THE AVAILABILITY AND USE OF SELF MEDIATED FEEDBACK IN IMPULSIVE, MODERATE AND REFLECTIVE CHILDREN

by

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CURRICULUM STUDIORUM

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ABSTRACT

Past research on learning and problem solving in impulsive and reflective children indicates that the manner in which these children apprehend and process stimulus information reflects qualitatively different levels of functioning. The present study was concerned with extending these findings to determine the effect of "conceptual tempo" on the child's capacity to evaluate the effectiveness of his behavior and to generate corrective feedback on the basis of that information. Based on their performance on the Matching Familiar Figures Test and the WISC Mazes, nine year old children were classified as impulsive, moderate (middle range) or reflective. These children were exposed to a prismatically induced 11.5 degree displacement of the visual field, with the intention of determining the type of feedback they relied on in adapting to the effects of the prisms. Subjects in each group were randomly assigned to one of two exposure conditions which differed in the type of information made available regarding the effect the prisms had on functioning. The Concurrent Display with Targets condition restricted feedback to sensory information regarding felt body position. The Terminal Display condition made available information about felt body position and information about errors in localizing targets in the visual field. Adaptation in the two conditions was measured in terms of change in felt body position, inter-

manual transfer of adaptation, and overall change in the visual motor system.

It was found that the adaptive process varied as a function of exposure conditions with significantly greater intermanual transfer and overall visual motor adaptation being exhibited by subjects in the Terminal Display condition. Additionally, "conceptual tempo" influenced the adaptive process. The reflective subjects exhibited significantly greater intermanual transfer in the Terminal Display condition than did the impulsive and moderate groups, indicating a higher degree of cognitive involvement in generating feedback about the way in which the prismatic displacement affected functioning.

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CHAPTER I

INTRODUCTION

Impulsive children often present a paradoxical and frustrating picture to those working with them. While they are perceptually alert, energetic and intellectually comparable to the non-impulsive child, they often appear to be socially immature, disruptive and may experience difficulties in learning. This has often led to the conclusion that these children are unmotivated or may be neurologically impaired.

These inferences are generally made on the basis of the readily observable characteristics of impulsivity, suggesting that the problems are due to a short attention span, distractibility, or the inability to slow down and work more carefully. While such observations may be valid, causality is generally attributed to them on the basis of quantitative factors; for example, statements like "the child does not attend <u>long enough</u>" or "he works <u>too quickly</u>" are often heard. Studies have shown, however, that slowing down the response rate or increasing the time spent on a problem did not significantly change the quality of performance of the impulsive child (Kagan, Pearson and Welch, 1966; Siegelman, 1969). Recently, the trend has moved away from a focus on quantitative factors to one which takes into account the quality of the actual problem solving process. In her work on hyperactive-impulsive children, Douglas (1974) notes that:

> "The consensus seems to be that it is the quality rather than the quantity of activity that is important; that is, it is necessary to take into account the extent to which the child's behavior is organized and goal directed and conforms to the demands made on him" (p. 158).

The present investigation was carried out to further the understanding of how the processes of learning and problem solving are influenced by impulsivity. One component of the learning process which may be influenced by the behavioral style of impulsive children is the capacity to make effective use of the feedback resulting from their actions. Feedback is an important component of the learning sequence which provides information serving to enhance the efficiency of future performance. It is defined in the cybernetic sense, referring to a system or organism which is controlled by the consequences of its own behavior. This capacity for self-regulation involves the apprehension of information about outputs (behavior) relative to intended goals and the conversion of that information into instructional inputs to the systems controlling behavior.

The manner in which this aspect of the learning process is influenced by the behavioral style of the impulsive child has remained relatively unexplored. It is the intention of this study to investigate the way in which impulsive children use available feedback in adapting to new and demanding situations.

THE CHARACTERISTICS AND MEASUREMENT OF IMPULSIVITY

The dynamics and characteristics of impulsivity should be understood before a consideration of their effects on the adaptive functioning of the child is possible. Although impulsiveness is often associated with a wide range of childhood psychopathologies, it may also describe a specific temperamental characteristic, varying in intensity in a normal curve in the general population. While impulsiveness may be evident in any personality at a given time, "people vary considerably in the frequency and intensity of impulsive behavior and in their ability to delay impulses and reflect on the wisdom of carrying them out" (p. 128, Bellak, Hurvich and Gediman, 1973). Recently, impulsivity has been considered to be a component of the "cognitive style", or one's habitual manner of approach or strategy in dealing with the world via the perceptual-cognitive system. Here, the impulsive-reflective dimension defines the rate or tempo at which information is processed (Kagan and Kogan, 1970).

Impulsivity is generally characterized by the tendency to act without forethought, with little reliance on inhibition and cognitive reflection as an adaptive mechanism. There is a tendency for the impulsive person to "initiate a reasoning sequence suggested by the first hypothesis that occurs to him and/or report an answer without sufficient reflection on its possible validity" (p. 308, Kagan, 1965). Most conceptualizations of impulsiveness stress the qualities of acting suddenly and without foresight (Harriman, 1947). There is an inability to institute a delay into the response sequence during which time the potential consequences of one's actions can be evaluated (Colvin, 1959; Kagan, 1965; Rapaport, 1951).

The conceptualization of impulsivity posited by Kagan and his co-workers (Kagan, Rosman, Day, Albert and Phillips, 1964; Kagan, 1965; Kagan, 1966) has had a strong influence on the direction and format of much of the research presently being carried out. Kagan views impulsivity in terms of "conceptual tempo", a dimension which was developed to help account for individual differences in information processing and problem solving abilities as a function of the rate at which these processes occur. In contrast to the impulsive child are those who are prone to reflect upon and analyze a situation before acting. These reflective children appear to introduce a delay into the response sequence to allow for a consideration of the alternatives before committing themselves to action.

The impulsive and reflective types are commonly classified on the basis of their reaction time and the quality of their performance (number of errors) on the Matching Familiar Figures Test (MFF) (Kagan, Rosman, Day, Albert and Phillips, 1964). The MFF Test is a complex discrimination task requiring the subject to choose the one alternative among six very similar variants which matches a standard stimulus. In the situation of high response uncertainty presented by this test, what appears to be measured is the extent to which the subject is able to delay the first impulse to respond. It is during this delay that one can evaluate his response to insure its accuracy. Those subjects responding rapidly with a high degree of error are defined as impulsive, while more accurate, slowly responding subjects are defined as reflective.

Similar to the characteristic of impulsivity, which appears to decrease with age, there is a general increase in response latency and decrease in errors on the MFF Test over the age range from five to eleven years (Kagan and Kogan, 1970; Campbell and Douglas, 1972). The MFF Test still showed moderately good stability with test - retest correlations on MFF response latencies having an average correlation of $r = .62$ for a sample of third and fourth graders, and $r = .50$ for first graders, with the tests being administered one year apart (Kagan, 1965).

The dimensions measured by the MFF Test show a moderate amount of generality across experimental situations and tasks. In terms of response latency, Kagan (1965) reports significant positive correlations between the MFF reaction time and delay scores in an interview situation and reaction times in other complex discrimination tasks. In dealing with concept identification problems, reflective subjects took significantly longer to complete the problems, and had a longer reaction time following the presentation of feedback regarding the quality of their performance (Nuessle, 1972). Reflectives also took significantly longer to choose playthings than did impulsives when there was some degree of uncertainty about the alternatives (Mann, 1973). In a group of pre-operational four year olds, Constantini, Corsini and Davis (1973) found an overall correlation of $r = .54$ between MFF performance and the capacity for inhibition on the motor level, the forerunner of inhibitory abilities on the cognitive level. Numerous studies describing the differences in problem solving strategies employed by the two groups are also considered to be an indicator of the construct validity of the impulsive-reflective dimension (Kagan and Messer, 1975).

Recently, there has been some question about the relationship between MFF performance and intelligence. Kagan, Rosman, Day, Albert and Phillips (1964) initially found MFF reaction time (RT) to be orthogonally related to verbal IQ. This relationship was supported by Bodi's (1972) finding of a -.04 correlation between MFF RT and the Peabody Picture Vocabulary Test, and Campbell and Douglas (1972) who found generally weak, non-significant correlations between MFF RT and the Verbal and Full Scale WISC IQ Scores. With respect to MFF errors, however, Block, Block and Harrington (1974) found a -.39 correlation between this measure and the WPPSI Full Scale IQ. This finding in conjunction with others of a similar magnitude (Eska and Black 1971; Lewis, Rausch, Goldberg, and Dodd, 1968) led Block, Block and Harrington (1974) to the conclusion that "MFF error scores ... reflect little else than intelligence" (p. 615, Block, Block and Harrington, 1974). While Campbell and Douglas (1972) report weak correlations between MFF error and the WISC Verbal and Full Scale IQ's (between -.16 and .04), a somewhat stronger, although non-significant, relationship was found between the WISC Performance Scale and MFF error (as high as -.28 and -.35 for different age groups). Similar findings by Plomin and Buss (1973), including a significant -.38 relationship between MFF error and the WISC Performance IQ, indicate that there is some degree of similarity between the skills necessary for successful performance in these two tests.

While the MFF Test has proven valuable in allowing a previously ambiguous characteristic to be operationally defined, Block, Block and Harrington (1974) caution against the error of attributing surplus meaning to the impulsive or reflective characteristics exhibited by subjects on the basis of their MFF performance alone. It was pointed out that while Kagan operationally defines these characteristics in the narrow sense prescribed by the measure, he often discusses them in the broader, generally understood sense. These authors further stress the multi-dimensional nature of this trait, pointing out the importance of basing the classification of impulsivity and reflectiveness on more than one behavioral measure.

A limited capacity for planning ahead is considered to be another distinguishing characteristic of the impulsive person. This quality appears to be related to the capacity for inhibition on the motor and cognitive level which allows time for a consideration of the direction and consequences of an act before the act is initiated (foresight). The capacity to perform successfully on the Porteus Maze Test appears to be based on these processes (Porteus,1965). Poor maze performance in spite of an otherwise average IQ may be considered to be an indication of impulsive tendencies (Porteus, 1965; Bodi, 1972). Maze performance has been found to correlate significantly with MFF errors (Bodi, 1972). Maze performance of adolescent delinquents has shown a strong relationship to the capacity to delay gratification and think ahead in more real life situations (Erikson and Roberts, 1971). In a study with first graders, Kainer (1965) also found that children who were better able to delay the need for immediate gratification performed significantly better on the mazes. In her work with hyperactive-impulsive children, Douglas (1972) reports that of all measures used, the Porteus Mazes showed the greatest degree of loading on the major factor under study, that of "attention-impulse control" (p. 276).

Block, Block and Harrington (1974) carried out an extensive study on the personality characteristics of pre-school impulsive and reflective children, correlating their MFF performance and responses on the California Child Q

Set personality test. They found reflectives to be "ego-resilient individuals" who have a good capacity for using past experience in adapting to new situations; impulsive children, however, appeared to be less resourceful and flexible in dealing with new situations. As a result, they are subject to greater feelings of anxiety. Furthermore, impulsive children are described as individuals who encounter difficulty in effectively organizing their experiences and who appear to be "structure-requiring and structure-seeking children" (p. 630).[1]

The characteristics described above seem to be most clearly apparent in the strategies of perceiving and thinking employed by impulsives and reflectives in dealing with demanding and complex problem solving situations. Strategy is defined as one's habitual manner of apprehending and utilizing stimuli necessary to deal with a problem effectively. In terms of the perceptual organization of the field, a process determining the quality of information to be made available to the child, Drake (1970) and Siegelman (1969) found that the visual scanning strategies of reflective subjects were systematic, careful and organized. Their approach involved a well differentiated, detailed analysis of the stimuli, yielding a good deal of information. In contrast,

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[1]Block, Block and Harrington based their analyses on MFF error scores only, and therefore labeled impulsives as "inaccurates" and reflectives as "accurates".

impulsives dealt with more "global chunks of the visual field" (p. 211, Drake, 1970), showing less structure and organization in their visual analysis. The information derived from such an approach appears to be less detailed,providing less useful data with which to solve a problem. On a perceptual learning task, the more analytic, reflective subjects tended to deal with stimuli on the basis of their distinctive features while the impulsive group showed no distinct preference in terms of style of perceptual learning (Odom, McIntyre and Neale, 1971). Odom, McIntyre and Neale, (1971) concluded that the different styles observed in the two groups may be attributed to the limited degree of cognitive evaluation employed by the impulsive group.

Following Klein's (1970) observation that through the functioning of the perceptual system we are able to understand the working of the overall ego system, it has been found that the perceptual styles described above parallel the conceptual strategies used by these children. In a task of deductive reasoning where the solution is obtained through a progressive narrowing of alternatives via constraint seeking questions, Ault (1973) reports that the different strategies employed by impulsive and reflective subjects indicate developmentally different levels of cognitive functioning. Reflective subjects showed a more orderly and directed approach resembling that of the older child, while a less effective, more immature strategy was observed in the impulsive group. Similar findings were reported by Adams (1972) on a probability learning task in which reflectives were observed to employ more logical guessing strategies in dealing with the problem than did a group of impulsives. In an effort to more precisely define the differential strategies used by these two groups in solving problems, McKinney (1973) analyzed the specific strategies used in dealing with matrix solution tasks. Of the four strategies possible, focusing, scanning, random and mixed, it was found that 73.3 percent of the reflectives consistently used focusing as compared to 33.3 percent of the impulsives; fifty-five percent of the impulsives used the random or mixed strategies compared to 25.5 percent of the reflectives; eleven percent of the impulsives compared to one percent of the reflectives used a more global, scanning strategy. This finding of a less directed, trial and error approach to problem solving would indicate that an understanding of the cognitive style of the impulsive child must go beyond a consideration of the rate of responding alone.

The validity of this assumption is most clearly apparent in the experimental programs which have attempted to improve the quality of the impulsive children's performance by teaching them to delay their initial impulse to respond and take more time before responding. These efforts have led to mixed findings. Yando and Kagan, (1968), Siegelman, (1969), and Debus (1970), found that training impulsive children to slow down their reaction time on the MFF Test led to a significantly longer latency but resulted in little change in number of errors. Thus, it appears that response rate alone is not responsible for the quality of performance exhibited by the impulsive child. Programs designed to teach these children strategies for dealing with complex stimulus information have proven to be more effective in enhancing the quality of their performance. Meichenbaum and Goodman (1971) found that training impulsive children to verbally instruct themselves to plan ahead, be more careful, and to be more systematic, improved the quality of their functioning. More recently, Egeland (1974) has sought to compare the relative value of these two approaches. He trained one group to delay their responses for 10-15 seconds before responding, while a second was taught more efficient scanning techniques, including search patterns and effective ways of analyzing the stimuli. While both groups showed equivalent amounts of change immediately after training, on a re-test two months later, the scanning group maintained a low level of errors compared to a substantial increase in errors in the group taught to delay their responses.

Although these studies have furthered our understanding of how the impulsive child functions in learning and problem solving situations, little work has been presented over the past decade explaining why these children perform as they do. Kagan, Rosman, Day, Albert and Phillips (1964) originally offered three possible explanations to account for the individual differences observed along the reflective-impulsive continuum; 1) constitutional factors, 2) degree of involvement with the task, 3) expectation of failure. Based on the work of Schaefer and Bayley (1963), who brought forth evidence that the different temperaments of infants remained stable for many years, Kagan, Rosman, Day, Albert and Phillips, (1964) appeared to emphasize the biologically based hypothesis of constitutional factors. In later works on "the dynamics of the conceptual tempo" (Kagan, 1966; Kagan and Kogan, 1970) constitutional factors were no longer considered. There seemed to be a shift in the locus of the explanatory statements to more peripheral and situationally based factors, for example, task uncertainty, desire for quick success, or anxiety about making errors, as the cause of an impulsive performance. Strong evidence for the constitutional hypothesis has recently been presented in a co-twin study by Plomin and Willerman (1975). Correlations of $r = .77$ and $r = .54$ were found between the MFF reaction time scores of identical and fraternal twins respectively, indicating a genetic basis for this temperamental trait. Constitutional factors alone, however, do not explain the way in which response rate influences both the style and quality of functioning observed in impulsive and reflective children. It would appear that psychoanalytic theory can offer a valuable explanatory framework for dealing with this problem.

The capacity for intra-psychic delay, which is considered to be weak in impulsives, stands at the center of Freud's theory of thought and conscious experience (Rapaport, 1951). Freud

(1911) considered delay of action to be essential in allowing for the interpolation of thought between impulse and action. It is during and as a result of this delay, that a small amount of drive energy becomes a "bound" cathexis and is used by the ego in an internalized "experimental action, a kind of groping forward involving only a small expenditure of energy in the way of discharge" (p. 347, Freud, 1911). Once this secondary process has occurred, the drive inhibition, or counter-cathexis, is removed and the impulse is allowed expression in motility. In this way, the organism finds the most efficient and adaptive channel for the release of the impulse, satisfying the needs of the organism and the demands of reality.

Rapaport (1951) further developed Freud's position by considering delay of discharge the "cradle of conscious experience" (p. 690). Through this counter-cathexis, the ego is able to hold the impulse in check, allowing additional energies to be invested into thought, "reflective awareness" (Rapaport, 1951) and "reflective self-representation" (Schafer, 1968). According to this analysis, the impulsive child should show less capacity for self awareness than the reflective child concerning the exact nature of his role in a behavioral sequence. Rapaport (1951) has postulated that the capacity for inhibition of impulses appears to be sensitive to individual differences in constitution which influence the intensity and rate of impulse expression and the capacity to delay the discharge of the impulse.

An extension of this discussion, offering important implications for the present study, is the existence of and necessity for a second reality check. The first reality check occurs between impulse and action; the second calls for the institution of another delay after the act to allow the organism to apprehend and evaluate the consequences of its actions relative to intended goals. This information will subsequently be integrated into memory to modify or reinforce the occurence of that behavior in the future. Such a feedback mechanism is a necessary compliment to, and check on, the initial reality test. White (1963) stressed the importance of feedback in reality testing, stating that our understanding of reality is the result of knowing the effect our actions will have in a given situation. Factors affecting the capacity for delay or inhibition in the initial reality testing should also act to reduce the cognitive involvement necessary to produce effective feedback by which a person can monitor his behavior.

DEVELOPMENTAL CONSIDERATIONS

The findings of a broad range of studies indicate that children classified as impulsive or reflective based on MFF performance employ qualitatively different styles of functioning in problem solving situations. The impulsive child has been shown to exhibit an ontogenetically less mature approach in the apprehension, processing, and utilization of stimulus information in dealing with conceptual and problem solving tasks (Achenbach, 1969; Ault, 1973; Drake, 1970). While the reflective child tends to be more analytic, systematic and conceptual in dealing with different situations (Kagan, Rosman, Day, Albert and Phillips, 1964; McKinney, 1973; Shine, 1971), impulsives tend to react in a more syncretic manner, dealing with more global aspects of the experiential field (Drake, 1970; Shine, 1971). These children tend to center on the perceptually dominant, immediately available aspects of the field. There appears to be less involvement of the cognitive faculties in analyzing and understanding the input beyond the perceptually given qualities of the stimulus configuration (Douglas, 1974; Shine, 1971). The information available to the impulsive child on the basis of these perceptual processes appears to differ in both quantity and quality from that received by the reflective subject (Shine, 1971).

Thus, on tasks of abstract reasoning, impulsive children tended to respond on the developmentally less mature associative level, employing the "superficial cues" given by the stimulus rather than engaging their reasoning processes to produce a more abstract response (Achenbach, 1969). In studying conceptual styles on an object classification task, Katz (1971) found that the categories formed by impulsive subjects were to a large extent based on the perceptually compelling aspects of the stimuli (color). There was less tendency to classify objects on the basis of the more substantive qualities of the stimuli (form). Schleifer (1971) found that in responding to moral dilemma situations, the response style of impulsive children was dominated to a large extent by the consequence of the act rather than by the intent of the character. This indicated a weakly differentiated, syncretic style of functioning which was also apparent in the finding that impulsivity correlates significantly with Witkin's dimension of field dependence (Campbell and Douglas, 1972; Massari, 1975). The organismic theory of Werner helps to explain these findings concerning a developmental difference between the functioning of impulsive and reflective subjects.

Werner (1948) views cognitive development as the result of a child's efforts to maintain an equilibrium state. When the equilibrium is disrupted by an external influence, the child is motivated to initiate actions which will re-establish the balance. The mechanisms employed by the child to deal with these situations are determined by his level of development. In the younger child, the relationship between the self and environment is not well differentiated and is mediated by sensory motor functioning. Spatial organization is still ego-centric and is tied to the coordinates of the body as defined by the action systems. With the onset of the operational stage, there is an increasing reliance on internalized, cognitive operations in facilitating adaptation. This produces a sharper self-world differentiation and thus a greater awareness of one's role in interactions with the environment. In the course of development, earlier modes of functioning become subordinated to the more recent ones, resulting in a hierarchically arranged adaptive system (Langer, 1969).

Integrating psychoanalytic and developmental theory with recent findings in the area of children's learning, White (1965) concluded that the transition in the level of functioning from the pre-operational to the operational period is due largely to the increased capacity for inhibition developing at that time. Through the inhibition of the more immediate, habitual style of response available to the child on the associative level, time is provided for the more complex and thorough processing of information on the cognitive level.

This progression is apparent in Devoe's (1969) study of the adaptive mechanisms employed by children of different ages in compensating for the prismatically induced disruption of the visual-motor equilibrium. It was found that six year olds relied predominantly on motor activity as a means of understanding the effect the prisms had on their functioning. It appeared to be the feedback from their movement which supplied the greatest source of information, with compensatory change occurring mainly on the level of the proprioceptive system. Devoe (1969) found that older children (14 years) strive to re-establish an equilibrium state through "comtemplative" means, with less reliance on physical involvement with the surroundings. Change appears to have been mediated by the information derived from more analytic activities and fed back to the central perceptual schema. This resulted in compensatory change within the visual system, with less change occurring in the ontogenetically lower proprioceptive system.

In many respects, the style of functioning observed in eight to eleven year old impulsive children resembles the sensory-motor functioning of a younger child. The weak capacity for delay limits the degree to which thought is involved in the organization of experience, producing a more syncretic understanding of their involvement with the environment. Psychoanalytic and organismic theories suggest that these factors may limit both the quality and degree of self awareness in the impulsive child. The issue of self awareness raises the question as to how well the impulsive child can focus on himself as the locus of his experience and behavior. To evaluate the consequences of a behavior, one must become aware of the extent of his role in the execution and outcome of the behavioral sequence. This requires the capacity to institute a delay at the end of a behavior. At that point, the analytic functions can be engaged to break down the totality of the behavioral gestalt into its component parts so that discrete information about the effectiveness and consequences of one's acts relative to the intended goals can be obtained. This process appears to be an important prerequisite for evaluative self monitoring, a function apparent in the behavior of reflective children, but which appears to be weak in the impulsive child.

The ineffective functioning of the cognitive feedback channel in problem solving behavior was apparent in the performance of the hyperactive- impulsive children studied by Freibergs and Douglas (1969) and Parry (1974). On a concept formation task, it was found that the rate and quality of the learning process were closely related to the schedule of reinforcement used in rewarding correct responses. Under a continuous reinforcement schedule learning was rapid and effective, but when the schedule was shifted to a 50% fixed ratio type, the hyperactive-impulsive subjects showed a marked decline in the quality of performance (Freibergs and Douglas, 1969). Similarly, in a delayed reaction time task, performance was effective when reinforcement was directly related to the demands of the task. When equal amounts of non-contingent, generalized praise were given, however, there was a sharp decline in the effectiveness of performance (Parry, 1974). Within the context of a consistent, externally mediated source of feedback to assist the impulsive child in evaluating and structuring his behavior, performance was adequate. When these supports were removed or reduced, and the child was required to supply himself with this evaluative information about the quality of his efforts, he was no longer able to function as effectively. It could be postulated that the existence of this ineffective feedback loop led Block, Block and Harrington (1974) to characterize the impulsive child as "structure-requiring and structure-seeking" (p. 630).

The capacity to use feedback effectively in modifying an inaccurate response style has been found to be closely related to the rate at which subjects respond following the presentation of the feedback about wrong responses. Impulsive subjects, who had a significantly shorter post feedback latency than reflective peers, appeared to invest less effort in the "retrieval-recoding process" which was necessary to use the feedback effectively as a basis for modifying future responses. As a result, impulsives showed a less effective and developmentally less mature approach to dealing with a concept identification task than did a group of reflective subjects (Nuessle, 1972).

In the experimental situations described above, the feedback available to the subjects was externally created and fed to them by the experimenter. Do impulsive and reflective children differ in situations where they must monitor the quality of their behavior by generating their own feedback? Assuming that the processes involved in producing feedback are closely related to the quality of functioning exhibited during the problem solving sequence, the response style of children classified as impulsive offers clues about how these children might generate information about the quality of their behavior. Their rapid response style is associated with the tendency to focus on the more superficial aspects of a complex stimulus. They often react on the basis of these initial sensory impressions, with little involvement of the analytic and evaluative faculties in satisfying the demands of a task. These impressions have been found to be of a more global nature. In contrast, the quality of functioning apparent in the performance of reflective subjects indicates that their longer reaction times are accompanied by an involvement of the evaluative and analytic functions in dealing with complex problems. It is assumed, therefore, that this more cognitively oriented approach should provide the reflective child with a richer source of evaluative information regarding the quality of their performance than would be expected for the impulsive group. Impulsive children should rely to a greater extent on the more immediately available sensory-motor cues in evaluating their efforts.

THE PRISMATIC RE-ARRANGEMENT OF VISION AS A CONTEXT FOR THE STUDY OF THE AVAILABILITY OF SELF-MEDIATED FEEDBACK

The perceptual adaptation paradigm was chosen as the context within which to test the assumptions made regarding the differential availability of feedback information as a function of "conceptual tempo". It presents a learning situation which can be successfully negotiated on the basis of either sensory feedback from the proprioceptive system, cognitive feedback information, or both, with qualitatively different patterns of visual motor (V-M) adaptation occurring as a function of the type of feedback available to the subject.

This procedure involves the study of the compensatory process within the visual motor system in response to a prismatically induced distortion or alteration of sensory input to the eye. This effect is achieved by having a subject wear prisms which alter visual input by laterally displacing it 11 degrees to the side. Such a manipulation serves to disrupt the correspondence which normally exists between the visual and motor systems, and thus disturbs the stable relationship between the organism and its environment. Adaptation or compensation represents the process by which the organism re-establishes equilibrium through auto-centric change. This compensation can occur through a recalibration of the proprioceptive system (Harris, 1965), a readjustment of the coordinates of the visual system (Rock, 1966), or a combination of the two factors (Hay and Pick, 1966; Wilkinson, 1971).

The degree of adaptation is determined by a comparison of visual-motor performance before and after prismatic exposure. When the prisms are removed, the compensatory adjustments developed during exposure are no longer adaptive, and thus become inappropriate. As a result, the sense of radial direction should show a shift in the opposite direction of the adaptive shift, yielding a temporary after-effect approximately equal in magnitude to the degree of adaptation. This phenomenon is called the negative aftereffect and is commonly used as the measure of adaptation (Epstein, 1967; Howard, 1971).

Although prismatic adaptation has been studied since the late 1800's, there is still controversy about the mechanisms producing adaptation and the conditions necessary for it to occur. It is generally agreed, however, that the availability of feedback concerning the way V-M functioning is affected by the prisms is a necessary pre-requisite for change. This feedback is the result of a "cue conflict" in which there is a discrepancy between the information received from two or more sources. It can take many different forms, depending on the sources (Wallach, 1968).

Based on the re-afference theory of von Holst, Held (1961; 1968) presented evidence that adaptation to prismatic displacement occurs only where the active self-produced movement of the subject provides him with re-afferent feedback. In other words, for every motor act initiated by the organism, there exists a relationship between the "efferent neural signals" of the motor act and the visual re-afference (concurrent visual feedback about the movement) which is stored in the memory (Held, 1968). With the introduction of prismatic distortion, the new re-afference comes into conflict with the expected re-afference habitually correlated with a given movement. Adaptation consists of a re-calibration of the efferent signals with a new set of re-afferent visual feedback.

Harris (1965) conceptualized adaptation in terms of a change or shift in the felt position of parts of the body. Based on proprioceptive feedback about the felt position of the body, the discrepancy between this information and that received through the visual sense is resolved through the person coming to feel that his body part is where it looks like it is (Harris, 1965).

Rock (1966) viewed the adaptation process as involving change within the visual cortex. Change is mediated by a re-calibration of existing memory traces to reflect the new association between eye direction and phenomenal direction. Where straight ahead was previously signaled by head straight ahead, eyes straight ahead, with foveal stimulation, after adaptation (i.e., to an 11° shift), straight ahead will be signaled by the head straight with the eyes turned 11° to the side allowing for foveal stimulation.

Held (1961), Rock (1966), and Harris (1965), appear to conceptualize adaptation as an unitary process, both in terms of its mechanisms and the conditions necessary for it to occur. While each of these investigators appears to have isolated a component of the overall process, their limited results appear to be artifacts of the restrictive nature of their designs. In the work of both Held and Harris, the subjects were allowed continuous view of their actively moving arm during prismatic exposure in what Howard (1968) called a "concurrent display" condition. Here, the arm and the visual field were equally displaced and continuous view of the arm allowed for visual guidance of all movements. Under these conditions, subjects made no errors in localizing objects to provide objective information about the effect the prismatic displacement had on their functioning. Thus, their results were limited by the fact that the discrepancy between the seen and felt arm position was the major source of information on which adaptation was based.

In a more "naturalistic" study, which placed no restrictions on the type of information available to the subjects regarding the prismatic distortion, Hay and Pick (1966) presented evidence that adaptation is not an unitary process. It was found that the initial period of exposure to laterally displacing prisms was marked by a rapid, although transitory, compensatory change in the proprioceptive system, as found by Harris (1963). Over time, with the impact of a greater variety of information regarding the displaced visual input, a more stable adaptation of the visual system developed which superceded the initial proprioceptive shift. This finding of at least two interacting components contributing to the adaptation process has received wide support (Craske and Crawshaw, 1974; Welch and Rhoades, 1969; Uhlarik, 1973). Wilkinson (1971) further defined the relationship between visual and proprioceptive adaptation as an additive one, with total adaptation within the V-M system equaling the sum of the change within the visual and proprioceptive components.

Recent emphasis in perceptual adaptation research has been on the importance of cognitive information rather than the more sensory information of felt body position or re-afference as an important source of feedback producing adaptation. The powerful influence which cognitive feedback has in informing the subject about the inter-modality discordance came under direct study with the development of the "terminal display with targets" condition of exposure to prisms (Howard, 1968). This required the subject to point at a visual target with his arm occluded so that visual guidance of the movement was not possible. The apparatus was arranged so that the subject was able to see only the end position of his pointing effort relative to the target. At first, errors in localizing the target were approximately equal to the degree of prismatic displacement. Pointing accuracy gradually increased as the subject actively adjusted his movements relative to the displaced visual input. The new movements came to feel normal over time (Howard, 1968). The adaptive process was guided by the information derived from the discrepancy between the apparent and the actual location of visual targets based on the subject's pointing errors.

The availability of error information has been found to be accompanied by the generalization of the adaptation effect to parts of the body not seen or used during the exposure period (Cohen, 1967). Under the more restrictive exposure conditions employed by Held (1961) and Harris (1965), this generalization effect was not found (Harris, 1965). This aspect of adaptation is generally measured by the degree of intermanual transfer (IMT) to the arm not used during exposure. IMT is considered to reflect a re-calibration within the "higher order coordinators" which are involved in processing the error information (Templeton, Howard and Wilkinson, 1974). It comprises the cognitive component of the adaptive process (Webster, 1969; Welch and Goldstein, 1972). Cohen's (1973) work on the effect of response rate on adaptation presents strong evidence supporting the finding that the magnitude of IMT is directly related to the degree to which the cognitive processes are involved in the adaptation process.

This work on cognitive feedback supports Wohlwill's (1966) earlier observation that any type of feedback which serves to inform the subject about the nature of the V-M re-arrangement will serve the similar function of producing adaptation. In the absence of re-afference and information about felt body position, purely cognitive information will promote an adaptive change. Wohlwill further notes that the pattern of the adaptive process will be differently affected by the type of information available to the subject. This formulation was influential in the development of the information processing theory of adaptation (Welch, 1969; Uhlarik, 1973). The theory states that all sources of feedback information (i.e., cognitive, proprioceptive, re-afference) are equivalent in their capacity to reduce intermodality conflict and thus produce more effective V-M functioning. Both the magnitude and rate of adaptation will increase, however, as the amount of information made available to the subject increases. Welch and Rhoades (1969) and Uhlarik (1973) have additionally found that certain forms of information are more powerful than others and that the locus and magnitude of adaptation varied as a function of the type of information made available to the subject.

By systematically varying the type of feedback available to subjects about the nature of the prismatic displacement, Uhlarik (1973) specified the relationship between this factor and the locus of adaptive change. In a cognitive feedback condition, subjects were not allowed sight of their target pointing efforts. Information about the accuracy of these efforts was transmitted verbally by the experimenter. In the concurrent display (CD) condition, information was restricted to the discrepancy between the seen and felt position of the arm and re-afferent feedback. In the terminal display (TD) condition, the information available involved both cognitively mediated error feedback and the discrepancy between seen and felt arm position. While significant V-M adaptation was found in all three conditions, the TD condition, which provided the greatest amount of feedback, produced the greatest overall shift, as predicted by the information processing theory of adaptation. The cognitive feedback condition produced somewhat greater adaptation than did the concurrent display condition. The actual locus of adaptive change (within the proprioceptive or visual systems) also varied as a function of the quality of feedback available in the different exposure conditions. The information available in the TD and cognitive feedback conditions produced strong change on measures of visual adaptation with a nonsignificant shift on the measure of proprioceptive adaptation. The reverse was found in the concurrent display condition. The fact that overall adaptation was smallest in the CD condition supports the finding that cognitive mediated error feedback represents the most powerful source of information in terms of reducing intermodality conflict and thus facilitating adaptive functioning (Welch and Rhoades, 1969).

In addition to the type of feedback available, the rate at which this information is processed during the exposure period also has a strong effect on the magnitude and locus of the adaptive change (Cohen, 1973; Taub and Goldberg, 1973). IMT, an indicator of higher order perceptual change, occurs only under exposure conditions where target pointing trials are spaced at intervals long enough to permit analysis and evaluation of the information available as a result of pointing error. If the practice is executed rapidly with only a short interval between trials (one or two seconds), little time is available for "a reinterpretation of the (distorted) visual information in terms of kinesthetic-proprioceptive information and a consolidation of the reinterpretation into memory to serve as a basis for future responding"(p. 608)

(Cohen, 1973). As practice becomes massed, action dominates experience placing fewer demands on the cognitive mediational processes, and thus reducing the magnitude of IMT.

The experimental manipulation of the type and amount of feedback available to the subject and the rate at which this information is made available, appears to exert a marked influence on the locus and the magnitude of adaptation. Therefore, it follows that developmental and organismic factors should also influence the course of the adaptive process by determining the type of information attended to in coming to understand the effect the prisms have on functioning. Additionally, the rate at which subjects process the information should also influence the adaptive process.

Interest in understanding the effect of individual differences on the adaptive process led Devoe (1969) to suggest that children at different ages rely on different sources of information in compensating for prismatically re-arranged vision. Older children (14 years) appeared to employ a more "conceptual-symbolic" means of coming to understand and deal with the prismatically altered state of affairs. The information fed back from these cognitive activities produced significant adaptation within the visual perceptual system. For this group, adaptive change within the proprioceptive system accounted for little of the overall change. For a group of six year olds, whose relationship with the world is still mediated on the sensory-motor level, the concrete actions they carried out on the environment provided the major source of information about the altered relationship between the self and environment. The feedback generated by this activity produced adaptation predominantly on the level of the proprioceptors; little change was observed on the more central, perceptual level.

The actual efficiency of visual and motor functioning also appears to have a significant determining effect on the extent of adaptation. Warren and Platt (1975) found that subjects screened on visual and motor tasks, and classified according to their ability, showed differential amounts of adaptation according to the degree of efficiency shown in the use of that system. Their results indicated that adaptation varied not only as a function of the type of information available, but also in terms of the subject's capacity to effectively use the different types of information. In the TD exposure condition, subjects with good visual abilities manifested a significantly greater amount of adaptation than subjects who were motorically more efficient. It was concluded that those subjects with more efficient motor systems did not rely as heavily on the visual channel of information (the source of cognitive feedback in this situation).

In view of the influence which individual differences have on the adaptive process, it is assumed that the rate at which individuals process information will influence how effectively different types of feedback are processed and used, thus affecting the pattern of V-M adaptation. The research findings presented earlier indicate that subjects classified as impulsive based on MFF performance tend to relate to the environment largely on the sensory-motor level, often operating on the basis of initial sensory impressions. The cognitive processes appear to be involved to a lesser extent in adjusting to new situations. Thus, it is expected that impulsive subjects will focus principally on feedback resulting from the felt position of the proprioceptive system as a source of information about the effect of the prismatic displacement. Engagement of the cognitive functions of analysis and evaluation in generating feedback should contribute to a lesser degree to the adaptive process. This should result in little change in the "higher order coordinators" of the visual system, as measured by IMT.

Subjects classified as reflective should involve their cognitive functions to a greater extent than impulsive subjects in understanding the effects of prismatic displacement. Therefore, these subjects should have more information available to them regarding the effect the prisms exert on functioning than the impulsive group. According to the information processing theory of adaptation, this should produce a greater overall V-M shift in the reflective group and greater intermanual transfer of the adaptation effect.

THE PRESENT STUDY

By exposing impulsive, reflective and moderate (middle range) children to a prismatically induced displacement of the visual field, it should be possible to determine the type of feedback information they rely on in understanding the way in which the displacement affects their V-M functioning. To achieve this end, the subjects in each of these groups will be exposed to one of two exposure conditions.

1. Concurrent Display with Targets (CDT) - Within the context of a homogeneous visual field containing three targets, the subject is required to point at the targets during which time he has continual view of the arm. Under these conditions the arm and the visual field are equally displaced and full visual guidance of the movements is possible. As a result, no pointing errors occur, restricting information about the visual displacement to the discrepancy between seen and felt arm position (proprioceptive feedback).

2. Terminal Display (TD) - Under the same physical conditions as in CDT, subjects are required to point at targets with the movement of their arm completely occluded. Subjects are permitted to only see the terminal position of their effort to localize the target. This arrangement provides error information regarding the discrepancy between the apparent and actual location of the target. To a lesser degree, proprioceptive feedback is also available.

Research findings indicate that the rapid, inaccurate response style of the impulsive child is associated with a limited capacity for the analysis and evaluation of the stimulus information on which they operate. There is the tendency to act on the basis of superficial, more immediately available cues with less involvement of the thought processes in task oriented behavior. Extending the implications of these findings to the subject's involvement in dealing with the results of his behavior, a similar pattern might be expected. In adapting to a prismatic disruption of V-M equilibrium, impulsive subjects should show a weaker reliance on feedback derived from cognitive functioning (evaluation of error information) than occurs in the reflective subjects. Sensory cues regarding felt arm position should be used to a greater extent by the impulsive group.

The characteristic mode of adjustment apparent in the functioning of the reflective child indicates a high degree of involvement in analyzing and evaluating stimuli. These processes should work to produce a richer source of information about the nature of the prismatic displacement and thus greater overall adaptation in the reflective group. The availability of this cognitive information should also lead to greater change in the "higher order coordinators" than will occur in the impulsive group.

At present, studies involving impulsive and reflective children have not included a moderate group. As a result, there is no data regarding their style of functioning to guide the development of hypotheses. If the impulsive-reflective continuum is a linear one, it is expected that the performance of this group should fall somewhere between the more extreme groups.

To test these assumptions, children of the middle childhood years (8 years 7 months to 9 years 11 months) were studied. These children were classified as impulsive, moderate or reflective on the basis of their performance on the MFF Test and the WISC Mazes. Choice of this age range was guided by a number of studies (Ault, 1973; McKinney, 1973; Nuessle, 1972), which indicate that impulsive subjects at this age should function in a manner characteristic of the younger, pre-operational child, whereas the functioning of reflective children should more closely resemble that of the child in the operational-conceptual stage.

MEASURES OF ADAPTATION

1. Proprioceptive Shift (PS) - This measure of proprioceptive adaptation requires the subject to localize the medial plane of the body with his eyes closed. Felt arm position relative to the body appears to be the major cue guiding this effort. Performance is measured by the degree of deviation in centimeters from an objective 0 cm. point based on the position of the head.

2. Proprioceptive Localization of Visual Targets (PVT) - This is a measure of the capacity to localize visual targets with the arm used during exposure. It is considered to reflect overall V-M adaptation, with performance involving the contribution of both the PS and the "higher order coordinators" (Templeton, Howard and Wilkinson, 1974). Performance is measured by the degree to which target localization efforts deviate from a 0 cm. point defined by the objective position of the target.

3. Intermanual Transfer (IMT) - This measure of the degree to which the adaptation effect has generalized to the arm not seen or used during the exposure period is generally considered to reflect an adaptive recalibration within the "higher order coordinators" of the visual system (Templeton, Howard and Wilkinson, 1974). It is measured in the same way as PVT, except that the arm not used during exposure is tested.

The phenomenon under study is considered to be an ongoing, developmental process rather than a discrete task to be measured only by its outcome. Thus, in addition to administering the standard measure of negative aftereffect, the measures of adaptation were also administered at a number of points during exposure to the prisms to determine the rate of adaptation.

HYPOTHESES

1 - Overall V-M adaptation, as measured by PVT, will be greater in the TD condition of exposure than in the CDT condition.

2 - In the TD condition, reflective subjects will exhibit greater overall V-M adaptation than impulsive subjects.

3 - Intermanual transfer of adaptation (IMT) will be greater in the TD condition than in the CDT condition.

4 - In the TD condition, reflective subjects will exhibit a greater degree of intermanual transfer than the impulsive subjects.

5 - Change in felt body position (PS) as a result of exposure to prismatic displacement will be greater in the CDT condition than in the TD condition.

6 - In the CDT condition, impulsive subjects will exhibit greater adaptation in terms of felt body position than the reflective subjects.

CHAPTER II

METHODOLOGY

Subjects

Children within the age range of 8 years 7 months and 9 years 11 months attending school in the Ottawa area (Ottawa Board of Education) served as the participants in this study. The three public schools involved were assigned by the director of research of the board and were situated in areas where the large majority of residents were lower-middle to middle class.

Subjects of both sexes were selected for participation on the basis of their performance on the MFF Test (Kagan, Rosman, Day, Albert and Phillips, 1964) and the WISC Maze Test (Wechsler, 1949). Further qualifications for inclusion in the study required that the child be of at least average intelligence and not wear corrective lenses. Intelligence was determined by performance on a brief form of the WISC which comprised of the information, vocabulary and block design subtests.

Generally, children are differentiated as impulsive or reflective on the MFF Test by carrying out a median split on the data for the error and reaction times. Those children scoring above the median in number of errors, and below the median for reaction time are considered to be impulsive. The reverse is true for reflectives. To increase within group homogeneity, a quartile split was carried out on the two dimensions of the MFF Test and the two dimensions measured by the

Maze test, scaled score and total number of errors. Using this method, impulsives and reflectives were defined as those who fell into the extreme quartiles (i.e. high error and low RT on MFF and low scaled score and high error on mazes) on at least three of the four dimensions and on the appropriate half of the median on a fourth. In this way, a third group, moderates, was created from those subjects falling into the middle quartiles on all four dimensions.

From an initial group of 154 children screened, 76 children were chosen to participate in the study. There were 26 impulsives, 26 reflectives and 24 moderates. Of the 78 children not included in the study, nine did not receive parental permission, six had an IQ below 90, and 64 did not fall into any of the categories along the impulsive-reflective dimension as defined above. The characteristics of the three groups involved in the study are defined in Table 1.

Procedure

Initial contact with the school population involved the individual administration of the MFF Test and the WISC Mazes according to the instructions presented by Kagan, Rosman, Day, Albert and Phillips (1964) and Wechsler (1949) (see Appendix 1). Children chosen to participate in the study were screened for level of general intelligence. Consent forms briefly describing the study were then sent home to the parents of these children (see Appendix 3).

Subjects in the impulsive, moderate and reflective groups were randomly assigned to participate in one of the two conditions of exposure to the prismatic displacement. Subjects in each condition were given a brief description of how the

TABLE 1

Mean Characteristics of the Three "Conceptual Tempo" Groups

	Impulsives		Moderates		Reflectives	
	Mean	SD	Mean	SD	Mean	SD
Age in months	111.1	3.9	111.2	4.6	110.0	4.6
WISC IQ Estimate	112.2	14.8	110.9	10.0	113.5	10.1
MFF Error	16.0	2.7	10.3	1.5	5.0	1.9
MFF RT	5.2	1.8	9.5	1.9	21.8	10.0
Mazes SS	10.3	1.6	12.0	0.8	14.7	1.6
Mazes Error	10.2	2.7	6.1	1.3	3.2	1.4
N	26		24		26	
Males	18		16		18	
Females	8		8		8	

apparatus worked and what was expected of them during the exposure period.

1. <u>Terminal Display Condition (TD)</u> - Subjects assigned to this condition were required to hold a pointer in their right hand which served as an extension of the index finger. With the pointer, subjects were instructed to point at a specified target on a frontal, visual display (see Figure 1, Appendix 2) by moving the hand forward to the position in which they saw the target. The pointing movement was carried out under the small table in front of them so that visual guidance of the moving arm was precluded. At the terminal position of the pointing effort, subjects were instructed to bring the pointer through the slit at the front of the table so they could determine the accuracy of their estimate of target position. They were cautioned not to move the pointer once it become visible, only to note its position and then withdraw their arm to the starting point.

2. <u>Concurrent Display Condition (CDT)</u> - In this condition the subject's arm was placed on top of the small table. Subjects held a pointer as an extension of their index finger, and were instructed to point at the targets specified during the course of the exposure period. After the pointing effort they were instructed to return their arm to the starting position in front of them. In this way, the arm was continuously in view.

The rate and order of pointing movements in both conditions was controlled by a tape recording which randomly called out the numbers one, two and three, corresponding to the three targets, at eight second intervals.

It was also explained to the subjects that at certain times during the experiment, they would be asked to mark a paper on the lower part of the frontal display to show the experimenter where they perceived different things (the targets and the imagined medial plane of the body). At these times, view of the arm was totally occluded allowing the subjects no feedback about their efforts.

Subsequently, subjects were asked to close their eyes and two pairs of goggles, one with 20 diopter prisms, which displaced the visual field 11.5 degrees to the right, and one with plain glass, were fitted to the child's head (see Appendix 2). The plain goggles were used during the pre- and post-exposure testing periods to maintain a continuity with conditions during exposure.

Wearing the plain goggles, subjects were given a pre-exposure test on each of the three measures of adaptation. Subjects were then asked to close their eyes and were fitted with the prismatic goggles. They were then re-tested on the three measures to determine the initial effects of the prisms. The exposure period was then begun under either the TD or CDT condition. After forty pointing trials (approximately 5.5 minutes), subjects were re-tested and then their eyes were covered to allow for a two minute rest. During this time, the paper on which the subjects marked the target positions was changed. A second block of forty pointing trials was then given.

At the end of this block, subjects were re-tested once again with the prisms in place. With their eyes closed, the prismatic goggles were then removed and the plain goggles were put on for a final testing on the three measures. Over the course of the experiment, testing occurred at the following intervals:

1. Pre - Before exposure to the prisms

2. T_0 - Initial exposure

3. T_1 - After 40 pointing trials

4. T_2 - After a second block of 40 pointing trials

5. Post - After the prisms were removed.

The order in which the measures were tested was counterbalanced between subjects. Administration of the measures was carried out as follows:

1. Proprioceptive Shift (PS) - Subjects were instructed to close their eyes and were asked to "point straight ahead of you, right in front of your nose, and mark the paper there". The use of a physical reference point (the nose) served to reduce the ambiguity of the target. Four pointing trials with the right arm were required here.

2. Proprioceptive Localization of Visual Targets (PVT) - With the arm used during exposure (right), the subjects were instructed to "point and mark the paper where you see the target whose number I will call out". In a random order, the subjects made nine points, three for each target.

3. Intermanual Transfer (IMT) - The same instructions and procedure as in PVT were employed here in testing the arm are not used during the exposure period.

CHAPTER III

RESULTS

Each of the measures of adaptation (PS, IMT and PVT) was conceptualized in terms of both an ongoing compensatory process as well as the overall effect of exposure to the prisms as indicated by the magnitude of negative aftereffect (N.A.). As such, analysis of ongoing adaptation during the exposure period was based on the change scores, in centimeters, from the initial exposure to the prisms (T_0) to the end of the first exposure period (T_1) and from T_1 to the testing at the end of the second exposure period (T_2). Negative aftereffect was indicated by the difference in performance from a pre- to a post-exposure testing on the measures. Using the objective target position and objective medial plane of the body as a 0 cm. point, the magnitude of the subject's deviation in estimating the position of that point at each time of testing provided the data from which the change scores were obtained. The mean deviation scores and change scores for each measure are presented in the appendix.

Two separate analyses of variance were carried out for each of the dependent measures. The amount of adaptive shift in estimating an objective target position from T_0 to T_1 as compared to T_1 to T_2 was analyzed as a function of "conceptual tempo" and exposure conditions in a 3x2x2 split plot ANOVA, with repeated measures on the time factor (Winer, 1971).

Magnitude of N.A. was analyzed via a 3x2 ANOVA. Planned comparisons between cell means suggested by the hypotheses of the study were carried out using Dunn's Multiple Comparison Test (Kirk, 1968).

In view of the initial differences in subjects based on the selection proceduce, and its possible effect on the overall homogeneity of variance, Hartley's F_{max} test (Winer, 1971), was used to measure this parameter. Where heterogeneity of variance was found, the significance level was set at $p < .025$, otherwise, the $p < .05$ level of significance was set as the criterion.

Included at the end of this section is an intercorrelation matrix describing the relationship between the dimensions of the WISC Maze Test, MFF Test and the IQ estimate for the sample of subjects studies here. A second intercorrelation matrix is also included describing the data for the larger group of children from which this sample was drawn.

PROPRIOCEPTIVE LOCALIZATION OF VISUAL TARGETS

The initial effect of exposure to the prisms for this measure of adaptation in the arm used during exposure (right) was to shift the apparent location of the targets in the visual field 9.8 cm. to the right. A one way ANOVA carried out on the change scores from the pre-exposure to the T_0 testing period indicated no significant difference in the initial response of the three "conceptual tempo" groups to the effects of the prisms, $F(2,73) = .97$; $p > .05$.

Rate of ongoing adaptation was determined by a comparison of the change scores from T_0 to T_1 to the change scores from T_1 to T_2 and was analysed as a function of exposure conditions and "conceptual tempo" in a 3x2x2 split plot ANOVA. The results of this analysis are presented in Table 2. The rate of adaptation for this measure was characterized by a large, initial adaptive shift ($\bar{X}$=4.6 cm.) after the first exposure period (T_0 to T_1) followed by a significantly smaller shift ($\bar{X}$=1.3 cm.) after the second exposure period (T_1 to T_2), $F(1,70) = 101.20$; $p < .01$. Variation contributing to the interaction between exposure conditions and rate of adaptation (BxC) and "conceptual tempo" and rate of adaptation (AxC), as well as the AxBxC interaction, was not statistically significant.

Impulsive, reflective and moderate subjects did not differ significantly in the total PVT (T_0 to T_1 + T_1 to T_2) exhibited during exposure, $F(2,70) = 1.38$; $p > .05$. Subjects allowed to view their arm continuously during exposure showed a significantly smaller ($\bar{X}$=5.0 cm.) PVT shift than subjects permitted to view only the end position of their pointing efforts ($\bar{X}$=6.8 cm.), $F(1,70) = 17.28$; $p < .01$. The "conceptual tempo" x conditions interaction was not statistically significant. Further analysis of the main effect for exposure conditions revealed that both the reflective and moderate groups exhibited significantly greater total adaptation in the

TABLE 2

Summary of Analysis of Variance of

T_0 to T_1 and T_1 to T_2 Change Scores for PVT

Source of Variation	SS	df	MS	F	p
Between		75			
Conceptual Tempo (A)	5.0	2	2.5	1.38	NS
Exposure Condition (B)	31.8	1	31.8	17.28	.01
AxB	10.2	2	5.1	2.76	NS
Within Cells	128.8	70	1.8		
Within Ss		76			
Time (C)	402.6	1	402.6	100.70	.01
AxC	7.6	2	3.8	.91	NS
BxC	1.3	1	1.3	.32	NS
AxBxC	2.6	2	1.3	.32	NS
CxWithin Groups	279.5	70	4.0		

TD condition (Ref. $\bar{X}$=7.6 cm., Mod. $\bar{X}$=7.1 cm.) than in the CDT condition (Ref. $\bar{X}$=4.5 cm., Mod. $\bar{X}$=5.4 cm.) ($d=1.6$, $p < .01$). Impulsive subjects showed no significant difference in total adaptation across conditions.

PVT negative aftereffects were analyzed as a function of "conceptual tempo" and exposure conditions in a 3x2 ANOVA which is summarized in Table 3. Impulsive, moderate and reflective subjects did not differ significantly in performance on this measure, $F(2,70) = 1.35$; $p > .05$. Subjects allowed continuous view of their arm during exposure exhibited significantly less N.A. ($\bar{X}$=2.7 cm.) than did subjects permitted to view only the terminal position of their pointing effort ($\bar{X}$=4.1 cm.), $F(1,70) = 10.45$; $p < .01$. The "conceptual tempo" x exposure conditions interaction was not statistically significant. Further analysis of the exposure conditions main effect reveals that, of the three "conceptual tempo" groups, only the reflective subjects showed significantly greater adaptation in the TD condition ($\bar{X}$=5.0 cm.) than in the CDT condition ($\bar{X}$=2.7 cm.) ($d=2.3$, $p < .01$).

INTERMANUAL TRANSFER

The initial effect of exposure to the prisms for this measure of adaptation in the arm not seen or used during exposure was to shift the apparent location of targets in the visual field 8.8 cm. to the right. A one way ANOVA carried out on the change scores from the pre-exposure to the T_0 testing period indicates no significant difference in the

TABLE 3

Summary of Analysis of Variance

for PVT Negative Aftereffect

Source of Variation	SS	df	MS	F	p
Conceptual Tempo (A)	10.2	2	5.1	1.35	NS
Exposure Condition (B)	39.4	1	39.4	10.45	.01
AxB	7.6	2	3.8	1.00	NS
Within Cell	261.9	70	3.8		

initial response of the three "conceptual tempo" groups to the prismatic displacement, $F(2,73) = .68$; $p > .05$.

Rate of ongoing adaptation was determined by a comparison of the change scores from T_0 to T_1 to the change scores from T_1 to T_2 and was analyzed as a function of exposure conditions and "conceptual tempo" in a 3x2x2 split plot ANOVA. The results of this analysis are presented in Table 4. The rate of adaptation was characterized by a shift of $\bar{X}=1.9$ cm. after the first exposure period, followed by a significantly smaller shift ($\bar{X}=1.0$ cm.) after the second period, $F(1,69) = 4.70$; $p < .05$. Interactions indicated no significant difference in the rate of adaptation as a function of "conceptual tempo", exposure conditions, or in terms of the AxBxC interaction.

Impulsive, moderate and reflective subjects did not differ in the total amount of IMT exhibited during the exposure period (T_0 to T_1 + T_1 to T_2), $F(2,69) = 2.16$; $p > .05$. Subjects in the CDT condition, showed significantly less IMT during exposure ($\bar{X}=1.6$ cm.) than subjects permitted to see only the terminal position of their pointing effort ($\bar{X}=4.3$ cm.), $F(1,69) = 18.73$; $p < .01$. The "conceptual tempo" x exposure conditions interaction was not statistically significant $F(2,69) = .54$; $p > .05$. Analysis of the variation contributing to the exposure conditions main effect revealed that in the TD condition, both the reflective ($\bar{X}=5.2$ cm.) and the moderate subjects ($\bar{X}=3.9$ cm.) exhibited significantly greater IMT

TABLE 4

Summary of Analysis of Variance of

T_0 to T_1 and T_1 to T_2 Change Scores for IMT

Source of Variation	SS	df	MS	F	p
Between		74			
Conceptual Tempo (A)	15.1	2	7.5	2.16	NS
Exposure Condition (B)	65.4	1	65.4	18.73	.01
AxB	3.8	2	1.9	.54	NS
Within Cells	240.7	69	3.5		
Within Ss		75			
Time (C)	27.7	1	27.7	4.70	.05
AxC	15.1	2	7.5	1.28	NS
BxC	21.4	1	21.4	3.63	NS
AxBxC	6.3	2	3.2	.54	NS
CxWithin Groups	406.0	69	5.9		

($d=2.3$, $p < .01$) than was observed in the CDT condition (Ref. $\bar{X}=2.3$ cm., Mod. $\bar{X}=.6$ cm.). The impulsive subjects showed no significant difference in performance across conditions ($p > .05$).

IMT negative aftereffect scores were analyzed as a function of "conceptual tempo" and exposure conditions in a 3x2 ANOVA, which is summarized in Table 5. A comparison of the within cell error terms for this analysis revealed a significant difference ($p < .05$), indicating a heterogeneity of variance between cells. As a result, the $p < .025$ level of significance was set as the criterion for this analysis.

Subjects in the TD condition exhibited significantly greater IMT N.A. ($\bar{X}=2.1$ cm.) than subjects exposed to the CDT condition ($\bar{X}=.2$ cm.) $F(1,70) = 16.54$; $p < .01$. A significant difference was also observed in the magnitude of N.A. exhibited by the reflective ($\bar{X}=3.5$ cm.), moderate ($\bar{X}=1.1$ cm.) and impulsive ($\bar{X}=1.8$ cm.) groups $F(2,70) = 7.97$; $p < .01$. The "conceptual tempo" x exposure conditions interaction was not statistically significant $F(2,70) = .48$; $p > .05$. Further analysis of the variation contributing to the main effects indicated that, of the three "conceptual tempo" groups, only the reflectives exhibited significantly greater IMT ($d=2.0$; $p < .01$) in the TD condition ($\bar{X}=3.5$ cm.) than in the CDT condition ($\bar{X}=.6$ cm.). Additionally, in the TD condition, reflective subjects exhibited significantly greater adaptation ($\bar{X}=3.5$ cm.) than the impulsive subjects ($\bar{X}=1.8$ cm.) ($d=1.7$,

TABLE 5

Summary of Analysis of Variance

for IMT Negative Aftereffect

Source of Variation	SS	df	MS	F	p
Conceptual Tempo (A)	62.2	2	31.1	7.97	.01
Exposure Condition (B)	64.5	1	64.5	16.54	.01
AxB	3.8	2	1.9	.48	NS
Within Cell	280.0	70	4.0		

$p < .025$).

PROPRIOCEPTIVE SHIFT

The initial effect of exposure to the prisms for this measure of change in felt body position was to shift the apparent location of the medial plane of the body 5.5 cm. to the right. A one way analysis of variance carried out on the change scores from the pre-exposure to the T_0 testing period revealed no significant difference in the initial response of the three "conceptual tempo" groups to the prismatic displacement $F(2,73) = 1.23$; $p > .05$.

Rate of ongoing adaptation was determined by comparing the change score from T_0 to T_1 with the change scores from T_1 to T_2 and was analyzed as a function of exposure conditions and "conceptual tempo" in a 3x2x2 split plot ANOVA. The results of this analysis are presented in Table 6. The rate of adaptation for this measure was characterized by a large initial shift of $\bar{X}=3.9$ cm. after the first exposure period, with a significantly smaller shift ($\bar{X}=.7$ cm.) occurring at the end of the second exposure period, $F(1,70) = 18.06$; $p < .01$. Variation contributing to the interaction between rate of adaptation and exposure conditions (BxC), rate of adaptation and "conceptual tempo" groups (AxC), and the AxBxC interaction was not statistically significant.

Impulsives, reflectives and moderates did not differ in the amount of total PS (T_0 to T_1 + T_1 to T_2) exhibited

TABLE 6

Summary of Analysis of Variance of

T_0 to T_1 and T_1 to T_2 Change Scores for PS

Source of Variation	SS	df	MS	f	p
Between Ss		75			
Conceptual Tempo (A)	2.5	2	1.3	.23	NS
Exposure Condition (B)	6.7	1	6.7	1.23	NS
AxB	6.4	2	3.2	.58	NS
Within Cells	380.7	70	5.4		
Within Ss		76			
Time (C)	381.0	1	381.0	18.06	.01
AxC	16.5	2	8.3	.39	NS
BxC	10.2	1	10.2	.50	NS
AxBxC	86.4	2	43.2	2.05	NS
CxWithin Groups	1,477.9	70	21.1		

during exposure $F(2,70) = .23$; $p > .05$. Subjects in the CDT condition did not differ significantly from subjects in the TD condition in performance on this measure $F(1,70) = 1.23$; $p > .05$. Additionally, the "conceptual tempo" x exposure conditions interaction was not significant $F(2,70) = .58$ $p > .05$.

Pre- to post-exposure change scores in localizing the medial plane of the body (PS N.A.) were analyzed as a function of "conceptual tempo" and exposure conditions in a 3x2 ANOVA. The results of this analysis are presented in Table 7 and reveal no significant differences for either the main effects or the AxB interaction.

INTER-CORRELATIONS BETWEEN SCREENING MEASURES

The correlations between the WISC IQ estimate and the initial screening measures are presented in Table 8. The findings indicate no significant relationship between the intelligence measure and any of the four dimensions employed to define the characteristics of impulsivity and reflectiveness. These correlations between the dimensions of the MFF and Maze Tests represent only those subjects pre-selected on the basis of a specific configuration of scores on the screening measures. A less biased indication of the relationship between these measures is reported in Table 9, which represents the inter-correlation matrix for the larger group of children from which the present samples were chosen. The findings

TABLE 7

Summary of Analysis of Variance

for PS Negative Aftereffect

Source of Variation	SS	df	MS	F	p
Conceptual Tempo (A)	8.9	2	4.5	.22	NS
Exposure Condition (B)	1.3	1	1.3	.06	NS
AxB	108.0	2	54.0	2.58	NS
Within Cell	1,466.1	70	20.9		

TABLE 8

Intercorrelations between the Initial Screening Measures and the IQ Estimate for Subjects Participating in the Study

	MFF RT	MFF Error	Maze SS	Maze Error	IQ Estimate
MFF RT	1.00				
MFF Error	- .75*	1.00			
Maze SS	.46*	- .61*	1.00		
Maze Errors	.63*	.81*	- .77*	1.00	
IQ Estimate	- .01	- .03	.18	.04	1.00

* $p < .01$ two tailed test

N = 78

TABLE 9

Intercorrelations between the Initial Screening Measures for the Larger Group of Children from which the Present Samples were Drawn

	MFF RT	Maze Error	Maze SS	Maze Error
MFF RT	1.00			
MFF Error	- .53*	1.00		
Maze SS	.52*	- .78*	1.00	
Maze Error	.18	- .06	- .06	1.00

* $p < .01$ two tailed test

N = 138

indicate a strong negative correlation between MFF error and the Maze scaled score, as well as a significant correlation between Maze scaled score and reaction time on the MFF Test. Additionally, a significant negative correlation was observed between MFF error and reaction time scores, indicating that the number of errors committed on the MFF Test is closely related to the rate at which one responds.

CHAPTER IV

DISCUSSION

The results of the present study indicate that both the type of feedback regarding the nature of the prismatic displacement and the rate at which subjects process that information influence the adaptive process. As predicted by the information processing theory of adaptation, it was found that the different types of information available in the two exposure conditions served the similar function of producing adaptation by informing subjects about the nature of the altered visual input. The different patterns of V-M change observed in the TD and CDT exposure conditions indicate, however, that the magnitude of adaptation within the different components of the V-M system varied as a function of the type of information made available to the subjects. The discussion of adaptation in this section refers to the change reflected in the N.A. scores.

In the CDT condition, the arm and the visual field were equally displaced with the opportunity for visual guidance of all movements. Under these conditions, the major source of feedback regarding the prismatic displacement was the discrepancy between the seen and felt position of the arm. This sensory-motor feedback produced a substantial adaptive shift in the felt position of the arm (PS). It provided insufficient information, however, for inducing change in the "higher order coordinators" of the visual system, which are responsible for a generalization of the adaptation effect to parts of the body not used during the exposure period. As a result, IMT was negligible in this condition. While adaptation is considered to be a multi-process phenomenon, involving change within the two components of the V-M system (Wilkinson, 1971), this appears to depend upon the availability of feedback from varied sources.

The target pointing error information available in the TD condition provided subjects with a more objective source of information regarding the effect the prismatic displacement had on functioning. It enabled them to actively compensate for their errors in localizing targets in the visual field and resulted in a significantly greater magnitude of IMT than occurred in the CDT condition. The feedback derived from this discrepancy between the actual and apparent location of visual targets appears to be essential to produce adaptation in the "higher order coordinators" and has been considered to involve a cognitive component of the adaptive process (Webster, 1969; Welch and Goldstein, 1972).

Proprioceptive adaptation was equivalent across exposure conditions, indicating that the stimulus information available in the TD condition provided a source of feedback about felt body position which was as powerful as that presented in the CDT condition. In view of this finding, the significantly greater overall V-M adaptation (PVT) exhibited in the TD condition can be attributed to the adaptive shift in the "higher order coordinators" of the visual system occurring in addition to the proprioceptive shift which was common to both conditions. This assumption is consistent with Wilkinson's (1971) finding that V-M adaptation, as measured by PVT, reflects the additive contribution of change within both the visual and proprioceptive systems.

Similar findings regarding intermanual transfer of the adaptation effect have been attributed to the fact that the different types of information presented by the two exposures make qualitatively different demands of the subject (Cohen, 1973). The continuously available sensory-motor feedback in the CDT condition required little interpretation and therefore required little involvement of the mediational processes. This resulted in minimal IMT. The TD condition, on the other hand, presented objective information regarding the discrepancy between the actual and apparent target location as discrete pieces of data separated by the interval between trials. This required the subject to actively evaluate the information, make an interpretation, and integrate this feedback into memory to allow for a modification of future responses (Cohen, 1973). The importance of the effective functioning of these processes in the occurrence of IMT was apparent in Cohen's (1973) finding that the magnitude of IMT decreased in a linear fashion as the rate at which subjects were required to respond increased. The increased response rate reduced the time interval between trials during which these cognitive processes could be engaged to deal with the stimulus information. As a result, less feedback was generated to produce IMT.

In view of the relationship between the type of feedback available, the rate at which it is processed and the magnitude of adaptation in the various components of the V-M system, the patterns of adaptation exhibited by the "conceptual tempo" groups studied here offer an indication of the way in which these children utilize the feedback available as a result of their behavior.

In the CDT condition, impulsive, moderate and reflective subjects used the sensory-motor feedback, resulting from the discrepancy between seen and felt arm position, equally well in adjusting to the effects of the prisms. As a result, no differences in performance were exhibited by the three groups on any of the measures of adaptation. In the TD condition, no significant differences were observed in the performance of the three groups on the PS and PVT measures, however, the reflective group exhibited significantly greater IMT than the impulsive group. The magnitude of IMT in the TD condition is dependent on the capacity for analyzing and evaluating the information resulting from the target pointing efforts. These processes influence the quality of feedback to be integrated into the central mediating centers to allow for a modification of future responses. The smaller magnitude of IMT exhibited by the impulsive subjects indicates that the amount and/or quality of feedback generated by these processes provided these subjects with less information to allow for a successful adaptation of their behavior, than occurred for the reflective group. This assumption is consistent with the information processing theory that the magnitude of adaptation in the different components of the V-M system is directly related to the amount and quality of feedback available to the subject regarding the nature of the prismatic displacement.

The limited extent to which both the impulsive and moderate subjects engaged their cognitive processes in generating feedback was apparent in a comparison of their performance on the PVT and IMT measures of adaptation across exposure conditions. It was expected that greater overall V-M adaptation would occur in the TD than the CDT condition due to the availability of objective error information in addition to the sensory-motor feedback which was common to both conditions. The impulsive and moderate groups exhibited little difference in the magnitude of PVT across conditions, however. The finding that IMT also did not significantly differ across conditions, for these two groups, indicates that they did not make effective use of the error information which was available to them. As a result, change within the "higher order coordinators" did not substantially add to the overall V-M adaptation in the TD condition.

Based on the expectation that reflective subjects would generate significantly greater feedback from their target pointing efforts than the impulsive subjects, it was hypothesized that they would exhibit significantly greater overall V-M adaptation in the TD condition than the impulsives. While the findings regarding IMT indicate that the reflective subjects did make more effective use of the error information, the two groups did not differ significantly on the measure of overall adaptation. Taking into consideration the total pattern of adaptation exhibited by the two groups, these results can be explained in terms of Wilkinson's (1971) finding that overall adaptation, as measured by PVT, reflects the sum of change within the components of the system. Adaptive functioning in manually locating a visual target can be mediated by change in the proprioceptive system, "higher order coordinators" of the visual system or both, with the resulting change in the two systems contributing additively to the overall adaptive shift.

While the impulsive subjects exhibited significantly less change in the "higher order coordinators" (IMT) than the reflective subjects, this adaptation was accompanied by a rather large shift in the felt position of the arm (PS). The additive effect of the change within these two systems enabled the impulsive subjects to perform as effectively on the PVT measure of adaptation as the reflective group. Although the reflective group exhibited significantly greater IMT, the magnitude of PS which occurred was less than that exhibited by the impulsive group (although not significantly). Both components of the overall V-M system appeared to contribute equally to the adaptive process in the reflective group, and the sum of the change reflected by the PS and IMT measures was similar to that observed for the impulsive group. As a result, no significant difference occurred in performance on the PVT measure between the two groups in the TD condition.

The overall V-M adaptation exhibited by the impulsive and reflective groups in the TD condition indicated that they both responded effectively to the demands of the situation by re-establishing coordinated functioning of the V-M system. The patterns of adaptation contributing to the overall shift indicate, however, that to some extent these groups relied on qualitatively different sources of feedback in understanding the effect that the prismatic displacement had on functioning. While this produced different amounts of adaptation in the two components of the V-M system for the two groups, the additive effect in terms of performance on the PVT measure was statistically equivalent.

The pattern of adaptation exhibited by the moderate group on the three dependent measures was not what was expected on the basis of their performance on the MFF and Maze Tests. The impulsive-reflective dimension, within which the moderate group represented the middle range, led to the expectation of a linear relationship between the three groups in terms of the magnitude of adaptation. A linear relationship did not occur, however, On all three measures, in both conditions, the magnitude of adaptation exhibited by the moderate group represented the extreme score in the direction which was predicted for the impulsive group, rather than the middle range score. This finding presents many questions about the nature of the moderate group. Is the group truly moderate in terms of their "conceptual tempo", or did the moderate performance on the screening measures result from the averaging out of a variety of characteristics to produce a middle range performance? If the later alternative is true, the moderate group should contain a more heterogeneous sample of subjects than either of the extreme groups. Evidence of this heterogeneity was apparent in this group's performance on the IMT measure of adaptation where individual differences have been shown to influence the adaptive process. For this measure, the moderate subjects in the TD condition exhibited significantly greater between subject variability than any of the other groups across the two conditions.

The expected differences in PS as a function of exposure conditions and "conceptual tempo" were all statistically non-significant. While the AxB interaction indicated that substantial differential amounts of adaptation were exhibited by "conceptual tempo" groups as a function of exposure conditions, the effect of these results were minimized by the high degree of within cell variance. This large between subject variation appears to be a function of the fact that for this measure no objective target was presented to the subjects on which to base their pointing efforts. Whereas the other two measures presented a physical target as a concrete point of reference, the instructions to "point straight ahead of you, right in front of your nose", for this measure, placed greater emphasis on egocentric interpretation rather than objective reality. With the eyes closed, localization of the medial plane of the body became a somewhat arbitrary task, varying between subjects and open to re-interpretation during the course of the exposure period. This situation may not have been a problem in other studies due to the fact that body image is more stable and well established in adults.

The hypotheses presented in this study were predicted on the basis of subjects' performance on the MFF Test and the WISC Mazes. The dimensions measured by these tests permitted definition of the impulsive-reflective continuum in terms of: (1) the capacity to inhibit the immediate impulse to act during the response process, in favor of delaying action to allow for a more careful consideration of available alternatives, (2) the capacity to plan ahead or look before one acts. The effectiveness of these reflective processes was determined by the quality of the responses. These characteristics were considered to reflect the typical manner in which impulsive and reflective subjects deal with new, demanding situations. This assumption was supported by the strong correlation found here between MFF error and WISC SS of $r = -.78$. As well, the correlations of $r = .52$ between MFF RT and Maze SS and $r = .53$ between MFF RT and MFF error indicate that there is a significant relationship between rate of response and the quality of performance.

Based on a study of pre-schoolers, Block, Block and Harrington (1974), have recently presented evidence that MFF reaction time, and to a greater extent response error, were basically a reflection of the subjects' intellectual capacity. The non-significant correlations found between the IQ estimate and MFF error and response rate (see Table 8) do not support Block, Block and Harrington's (1974) findings. In addition, maze performance, which has been considered to be an indicator of intelligence, (Wechsler, 1949) did not correlate significantly with the IQ estimate. Thus, it would appear that both the rate and quality of performance on these measures were related to factors other than intelligence. The characteristics of an impulsive or reflective response style, as measured by the MFF and Maze Tests, appear to be independent of intellectual capacity.

Observations regarding the way in which the children went about dealing with the two screening measures offer insights into their general functioning and in terms of their adaptation to the prismatic displacement. On the WISC Mazes, the performance of impulsive subjects was generally characterized by fast, expansive movements in which there was often little regard for the boundaries within which performance was to be restricted. When confronted with a choice of response alternatives, the more impulsive subjects appeared to test out the response possibilities by physically trying them out or acting on them as a means of determining their viability. There often appeared to be no sharp distinction between the decision making processes and the action of executing the task. In contrast, those subjects defined as reflective moved more slowly and carefully through the mazes, frequently inhibiting action at a point of decision to consider the available alternatives before responding.

A similar pattern was observed in performance on the MFF Test. Impulsive children tested their initial hypothesis by acting on it verbally in the form of a response. Rather than inhibiting action to engage their evaluative faculties in determining the validity of their initial impression, impulsive subjects responded, relying on an external source (the examiner) to carry out this evaluative function for them. The considerably longer RT and lower number of errors exhibited by the reflective group indicated that they inhibited the initial impulse to act in favor of engaging their evaluative functions in dealing with the problems presented.

In many ways, the manner of approach employed by these subjects is indicative of developmentally different levels of functioning as described in the theories of Piaget (1951) and Werner (1948). To a great extent, the impulsive child dealt with the two tasks on the sensory-motor level. Mastery of the problems appeared to be closely related to the physical actions carried out on the stimuli and guided by initial sensory impressions rather than information derived from a more detailed analysis of the situation. The performance of the reflective group, on the other hand, indicated a greater effort at internally manipulating information and carrying out operations on the stimulus input before committing themselves to action.

It would appear that the circumstances presented by the Mazes and MFF Test cause certain children to function in a developmentally less mature and less effective manner than is available to them within their adaptive capacities. Werner and Kaplan (1963) have observed that adaptive functions become hierarchically arranged during the course of development with earlier modes of functioning being subordinated to more advanced ones. It is only under "special" circumstances that the earlier ones may again be relied on. This is particularly true at times when the availability of the more mature mechanisms becomes blocked.

The "special" conditions influencing behavior here appear to be a function of both internal and external factors interacting to influence the subject's capacity for inhibition. The pressure of being timed in this evaluative situation where the child is presented novel and complex stimuli produces a situation, according to Kagan and Messer (1975), in which some children feel anxious about their capacity to succeed due to feelings of incompetance. This anxiety then causes the children to respond too quickly. While the anxiety hypothesis may explain the motivational factors influencing rate of response and its effect on accuracy, it does not explain why rapid and slow response rates are accompanied by the qualitatively different styles of functioning exhibited by the impulsive and reflective subjects.

White (1965) suggests that the availability of a given response style in the present situation appears to be dependent upon both the capacity for inhibition and "any momentary or long term influence which tends to speed up or slow down the subject's response tempo" (p. 189, White, 1965). White's work in the area of learning processes has revealed a "temporally stacked" response hierarchy arranged such that different response styles become operational during different time zones. Those capacities which were acquired early in development are most immediately available to the subject within the "zone of automation". Through the inhibition of these first available response processes, an engagement of the cognitive processes available in the "zone of decision" becomes possible.

It appears that the relatively fast rate of response exhibited by the impulsive subjects in responding to MFF and Maze items, limited the degree to which the cognitive functions were engaged to deal with the situation. While the capacity for inhibition is generally well developed by this age, the circumstances surrounding the initial screening appeared to interfere with the effectiveness of the inhibitory processes necessary for cognitive involvement.

Applying White's (1965) conceptual framework to the processing of information available during exposure to the prismatic displacement, it appears that the feedback derived from target pointing error is made available through the functioning of the analytic and evaluative faculties which become operative within the "zone of decision". The self-corrective adaptive processes occurring within the proprioceptive system, however, are based on the more immediate sensations resulting from the felt position of the arm. They appear to involve the more automatic corrective processes which do not depend on cognitive functioning.

In the TD condition, feedback resulting from both the discrepancy between seen and felt arm position and target pointing error, was immediately available to subjects as a function of the movements they were required to perform. The availability of error feedback has been shown to be closely related to the occurrence of IMT and feedback from the discrepancy between seen and felt arm position has been accompanied by a proprioceptive shift (Cohen, 1967; Uhlarik, 1973). It is reasonable to assume therefore, that these qualitatively different types of information are not processed by the same system. Additionally, depending on the system involved in processing it, White's (1965) analysis would indicate that these types of information may be processed at different times. This inference is supported by Cohen's (1973) finding that the rate at which a subject is required to respond in the TD condition (and thus, the rate at which the information is processed) will influence the magnitude of IMT. As the interval between responses decreases from 10 to 1.25 seconds, there is progressively less time for evaluating the stimulus and consolidating that information into memory. As a result, the magnitude of IMT decreases, with almost none occurring when the between trial interval is 1.25 seconds. In contrast, the processing of sensory cues regarding felt body position occurs rapidly after the onset of the stimulus. Equivalent amounts of proprioceptive adaptation occurred irrespective of the length of time between responses (10, 5, or 2.5 seconds). It appears that the processing of information on which this adaptation is based occurs within the first 2.5 seconds after the onset of the stimulus.

These temporal factors become particularly important in view of the different rates at which impulsive and reflective children process information. The processing of information based on felt body position appears to occur immediately after the onset of the stimulus and requires no cognitive involvement. The non-significant difference in PS exhibited by the impulsive and reflective groups in the TD condition indicates a similar ability to process feedback information occurring in this time zone. Where the magnitude of adaptation was more directly related to the length of time the subject was involved in processing the available stimulus information, a significant difference was apparent in the performance of the two groups. While both groups exhibited IMT in the TD condition, the greater magnitude of change exhibited by the reflective group indicates a more sustained involvement in dealing with the information resulting from their target pointing efforts. This provided a greater time interval during which the evaluative and interpretive functions could be engaged to generate the feedback appropriate to induce a change in the "higher order coordinators" of the visual system. As a result of the greater magnitude and/or quality of information produced during this extended task involvement, greater IMT occurred, as predicted by the information processing theory of adaptation.

CHAPTER V

CONCLUSIONS

The demands of the prismatic exposure phase of this study were very different from those presented by the MFF and WISC Maze Tests. Adaptation to the prisms required no real decision making or planning, little analysis of complex visual stimuli and the rate of response was controlled experimentally to insure equivalent rates of activity for all groups. Still, the patterns of adaptation exhibited by the impulsive and reflective groups were consistent with the style of functioning observed in their performance on the screening measures with regards to the degree of cognitive involvement in task performance.

The factors which interfered with the effectiveness of the impulsive subjects' performance on the screening measures also operated to diminish their capacity to generate feedback based on the results of their performance in the prismatic exposure phase of this study. Their rapid response style appears to influence the degree to which the analytic and evaluative processes were engaged in dealing with the information available as a result of their efforts. The present study extends the findings of Achenbach (1969), Odom, McIntyre and Neale (1971), Shine (1971) and others which indicate that the impulsive child does not engage his cognitive processes as effectively as the reflective child in dealing with problem solving situations. Additionally, the present findings indicate that the differences observed between the performance of impulsive and reflective children across a variety of tasks (i.e. Adams, 1972; Ault, 1973) may be partially explained by the fact that impulsive children are not as strongly influenced by the consequences of their behavior as the reflective child.

Presently, training programs devised to increase the effectiveness of the performance of impulsive children have centered around those skills necessary for the actual execution of the task. The children have been trained to slow down and direct their attention in a more systematic and analytic manner to insure that the quality of information supplied by the perceptual processes is adequate to deal with the problem. Training in organized, deductive problem solving strategies helps the child to manipulate this stimulus information in an effective manner.

Once the task has been carried out, it is essential that the impulsive child be trained to maintain involvement with the task long enough to evaluate the results of his efforts relative to the goal state to which they were intended. It is during this extended involvement that the child can be trained to apply the analytic and evaluative skills he has acquired, to generate self-corrective feedback information. The technique of modeling and self-instruction developed by Meichenbaum and Goodman (1971) could be extended to facilitate this process by having the child verbalize the need for checkback and then make evaluative statements about the quality of his performance. In this way, the child would be able to monitor his efforts more effectively. He gains the capacity to function more independently, relying on himself rather than others to make judgements about the quality of his work.

REFERENCES

REFERENCES

Achenbach, T. Cue learning, associative responding and school performance in children. Developmental Psychology, 1969, 1, 717-724.

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

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

Bellak, L., Hurvich, M., and Gediman, H. Ego-functions in schizophrenics neurotics, and normals. New York: John Wiley and Sons, 1973.

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

Bodi, S. Ego delay capacity and the development of conceptualization in a group of disadvantaged children. Unpublished doctoral dissertation, St. John's University, 1972.

Campbell, S., and Douglas, V. Cognitive styles and responses to the threat of frustration. Canadian Journal of Psychology, 1972, 4, 30-42.

Cohen, M. Continuous versus terminal visual feedback in prism aftereffects. Perceptual and Motor Skills, 1967, 24, 329-335.

Cohen, M. Visual feedback, distribution of practice, and intermanual transfer of prism effects. Perceptual and Motor Skills, 1973, 37, 599-609.

Colvin, R. Interpersonal concomitants of impulse control in emotionally distrubed children. In R. Colvin (Chm.), Manifestations and measures of impulse control and behavioral concomitants. Symposium presented at the A.P.A., Cincinnati, September, 1959. Cited by O'Keefe, E. Comparison of high and low impulse groups on two tests of motor inhibition, Perceptual and Motor Skills, 1973, 37, 435-441.

Constantini, A., Corsini, D., Davis, J. Conceptual tempo, inhibition of movement, and acceleration of movement in 4, 7, and 9 year old children. Perceptual and Motor Skills, 1973, 37, 779-784 .

Craske, B., and Crawshaw, M. Adaptive changes of opposite sign in the oculomotor systems of the two eyes. Quarterly Journal of Experimental Psychology, 1974, 26, 106-113.

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

Devoe, S. Age differences in adaptation to visual rearrangement to prisms. Unpublished Ph.D. Thesis, Clark University, 1969.

Douglas, V. Stop, look and listen: The problem of sustaining attention and impulsive control. Canadian Journal of Behavioral Science, 1972, 4, 259-285.

Douglas, V. Sustained attention and impulsive control: Implications for the handicapped child. In Psychology and the handicapped child, U.S. Department of Health, Education and Welfare; Office of Education, 1974, 149-168.

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

Egeland, B. Training impulsive children in the use of more efficient scanning strategies. Child Development, 1974, 45, 165-172.

Epstein, W. Varieties of perceptual learning. New York: McGraw-Hill, 1967.

Erikson, R., and Roberts, A. Some ego functions associated with delay of gratification in male delinquents. Journal of Consulting and Clinical Psychology, 1971, 36, 378-382.

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

Freibergs, V., and Douglas, V. Concept learning in hyperactive and normal children. Journal of Abnormal Psychology, 1969, 74, 388-395.

Freedman, S. On mechanisms of perceptual compensation. In Freedman, S.J. (Ed.), The neurophysiology of spacially oriented behavior. Homewood, Illinois: Dorsey Press, 1968.

Freud, S. (1911) Formulations regarding the two principles in mental functioning. In D. Rapaport (Ed.), Organization and pathology of thought. New York: Columbia University Press, 1951.

Harris, C. Perceptual adaptation to inverted, reversed and displaced vision. Psychological Review, 1965, 72, 419-444.

Harrison, P. The new dictionary of psychology. New York: Philosophical Library, 1947.

Hay, J., and Pick, H. Visual and proprioceptive adaptation to optical displacement of the visual stimulus. Journal of Experimental Psychology, 1966, 71, 150-158.

Held, R. Exposure history as a factor in maintaining stability of perception and coordination. Journal of Nervous and Mental Disorders, 1961, 132, 26-32.

Held, R. Plasticity in sensorimotor coordination. In Freedman, S. (Ed.) The neuropsychology of spacially oriented behavior, Homewood, Ill.: Dorsey Press, 1968.

Howard, I. Displacing the optical array. In Freedman, S. (Ed.), The neuropsychology of spacially oriented behavior, Homewood, Ill.: Dorsey Press, 1968.

Howard, I. Perceptual learning and adaptation. British Medical Journal, 1971, 27, 248-252.

Howard, I., and Templeton, W. Human spatial orientation. New York: Wiley, 1966.

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

Kagan, J. Impulsive and reflective children: Significance of conceptual tempo. In S. Sapir and A. Nitzberg (Eds.), Children with learning problems. New York: Brunner Mazel, 1973.

Kagan, J., and Messer, S. A reply to "Some misgivings about the matching familiar figures test as a measure of reflection-impulsivity." Developmental Psychology, 1975, 11, 244-248.

Kagan, J., and Kogan, N. Individual variations in cognitive processes. In P. Mussen (Ed.), Carmichael's manual of child psychology. Vol. 1, New York: Wiley, 1970.

Kagan, J., Pearson, L., and Welch, L. The modifiability of an impulsive tempo. Journal of Educational Psychology, 1966, 57, 359-365.

Kagan, J., Rosman, B., Day, D., Albert, J., and Phillips, W. Information processing in the child. Significance of analytic and reflective attitudes. Psychological Monographs, 1964, 78, No. 1.

Kainer, R. The Porteus maze test and the delay of gratification. Unpublished thesis, Teacher's College, Columbia University, 1965. Cited by Bodi, 1972.

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

Kirk, R. Experimental design: Procedures for the behavioral sciences. California: Brooks (Cole Publishing Company), 1968.

Klein, G. Perception, motives, and personality. New York: Alfred A. Knopf, 1968.

Langer, J. Theories of development. New York: Holt, Rinehart, and Winston, Inc., 1969.

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

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

Massari, D. The relationship of reflection-impulsivity to field dependence-independence and internal-external locus of control. Journal of Genetic Psychology, 1975, 126, 61-67.

McKinney, J. Problem solving strategies in impulsive and reflective second graders. Developmental Psychology, 1973, 8, 145.

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

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

Odom, R., McIntyre, C., and Neale, G. The influence of cognitive style on perceptual learning. Child Development, 1971, 42, 883-891.

Parry, P. Unpublished study. Cited by Douglas,V., Sustained attention and impulse control:Implications for the handicapped child. In Psychology and the handicapped child, U.S. Department of Health, Education and Welfare; Office of Education, 1974, p. 149-168.

Piaget, J. The psychology of intelligence. London: Routledge and Kegan Paul, Ltd., 1951.

Plomin, R., and Buss, A. Reflection-impulsivity and intelligence. Psychological Reports, 1973, 33. 726-730.

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

Porteus, S. Porteus maze test: Fifty years application. Palo Alto: Pacific Books, 1965.

Rapaport, D. Toward a theory of thinking. In D. Rapaport (Ed.). Organization and pathology of thought. New York: Columbia University Press, 1951.

Rock, I. The nature of perceptual adaptation. New York: Basic Books, 1966.

Schleifer, M. Moral judgement of children. Unpublished doctoral dissertation, McGill University, 1971. Cited by Douglas, 1974.

Schafer, R. Aspects of internalization. New York: International Universities Press, 1968.

Schaefer, E., and Bayley, N. Maternal behavior, child behavior, and their intercorrelations from infancy through adolescence. Monographs of the Society for Research in Child Development, 1963, 28. Whole No. 3. Cited by Kagan, et al, 1964.

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

Shine, D. Cognitive impulsivity and Piaget's theory of perceptual decentration. Unpublished thesis, Fordham University, 1971. Dissertation Abstracts, 71-26, 995.

Stein, N. and Landis, R. Differential reinforcement of low rate performance by impulsive and reflective children. Journal of Experimental Child Psychology, 1975, 19, 37-50.

Taub, E., and Goldberg, I. Prism adaptation: Control of intermanual transfer by distribution of practice. Science, 1973, 180, 755-757.

Templeton, W. Howard, I., and Wilkinson, A. Additivity of components of prismatic adaptation. Perception and Psychophysics, 1974, 15, 249-257.

Uhlarik, J. A device for presenting targets and recording positioning responses in one dimension. Behavioral Research Methods and Instruments, 1972, 4, 15-16.

Uhlarik, J. Role of cognitive factors on adaptation to prismatic displacement. Journal of Experimental Psychology, 1973, 98, 223-232.

Wallach, H. Informational discrepancy as a basis of perceptual adaptation. In Freedman, S. (Ed.), The neurophysiology of spacially oriented behavior. Homewood, Ill.: Dorsey Press, 1968.

Warren, D., and Platt, B. Understanding prism adaptation: An individual differences approach. Perception and Psychophysics, 1975, 17, 337-345.

Webster, R. The relationship between cognitive, motor-kinesthetic, and oculomotor adaptation. Perception and Psychophysics, 1969, 6, 33-38.

Welch, R. Adaptation to prism-displayed vision: The importance of target pointing. Perception and Psychophysics, 1969, 5, 305-309.

Welch, R., and Rhoades, R. The manipulation of informational feedback and its effects upon prism adaptation. Canadian Journal of Psychology, 1969, 23, 415-428.

Welch, R., and Goldstein, G. Prism adaptation and brain damage. Neuropsychologia, 1972, 10, 387-394.

Werner, H. Comparative psychology and mental development. New York: International Universities Press, 1948.

Werner, H., and Kaplan, B. Symbol formation. New York: John Wiley and Sons, 1963.

Wechsler, D. Wechsler intelligence scale for children. New York: The Psychological Corporation, 1949.

White, R.W. Ego and reality in psychoanalytic theory. Psychological Issues, 1963, 3, Whole No. 3.

White, S. Evidence for a hierarchical arrangement of learning processes. In L.P. Lipsitt and C. Spiker (Eds.), *Advances in child development and behavior*. Vol. 2, New York: Academic Press, 1965.

Wilkinson, A. Visual-motor control loop: A linear system. *Journal of Experimental Psychology*, 89, 250-257, 1971.

Winer, B. *Statistical principles in experimental design.* New York: McGraw-Hill, 1971.

Wohlwill, J. Perceptual learning. In P. Farnsworth (Ed.), *Annual review of psychology*, Palo Alto, Calif.: Annual Reviews, Inc., 1966.

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

APPENDIXES

Appendix 1

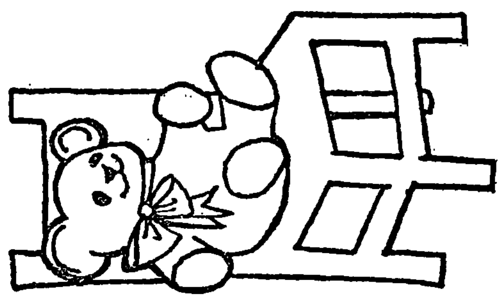
Screening Measures

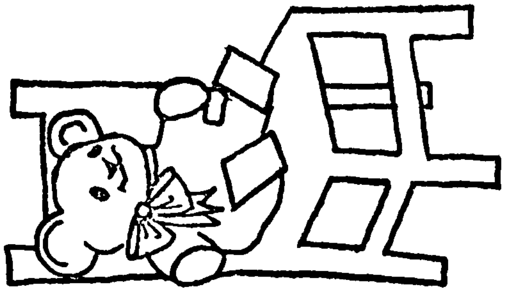
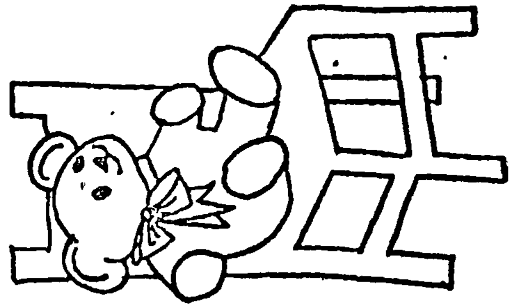
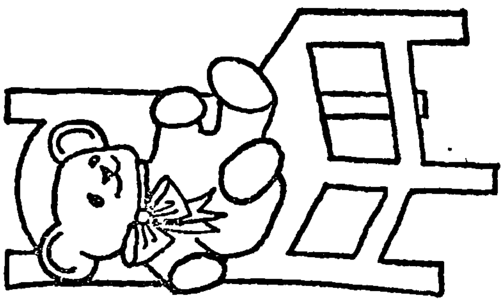
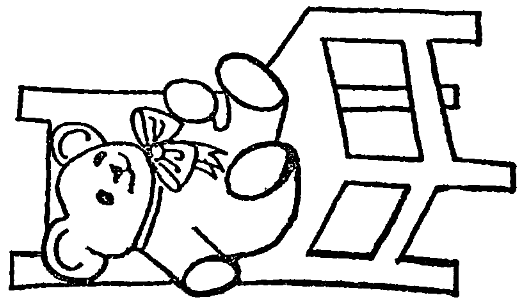
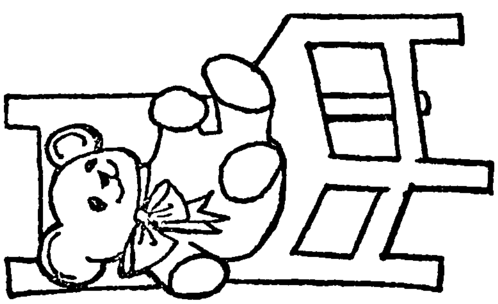
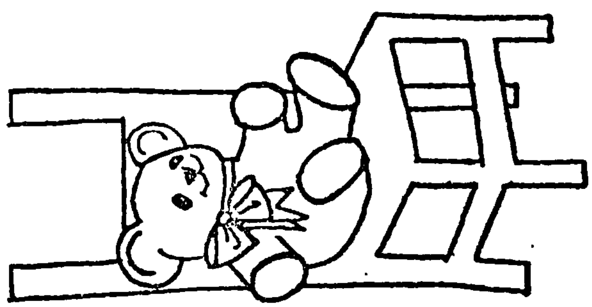
Appendix 1.1

Instructions and Sample Item for the Matching Familar Figures Test.

DIRECTIONS

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



Appendix 1.2

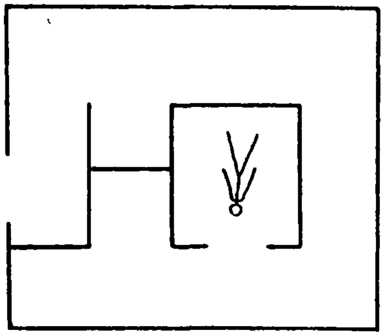
Instructions and Sample Item for the WISC Maze Test

"This is a maze. You are to start here (pointing to cross) and find your way out to the exit line here (pointing to exit) without going up any blind alley or cutting through the walls. Start here and find your way out. Do not lift your pencil until you have finished. Ready, begin".

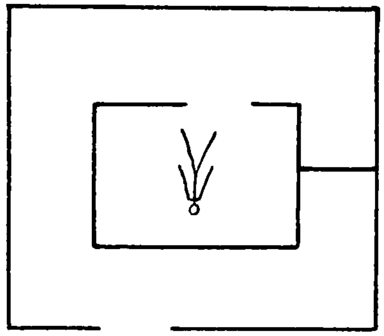
SUBJECT ↑

NAME________________________________

MAZE TEST



B 30



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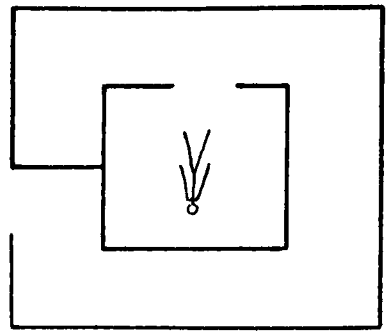
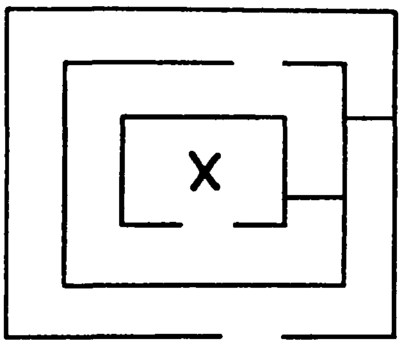
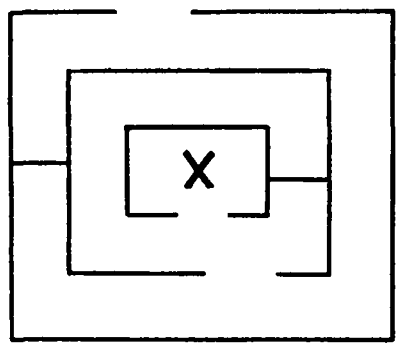


SAMPLE



1 30



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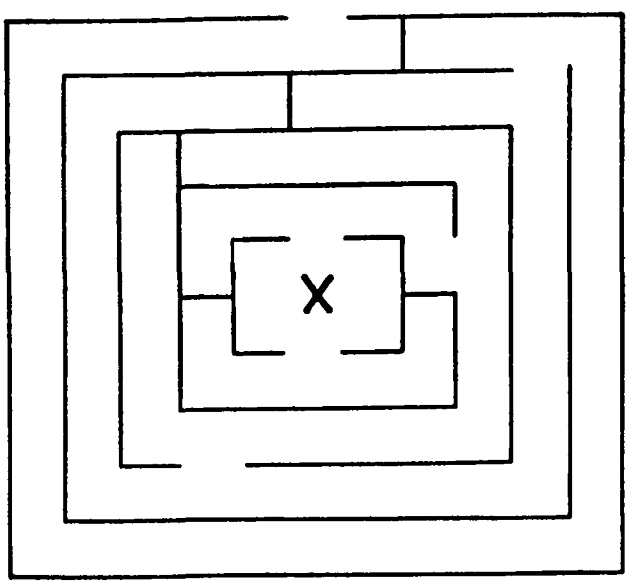
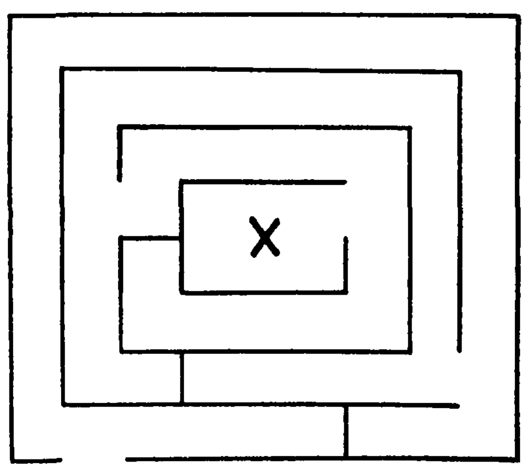


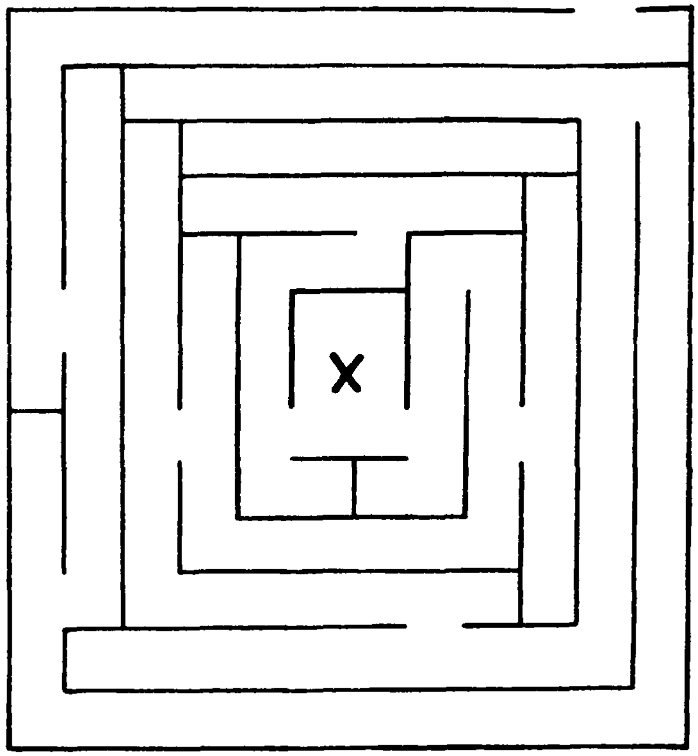
3 60



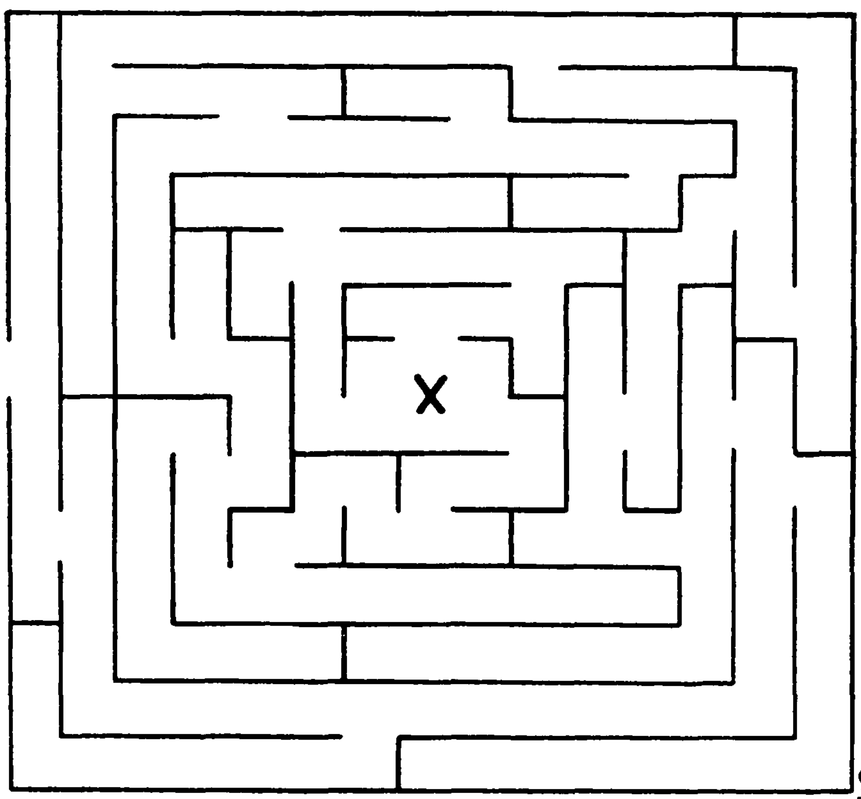
2 45

EXAMINER ↓

SUBJECT ↑



4
120



5
120

WECHSLER I.S.C.

EXAMINER ↓

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Appendix 2

Apparatus

Prisms

Prismatic displacement of the visual field was accomplished by applying 20 diopter, Fresnel prisms to the lenses of a pair of adjustable welder's goggles. The prisms, placed in a base left position, produced an 11.5 degree lateral shift of the visual field to the right. At 57 cm. from the eye, the distance of the visual display, the displacement equalled 11.1 cm. An additional effect of the prisms was to cause a slight curvature of vertical lines and the creation of a chromatic fringe on the edges of objects in the visual field.

Exposure and Measurement Apparatus

The apparatus presented in Figure 1 provided the context within which the two exposure conditions and the testing of the three dependent measures took place. This apparatus is a modification of the device described by Uhlarik (1972). It consists of a small table attached to a curved frontal display containing three vertical lines (targets). This was placed on a larger table at which the subject was seated. When the subject's head was placed in the chin rest attached to the larger table, the frontal display was 57 cm. from the eye. At the front of the small table, a slit was provided so that

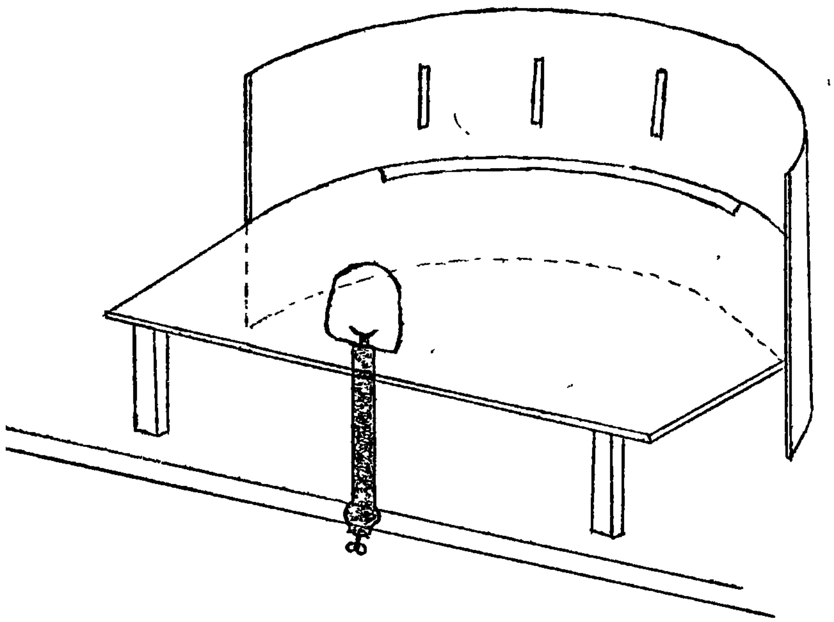

FIGURE 1. Exposure and Testing Apparatus

subjects in the TD condition could bring a hand held pointer through to view the terminal position of their pointing effort. Parts of the apparatus were painted flat black and parts covered with black felt to reduce excess light reflection.

On the lower portion of the frontal display, totally obscured by the small table top, was a cork board onto which paper could be tacked. During testing of the dependent measures, subjects marked this paper with a felt tipped marker to indicate where they perceived different targets to be. The pen was held as an extension of the index finger. Different colored pens were used for each measure.

The Ottawa Board of Education
Le Conseil scolaire d'Ottawa
330 Gilmour
Ottawa, Canada
K2P 0P9

Please Quote File Reference
Prière de rappeler la référence

No. ....

PARENTAL CONSENT FORM

Dear Parent:

The Ottawa Board of Education frequently receives requests to cooperate in research studies. Each request is carefully reviewed for technical adequacy by our Research Centre. Those requests which are acceptable on technical grounds are then carefully reviewed by an Advisory Research Committee which selects studies likely to produce information which will assist in providing quality education.

A recently approved study will investigate the way in which children re-establish normal perception when they are wearing glasses that tilt their vision approximately 11 degrees. The study is to be conducted by Mr. Paul Shapiro, a doctoral student at the University of Ottawa. Each child who participates in this study will be asked to wear special glasses which have the effect of making objects which are normally perceived in the upright position appear to be tilted 11 degrees. The glasses will be worn for about 15 minutes.

This is a task which many children at different times have participated in and most find it to be an unusual and interesting experience. While wearing the glasses, the child will be asked to perform some simple object locating task in order to study his or her adjustment to the effect of the glasses.

Your son or daughter has been included among the students requested to participate in this research. Any test scores or other measures of students participating in this study will be kept confidential nor will such scores be plaçed at any time on the student's school records. Your child's name will not appear in any record or report of the results of this study.

The research procedures are not harmful. Rather, it is likely that participating students will find the study interesting. We consider that this research will provide educationally useful information and therefore request that you allow your child to participate.

Cordially,

G. Halpern, Ph.D.
DIRECTOR OF RESEARCH

- -

Please check one { Permission Granted ☐ / Permission Denied ☐ }

Date ____________________ Parent's Signature ____________________

PLEASE RETURN THIS FORM TO YOUR SCHOOL AS SOON AS POSSIBLE.

Appendix 4

Appendix 4.1

TABLE 10

Mean Deviation in Cms. from Objective Target

in Proprioceptive Localization of Visual Targets

Time of Testing	Conceptual Tempo		
	Impulsive	Moderate	Reflective
	Continuous Display with Targets		
Pre	.7	1.6	.8
T_0	9.9	11.4	10.4
T_1	6.1	6.7	6.6
T_2	4.8	6.0	5.9
Post	-2.3	- .8	-1.9
	Terminal Display		
Pre	.8	.1	.6
T_0	10.3	9.4	10.9
T_1	6.0	4.0	5.4
T_2	4.6	2.3	3.4
Post	-3.0	-3.7	-4.4

* Negative Sign indicates position to the left of the objective target (0.0 point).

Appendix 4.2

TABLE 11

Mean Change Scores in Cms. for

Proprioceptive Localization of Visual Targets

Time of Testing	Conceptual Tempo		
	Impulsive	Moderate	Reflective
	Continuous Display with Targets		
$T_0 - T_1$	3.8	4.7	3.8
$T_1 - T_2$	1.3	.7	.7
Pre - Post (N.A.)	3.0	2.4	2.7
	Terminal Display		
$T_0 - T_1$	4.3	5.4	5.5
$T_1 - T_2$	1.4	1.7	2.0
Pre - Post (N.A.)	3.8	3.8	5.0

Appendix 4.3

TABLE 12

Mean Deviation in Cms. from Objective Target in Intermanual Transfer of Adaptation

Time of Testing	Conceptual Tempo		
	Impulsive	Moderate	Reflective
	Continuous Display with Targets		
Pre	.2	.1	.7
T_0	8.6	8.3	10.7
T_1	7.1	8.3	9.6
T_2	6.6	7.7	8.4
Post	- .4	.7	.1
	Terminal Display		
Pre	.1	.2	0.2
T_0	8.8	9.1	9.1
T_1	6.0	6.9	5.3
T_2	5.1	5.2	3.9
Post	-1.7	- .9	-3.3

* Scores with Negative Sign indicate position to the left of the objective target (0.0 point).

Appendix 4.4

TABLE 13

Mean Change Scores in Cms. for

Intermanual Transfer of Adaptation

Time of Testing	Conceptual Tempo		
	Impulsive	Moderate	Reflective
	Continuous Display with Targets		
$T_0 - T_1$	1.5	0.0	1.1
$T_1 - T_2$	.5	.6	1.2
Pre - Post (N.A.)	.6	- .6	.6
	Terminal Display		
$T_0 - T_1$	2.8	2.2	3.8
$T_1 - T_2$	.9	1.7	1.4
Pre - Post (N.A.)	1.8	1.1	3.5

Appendix 4.5

TABLE 14

Mean Deviation in Cms. in Localizing
the Objective Medial Plane of the Body

Time of Testing	Conceptual Tempo		
	Impulsive	Moderate	Reflective
	Continuous Display with Targets		
Pre	.7	2.9	.2
T_0	6.6	7.9	6.4
T_1	2.4	5.3	3.0
T_2	1.7	4.1	2.7
Post	-2.0	-2.4	-3.0
	Terminal Display		
Pre	2.0	- .9	1.0
T_0	5.7	6.8	6.5
T_1	2.4	1.2	2.4
T_2	.8	2.2	1.0
Post	-3.6	-3.5	-2.4

* Negative Scores indicate position to the left of the objective target (0.0 cm. point).

Appendix 4.6

TABLE 15

Mean Change Scores in Cms. for

Proprioceptive Shift

Time of Testing	Conceptual Tempo		
	Impulsive	Moderate	Reflective
	Continuous Display with Targets		
$T_0 - T_1$	4.2	2.6	3.4
$T_1 - T_2$	.7	1.2	.3
Pre - Post (N.A.)	2.7	5.3	3.2
	Terminal Display		
$T_0 - T_1$	3.3	5.6	4.1
$T_1 - T_2$	1.6	-1.0	1.4
Pre - Post (N.A.)	5.6	2.6	3.4

* Negative Scores indicate shifts opposite the direction of of adaptation.