4.89922601	0.72235147	0	21.00000000	EQUAL	0.0452	90.0	0.9641

FOR HO: VARIANCES ARE EQUAL, F'= 1.29 WITH 45 AND 45 DF PROB > F'= 0.3964

VARIABLE: LATENCY RETEST LATENCY

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
1	46	18.58043478	9.16569982	1.35140871	2.20000000	44.10000000	UNEQUAL	-1.0748	89.6	0.2854
2	46	20.56956522	8.57603559	1.26446746	6.80000000	49.50000000	EQUAL	-1.0748	90.0	0.2853

FOR HO: VARIANCES ARE EQUAL, F'= 1.14 WITH 45 AND 45 DF PROB > F'= 0.6574

VARIABLE: ERROR RETEST ERRORS

TR	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
1	46	4.67391304	4.43748852	0.65427199	0	18.00000000	UNEQUAL	0.9694	90.0	0.3349
2	46	3.78260870	4.38133944	0.64599326	0	17.00000000	EQUAL	0.9694	90.0	0.3349

FOR HO: VARIANCES ARE EQUAL, F'= 1.03 WITH 45 AND 45 DF PROB > F'= 0.9323

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Doctor of Philosophy

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