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THE ROLE OF TEMPORAL FACTORS AND DIMENSIONAL SALIENCE
IN CONCEPT ATTAINMENT BY YOUNG CHILDREN

by Donna Marie Campbell

Thesis presented to the Faculty of
Graduate Studies of Carleton University
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy

May, 1977

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The undersigned recommend to the Faculty
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in Concept Attainment by Young Children"

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Abstract

A matching-to-sample task was used in two studies to investigate the role of (1) time-limits imposed upon responding and (2) relative dimensional salience on concept attainment by four and ten year old children. The hypothesis examined in both studies proposed that the mediational deficiency of young children in concept attainment tasks can be accounted for by their tendency to respond impulsively (or quickly) to highly salient dimensions of stimulation, thereby interrupting longer latency mediated modes of responding. This hypothesis was derived from the formulations of Kendler (1968) and White (1965) concerning the age-related transition from single-link to mediational modes of processing.

As a test of the hypothesis, an attempt was made to experimentally duplicate, for older subjects, the conditions under which younger children are thought to learn, by means of forcing the subjects to respond quickly. It was expected that under such conditions, older subjects would show the same behavior patterns as are seen in younger children.

In study 1, 160 four and ten year olds were required to match pictures on the basis of one of the two task dimensions, either color or size. Two levels of time-limits (1.2 and 10 seconds) were combined with two levels of relative salience of the irrelevant dimension (salient and nonsalient), resulting in four main conditions for each age group. Each condition was equated for subject preferences measured by a dimensional preference test given prior to training. An Intra-

dimensional shift task followed the original task, in which the relative salience of the irrelevant dimension also varied as salient and non-salient. Equal number of subjects from each of the main conditions of the first problem were assigned to one of the two shift conditions.

The results of study 1 indicated that both four and ten year olds reached criterion in approximately the same number of trials when the irrelevant dimension was relatively nonsalient compared to the relevant dimension. Under salient conditions, however, the four year olds were significantly slower in reaching criterion than were the ten year olds, and made more errors responding on the basis of the irrelevant dimension. In addition, the performance of the ten year olds in the 1.2 second-salient condition was significantly impaired in comparison to the other three ten year old conditions, which did not differ from each other.

Other findings, however, did not support the hypothesis. Four year olds responded significantly slower than did ten year olds. Short time-limits reliably impaired the performance of the four year olds, regardless of relative dimensional salience. Further, no transfer effects were observed during shift learning in those groups of ten year olds which had learned the first problem under 1.2 second time-limits, nor in the four year olds.

Study 2 examined the attainment of a functional concept (clothing) by 80 four and ten year olds, as a function of time-limits (2 and 10 seconds) and the relative salience of the irrelevant dimension, color (salient and nonsalient). The results indicated that four year olds required significantly more trials to reach criterion, made more errors

by responding to the irrelevant dimension, and took longer to respond than did ten year olds. Reducing the salience of the irrelevant dimension had no effect on performance by either age group. Short time-limits had a detrimental effect on learning, particularly in the four year old groups. Less than half of the four year olds attained the concept of clothing, compared to 100% of the ten year olds.

The results of the present studies did not confirm the hypothesis that age differences in concept attainment are causally related to temporal factors associated with overt behavior. The short time-limits used in these studies did not prevent the older children from employing mediational mechanisms; rather, they interfered with perceptual processing. Relative dimensional salience was observed to determine the order in which the task dimensions were processed, and influenced the performance of the four year olds to a greater extent than for the ten year olds. The age differences observed in concept attainment were interpreted as reflecting differences in level of perceptual development and inhibitory mechanisms.

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INTRODUCTION

The purpose of the present research was to examine the role of two variables, response time limitations and salience of the irrelevant dimension, on concept attainment in two age groups of children. Previous research suggests that these two variables may be important factors underlying age differences in problem solving proficiency. For example, Peterson (1973a) proposes that fast responding by young children interferes with sophisticated cognitive functioning, and thus impairs their performance in relation to performance by older children. Similarly, other researchers (Shepp & Howard, 1973; Silleroy, Warner, & Johnson, 1973; Smiley, 1973) have implicated deficits in inhibitory mechanisms in young children, in that young children have relatively more difficulty in ignoring salient, irrelevant information present in a concept attainment task than do older children. These hypotheses will be examined in greater detail following a discussion of the literature and prevalent theories related to the developmental aspects of concept attainment.

As in the case of simple discrimination learning, the process of concept attainment requires the development of a differential pattern of responding to a variety of external stimuli. Concept attainment tasks, however, are more complex than simple discrimination tasks in that the stimulus pattern designated as correct on one trial may not be identical to the correct stimulus pattern on the next trial. The critical feature of the problem is the detection of a rule, which holds

on all trials, by which a response made on the basis of that rule is classified as correct. Concept attainment problems contain a variety of possible solutions, the problem being to identify the rule correlated perfectly with positive feedback.

Since 1960, there has been growing interest in the processes underlying concept attainment, and particularly in the ontogeny of conceptual behavior. The impetus for this research arose from two studies examining concept shift learning in young children. Preschoolers (Kendler, Kendler, & Wells, 1960) and kindergarten children (Kendler & Kendler, 1959) were trained in a two-choice discrimination problem and shifted following criterion performance to a condition in which the original discrimination was reversed (a reversal shift), or to a condition in which a new discrimination was presented (a nonreversal shift). The results of these two studies suggested the possibility of an age trend in the processes underlying conceptual behavior. Whereas preschoolers learned a nonreversal shift faster than a reversal shift, kindergarten children learned reversal and nonreversal shifts at approximately the same rate. In view of earlier findings that adults reverse a previously learned discrimination faster than they learn a new discrimination (Buss, 1953, 1956; Harrow & Friedman, 1958; Kendler & D'Amato, 1955), the Kendlers suggested that the apparently discrepant results of their studies represent evidence of a developmental transition from one mode of conceptual behavior to another.

Following the publication of the Kendlers' studies, there has been a resurgence of interest in examining and explaining the increasing efficiency observed in concept attainment with increasing age. Not

only is the appropriate concept identified more quickly by older subjects, but, in addition, they are capable of assimilating greater amounts of information (Osler & Kofsky, 1965).

Three predominant explanatory accounts of the ontogeny of conceptual behavior have emerged in the last fifteen years. Each draws upon a traditional psychological theory. The S-R mediational model proposed by the Kendlers (Kendler & Kendler, 1968) emanates from the stimulus-response (S-R) model of learning (Hull, 1943; Spence, 1956); the attentional model developed by Zeaman and House (1963) and Mackintosh (1965) comes from the noncontinuity theory of Lashley (1942) and Krech-evsky (1938); finally, the differentiation interpretation presented by Tighe and Tighe (1966) evolved from a perceptual learning theory propounded by the Gibsons (Gibson & Gibson, 1955; Gibson, 1969). The major differences between these interpretations lie in their respective assumptions concerning the nature of the effective stimulus and in the nature of the mechanism whereby the stimulus environment comes to control conceptual behavior (Tighe & Tighe, 1972).

Both the S-R mediational and attentional models of discrimination and concept learning assume that the distinguishing features of the stimulus complex are immediately perceived and differentiated by the subject at the start of the task. For these theories, then, discrimination learning and concept attainment is mainly a process of modifying the external stimulus by internal response processes, the feedback from which become the primary determinants of conceptual behavior (Tighe & Tighe, 1966). In the case of S-R mediational theory, the external stimulus complex gives rise to internal representational

responses, whose feedback direct and control discriminative behavior. Attentional theory, on the other hand, assumes that a selective attending response is made to one of the dimensions in the task which serves to expose the stimulus attributes of that dimension, while information from the remaining dimensions is filtered out and not processed.

Differentiation theory, on the other hand, proposes that the distinguishing features of the stimulus complex, that is, the dimensions of the task, are not immediately perceived by all subjects, but rather, only through repeated experiences with objects which vary quantitatively in terms of some property, does that property emerge as a dimension of variation. The discrimination of distinguishing features is assumed to be the result of perceptual learning, independent of associative and reinforcement processes (Tighe & Tighe, 1966, p. 362).

A second distinction that can be made between these models arises from their respective interpretation of the processes involved in concept learning. Whereas the attentional model assumes that a single learning process is operative at all ages, S-R mediational theory argues that "there are two learning processes, one more efficient than the other, and the ontogeny of learning is due to an increasing probability that the subject will utilize the more efficient process" (Kendler & Kendler, 1970). Thus learning processes are qualitatively different, and only one or the other is used at any one time by a subject. Tighe & Tighe (1972) have presented a similar account of the ontogeny of learning. They have proposed that two learning patterns can be identified depending on whether a subject uses the object-reward or dimension-reward relations of the task. From this point of view,

however, both aspects of stimulation are processed concurrently (not alternatively, as suggested by Kendler and Kendler [1970]), and thus both may influence concept behavior, although the extent to which one or the other is used depends on a number of subject and task variables (Tighe & Tighe, 1972, p. 139). One may deduce from this model that dimension-reward relations are increasingly utilized by older subjects. Age differences, however, from this point of view, are viewed as quantitative differences in the underlying processes, rather than as qualitative differences as suggested by the Kendlers' theory of mediated learning processes.

The studies reported in this research project will examine the hypothesis that young children employ different learning processes from those used by older children. Furthermore, the studies will explore the role of two variables which might account for the age-related differences in concept attainment. Specifically, it will be hypothesized that the use of single-link modes of learning by young children is related to a lack of inhibitory development necessary for restraining responding to salient forms of stimulation, in order that more sophisticated mediated modes of learning can occur.

SELECTIVE REVIEW OF RESEARCH IN THE ONTOGENY OF CONCEPT ATTAINMENT

1. S-R Mediation Model

The first attempt to account for ontogenetic trends in concept attainment was presented by Kendler and Kendler (1962, 1968, 1970). They proposed a two process model of the development of human conceptual behavior, which involves a transition "beginning in early childhood, from a sensorimotor level of functioning to a level mediated by symbolic representational responses" (Kendler, 1972, p. 1). At the sensorimotor level, learning is hypothesized to be characterized by single-link, or simple stimulus-response (S-R) associative mechanisms. With increasing maturity, the learning process becomes more complex and efficient in that it is assumed to become increasingly dependent on symbolic representational mediating responses made to certain aspects of the stimulus environment. The Kendler's further suggest "the change is relatively permanent in that it is not learned and unlearned in each new problem presented. And, finally, the transition results in an increased capacity for self-regulation, since the symbolic mediating response system is conceived to be a self-generated mechanism which stabilizes behavior to a range of stimuli and thereby reduces the control of random fluctuations in the environment" (Kendler & Kendler, 1970, pp. 25-26).

Concept Shift Studies. Empirical support for the developmental mediation interpretation of the ontogeny of learning has emerged from a variety of experimental paradigms. One of the most common paradigms

used to investigate underlying processes in discrimination and concept attainment is the discrimination or concept shift paradigm. In this procedure, the subject is shifted to a new problem immediately after he has attained criterion performance on an initial task. There are numerous types of shift problems. A reversal shift (R) refers to the situation in which the relevant dimension of the initial task remains relevant in the transfer task, although the reinforcement contingencies associated with the stimulus cues of that dimension are reversed. In an extradimensional shift (ED), the irrelevant dimension of the original problem now becomes relevant for solution, while the previously relevant dimension becomes irrelevant. A nonreversal shift (NR) is very similar to the above ED shift, in that the previously irrelevant dimension becomes relevant for solution of the shift task. The major difference between these two shift tasks centers on the status of the irrelevant dimension during the shift task. In an ED task, all the stimulus values of the irrelevant dimension continue to be presented within a trial (i.e., the irrelevant dimension varies within a trial). During a NR shift, however, the irrelevant dimension is varied between trials, that is, only one stimulus value is presented on each trial, or remains constant on all trials. Another type of shift, the intradimensional shift (ID), refers to the case where the relevant dimension in the original task remains relevant during the shift problem, although new stimulus values are presented. Finally, an optional shift problem allows the subject to respond on the basis of a reversal or nonreversal shift. In this situation, the subject is first given a two-dimensional problem to solve, with one relevant dimension, and then is transferred

to a second problem in which the cues on the two dimensions are redundant, so that either dimension can be used for solution. If the subject continues to use the originally relevant dimension, he must reverse his original response habit; on the other hand, he can solve the second problem by switching to the originally irrelevant dimension, thus executing a NR shift. A transfer test following the second problem indicates which of the two shifts is chosen by the subject.

The original formulation of the developmental mediational model arose from a disparity in data obtained using the concept-shift paradigm between infra-human subjects and college students. Infra-human subjects apparently execute a nonreversal shift faster than a reversal shift (Kelleher, 1956); college students perform better on a reversal shift than on a nonreversal shift (Buss, 1953, 1956; Harrow & Friedman, 1958; Kendler & D'Amato, 1955). The Kendlers (Kendler & Kendler, 1962) proposed that the apparent behavioral discontinuity in shift learning could be explained by a two process model of learning. The behavior of infrahuman subjects may be represented by traditional single-link S-R formulations originally expounded by Spence (1936, 1956) and Hull (1943). Theoretically, in a two dimensional problem, at the end of training on the original problem, the excitatory potential of the reinforced cue on the relevant dimension is high relative to that of the nonreinforced cue on the same dimension. In addition, the excitatory potential of the two cues on the irrelevant dimension should be equivalent, and intermediary to the two cues on the relevant dimension, since they are rewarded 50% of the time. During the transfer task, then, the time required for obtaining the necessary net difference in

excitatory potential between the two cues for differential responding would be longer in a reversal shift situation than in a nonreversal shift, since the difference in the magnitude of excitatory power of the two relevant cues in the reversal shift is greater than it is for the relevant cues in the nonreversal case. The behavior of college students is more adequately handled by a model which assumes that these subjects utilize representational mediating response mechanisms which become conditioned to overt behavior. In a reversal shift, the mediating mechanism acquired in the original problem is still appropriate for the reversal shift problem, and only the overt choice response must be changed. In a nonreversal shift, however, a new mediating response mechanism, as well as new choice responses, must be acquired to solve the task. Thus, a reversal shift is easier to accomplish than a nonreversal shift in the case of mediating subjects.

The evidence suggesting a phylogenetic trend in the processes underlying discrimination and concept learning led to the examination of a possible ontogenetic trend underlying concept attainment. In the first study (Kendler & Kendler, 1959), kindergarten children were trained on a two-choice simultaneous discrimination with one relevant dimension and one variable within irrelevant dimension. Following criterion performance, the subjects were shifted to either a R or NR shift problem. The data indicated no differences in performance between either shift condition. However, when the subjects were dichotomized into fast and slow learners on the first problem, fast learners demonstrated better performance on the reversal task than on the nonreversal task, while slow learners executed a nonreversal shift faster than a reversal shift. A second study (Kendler, Kendler, & Wells, 1960) sampled children from a younger age range, nursery school

children. The results indicated that the younger children performed better on a nonreversal shift than on the reversal shift.

The Kendlers interpreted the results of the above studies as evidence of an ontogenetic trend in the modes of learning processes underlying conceptual behavior. Specifically, the superior performance of the nursery school children in the nonreversal condition relative to the reversal condition was assumed to reflect the prevalence of single-link processing in this age group, while the mixed performance of the older children in kindergarten was interpreted as evidence of the transition period between single-link and mediating processing. The fast learners were inferred to be using a mediational strategy, while the slow learners were thought to be still employing single-link processes in learning. The transition period, then, was assumed by the Kendlers to occur generally between the ages of five and seven years.

Evidence of a developmental trend in the use of mediational processes in learning has also emerged from the use of the optional shift paradigm. In order to examine developmental differences in reversal shift and non-reversal shift behavior, the Kendlers conducted two studies employing the optional shift procedure which together sampled an age range from three to twelve years inclusively, and college students, and in which the tasks included dimensional combinations of color-form, size-color, size-form, and size-brightness (Kendler, Kendler, & Learnard, 1962; Kendler & Kendler, 1970). The data from these two studies indicated a monotonic increase in the percentage of subjects making optional reversal shifts with age, with a corresponding decrease in the percentage of subjects showing non-reversal shifts, regardless of the dimensions involved. Thus, as age increases, the probability that a human subject, given a choice, will

reverse rather than learn a nonreversal shift, also increases. The Kendlers again interpreted this trend as demonstrating the increasing probability with increasing age that the human subject behaves according to a mediational formulation (Kendler & Kendler, 1968).

Effects of Verbalization on Learning and Transfer. The nature of the hypothetical mediating mechanism proposed by the Kendlers has also been subjected to experimental attention. The Kendlers have been vague concerning this issue. They have, however, suggested that the hypothetical mediational mechanism is probably of a verbal or perceptual nature (Kendler, Kendler, & Learnard, 1962).

The assumption that language and verbal processes play an important role in the development of higher-order cognitive functioning is pervasive in psychological thinking (e.g., see the work by Luria [1961] and Vygotsky [1962] on the role of inner speech in controlling thought processes and behavior). There is considerable evidence that verbal cues can mediate the transfer of motor behavior in human learning paradigms (see Cantor, 1965). It would seem reasonable, then, to assume that verbal processes play an important role in conceptual learning. Recent work has been directed at examining the role of language in concept attainment, and at the possibility that the poor performance of young children on such tasks results from their inability to use verbal symbols as mediators.

One approach has been to have the children verbalize during the task. The rationale behind this approach is that providing appropriate verbal labels may encourage the children to use them as mediators. Two studies have found that overt verbalization of cues on the relevant

dimension improves performance during the original problem in the case of young children, three to six years (Kendler, 1964; Mumbauer & Odom, 1967). Furthermore, overt verbalization during the original problem also influences subsequent shift performance. In an early study, Kendler and Kendler (1962) required four and seven year old children to verbalize one of the stimulus properties of the correct cue. One group of children described the cue from the relevant dimension, a second group described a cue from the irrelevant dimension, while a third group said nothing. Following criterion, all children were presented with a reversal shift. The effect of relevant verbalization in the four year old children was to decrease the number of trials required for criterion, while irrelevant verbalization retarded performance relative to the control condition. In the case of the seven year olds, overt relevant verbalization did not improve performance relative to the control group; however, irrelevant verbalization significantly interfered with performance. The interpretation offered by the Kendlers of these data attributes the effect of relevant verbalization on reversal learning as one of increasing the probability that the younger children will behave in a mediational fashion by providing them with appropriate mediators. Such an effect disappears in the older children since presumably they are already employing mediational strategies.

Other studies have found overt relevant verbalization to improve reversal learning in young children (Kendler, Glasman, & Ward, 1972; Mumbauer & Odom, 1967; Silverman, 1966; Yussen, 1972). In addition, Kendler (1964) has reported that overt relevant verbalization during the initial problem increases the percentage of kindergarten children

executing reversal shifts in an optional shift paradigm.

The issue of a developmental transition in the role which verbal processes play in concept attainment has also been examined with a different approach. Previous studies indicated that verbal cues can serve to covertly mediate between stimuli and responses which have not been directly paired (Birge, 1941; Jeffrey, 1953; Shepard, 1956). Kendler (1972) has recently extended these findings on a developmental scale. Using a procedure similar to that used by Birge (1941), four different stimuli were paired with two verbal responses (a-"one", b-"two", c-"one", d-"two"). During the second phase, two of the stimuli were paired with two different motor responses (a-left, b-right), followed by a test of mediated transfer in which the four different stimuli were presented and the particular response elicited observed (a-left, b-right, c-?, d-?). The design involved four age levels (kindergarten, second grade, fourth grade, and college students) combined with two levels of verbalization (overt label versus no overt label). Two response measures were recorded: the proportion of subjects whose initial test response was consistent with the verbal labels learned in phase one, and the proportion of subjects who made no errors during the first 12 trials of phase three, during which subjects were rewarded as in phase two or rewarded for mediated responses.

Analyses of both response measures revealed a main effect of age, and verbalization, although the interaction was not significant. Thus, there was a steady increase in the proportion of subjects responding in a mediational fashion with age for both the overt and nonovert label conditions. Kindergarten children responded at chance levels in the

nonovert condition. A control group demonstrated that the observed mediational deficiency in younger children could not be attributed to a failure to remember the verbal labels from phase one. Kendler concluded that younger children exhibit a deficiency in mediational capacities, a deficiency involving both production and control. Control deficiency, the hypothetical deficiency due to the failure of the stimulus feedback of the implicit verbal mediator to control behavior, was inferred from the data to decrease substantially between kindergarten and fourth grade. Production deficiency, the failure to abstract or produce the appropriate mediator, continued to be evident until fourth grade, then decreased. Mediational deficiency, then, is seen as devolving in two stages. In the early years, neither the relevant dimension is abstracted from the stimulus complex, nor, if provided, can the symbolic representation of this dimension be used in controlling behavior. Later, symbolic mediators come to control overt behavior, although there still remains some difficulty in producing the appropriate mediators for the stimulus complex.

Additional evidence of a developmental trend of verbally mediated behavior comes from a series of concept shift studies in which the stimuli were conceptually similar rather than physically similar (Kendler, Kendler, & Marken, 1969). In these studies, subjects between the ages of 4 and 18 years were required to sort pictures of common objects into two conceptually consistent categories. Following criterion, the subjects were then shifted to a reversal or half-reversal condition. In the half-reversal condition, only half of the stimulus cues within each category are reversed, with the result that the new subsets

are not conceptually consistent. The data showed that as age increased, there was a significant increase in speed with which a reversal shift was performed relative to the speed at which a half-reversal shift was learned.

Another developmental study of concept attainment, by Odom (1966), has provided evidence of an age trend in the use of single-link or conceptual strategies in problem-solving. Using pictures of animal's heads and bodies as stimuli, he observed that as age increased, the subjects progressed from the use of single-link modes of learning to stimulus labelling and finally to the use of conceptual categories in concept identification.

Summary. The Kendler and Kendler (1962, 1968, 1970) formulation has been criticized on two counts. First, some studies have reported young children under the age of five years to have reversed faster than to have learned a nonreversal or extradimensional shift (Caron, 1969, 1970; Dickerson, 1966; Dickerson, Wagner, & Campione, 1970; Mumbauer & Odom, 1967). This would seem to indicate that these children are engaging in mediational strategies at an age which the Kendlers have proposed single-link processing to be predominant. These investigators have pointed to a possible confounding from the effects of dimensional preference, and from the status of the irrelevant dimension during shift. The Kendlers (Kendler & Kendler, 1969) have refuted this point by demonstrating that the developmental relation between age and frequency of reversal shifts in an optional shift procedure occurs even under conditions where the effect of dimensional preference has been equalized among age groups by counterbalancing.

Another criticism concerns the nature of the proposed mediating response mechanism. The problem is one of determining the mechanism whereby verbal labels produce facilitation of learning. Whereas the Kendlers attribute facilitation effects to the use of the verbal labels as mediators of conceptual behavior, other researchers (Dickerson, 1970; Wolff, 1967) have suggested that verbal labelling procedures increase the probability that the subject will attend to the relevant dimension of information. The problem of separating verbal, perceptual, and attentional factors in learning is a difficult one and has not been adequately dealt with as of yet. There are also contradictory reports of verbalization having no effect on concept attainment (see Wolff, 1967), and in one study (Mumbauer & Odom, 1967), a report of facilitation by verbalization on extradimensional shift learning.

2. Attentional Model

In recent years there has been a resurgence of interest in some of the ideas originally proposed by Lashley and Krechevsky during the 1930's. Although several models have been developed to explain attentional processes in learning (e.g., Mackintosh, 1965; Trabasso & Bower, 1968), the one-look model formulated by Zeaman & House (1963) is most frequently referred to in the developmental concept attainment literature. This mathematical model assumes that a selective attending response is necessary before differential responding can be learned. Each of the dimensions in the task, relevant and irrelevant, is assumed to elicit an appropriate observing response with a particular probability (P_0). When an attending response is made to a dimension, the

stimulus values of the dimension are exposed to the subject. Only one attending response is assumed to be made on each trial. Once an observing response has been made to a dimension, approach responses are made to the specific cues with a probability of P_R and $1-P_R$. Reinforcement results in an increase in the probability of attending to the particular dimension involved on the reinforced trial. Since the probability of attending to all dimensions is mutually exclusive and exhaustive (that is, the probabilities summate to unity), an increase in P_0 to one dimension results in a decrease in P_0 to other dimensions. Similarly, nonreinforcement to one dimension, which decreases P_0 to that dimension, will indirectly increase P_0 to other dimensions. Response probabilities follow the same laws. Thus, if a subject attends to the relevant dimension and is reinforced, P_0 increases as does P_R . If the subject makes the wrong response, P_0 decreases, and so does $1-P_R$, which in effect increases P_R , or the probability of making a correct response when the relevant dimension is attended. If the subject attends to an irrelevant dimension, and is reinforced, P_0 of that dimension increases, thus decreasing the probability of attending to the other dimensions, including the relevant one, and in addition, the probability of responding to cues on that dimension will increase. However, responding on the basis of an irrelevant dimension leads to 50% reinforcement, and on nonreinforced trials, the P_0 to other dimensions, including the relevant dimension increases. One corollary is that P_R increases faster than P_0 , since it never undergoes direct or indirect extinction (Zeaman & House, 1963).

Differences in speed of acquisition of concept problems between

subjects of varying intelligence and, presumably, varying ages, are inferred to result from differences in the initial probability of attending to the relevant dimension, and not from differences in rate of acquisition of the instrumental choice responses.

Intradimensional, Extradimensional, and Reversal Shifts

Much of the empirical support of attentional models of concept learning has come from the use of the concept shift paradigm. One deduction that can be made from attentional or 'chaining' theories of discrimination learning and concept attainment is that an intradimensional shift should be easier to learn than an extradimensional shift, since the probability of attending to the relevant dimension at the beginning of the transfer task is higher in the case of an intradimensional shift relative to an extradimensional shift. Several studies have provided support for this hypothesis in both adults (Harrow, 1964; Isaacs & Duncan, 1962) and children (Dickerson, 1966; Eimas, 1966a; Furth & Youniss, 1964; Garber & Ross, 1968; Mumbauer & Odom, 1967; Trabasso, Deutsch, & Gelman, 1966). Similarly, according to this model, an intradimensional shift should be easier than a reversal shift, since a reversal shift involves both positive transfer of appropriate attending responses, and negative transfer from response habits, while an intradimensional shift involves only positive transfer. Again, there is evidence for this deduction in adults (Harrow, 1964; Isaacs & Duncan, 1962) and children (Furth & Youniss, 1964; Trabasso, Deutsch, & Gelman, 1966).

According to the Zeaman and House (1963) model, the direction of

reversal-extradimensional differences depends on the particular parameter values of the degree of transfer of the attending response and the rate of extinction of the instrumental response. Superior reversal learning would be expected if the rate of extinction of the instrumental response is faster than that of the attending response. On the other hand, if there is no appreciable transfer of the attending response, and the instrumental response is resistant to extinction, faster extradimensional shift learning than reversal learning would be expected to occur. Empirical evidence indicates that adults learn a reversal shift faster than an extradimensional shift (Buss, 1953, 1956; Harrow & Friedman, 1958; Kendler & D'Amato, 1955). In children, however, the findings are somewhat contradictory. Faster reversal learning has been reported by Dickerson (1966), Dickerson, Wagner, and Campione (1970), Milgram and Furth (1964), Mumbauer and Odom (1967), and Tighe and Tighe (1967). On the other hand, Kendler, Kendler, and Wells (1960), Marsh (1964), and Tighe and Tighe (1967) report faster extradimensional shift learning than reversal shift learning, while Dickerson, Wagner, and Campione (1970), Kendler and Kendler (1959), Tighe (1965), and Trabasso, Deutsch and Gelman (1966) report no differences in performance between conditions. This variability in results has led investigators to specify certain nondevelopmental factors which may influence the probability that the attending response will be transferred from one task to another. Among these factors are dimensional dominance, measured in terms of subjective preference (dimensional preference), or in terms of relative salience of

the relevant and irrelevant dimensions (dimensional salience), status of the irrelevant dimension, and overtraining of the original solution.

Dimensional Dominance

Dimensional preference. There is well substantiated evidence that children show strong and stable individual preferences for certain dimensions of stimulation at different ages (Brian & Goodenough, 1929; Colby & Robertson, 1942; Corah, 1964; Kagan & Lemkin, 1961; Odom & Guzman, 1972; Suchman & Trabasso, 1966a). More recently, the suggestion has been made that such dimensional preferences may serve as an index of the probability of attending to a given dimension; hence, there should be a relation between learning speed and preference for the relevant dimension. The results of several studies have borne out the above prediction in a variety of situations employing different dimensions and age groups (Brown, 1970; Crane & Ross, 1967; Heal, Bransky, & Maniken, 1966; Mitler & Harris, 1969; Suchman & Trabasso, 1966b; Trabasso, Stave, & Eichberg, 1969; Wolff, 1966). For example, Suchman and Trabasso (1966b) report that concept attainment by preschool children is significantly facilitated, in terms of decreased errors, when the subject's preferred dimension is relevant to the solution, compared to the condition where the subject's preferred dimension is irrelevant. Similarly, when two dimensions are relevant and redundant to the solution, subjects learn more about their preferred dimension than the nonpreferred dimension.

Dimensional preference has also been shown to influence transfer performance in concept shift studies. Reversal learning is facilitated when the preferred dimension is relevant (Caron, 1969; Heal, Bransky,

& Maniken, 1966). Similarly, extradimensional shift learning appears to be facilitated when the relevant shift dimension is dominant in terms of subjective preference (Caron, 1969).

Dimensional salience. Dimensional dominance in the above studies has been measured by various types of preference tests administered prior to the concept learning task. Several investigators have suggested that dimensional dominance can also be assessed by dimensional salience, measured in terms of relative cue similarity (Kendler, Basden, & Bruckner, 1970; Kendler, 1971; Smiley, 1972a). That is, the larger the relative difference between cues on a particular dimension relative to the difference between cues on another dimension, the greater the relative salience of that dimension. Shepp and Zeaman (1966) have demonstrated that the number of trials required for solution of a simple discrimination problem decreases as the physical differences between the cues increases. Detailed examination of their data reveals that the performance difference occur during the initial stage of discrimination learning, a period characterized by random responding, during which time the appropriate attending response is theoretically being strengthened.

Other investigators have also manipulated dimensional salience in a two-dimensional task by varying the relative cue similarity of the two dimensions. Campione (1969) reports that relatively large differences between cues on the dimension of size, compared to differences between the stimulus values on color and form dimensions, results in significantly faster learning when size is the relevant dimension. Shepp and Howard (1973) used the dimensions of tint and hue in order

to carefully vary physical differences along these dimensions. Their results indicate that tasks in which the relevant dimension is relatively more salient than the irrelevant dimension are learned more slowly than are tasks with either the relevant dimension high in discriminability relative to the irrelevant dimension, or tasks with both the relevant and irrelevant dimensions of high discriminability. Smiley (1972a) has also observed that rate of discrimination learning is related to both preference, measured by prior preference tests, and relative cue similarity of the relevant and irrelevant dimensions. Learning is faster when the relevant dimension is more preferred than the irrelevant dimension, and also when the cue differences along the relevant dimension are greater than along the irrelevant dimension.

Dimensional salience also influences transfer performance. Extra-dimensional shift learning is facilitated when the relevant dimension is more salient than the irrelevant dimension (Campione, 1969; Shepp & Howard, 1973). There is some question, however, as to the effects of dimensional salience on intradimensional shifts. Campione (1969) reports that relative salience of the relevant and irrelevant dimensions does not affect the speed of intradimensional shift solution. Similarly, Eimas (1966a) obtained no differences in intradimensional shift performance as a function of relative ease of learning about the relevant and irrelevant dimension. On the other hand, Shepp and Howard (1973) report that the speed of intradimensional shift learning is slower when the irrelevant dimension is more salient than the relevant dimension, compared to the condition where the relevant dimension is more salient or of equal salience than the irrelevant dimension.

It is apparent, then, that the relative preference or salience of the relevant and irrelevant dimensions is one factor which influences the speed of reversal, extradimensional, and possibly intradimensional shift learning. In addition, there is evidence that the percentage of subjects choosing a reversal shift in an optional shift procedure is influenced by the relative salience and relative preference of the relevant and irrelevant dimensions, in that more subjects reverse rather than execute a nonreversal shift when the relevant dimension is more salient or preferred compared to the irrelevant dimension (Smiley, 1972b, 1973). Heal, Bransky, and Maniken (1966) have suggested that the contradictory results concerning reversal-extradimensional shift comparisons may be due to confounding from individual subject preferences.

Status of the Irrelevant Dimension

In many concept attainment studies, two or more stimulus compounds are presented simultaneously on each trial to which the subject must respond by selecting one of the compounds. Each stimulus compound consists of a value from the relevant and the irrelevant dimensions. On each trial, the stimulus compounds differ with respect to the stimulus values of the relevant dimension. However, the stimulus values of the irrelevant dimension may vary within a trial, vary between trials or be constant within a trial, or may be constant on all trials. In the initial evaluation of reversal-extradimensional differences, many of the early studies differed with respect to this variable (e.g., Dickerson, 1966; Kendler & Kendler, 1959; Kendler, Kendler, & Wells, 1960;

Marsh, 1964). Since variability of stimulation is theoretically assumed to increase the probability of attending (Eimas, 1965), it is reasonable to infer that the status of the irrelevant dimension may influence shift learning. Recent studies have shown that this procedural difference may, indeed, be an important factor in determining the direction of reversal-extradimensional differences.

Dickerson, Wagner, and Campione (1970) trained kindergarten children in a two-choice simultaneous discrimination task, in which the stimulus values of the irrelevant dimension varied within trials. Following training, the subjects were shifted to a reversal, extradimensional, or intradimensional shift, with the irrelevant dimension either variable within or variable between trials. New stimulus values along both dimensions were used in the shift task. No differences in shift performance were found in the variable-between condition. In the variable within condition, however, the extradimensional shift was significantly slower to learn than both the reversal and intradimensional shift, which did not differ from each other. Dickerson et al. (1970) conclude that the contradictory results obtained by Dickerson (1966) of faster reversal learning than extradimensional learning, and Kendler and Kendler (1959) of faster extradimensional learning than reversal learning, might be explained by the presence of a variable within irrelevant dimension during shift in the former study and a constant irrelevant dimension in the latter.

Tighe and Tighe (1967) also examined the effects of a constant and variable within irrelevant dimension in shift. Four year olds and ten year olds were trained on a two-choice simultaneous discrimination

with the irrelevant dimension variable within trials. Following criterion, the subjects were shifted to a reversal or an extradimensional shift, with the irrelevant dimension variable within or variable between trials. The same stimulus cues were used in training and shift. The ten year olds performed equally well on reversal and extradimensional tasks when the irrelevant dimension was constant. Under variable within conditions, however, they learned the reversal task significantly faster than the extradimensional task. Performance on both types of tasks was superior under the condition of a constant irrelevant dimension. These data duplicate those of Dickerson et al. (1970). The four year olds, however, found reversal more difficult than an extradimensional task, regardless of whether the irrelevant dimension was variable within or variable between trials.

In a comparison of performance under different types of extradimensional and nonreversal shifts in kindergarten children, Dickerson (1967) reports that learning was faster when the irrelevant dimension was constant within trials relative to performance when the irrelevant dimension was variable. Further, under both conditions of variable within and variable between, there were no differences in shift performance as a function of whether the irrelevant dimension was novel to the subjects, or had been present in the training phase as the irrelevant dimension. That is, the presence of an irrelevant dimension which varies within trials, regardless of whether it is familiar or novel to the subject impairs shift learning.

Number of Irrelevant Dimensions

The number of variable irrelevant dimensions in the stimulus

complex has been found to be a significant variable in determining the speed of acquisition of the solution, a relation also predicted by attentional models of learning. Several concept identification studies using adult subjects have reported a linear increase in the number of errors as the number of irrelevant dimensions increases (Archer, Bourne, & Brown, 1955; Bourne & Haygood, 1959, 1961). Similar results have been reported with young children in concept identification paradigms (Osler & Kofsky, 1965) and in two dimensional simultaneous discrimination procedures (Eimas, 1966b; Tighe & Tighe, 1969). Reversal learning has also been reported to be retarded by the presence of variable irrelevant dimensions during the shift task (Eimas, 1966b; Tighe & Tighe, 1969).

Amount of Original Training

Another variable that has been hypothesized to influence the probability of attending to a dimension is overtraining of a response to that dimension. The data, however, concerning overtraining effects, are not very clear. Overtraining generally facilitates reversal learning in adults and older children (see Wolff, 1967). With younger children, some studies have reported facilitating effects in reversal learning (Cross & Tyler, 1966; Eimas, 1966b; Youniss & Furth, 1965); other studies have reported no effects (Mumbauer & Odom, 1967; Stevenson & Weir, 1959), while one study (Eimas, 1966b) reports negative transfer from overtraining, in kindergarten children. Overtraining may interact with the salience of the relevant and irrelevant dimensions in affecting reversal performance. When the relevant dimension

is not as salient as the irrelevant dimension, overtraining appears to facilitate reversal learning; however, overtraining appears to have no significant effect when the relevant dimension is highly salient (Eimas, 1966b; Mumbauer & Odom, 1967).

Overtraining also appears to facilitate intradimensional shift learning in adults and older children (Eimas, 1966b; Garber & Ross, 1968; Uhl, 1966). Eimas (1966a) and Heal (1966) have found facilitating effects in kindergarten children. Both of these studies gave relatively large amounts of overtraining. On the other hand, Shepp and Howard (1973), Garber and Ross (1968), and Mumbauer and Odom (1967) report no effects of overtraining.

Overtraining has been hypothesized to increase the probability of attending to the relevant dimension in the task, and thus increases the probability that the relevant dimension will be attended during reversal learning, facilitating performance. According to this rationale, overtraining should hamper extradimensional shift learning. Empirical evidence indicates that overtraining facilitates extradimensional shift learning in adults. Similarly, positive transfer effects in extradimensional shift performance have been reported by Eimas (1966a) and Garber and Ross (1968) in young children. Other studies have reported no significant transfer effects (Furth & Youniss, 1964; Marsh, 1964; Shepp & Howard, 1973; Tighe & Tighe, 1965). It is possible, therefore, that the positive transfer effects found in reversal and intradimensional shift performance attributed to increased probability of attending to the relevant dimension, may in fact be due to transfer of nonspecific effects.

Summary

The attentional model of discrimination learning and concept attainment has garnered a substantial amount of support in the literature (see reviews by Wolff, 1967; Shepp & Turrisi, 1967; and Esposito, 1975). Its success would seem to be due to its simplicity. There are, however, two difficulties with the model. The first concerns the assumption of an immediate perception of dimensionality; that is, the subjects are assumed to make attending responses to dimensions of stimulation, and not to specific aspects of the stimulus complex. There is some evidence which suggests that young children are not under dimensional control, but rather are under the control of specific stimulus compounds (Johnson & White, 1967; Rogers & Johnson, 1973; Tighe & Tighe, 1972). Secondly, the model assumes a hierarchy of probabilities of attending responses, such that certain dimensions are attended to more frequently than are others. However, the model does not specify the reasons for developmental changes in the probability of attending to certain dimensions, along both the physical continua, or linguistic and analytic dimensions.

3. Perceptual Differentiation Model

Differentiation theory, as propounded by Tighe and Tighe (1966, 1972) emphasizes the role of perceptual processes in discrimination and concept learning. They point out that discrimination learning involves two processes, perceptual learning and associative learning. Perceptual learning, in this case, refers to an increase in sensitivity to the stimulus variables present in the stimulus complex, that is,

the ability to differentiate the distinguishing features of the stimulus complex. Further, perceptual learning is assumed to be mainly a function of experience. Age differences in ease of discrimination and concept attainment, from this point of view, are hypothesized to reflect different levels of perceptual learning, that is, differences in the nature of the effective stimulus as perceived by the subject (Tighe & Tighe, 1966).

The level of perceptual learning attained by a subject determines which properties of the stimulus objects will be associated with reinforcement. Thus, if the subject has not isolated the relevant distinguishing features of the stimulus complex, he may relate the specific properties of the stimulus object to reinforcement. On the other hand, if he has isolated the relevant distinguishing features of the stimulus complex, he will detect the invariant relationship between the dimensional attribute and reinforcement. In other words, a subject may discriminate on the basis of the object-reward relations of the task, or on the basis of the dimension-reward relations of the task. Further, both aspects of stimulation are processed concurrently, and thus, both control behavior, although the degree to which one or the other may control choice behavior depends on a number of subject and task variables, such as prior experience and salience of the task dimensions (Tighe & Tighe, 1972).

Tighe and Tighe (1966) have suggested that the observed developmental differences in reversal and extradimensional learning may be a function of the level of perceptual learning exhibited by the subject. More specifically, they propose that, when a subject discriminates on

the basis of object-reward relations, each simultaneous presentation of the two stimulus compounds in a two-dimensional problem (referred to as a stimulus pair) is learned as an independent problem. The relative ease of extradimensional over reversal learning is greater in this case, since only one of the stimulus pairs is changed in the extradimensional task and thus only one subproblem must be relearned. In the reversal task, however, both of the stimulus pairs are reversed, and thus requires more time for criterion to be attained. For those subjects who have isolated the relevant feature of the task, reversal learning proceeds at a faster rate than extradimensional learning, since the relevant dimension remains relevant during the reversal shift, and the subject need only learn about the relation between the one aspect of the dimension and reward, while in an extradimensional shift, he must focus on a new relevant feature before learning the appropriate stimulus-reward relationship.

The Tighes have gathered substantial evidence to support the hypothesis that a basic process of discrimination learning is perceptual differentiation. They propose that "a condition which fosters perceptual differentiation of the distinguishing features within a discrimination task might increase the ease of reversal shift relative to extradimensional shift learning in young children" (Tighe & Tighe, 1972, p. 140). As a test of this hypothesis, Tighe (1965) gave five to six year olds perceptual pretraining with stimuli that were to be used in a subsequent discrimination shift task. The pretraining took the form of nonreinforced same-different judgments between a standard stimulus and a series of successively presented stimuli which varied

in either one or two dimensions simultaneously. Another group received training on an unrelated task to control for nonspecific transfer effects. Following pretraining, the subjects were trained on a two-choice simultaneous discrimination task, followed by a shift to a reversal or nonreversal task. The results supported the differentiation hypothesis. Perceptually pretrained reversal subjects reached criterion in significantly fewer trials than either the perceptually pretrained nonreversal subjects, the control reversal, and nonreversal subjects. The latter three groups did not differ significantly from each other.

Further research has demonstrated that the amount of perceptual pretraining, the number of stimulus values per dimension, and the type of perceptual response required significantly influences reversal learning, while the presence or absence of reinforcement or the manner of stimulus presentation has no influence on reversal training (Tighe & Tighe, 1968). The addition of verbal labelling to perceptual pretraining does not significantly improve reversal learning relative to perceptual pretraining alone (Tighe & Tighe, 1969, 1970). The effectiveness of perceptual pretraining also depends on whether the standard stimulus and comparison stimulus vary simultaneously on one or both dimensions of the task. Unidimensional judgments in pretraining significantly facilitate subsequent concept attainment (Osler & Madden, 1973), and reversal learning (Tighe & Tighe, 1972), while bidimensional judgments have no effect on subsequent performance.

A recent area of research has provided the additional evidence

that the observed developmental trend in conceptual abilities is related to developmental levels of perceptual learning. In a subproblem analysis of discrimination shift learning, Tighe, Glick and Cole (1971) re-examined the shift data from an earlier study (Tighe & Tighe, 1967) in which four and ten year old children were given reversal and extradimensional shift problems under conditions of a variable irrelevant dimension. Overall analysis of the earlier study indicated that the ten year olds acquired the reversal task faster than the extradimensional task, while the four year olds learned the extradimensional task faster than the reversal task. In an examination of the acquisition functions of the individual stimulus pairs (or subproblems) for both age groups, differences in the manner in which the two age groups acquired the reversal and extradimensional tasks became apparent. In the case of the four year olds, performance on the unchanged stimulus pair of the extradimensional task was maintained at a high level of correctness, while performance on the changed stimulus pair of the extradimensional task, as well as the two reversal subproblems, initially showed a severe drop in the percentage correct, followed by a gradual increase. Subproblem learning functions for the ten year olds indicated that performance on both stimulus pairs of the reversal and extradimensional tasks dropped substantially, with the reversal learning functions quickly overtaking the extradimensional learning functions. Tighe & Tighe (1972) interpret these data as demonstrating differences in the nature of the effective stimulus. Independent subproblem learning, shown by the four year olds, is suggested to occur when behavior is under the control of the object-reward relations of the task, whereas

interdependent subproblem learning, shown by the ten year olds, occurs when the subject detects and uses the dimension-reward relations of the task.

Summary

There has been little critical evaluation of the perceptual differentiation theory proposed by the Tighes. The reason for this lack of criticism may be due to the theoretical similarity of this theory with both the attentional model and the mediational model. The perceptual differentiation theory incorporates elements of both positions, and provides an eclectic approach to the study of the ontogeny of conceptual behavior.

THEORETICAL ORIENTATION AND HYPOTHESES

Each of the predominant explanations of developmental differences in concept attainment has received support at the empirical level. There is, however, a great deal of contradictory evidence, particularly with respect to the concept shift literature. Although some studies support the notion of a developmental transition in the learning processes utilized in concept learning, other studies implicate the importance of such variables as dimensional dominance and salience, the number of irrelevant dimensions, and the status of the irrelevant dimension, all of which have been assumed to influence attentional processes.

A possible resolution of these different approaches lies in a theory advanced by White (1965, 1966). He has proposed a model of the ontogeny of learning which assumes two parallel levels of functioning, associative and cognitive, arranged in a competitive hierarchy. These two levels are conceived of as "temporally stacked", with the faster associative mode having precedence, on any given trial, over the cognitive mode. The critical factor for the transition to a cognitive level of function is the capability to inhibit faster associative functions. Younger children, according to this model, utilize the faster associative, or single-link processes. Between five and seven years, however, various maturational and environmental factors lead to the inhibition of lower level functioning in order that the higher level, the cognitive level, may operate. Both levels of functioning

remain available to older subjects, and under certain disinhibiting conditions, the faster associative mode may reappear. In summary, then, this model makes two assumptions. First, young children engage in short-latency associative behavior which interferes with longer-latency cognitive behavior. Secondly, young children are deficient in inhibitory control.

Temporal Factors in Mediated Transfer

The notion that overt response latency is related to the type of conceptual behavior exhibited by a subject has also been advanced by Kagan (1966). Certain children, termed 'reflective', take longer to respond, and make fewer errors on a matching test, tend to be more efficient problem solvers and make more analytic responses, compared to impulsive children who respond faster and make more errors.

Temporal factors in mediated transfer have been studied in adults by means of the paired-associate paradigm, together with time-limits. The results indicate that increasing the anticipation interval tends to increase the amount of mediation occurring in the transfer phase (Runquist & Marshall, 1963; Schultz & Lovelace, 1964; Schwenn & Underwood, 1965). Richardson (1968) has demonstrated that the recall latency of a mediated response is an increasing function of the number of units in the chain. Thus, following B-C, C-D list learning, subjects instructed to recall the corresponding D word on presentation of the B word take longer to respond than when presented with C words. In addition, if subjects are required to respond within a short interval of time, say one second, performance on a final list, S-D, consisting

of stimuli and responses which have been associated in a chaining fashion (B-C, C-D, S-B, S-D) is significantly poorer than under a longer anticipation interval of four seconds. It would appear, then, that mediated behavior may require more time than would single-link associations.

Temporal factors have been studied in relation to mediation deficiency by Peterson (1973a) in second graders and college students. The design employed an acquired equivalence of cues paradigm in which a single verbal response was paired with two visual stimuli, following which a motor response was paired with one of the visual stimuli, and the second visual stimulus was presented to test for mediated transfer. Time limitations of .5, .88, 1.36, and 5.1 seconds were placed on responding for different groups of subjects during the last half of the second phase and during the transfer test. Mediating subjects were identified as those subjects who made 8 out of 10 correct, on-time mediating responses. Single-link subjects were classified as those subjects who made 8 out of 10 correct on-time responses to the training stimuli, but failed to make 8 out of 10 mediating responses. Those subjects who failed to meet either of the two above criteria were labelled inconsistent. The results from the college students indicate that, with shorter time limits, the proportion of single-link subjects increases significantly, while the proportion of mediating subjects decreases. For second graders, the proportion of mediating subjects decreases significantly with increasing time restraints, while the proportion of single-link subjects remains constant. It is

possible that many of the subjects in the second grade had not reached the cognitive level of learning, and thus responded in a single-link fashion regardless of the time interval. These data provide evidence that both S-R and mediational modes of learning co-exist in adults, and that mediational modes of behavior in both children and adults are a function of response time-limits.

A subsequent study by Peterson (1973b) has demonstrated that under the same conditions as above, requiring second grade children to delay their response for three seconds increases the amount of mediation observed. She concludes that "one factor responsible for children's mediation deficiency is a slow mediation latency relative to an overt response latency" (p. 2).

Inhibitory Deficit Hypothesis

One implication of an inhibitory deficiency hypothesis is that young children should be more distracted by irrelevant stimulation than older children. This hypothesis has frequently appeared in the literature (Eimas, 1966b; Osler & Kofsky, 1965; Shepp & Howard, 1973). Several studies have reported that increasing the number of irrelevant dimensions in the task significantly impedes performance in young children (Eimas, 1966b; Osler & Kofsky, 1965; Tighe & Tighe, 1969; Zelniker, Oppenheimer, & Renan, 1975). The effect diminishes with increasing age. Older children make fewer errors on tasks with several irrelevant dimensions than do younger children (Osler & Kofsky, 1965; Zelniker, Oppenheimer, & Renan, 1975). Osler and Kofsky (1965) also report that those young children who failed to solve the problem

appeared to be responding to the irrelevant dimensions. Eimas (1966b) reports that increasing the number of irrelevant dimensions in a spatial task significantly hampered performance by kindergarten children but did not affect performance by second graders. Second graders, however, were influenced significantly by increased irrelevant dimensions in a visual discrimination. Since a spatial discrimination is generally easier than is a visual discrimination, these data may reflect a developmental trend in the ability of young children to reject irrelevant stimulation.

The negative effect of the presence of irrelevant dimensions on the acquisition rate of young children appears to interact with the relative salience of the relevant and irrelevant dimensions. As noted earlier, young children acquire the solution to a problem faster under the condition where the relevant dimension is more salient than the irrelevant dimension compared to the condition where the relevant dimension is less salient than the irrelevant dimension. The magnitude of the effect, however, is related to the developmental level of the subjects; the older the subjects, the smaller the difference in solution rate under the above two conditions (Odom & Mumbauer, 1971; Smiley, 1973). Thus, there appears to be a developmental process which increases the probability that a subject will assimilate information equally well from either a dominant or nondominant dimension. All age groups sampled in these two studies solved the problem equally at the same rate when the relevant dimension was dominant. However, when the relevant dimension was nondominant, the younger age groups

were significantly slower to reach criterion than were the older children for whom the dominance of the relevant dimension did not influence their performance.

The above evidence suggests that younger children may have difficulty solving problems with nondominant relevant dimensions due to the interfering effects of competing responses made to the more dominant, though irrelevant dimension. The results of several studies by Johnson, Warner, and Silleroy (1971) support this contention. In the first study, five year olds were considerably slower than eight year olds in reaching criterion when the relevant dimension was less dominant than the irrelevant dimension. When the dominant irrelevant dimension was held constant on all trials in a second study (and thus did not attract the attention of the subjects), the five year olds solved the task as quickly as did other five year olds who solved tasks in which the relevant dimension was more dominant than the irrelevant dimension. These former five year olds also solved the problem faster than did those five year olds for whom the relevant dimension was the same nondominant dimension, but for whom the dominant irrelevant dimension varied within trials, and thus elicited competing attentional and choice responses.

A third study indicated that prior training on problems with a nondominant relevant dimension will facilitate later problem solving with other nondominant relevant dimensions. This latter study is interesting in that the pretraining problems involved different dimensions than the ones used in transfer. Again these data suggest that the difficulty of young children in solving problems with nondominant

dimensions stems from their tendency to respond to the dominant, irrelevant dimension. It might be pointed out here that Eimas (1967) has also reported that learning is slower when the irrelevant dimension is variable within trials, especially in the case where the relevant dimension is less salient than the irrelevant dimension.

Odom and Corbin (1973) have observed that multidimensional problem solving is impaired by unidimensional processing of highly salient dimensions. The effect is stronger in younger children than in older children. On the other hand, when the task does not require multidimensional processing but can be solved on the basis of attending only to the most salient dimension, age differences are not significant.

Based on a modified version of White's (1965) proposal, the general hypothesis to be examined in these studies is as follows: the underlying factor of the observed developmental differences in concept attainment is mediational deficiency on the part of young children, in the age range four to five years, due to their tendency to respond impulsively to highly salient forms of stimulation, which interferes with learning in the situation where the relevant dimension is not as salient as the irrelevant dimension(s). Further, their tendency to respond impulsively serves to terminate the response before cognitive functioning can occur. Thus, their behavior, under conditions of a nondominant or nonsalient relevant dimension, either during original learning or during shift, will be inferior to that of older children, who utilize mediated or cognitive modes of learning.

Two deductions follow from this hypothesis. First, if young children are impulsive and engage in short-latency behavior, then

the imposition of short time-limits on responding should not significantly affect their performance on a concept attainment task. On the other hand, if older subjects utilize long-latency mediated modes of learning, short time-limits should have a detrimental effect on their behavior. Indeed, requiring the older children to respond within a short period of time should reduce the incidence of mediated behavior while increasing the probability of single-link behavior.

Secondly, if young children are more reactive to highly salient forms of stimulation, and lack the ability to restrain responses to salient or preferred stimuli, it follows that the manipulation of relative salience of the relevant and irrelevant dimensions will significantly influence concept attainment performance in these children. On the other hand, older children are assumed to be more adept at ignoring irrelevant stimulation and focussing on the relevant source of information. The relative salience of the relevant and irrelevant dimensions, therefore, should not be a significant factor controlling rate of concept attainment for these children.

The implications of the above deductions were examined in two studies reported below. Both studies investigated concept attainment in four year old and ten year old children. Two independent variables were manipulated in each study, response time-limits, and the salience of the irrelevant dimension relative to the relevant dimension. In both studies, salience was defined in terms of the degree of relative cue similarity. That is, a dimension is termed salient when the physical difference between the values on that dimension is much greater compared to the difference between the cues on an alternate dimension, which is

referred to as the nonsalient dimension.

A matching to sample method was used in both studies. This paradigm was chosen over the two-choice simultaneous discrimination procedure for two reasons. First, a simultaneous discrimination learning situation involves at least two distinct processes; first, abstracting the relevant dimension, and, secondly, learning an approach response to one set of cues and an avoidance response to another set of cues. A matching-to-sample procedure involves only the selection of the relevant dimension, and making an identity match between the standard and one of the comparison stimuli. Secondly, the matching-to-sample procedure allows one to evaluate and measure more directly the potential competing influences of a salient, though irrelevant dimension. On each trial, a match can be made on the basis of the relevant or irrelevant dimension. By examining response sequences on a series of trials, the influence of the relative salience of the irrelevant dimension on response latency and stimulus choice can be evaluated.

STUDY 1

The first study was designed to investigate the effects of time-limits and relative salience of the relevant and irrelevant dimensions on concept attainment by four year old and ten year old children, using traditional stimulus patterns. The relevant and irrelevant dimensions in this study were ones which have been traditionally used by researchers in this area, and are based on physical similarities in size and colour.

The study was conducted in three stages. During the first stage, subjects were given a preference test and classified as either size or colour dominant. The second stage consisted of a concept attainment task, in which the subjects had to make an identity match based on the dimension designated as relevant. During this stage, one half of the subjects were allowed time-limits of 1.2 seconds, while the other half were given 10 seconds in which to respond. Furthermore, one half of the subjects in each of the two above time-limit conditions were presented with a task in which the irrelevant dimension was more salient than the relevant dimension (Salient condition). For the remaining half of the subjects, the irrelevant dimension was less salient than the relevant dimension (Nonsalient condition).

Immediately following criterion performance, subjects were given an intradimensional shift task (both the relevant and irrelevant dimensions were the same as in the first task). Half of the subjects in each condition of the first problem were trained with a shift problem

in which the irrelevant dimension was more salient than the relevant dimension (Shift-salient condition); for the remaining half of the subjects, the irrelevant dimension was less salient (Shift-nonsalient). No time-limits were imposed during the shift task.

An analysis of the first problem performance data was expected to reveal a significant interaction between the effects of age, time-limits, and the relative salience of the irrelevant dimension. Young children, who have been assumed to be fast responders and single-link processors, should not be significantly influenced by the imposition of time-limits on responding. On the other hand, their performance was expected to vary significantly as a function of the relative salience of the relevant and irrelevant dimensions. Under nonsalient conditions, they were expected to perform similarly to the older children, since they have been assumed to respond only to the most salient information and need only to learn an identity match between the two stimulus values on that dimension. Under salient conditions, however, they were expected to perform considerably poorer than the older children, since they would be required to learn more specific identity matches between the appropriate stimulus compounds than would older children who were presumed to respond to the dimensional aspects of the stimuli.

The performance of the older children was expected to be significantly impaired only under the combined condition of short time-limits and a salient irrelevant dimension. That is, under short time-limits, these older children should be forced to utilize more basic associative processes, reducing the amount of mediated behavior and increasing the incidence of single-link behavior. In this case, the relative salience

of the irrelevant dimension would be an important factor in determining speed of solution, just as it is assumed to be in the case of younger children.

The results of the shift phase were expected to provide additional evidence of a developmental transition of learning processes. Recall that the shift phase consisted of an intradimensional shift task. Thus, although new stimulus values were used along both dimensions during shift, for each subject, the same dimension was designated relevant in both the first problem and the shift problem. It was argued that for any subject who had reached criterion on the first problem by using mediational or conceptual processes, varying the relative salience of the same relevant dimension during the shift task would not have any effect on the speed of attaining criterion in the shift task, since the same mediating response could be used in both cases. Subjects who had utilized single-link processes would be required to learn a new set of associations during the shift problem, and would be sensitive to the relative salience of the relevant and irrelevant shift dimensions.

Analysis of the shift phase data was expected to result in significant differences between the shift-salient and shift-nonsalient conditions for all of the four year olds. In the case of the ten year olds, significant differences as a function of shift-salience were expected only in those conditions which learned under 1.2 second time-limits during the first problem. The short time-limits, in this case, should have functioned to prevent these subjects from employing mediational processes during problem solving, and forced them to use single-

link processes.

Method

Subjects. The younger group of children consisted of eighty nursery school children selected from St. Martin's Nursery School in Ottawa, Canada. The ages of these children ranged from 48 to 60 months, with a mean age of 53 months. The second group of children were selected from the fourth and fifth grades of an Ottawa elementary school. The age range of these children varied from 109 to 142 months, with a mean of 128 months. Both schools were located in the same middle-class suburban area of Ottawa, Canada.

Experimental design. The design is a factorial combination of five variables: age (four and ten year olds), relative salience of the irrelevant dimension (salient and nonsalient), response time-limits during initial training (1.2 seconds and 10 seconds), relative salience of the irrelevant shift dimension (shift-salient and shift-nonsalient), and dimensional dominance (dominant and nondominant). Ten subjects were assigned to each of the sixteen conditions.

The experiment was run in three phases: (a) a preference test of the dimensions to be used in the tasks, (b) practice and initial training, and (c) shift learning. Following the preference test, each subject within each age group was randomly assigned to one of the eight conditions, with the restriction that each cell contain an equal number of dominant and nondominant subjects as well as an equal number of females and males. Half of the subjects within each condition were trained with colour as the relevant dimension, while for the remaining half,

size was the relevant dimension.

Stimulus materials and apparatus. The stimuli for the preference test consisted of circles, either one or three inches in diameter, coloured orange or brown and presented on 8 inch by 8 inch white cards. The stimuli were arranged in a triad on each card with the standard stimulus at the apex, and the comparison stimuli on the bottom row. A set of eight cards was constructed, representing all possible combinations of size and colour, when values of the comparison stimuli along each dimension are opposed to that of the standard, and counterbalanced for position.

The stimuli used in the practice problem were photographs of three common objects, a cup, whistle, and a key. The stimuli were white and measured between 4 and 6 cm. in width and height. Three stimuli were arranged in a triad and photographed on a black background. Six slides were constructed, each containing two identical stimuli while the third stimulus was selected from the remaining two stimuli of the set, so that each object was paired with each other object an equal number of times.

The training stimuli were photographs of squares measuring 6, 5, or 2 cm. along the edges. These were cut from Pantone Color Papers in three shades, matched for saturation value: green (#354), red (#206), and pink (Rhodamine red). All stimuli were photographed on a black background. Each training slide contained three stimuli arranged in a triad, with the standard stimulus at the apex, and two comparison stimuli on the bottom row. On half of the slides, both of the comparison stimuli differed from the standard in respect to values along one

dimension; that is, cue values were opposed along each dimension. Thus, on any one slide the standard stimulus might be a 6 cm. red square, while the comparison stimuli might be a 6 cm. green square and a 5 cm. red square. On the other half of the slides, one of the comparison stimuli was identical to the standard stimulus.

Two stimulus sets were constructed. One set consisted of 6 and 2 cm. squares in pink and red, in which case size was deemed more salient than colour. The other set consisted of 6 and 5 cm. squares in red and green; in this set, colour was more salient than size. Each set contained 16 slides, representing every possible combination of stimulus colour, size, and position.

The shift stimuli were constructed in the same way as were the training stimuli. Two sets were constructed, one set consisting of 4 and 1.5 cm. squares colored blue and aquamarine, with size more salient than colour, while the other set consisted of 4 and 2.9 cm. squares colored in blue and yellow, so that for this set colour was more salient than size. The squares were cut out of Pantone Color Papers in blue (Reflex blue), aquamarine (Process blue), and yellow (Yellow), with each hue matched for saturation value. The relative difference between the hues was the same as for those of the training stimuli. Similarly, the relative difference in area of the squares was the same as for those of the training stimuli.

The apparatus consisted of a metal stimulus panel, painted in flat gray, and measuring 12 inches by 12 inches, with an 8 inch by $5\frac{1}{2}$ inch window in the center. Three plexiglass panels, one 4 inches by $2\frac{1}{2}$ inches, and two 3 inches by $2\frac{1}{2}$ inches, were fitted into the window,

with microswitches attached to the back of them. A 6 inch horizontal ledge, with an 'X' marked in the center, was placed at the bottom of the stimulus panel. A Kodak slide projector was placed behind the stimulus panel. Stimulus presentation time and intertrial interval were controlled by an Interval Clock Timer, and response latencies measured by means of a Hunter Timer.

Procedure. Preference testing was conducted three days prior to experimental training. Individual subjects were brought to a quiet room, and seated at a table in front of the experimenter. A card containing the preference stimuli was placed in front of the subject with the following instructions: "I am going to show you some pictures. I want you to point to two of them that look the same to you." If the subject did not understand, the experimenter pointed to the standard and said, "Which one of these (pointing to the comparison stimuli) looks more like this one?" Eight cards were presented to the subject. The subjects were classified as either size or colour dominant if they made six or more consistent choices from the respective dimension.

First problem. The experimental session was conducted in a quiet, dark room close to the classrooms. Each subject was tested individually. As soon as the subject was seated comfortably in front of the apparatus, the experimenter asked the subject to indicate which hand he normally used for drawing or writing. The session was then introduced with a simple matching-to-sample practice problem. The practice stimuli were projected onto the windows of the stimulus panel in front of the subject, and the experimenter said, "We are going to play a game with these pictures. Can you point to one of the pictures

down here (pointing to the pictures in the bottom windows) that looks like the picture up here (pointing to the top window)? . . . Good. Now push the picture. Good. From now on, I want you to push the picture down here that looks like the one up here. Push it hard to turn it off." If the subject pressed the incorrect picture, the trial was repeated with the experimenter repeating the instructions. This procedure was continued until the subject made six correct responses. During the next phase of practice, the appropriate time-limits were introduced. The experimenter then said, "That's very good. From now on, I want you to push one of these pictures before they turn off. I'm going to show you how long you have before the pictures turn off. See? (demonstrating picture duration) O.K. Let's see if you can push the right picture before it goes away. Remember, I want you to push the picture down here that looks like the one up here, before they turn off." Practice trials were continued until the subject made six correct on-time responses. The practice slides were presented in a random order with the restriction that each one occurred once in a block of six trials. A Gellerman series (Fellows, 1967) was used to counterbalance the position of the correct stimulus.

Immediately following practice, the experimenter turned to the subject and said, "That was really good. Now, we're going to play the same game, but this time I'm going to show you some new pictures. These pictures are a little different from each other. So I want you to see if you can guess which one of these (bottom) pictures goes with the picture up here. Every time you guess the right picture, I am going to put a marble in this can for you. So let's see if you can guess the

right picture, every time so that you can get a marble every time you push a picture. And remember, you have to push the right picture before it turns off, before I can give you a marble. O.K.? If you can get a marble every time, I've got a prize for you." The instructions for the ten year olds were similar in content, but not as simplified. They were told that when they guessed the correct picture, and if they pushed before the pictures turned off the screen, the experimenter would drop a marble in the can to indicate a correct response. Incorrect responses were followed by the experimenter telling the subject, "No, that was the wrong picture." If the subject pointed towards the correct picture, but was too slow, the experimenter informed him that he was too slow, and to try again a little faster. The slides turned off as soon as the subject pushed the panel, or when the time-limit interval was up.

Subjects were rewarded for matching on the basis of the dimension, size or colour, designated by the experimenter as relevant for that subject. The irrelevant dimension was held variable within trials. Training was continued until a criterion of 12 out of 12 correct, on-time responses was reached, with an upper limit of 96 trials.

The stimulus set for subjects assigned to the salient condition with colour as the relevant dimension consisted of 6 cm. and 2 cm. squares colored in red and pink. For those subjects assigned to size as the relevant dimension, the salient stimulus set consisted of 6 cm. and 5 cm. squares in red and green.

In the case of the nonsalient conditions, when colour was relevant, the stimulus set consisted of 6 and 5 cm. squares in red and green;

when size was relevant, the stimulus set used was 6 and 2 cm. squares in red and pink.

Within each stimulus set, the order of presentation of the 16 combinations of stimulus events was randomly determined, with three restrictions. First, the position of the correct matching stimulus was arranged according to a Gellerman series, such that within every block of 16 trials, the position of the correct matching stimulus occurred equally often in each window, but no more than three times successively in the same window. Secondly, each of the 16 combinations occurred once within a block of 16 trials. Third, combinations in which the standard and one of the comparison stimuli were identical, and combinations in which both of the comparison stimuli differed from the standard, were ordered in such a way that no one type occurred more than three times in succession. Five different orders were predetermined, and two subjects, one for each dimension, were randomly assigned to each order.

Shift phase. Upon finishing the training phase, the subjects were informed that they would be presented with "some more pictures", and to continue to win marbles for each response. Training was continued until the subject made 12 out of 12 correct responses, with an upper limit of 48 trials.

For each subject, the dimension designated as relevant during the original training remained relevant during shift, although new stimulus values were presented on both dimensions. The stimulus set for those subjects assigned to the shift-salient condition consisted of 4 and

2.9 cm. squares in blue and yellow for size relevant subjects, and 4 and 1.5 cm. squares in blue and aquamarine for color relevant subjects. The stimulus sets for the shift-nonsalient conditions were 4 and 1.5 cm. squares in blue and aquamarine for size relevant subjects, and 4 and 2.9 cm. squares in blue and yellow for color relevant subjects. Stimulus orders were determined in the same manner as were those for training.

Subjects were rewarded with marbles for correct responses. No time-limits were imposed during shift.

The intertrial interval during both original training and shift was 6 seconds, during which a blank slide was projected onto the windows.

Results of Study 1

Several response measures were recorded from each subject during training on both the original problem and the shift problem. These consisted of (1) trials to a moderate criterion of nine out of ten correct ontime responses, (2) trials to the more stringent criterion of 12 out of 12 correct ontime responses, (3) number of errors, (4) number of omissions, and (5) response latency. The data of each of these response measures for each subject are given in Appendix 1.

First Problem

Trials to criterion, errors, and omission data. The data from these four response variables were analyzed together by means of a multivariate analysis of variance (MANOVA), and by separate univariate analyses of variance (ANOVA) on each of the first four response

variables. Preliminary examination of the data indicated that order of stimulus presentation had no influence on any of the response variables, and did not interact with any of the experimental or subject factors. Order therefore was not considered as a factor in subsequent analyses.

To assess the influence of the factors of interest in this study, the data from the four response variables were subjected to a $2 \times 2 \times 2 \times 2 \times 2$ MANOVA with relative salience, time-limits, shift-nonsalience, dominance, and age as between-subject factors in the analysis. The factor of shift-salience was included to determine whether there were any differences, during original training, between the shift-salience groups. A summary of this analysis is presented in Appendix 2, together with the summary of the univariate analyses in Appendices 3, 4, 5, and 6. The means of each response measure for each condition appropriate to these analyses are presented in Table 1.

Table 2 presents a summary of the significant effects revealed in the MANOVA, together with the respective significant effects revealed by the univariate analyses, and the results of the analyses for simple effects using one or more of the response measures.

As can be seen from Table 2, the multivariate analysis of variance yielded significant main effects for age ($F(4,125) = 29.73, p < .001$), time-limits ($F(4,125) = 23.694, p < .001$), and salience ($F(4,125) = 21.56, p < .001$). In addition, there were significant interactions between salience and age ($F(4,125) = 11.91, p < .001$), time-limits and age ($F(4,125) = 7.008, p < .001$), salience and time-limits ($F(4,125) = 4.174, p < .004$), and salience and dominance ($F(4,125) = 2.85, p < .026$).

Table 1

Means of Each Condition During the First Problem for Trials to a Moderate Criterion (TC-M), Trials to a Difficult Criterion (TC-D), Errors, and Omissions
Data in Study 1

	Nonsalient				Salient			
	1.2 sec		10 sec		1.2 sec		10 sec	
	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient
<u>TC-M:</u>								
<u>Four Year Olds</u>								
Dominant	35.6	36.0	11.0	11.6	65.0	77.8	28.6	68.4
Nondominant	19.8	53.8	9.4	9.6	82.6	96.0	78.6	54.4
<u>Ten Year Olds</u>								
Dominant	17.4	10.8	9.4	17.2	38.8	24.6	30.6	12.4
Nondominant	17.2	20.6	9.4	14.4	32.2	30.6	12.0	12.8
<u>TC-D:</u>								
<u>Four Year Olds</u>								
Dominant	32.8	50.0	17.4	18.0	73.8	88.2	34.6	74.4
Nondominant	32.0	62.8	13.6	14.6	83.6	96.0	80.0	62.4
<u>Ten Year Olds</u>								
Dominant	20.8	14.4	12.8	20.2	42.2	31.6	36.0	17.2
Nondominant	28.2	30.2	12.8	17.4	38.2	36.6	15.8	16.6

Table 1 (Continued)

	Nonsalient				Salient			
	1.2 sec		10 sec		1.2 sec		10 sec	
	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient
<u>Errors:</u>								
<u>Four Year Olds</u>								
Dominant	11.1	8.3	2.1	2.5	25.5	27.3	11.3	30.3
Nondominant	2.9	10.7	.9	1.1	31.9	41.3	38.5	23.9
<u>Ten Year Olds</u>								
Dominant	2.1	.9	.9	4.1	10.7	6.7	5.9	2.7
Nondominant	4.1	4.7	.9	1.9	9.1	10.3	1.9	3.1
<u>Omissions:</u>								
<u>Four Year Olds</u>								
Dominant	5.1	5.9	.5	.9	7.5	15.7	1.1	2.5
Nondominant	4.5	14.7	.5	.5	16.3	20.9	1.9	1.1
<u>Ten Year Olds</u>								
Dominant	2.9	1.3	.5	.5	3.9	2.7	.5	.5
Nondominant	2.3	1.7	.5	.7	2.5	3.6	.5	.5

Table 2

A Summary of the Reliable Effects in the Multivariate Analysis of Variance, Together with the Reliance Effects Reported in the Univariate Analyses of Variance, and the Results of the Analyses of the Simple Effects, for Trials to a Moderate Criterion, Trials to a Difficult Criterion, Errors, and Omission Data from Study 1

Reliable Effects in the MANOVA Reliable Effects in the Univariate Analyses
 (* = $p < .05$)

	TC-M	TC-D	Errors	Omissions
1. Age	*	*	*	*
2. Time-limits	*	*	*	*
3. Sallience	*	*	*	*
4. Sallience X Age	*	*	*	*
Simple Effects of:				
Sallience for 10 year olds				
Sallience for 4 year olds	(F = 93.09)**	*	(F = 106.21)	(F = 15.04)*
Age for salient group	*	*	*	*
Age for nonsalient group	(F = 91.93)		(F = 94.51)	(F = 34.73)*
				(F = 6.27)

Table 2 (continued)

Reliable Effects in the MANOVA

Reliable Effects in the Univariate Analyses
(* = $p < .05$)

	TC-M	TC-D	Errors	Omissions
5. Time-limits X Age	*	*	*	*
Simple Effects of:				
Time-limits for 10 year olds				
Time-limits for 4 year olds	*	*		* ($F = 84.57$)
Age for 1.2 sec group	*	*		* ($F = 61.63$)
Age for 10 sec group	*	*		
	($F = 54.66$)			
	($F = 16.48$)			
6. Sallence X Time-limits				*
Time-limits for sallent group				
Time-limits for nonsallent group				* ($F = 52.95$)
Sallence for 1.2 sec group				* ($F = 14.52$)
Sallence for 10 sec group				* ($F = 15.34$)

Table 2 (continued)

Reliable Effects in the MANOVA		Reliable Effects in the Univariate Analyses (* = $p < .05$)			
		TC-M	TC-D	Errors	Omissions
7. Saliency X Dominance					
Simple Effects of:					
Saliency for dominant Ss				*	
				($F = 22.90$)	
Saliency for nondominant Ss				*	*
				($F = 51.67$)	($F = 6.38$)
Dominance for salient group				*	
				($F = 4.60$)	
Dominance for nonsalient group					
8. Saliency X Time-limits X Age					
Simple Effects of:					
Saliency for 1.2 sec, 4 year old group		*	*	*	*
		($F = 43.48$)	($F = 38.37$)	($F = 50.68$)	($F = 23.19$)
Saliency for 10 sec, 4 year old group		*	*	*	
		($F = 49.70$)	($F = 57.81$)	($F = 55.60$)	
Saliency for 1.2 sec, 10 year old group		*	*	*	
		($F = 4.27$)	($F = 4.96$)		

Table 2 (continued)

Reliable Effects in the
MANOVA

	TC-M	TC-D	Errors	Omissions
Sallence for 10 sec, 10 year old group				
Time-limits for salient, 4 year old group	* (F = 11.07)	* (F = 13.34)		* (F = 73.59)
Time-limits for nonsalient, 4 year old group	* (F = 15.03)	* (F = 25.61)	* (F = 4.18)	* (F = 19.65)
Time-limits for salient, 10 year old group	* (F = 3.99)	* (F = 6.50)		
Time-limits for nonsalient, 10 year old group				
Age for 1.2 sec, salient group	* (F = 56.13)	* (F = 61.05)	* (F = 46.62)	* (F = 57.76)
Age for 10 sec, salient group	* (F = 36.84)	* (F = 45.06)	* (F = 47.89)	
Age for 1.2 sec, nonsalient group	* (F = 8.78)	* (F = 14.79)		* (F = 12.31)
Age for 10 sec, nonsalient group				

Table 2 (continued)

Reliable Effects In the
MANOVA

Reliable Effects In the Univariate Analyses (* = $p < .05$)		TC-M	TC-D	Errors	Omissions
9. Time-limits X Age X Dominance					
Simple Effects of:					
Time-limits for dominant, 4 year olds	*	(F = 12.59)	* (F = 20.34)	* (F = 3.96)	* (F = 21.68)
Time-limits for nondominant, 4 year olds	*	(F = 14.06)	* (F = 17.06)		* (F = 69.81)
Time-limits for dominant, 10 year olds					
Time-limits for nondominant, 10 year olds					
Age for 1.2 sec, dominant group	*	(F = 22.87)	* (F = 35.32)	* (F = 15.72)	* (F = 13.92)
Age for 10 sec, dominant group			* (F = 5.55)	* (F = 6.23)	
Age for 1.2 sec, nondominant group	*	(F = 32.18)	* (F = 32.68)	* (F = 20.12)	* (F = 54.46)
Age for 10 sec, nondominant group	*	(F = 14.97)	* (F = 19.12)	* (F = 18.80)	
Dominance for 1.2 sec, 4 year old group					* (F = 12.53)

Table 2 (continued)
Reliable Effects in the Univariate Analyses
(* = $p < .05$)

	TC-M	TC-D	Errors	Omissions
Dominance for 10 sec, 4 year old group				
Dominance for 1.2 sec, 10 year old group				
Dominance for 10 sec, 10 year old group				

* $df = (1,128)$ for all F ratios

Finally, two triple interactions were found to be reliable: the interaction between relative salience, time-limits, and age ($F(4,125) = 2.770, p < .029$), and the interaction between time-limits, age, and dominance ($F(4,125) = 3.188, p < .017$). No other significant effects were found; in particular, the main effect of shift-salience nor any interaction containing this factor were reliable, indicating that there were no differences between the shift-salience groups during original training.

In view of the significant interaction between age, salience and time-limits, any statements concerning the significant main effects and interactions between these factors must be qualified to some extent. An interpretation of these effects can be discerned from an examination of Figure 1, in which the means of each condition appropriate to the triple interaction between relative salience, time-limits, and age are shown for each response variable. It should be noted here that none of the univariate analyses of each response measure yielded a significant result for this interaction (see Table 2, p. 59).

It is clear from these data that the two age groups differ in the way in which they respond to the combined effects of time-limits and salience. In the four year old group, both short time-limits and high levels of salience operate, independently of each other, to retard performance (see also Table 2, p. 59). In the case of the ten year olds, however, performance is significantly impaired only under the combined effects of short time-limits and salient conditions (Table 2, p. 60). In general, the four year olds perform more poorly than the ten year olds, with the exception of the 10 second nonsalient condition, in which

Figure 1. Sallience X Time-limits X Age interaction for four response variables of Problem One, Study 1.

Figure 1.- (continued)

performance differences as a function of age were not reliable (Table 2, p. 60).

It is also clear from Figure 1 that the four response measures show slightly different patterns for this interaction. Examination of the results of the analyses of simple effects presented in Table 2 (pp. 59-60) indicates that both trials to a moderate criterion (TC-M), and trials

to a difficult criterion (TC-D) yielded the same significant effects. Four year olds took significantly longer to reach criterion under 1.2 second time-limits than under 10 second time-limits under both salient and nonsalient conditions. Similarly, four year olds were significantly impaired in their performance under salient conditions compared to nonsalient conditions, for both 1.2 second and 10 second time-limits.

Analyses of the simple effects of salience, in the ten year old group, indicates performance was significantly impaired under salient conditions only under 1.2 second time-limits. Similarly, ten year olds took longer to reach criterion under 1.2 second time-limits than under 10 second time-limits, only under conditions of salient irrelevant stimulation. Analyses of the simple effects of age indicate that four year olds took significantly more trials to reach criterion than did the ten year olds in the 1.2 second-salient, 1.2 second-nonsalient, and 10 second-salient conditions, but not in the 10 second-nonsalient condition.

The error data (see Table 2, p. 59) show a pattern similar to that presented by the data for trials to criterion data, with four year olds making significantly more errors under salient conditions than under nonsalient conditions for both levels of time-limits. Similarly, significantly more errors were made by the four year olds under 1.2 second

time-limits than under 10 second time-limits, for salient and nonsalient conditions of irrelevant stimulation. The latter effect, however, was reliable only at a .10 level of significance. In the case of the ten year olds, more errors were made under salient conditions than under nonsalient conditions when subjects were allowed only 1.2 seconds in which to respond, but not in the case where they were allowed 10 seconds in which to respond. This difference was reliable at $p = .10$ level of significance. Analyses of the simple effects of time-limits for both levels of salience indicates that time-limits has a reliable effect ($p < .10$) only when the relevant dimension is less salient than the irrelevant dimension. Analysis of age differences indicates that under salient conditions, four year olds made significantly more errors than did the ten year olds at both levels of time-limits. However, when nonsalient conditions prevailed, no age differences were observed under either 1.2 seconds or 10 second time-limits.

The omission data account for the major source of differences among response measures (see Table 2, p. 59). The predominant difference is in the relatively low frequency of omissions occurring under 10 second time-limits, regardless of age or salience of the irrelevant dimension. Apparently few children required more than 10 seconds in which to respond under these particular conditions. Analyses of the simple effects of salience in the four year olds indicates that significantly more omissions were made under salient conditions than under nonsalient conditions of irrelevant stimulation only in those groups operating under 1.2 second time-limits. Also, significantly more omissions occurred under 1.2 second time-limits than under 10 second time-limits for both salient and

nonsalient conditions. In the case of the ten year olds, more omissions were made under 1.2 second time-limits than under 10 second time-limits in the salient condition, reliable at the $p = .10$ level of significance, although not under nonsalient conditions. The difference in number of omissions between the salient and nonsalient groups was not reliable under either 1.2 second or 10 second time-limits. Finally, no age differences were observed under 10 second time-limits for either salient or nonsalient groups. Under 1.2 second time-limits, four year olds made significantly more omissions than ten year olds in both salient and nonsalient groups.

The factor of dominance was not significant in the results of the MANOVA, nor in any of the ANOVAs. However, the interaction between salience and dominance was reliable in the MANOVA results, though not in any of the univariate ANOVAs (Table 2, p. 59). The error data were associated with the largest F score (see Appendix 5) for this interaction and are presented in Figure 2, along with the omission data for comparison. Analyses of the error data (see Table 2, p. 59) indicate that nondominant subjects made significantly more errors than dominant subjects under salient conditions of irrelevant stimulation. No differences were observed between dominant and nondominant subjects under nonsalient conditions. In addition, the number of errors made under salient conditions of irrelevant stimulation was significantly higher than under nonsalient conditions, for both dominant and nondominant subjects. Examination of the omission data reveals that nondominant subjects made significantly more omissions under salient conditions than under nonsalient conditions, although the remaining comparisons did not yield

Figure 2. Mean number of errors and omissions made during the first problem as a function of salience and dominance of Study 1.

significant results.

The Time-limits x Dominance x Age interaction was also observed to be reliable according to the results of the MANOVA. As can be seen in Table 2 (p. 61), none of the univariate ANOVAs revealed a significant interaction, although the omission data were associated with the largest F score (see Appendix 6). Figure 3 presents the means of each condition for all four response measures. Examination of the trials to criterion measures indicates the presence of an interaction between the factors of time-limits and dominance in the ten year old data, and only a main effect of time-limits in the four year old data (see Table 2 for statistical results). Analyses of the simple effects of time-limits, using TC-D as data, indicates that in the ten year olds, nondominant subjects required more trials to reach criterion in the 1.2 second condition than in the 10 second condition. For dominant ten year olds, the difference was not reliable. No significant differences were observed between dominant and nondominant subjects under either 1.2 second or under 10 second time-limits. In the case of the four year olds, significantly more trials were required to reach criterion under 1.2 than under 10 second time-limits, for both dominant and nondominant subjects, while no difference was observed between dominant and nondominant subjects in either the 1.2 or the 10 second conditions.

The error data show a similar pattern to that presented by the trials to criterion measures. In the case of the ten year olds, the largest number of errors were made by nondominant subjects under 1.2 second time-limits. However, none of the comparisons as a function of dominance and time-limits were statistically significant. Four year olds

Figure 3. Time-limits X Dominance X Age interaction for four response variables during the First Problem of Study 1.

Figure 3. (continued)

made significantly more errors under 1.2 second time-limits than under 10 second time-limits, regardless of dominance, $.10 < p < .05$. No significant differences were observed between dominant and nondominant four year-olds under either time-limit (see Table 2).

As was the case with the Saliency x Time-limits x Age interaction, the pattern presented by the omission data differs somewhat from that seen in the remaining response measures for the Time-limits x Dominance x Age interaction. The pattern is related to the situation occurring in the 10 second condition, in which very few omissions occurred for any of the subjects (see Figure 3). Thus, no differences were observed in either the four year old data or the ten year old data, regardless of dominance, under 10 second time-limits. Under 1.2 second time-limits, nondominant four year olds made significantly more omissions than did the dominant four year olds. Both dominant and nondominant four year olds made more omissions under 1.2 second time-limits than under 10 second time-limits. In the case of the ten year olds working under 1.2 second time-limits, no differences were observed in the number of omissions made by dominant and nondominant subjects; nor was the difference in performance as a function of time-limits significant for either dominant or nondominant ten year olds.

Since there was a suggestion of heterogeneity of variance in the raw data, MANOVA and univariate ANOVAs for each response measure were conducted on logarithmic transformations of the raw data. The results of the MANOVA of the transformed data indicated that the main effects of age, time-limits, and relative saliency were significant, as well as the interactions between time-limits and age, saliency and time-limits,

and salience and age. Neither the interactions between salience and dominance, nor between time-limits, dominance, and age were reliable. The Salience x Time-limits x Age interaction was reliable at the $p = .11$ level of significance, of the MANOVA, and at the $p = .01$ level in the ANOVA of the TC-D data.

Criterion versus noncriterion subjects. Several of the four year olds did not reach criterion performance in phase one, particularly in the salient conditions. The percentage of subjects attaining criterion in the 1.2 second-nonsalient, 10 second-nonsalient, 1.2 second-salient, and 10 second-salient conditions was 85%, 100%, 40%, and 65%, respectively. It is obvious that learning under conditions where the relevant dimension is less salient than the irrelevant dimension is particularly difficult for the four year old subjects. On the other hand, all of the ten year olds attained criterion performance during phase one.

Since a considerable number of four year olds failed to attain criterion, it is possible that the age differences found in the previous analyses were the result of the poor performance of the noncriterion four year olds and not representative of four year olds in general. Consequently, in order to determine whether there were any differences between the four year olds who reached criterion and the ten year olds, the TC-M data of these two groups were analyzed. Since there were unequal number of subjects in the two groups, a $2 \times 2 \times 2$ univariate analysis of variance using unweighted means was performed on the data with salience, time-limits, and age as factors. A summary of this analysis is presented in Appendix 7, and the means of each group presented in Table 3. The results indicated the following effects to be reliable: age ($F(1,130) =$

Table 3

Mean Number of Trials Required to Attain a Moderate Criterion,
for Each Condition of Saliency, and Time-limits for
Criterion for Four Year Olds and Ten Year Olds.
The Cell Frequencies are in Parentheses

Criterion Four Year Olds

	Nonsalient	Salient
1.2 seconds	25.71 (17)	56.88 (8)
10 seconds	10.40 (20)	36.77 (13)

Ten Year Olds

	Nonsalient	Salient
1.2 seconds	16.50 (20)	30.30 (20)
10 seconds	12.60 (20)	16.95 (20)

29.15, $p < .01$), salience ($F(1,130) = 58.53$, $p < .01$), time-limits ($F(1,130) = 28.34$, $p < .01$), the interaction between salience and age ($F(1,130) = 15.88$, $p < .01$). The interaction between time-limits and age approached significance ($F(1,130) = 3.37$, $.10 > p > .05$). Neither the interaction between salience and time-limits, nor the interaction between salience, time-limits, and age were reliable. The results of this analysis closely approximates those of the univariate analysis of the TC-M data in which all the four year olds and ten year olds were included. It would appear that even in the case where only the data of criterion four year olds is used in a comparison with that of ten year olds, age differences as a function of relative dimensional salience and time-limits are obtained.

Errors as a function of trial type. A quantitative measure of the potential negative influence of the presence of irrelevant stimulation can be assessed by examining how errors distribute with changes in trial type, that is, by determining whether more errors were made on trials in which the standard stimulus differed from the correct matching stimulus on the irrelevant dimension (Different trials) than on trials where the standard stimulus and the correct matching stimulus were identical (Same trials). Hence, a difference score of the number of errors made on Different trials minus the number of errors made on Same trials was calculated for each subject. A t test for correlated observations indicated that significantly more errors occurred on Different trials than on Same trials ($t(159) = 4.69$, $p < .05$). A $2 \times 2 \times 2 \times 2$ ANOVA with salience, time-limits, dominance, and age as between subject factors was performed on transformed difference scores ($X' = \sqrt{X + .5}$). A summary of this analysis

is presented in Appendix 8, while means of each condition are presented in Table 4. The results indicated that more errors were made on Different trials under salient conditions than under nonsalient conditions ($F(1,144) = 17.0, p < .01$). Further, more errors were made on Different trials by nondominant subjects than by dominant subjects ($F(1,144) = 6.42, p < .01$). Four year olds made more errors on Different trials than did ten year olds ($F(1,144) = 4.69, p < .01$). Finally, there was a trend for the interaction between salience and age to be reliable ($F(1,144) = 3.24, .10 < p < .05$), indicating that the difference scores did not vary as a function of salience as greatly in the ten year olds as in the four year olds. Neither the main effect of time-limits, nor any other interactions approached significance. Examination of the means of the transformed difference scores, from Table 4 indicates that, under nonsalient conditions, the difference scores did not vary substantially as a function of time-limits in either age group. Under salient conditions, the difference scores increased in magnitude for both the 1.2 second and 10 second conditions. In the four year olds, while in the ten year olds, the difference scores increased substantially only under 1.2 second conditions. This interaction between time-limits, salience, and age, however, was not reliable. The results of this analysis suggest that younger subjects made more errors responding on the basis of the irrelevant dimension, particularly in the salient condition, than did the older subjects. In addition, errors made by nondominant subjects tended to result from a tendency on their part to respond on the basis of their more preferred dimension, which in this case was irrelevant to the solution.

Table 4

Means of Transformed Difference Scores ($X' = X + .5$) of
Errors for Each Condition of Salience, Time-limits,
Dominance, and Age, During Original Training.
Untransformed Difference Scores
are Presented in Parentheses

Four Year Olds				
	Nonsalient		Salient	
	1.2 sec	10 sec	1.2 sec	10 sec
Dominant	0.73 (0.03)	0.82 (0.17)	2.38 (5.16)	1.36 (1.35)
Nondominant	1.16 (0.85)	0.77 (0.09)	3.19 (9.05)	2.73 (6.95)
Ten Year Olds				
	Nonsalient		Salient	
	1.2 sec	10 sec	1.2 sec	10 sec
Dominant	0.35 (-.38)	0.58 (-.16)	1.33 (1.27)	0.70 (-.71)
Nondominant	1.09 (0.69)	1.09 (0.69)	2.08 (3.83)	1.41 (1.49)

Response latency. The means and standard deviations of response latency for each condition are presented in Table 5. A $2 \times 2 \times 2 \times 2 \times 2$ analysis of variance was performed on this measure, with salience, time-limits, dominance, age, and shift-salience as between subject factors. A summary of this analysis is presented in Appendix 9. The results indicate that the factors of salience ($F(1,128) = 21.677, p < .05$), time-limits ($F(1,128) = 251.614, p < .05$), and age ($F(1,128) = 154.468, p < .05$) significantly influenced response latency. Significant interactions were found between salience and time-limits ($F(1,128) = 13.58, p < .05$), salience and age ($F(1,128) = 11.59, p < .05$), time-limits and age ($F(1,128) = 40.598, p < .05$), salience, time-limits, and age ($F(1,128) = 7.839, p < .05$), and the interaction between all five factors ($F(1,128) = 5.548, p < .05$). The interaction between salience, time-limits, and age is shown in Figure 4. Analysis of the simple effects indicated that the factor of salience had a significant influence on response latency only in the case of the four year olds under 10 second time-limits ($F(1,128) = 52.87, p < .05$). Four year olds took significantly longer to respond under salient conditions than under nonsalient conditions when allowed 10 seconds in which to do so. Ten year olds, on the other hand, took approximately the same amount of time to respond under both salient and nonsalient conditions.

Response latencies were significantly shorter under 1.2 second time limits than under 10 second time-limits for four year olds, under both salient ($F(1,128) = 206.18, p < .05$), and nonsalient conditions ($F(1,128) = 62.02, p < .05$); and for ten year olds, under salient ($F(1,128) = 26.91, p < .05$) and nonsalient conditions ($F(1,128) = 18.51, p < .05$). Finally,

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Table 5

Mean Latency and Standard Deviation of Each Condition
During the First Problem of Study 1

	Four Year Olds			
	Nonsalient		Salient	
	1.2 sec	10 sec	1.2 sec	10 sec
Dominant				
M	2.145	3.157	2.260	3.840
SD	.10	.37	.36	.70
Nondominant				
M	2.194	3.070	2.260	4.129
SD	.09	.62	.09	.73
	Ten Year Olds			
	Nonsalient		Salient	
	1.2 sec	10 sec	1.2 sec	10 sec
Dominant				
M	1.834	2.323	1.859	2.414
SD	.11	.20	.09	.40
Nondominant				
M	1.851	2.393	1.870	2.559
SD	.09	.46	.06	.50

Figure 4. Mean latency during the First Problem as a function of salience, time-limits, and age, Study 1.

ten year olds responded reliably faster than four year olds under 1.2 second-salient ($F(1,128) = 39.67, p < .05$), 10 second-salient ($F(1,128) = 156.31, p < .05$), 1.2 second-nonsalient ($F(1,128) = 7.43, p < .05$). In general, then, ten year olds respond faster than four year olds, and are not affected substantially by differences in the salience of the irrelevant dimension. Four year olds, however, are slower in responding to stimuli, and are significantly influenced by the salience of the irrelevant dimension.

Analysis of latencies as a function of trial type indicated that latencies on Different trials were significantly longer than latencies on Same trials ($t(159) = 6.28, p < .05$). The difference scores of latencies on Different trials less latencies on Same trials (D-S latency difference scores) were analyzed by a $2 \times 2 \times 2 \times 2$ ANOVA, with salience, time-limits, dominance, and age as factors. A summary of this analysis is presented in Appendix 10, and the means and standard deviations of each condition are shown in Table 6. Only the main effects of time-limits ($F(1,144) = 32.31, p < .05$), and the interaction between time-limits and age ($F(1,144) = 4.31, p < .05$) yielded significant results. The interaction reflects the lack of significant differences between the two age groups under 1.2 second time-limits ($F(1,144) = .169, p < .05$), while under 10 second time-limits, D-S latency scores were significantly larger for four year olds than for ten year olds ($F(1,144) = 6.37, p < .05$). Under 10 second time-limits, then, the latency difference between Different and Same trials was considerably larger for the four year olds than for the ten year olds. In addition, D-S scores were significantly larger under 10 second time-limits than under 1.2 second time-limits for both

Table 6
Means and Standard Deviations of D-S Latency Difference
Scores in Study 1, First Problem

Four Year Olds				
	Nonsalient		Salient	
	1.2 sec	10 sec	1.2 sec	10 sec
Dominant				
M	-.017	.436	.025	.376
SD	.09	.46	.08	.77
Nondominant				
M	.031	.389	.023	.48
SD	.08	.35	.09	.62
Ten Year Olds				
	Nonsalient		Salient	
	1.2 sec	10 sec	1.2 sec	10 sec
Dominant				
M	.018	.175	.08	.099
SD	.05	.16	.06	.17
Nondominant				
M	.04	.393	.045	.269
SD	.06	.49	.07	.30

four year olds ($F(1,144) = 30.10, p < .05$), and ten year olds ($F(1,144) = 6.51, p < .05$).

Examination of latency measures as a function of trials on which correct and incorrect responses were made indicates that, for those subjects who committed errors, latencies on incorrect trials were significantly longer than latencies on correct trials ($t(159) = 3.02, p < .05$).

Correlation between response latency and errors. Table 7 presents the correlation coefficients between mean latency and number of errors made by a subject for each condition. As can be seen from the table, only three of the coefficients proved to be significant. A significant negative correlation was found for both four year olds ($r = -.25, p < .05$) and ten year olds ($r = -.25, p < .05$) between mean latency and number of errors, under salient conditions when data from both the 1.2 second and 10 second conditions were included in the analysis. In addition, the four year old data yielded a significant negative correlation ($r = -.45, p < .05$) from data obtained under 1.2 second-salient conditions. Although the remaining correlation coefficients calculated from data of the remainder of the groups operating under salient conditions were not significant, they consistently revealed a negative relation between latency and number of errors. This would indicate a trend for shorter latencies to be associated with higher error scores.

Correlation coefficients were also calculated between the D-S latency difference scores and the number of errors made by a subject. These are tabled in Table 8. Under salient conditions, there was a strong tendency for D-S latency scores to be negatively correlated with number of errors. Significant negative correlations were found in the

Table 7

Correlation Coefficients between Mean Latency and the Number
of Errors for Subjects in Each Condition of Salience and
Time-limits, during the First Problem of Study 1

FOUR YEAR OLDS			
	1.2 sec (N = 20)	10 sec (N = 20)	Both (N = 40)
Nonsalient	.04	.20	-.20*
Salient	-.45*	-.32	-.25*
TEN YEAR OLDS			
	1.2 sec (N = 20)	10 sec (N = 20)	Both (N = 40)
Nonsalient	.21	.10	-.03
Salient	-.10	-.19	-.25*

*p < .05

Table 8

Correlation Coefficients between the Difference Scores (D-S) of Latency and the Number of Errors for Subjects in Each Condition of Salience and Time-limits for the First Problem Data, Study 1

FOUR YEAR OLDS			
	1.2 sec (N = 20)	10 sec (N = 20)	Both (N = 40)
Nonsalient	.25	.21	-.17
Salient	-.25	-.51*	-.42*
TEN YEAR OLDS			
	1.2 sec (N = 20)	10 sec (N = 20)	Both (N = 40)
Nonsalient	.46*	-.03	-.04
Salient	-.46*	-.34	-.33*

*p < .05

data of the ten year olds ($r = -.33$, $p < .05$), and the four year olds ($r = -.42$, $p < .05$) when the data of the two time-limit conditions were combined. In addition, a significant negative relation was found in the four year old data obtained under 10 second conditions ($r = -.51$, $p < .05$), and in the ten year old data obtained under 1.2 second time-limits ($r = -.46$, $p < .05$). Finally, the positive correlation between D-S latency scores and errors found in the ten year old data under 1.2 second non-salient conditions was reliable ($r = .46$, $p < .05$), indicating that under these conditions, larger D-S latency scores were associated with larger number of errors.

Hypothesis behavior. Individual response protocols were examined to determine the distribution of hypotheses based on the relevant and irrelevant dimensions, as a function of salience, time-limits, and age. The primary interest here was to determine whether the salience of the irrelevant dimension had an influence on the initial selection of an hypothesis-based on the relevant dimension. Thus, the first four responses of each subject were examined to determine whether that subject was responding on the basis of the relevant dimension was using either a matching or oddity response strategy, the irrelevant dimension (matching or oddity), position (alternation or perseveration), or responding in an inconsistent fashion.

Table 9 presents the percentage of subjects responding initially on the basis of the relevant dimension together with the percentage of subjects reaching criterion in each condition. The powerful effect of the relative dimensional salience on determining problem-solving strategies is evident from these figures in that most subjects responded initially

Table 9

Percentage of Subjects Initially Responding on the Basis
of the Relevant Dimension in the First Problem, and
the Percentage of Subjects Reaching Criterion
In Each Treatment Condition of Study 1

	Percentage Responding Initially to the Relevant Dimension	Percentage Reaching Criterion
FOUR YEAR OLDS		
1.2 second-nonsalient	80%	85%
10 second-nonsalient	80%	100%
1.2 second-salient	5%	40%
10 second-salient	20%	65%
TEN YEAR OLDS		
1.2 second-nonsalient	85%	100%
10 second-nonsalient	70%	100%
1.2 second-salient	0%	100%
10 second-salient	15%	100%

to the more salient dimension. The second point to be noted is the superior adaptability of the ten year olds, who, like the four year olds, are initially attracted to the irrelevant dimension when it is more salient, are capable of switching faster (in terms of number of trials), and in greater frequency (in terms of number of subjects) to the relevant, though nonsalient dimension.

Shift Problem

Trials to criterion, errors, and omission data. The data of the four response measures were analyzed together by MANOVA and individually by univariate ANOVAs, appropriate for a $2 \times 2 \times 2 \times 2 \times 2$ factorial design with salience, time-limits, shift-salience, dominance, and age as factors. The results of the MANOVA and the ANOVAs are presented in Appendices 11, 12, 13, 14, and 15. The means of each condition for each measure are presented in Table 10. Preliminary analyses of the data indicated that the order of stimulus presentation had no effect on the performance of the subjects, and did not interact with any of the other experimental or subject variables.

The results of the MANOVA indicated that the main effect of age was reliable ($F(4,125) = 9.07, p < .001$). Similar results were obtained from the ANOVAs of each response measure. Four year olds required significantly more trials to reach both moderate and difficult criteria, made more errors, and made more omissions than did the ten year olds.

The main effect of dominance was also reliable according to the MANOVA ($F(4,125) = 2.86, p < .006$), as well as in the analyses of the TC-M, TC-D, and error data. Nondominant subjects required significantly

Table 10

Means of Each Condition During Shift Learning for Trials to a Moderate Criterion (TC-M), Trials to a Difficult Criterion (TC-D), Errors, and Omissions Data of Study 1

	Nonsalient				Salient			
	1.2 sec		10 sec		1.2 sec		10 sec	
	Shift-Nonsalient	Shift-Salient	Shift-Nonsalient	Shift-Salient	Shift-Nonsalient	Shift-Salient	Shift-Nonsalient	Shift-Salient
<u>TC-M:</u>								
<u>Four Year Olds</u>								
Dominant	9.4	29.0	9.4	24.8	10.4	28.8	9.4	24.6
Nondominant	9.2	44.8	9.2	32.6	12.6	36.0	10.2	42.6
<u>Ten Year Olds</u>								
Dominant	9.2	18.0	9.0	18.0	9.0	12.0	9.0	10.8
Nondominant	9.2	16.0	9.0	25.8	9.0	22.0	9.0	17.8
<u>TC-D:</u>								
<u>Four Year Olds</u>								
Dominant	15.6	32.0	12.8	27.0	18.2	30.8	13.4	27.8
Nondominant	13.8	45.8	13.0	33.8	21.2	47.0	14.4	45.4
<u>Ten Year Olds</u>								
Dominant	13.2	21.0	12.0	19.8	12.0	17.4	12.0	14.6
Nondominant	14.4	27.8	12.0	35.4	12.0	27.0	12.0	23.0

Table 10 (continued)

		Nonsalient		Salient			
		1.2 sec	10 sec	1.2 sec	10 sec	Shift- Nonsalient	Shift- Salient
Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient

Errors:

Four Year Olds

Dominant	1.1	12.3	.5	7.7	1.3	14.3	.9	9.3
Nondominant	.9	22.7	.7	16.3	2.5	21.1	1.3	21.1

Ten Year Olds

Dominant	.7	6.9	.5	1.7	.5	2.9	.5	1.5
Nondominant	.9	6.5	.5	11.9	.5	7.5	.5	5.9

Omissions:

Four Year Olds

Dominant	.5	.7	.9	.5	1.3	.7	.5	.5
Nondominant	.5	.9	.5	1.5	.5	1.9	.5	.7

Ten Year Olds

Dominant	.5	.5	.5	.5	.5	.5	.5	.5
Nondominant	.5	.5	.5	.5	.5	.5	.5	.5

more trials to reach either criterion and made more errors than did dominant subjects.

The effect of shift-salience was significant in the results of the MANOVA ($F(4,125) = 26.58, p < .001$), as well as in the analyses of the TC-M, TC-D, and error data. Subjects in the shift-nonsalient condition required fewer trials to attain either criterion, and made fewer errors than did subjects in the shift-salient conditions.

The interaction between shift-salience and age was reliable in the MANOVA ($F(4,125) = 8.55, p < .001$), and in the results of the analyses of TC-M, TC-D, and errors. Analyses of the simple effects of shift-salience for each age group, using TC-M as data, revealed that differences in the number of trials required for criterion performance as a function of shift-salience were significant for both four year olds ($F(1,128) = 114.46, p < .001$), and ten year olds ($F(1,128) = 10.91, p < .01$). Analyses of the simple effects of age for each level of shift-salience indicate that while the difference in performance between the four year olds and the ten year olds under shift-nonsalient conditions was not reliable, the age difference was significant under shift-salient conditions ($F(1,128) = 60.75, p < .01$). This interaction is presented in Figure 5.

The interaction between the factors of shift-salience and dominance was also significant according to the results of the MANOVA ($F(4,125) = 3.96, p < .005$), and in the analyses of each of the response measures. Analysis of the simple effects of dominance for each level of shift-salience indicates that under shift-nonsalient conditions, the difference in the number of trials required to reach a moderate criterion by dominant

Figure 5. Mean number of trials required to reach a moderate criterion during shift as a function of age and shift-salience, Study 1.

and nondominant subjects was not reliable. Under shift-salient conditions, however, the difference between dominant and nondominant subjects was significant ($F(1,128) = 24.65, p < .01$). Analysis of the simple effects of shift-salience for dominant and nondominant subjects indicates that the difference in performance of dominant subjects under shift-nonsalient and shift-salient conditions was reliable ($F(1,128) = 21.12, p < .01$), and similarly, the difference for nondominant subjects was significant ($F(1,128) = 88.46, p < .01$). This interaction is presented in Figure 6.

Analyses of the logarithmic transformations of the response measures resulted in the same patterns of results. The main effects of age, dominance, and shift-salience were significant, as were the shift-salience and age interaction and the shift-salience and dominance interaction. No other main effects or interactions were reliable according to the MANOVA results.

The shift performance of those four year olds who attained criterion performance on the first problem was compared to the performance of those four year olds who failed to reach criterion. A 2×2 analysis of variance of unweighted means was performed on the TC-M data of criterion and noncriterion four year olds, with shift-salience and performance on problem one (criterion or noncriterion) as factors. A summary of these results is presented in Appendix 16, and the means in Table 11. The results indicated that the main effect of shift-salience was reliable ($F(1,76) = 122.69, p < .01$). Performance of both groups of subjects was better under shift-nonsalient conditions than under shift-salient conditions. The difference in shift performance of the criterion

Figure 6. Mean number of trials to attain a moderate criterion during shift as a function of subject dominance and shift-salience, Study 1.

Table 11

The Mean Number of Trials Required to Reach a Moderate
Criterion in the Shift Problem by Criterion and
Noncriterion Four Year Olds as a Function
of Shift-salience, Study 1

	Criterion Four Year Olds	Noncriterion Four Year Olds
Shift-nonsalient	9.22	11.46
Shift-salient	30.13	48.00

versus noncriterion subjects was also significant ($F(1,76) = 13.83$, $p < .01$), reflecting the superior performance during shift learning on the part of the criterion subjects. Finally, the interaction between shift-salience and first problem performance was reliable ($F(1,76) = 8.38$, $p < .01$). Analyses of the simple effects of shift-salience for criterion subjects revealed that the difference in performance under shift-nonsalient and shift-salient conditions was also reliable ($F(1,76) = 91.28$, $p < .01$). Analyses of the simple effects of first problem performance for each level of shift-salience showed that under shift-nonsalient conditions, the difference in performance of criterion and noncriterion subjects was not significant; under shift-salient conditions, however, the difference between criterion subjects and noncriterion subjects was reliable ($F(1,76) = 21.83$, $p < .01$). These results indicate that criterion and noncriterion subjects learned the shift problem at comparable rates when the problem was relatively easy when the relevant dimension was more salient than the irrelevant dimension. Under more difficult conditions where the relevant dimension was less salient than the irrelevant dimension, none of the subjects who had failed to solve the original problem were successful in solving the shift problem. Most of the criterion subjects, on the other hand, were able to attain the solution.

In order to determine whether age differences observed during shift learning were due primarily to the data of the noncriterion subjects of the first problem, an analysis of variance using unweighted means was performed on TC-M data of the four year old criterion subjects and the ten year old subjects, with age, dominance, and shift-salience as

factors. The results of the analysis are presented in Appendix 17, and the means in Table 12. The results indicated that the following effects were reliable: the main effects for age ($F(1,130) = 18.71, p < .01$), dominance ($F(1,130) = 9.44, p < .01$), shift-salience ($F(1,130) = 73.85, p < .01$) and the interactions between shift-salience and age ($F(1,130) = 17.96, p < .01$), and shift-salience and dominance ($F(1,130) = 9.84, p < .01$). Since these data present the same pattern that was observed in the overall analysis, it may be concluded that the age differences previously observed were not primarily due to the inferior performance of the noncriterion four year olds.

Errors as a function of trial types. Errors in the shift problem were also examined as a function of trial type (Same or Different). As for the first problem, difference scores were calculated for each subject by subtracting the number of errors made on Same trials (trials on which the correct matching stimulus was identical to the standard stimulus) from errors made on Different trials (trials on which the correct matching stimulus differed from the standard with respect to values on the irrelevant dimension). Table 13 presents the means of transformed difference scores ($X' = \sqrt{X + .5}$) for each condition. A $2 \times 2 \times 2 \times 2 \times 2$ analysis of variance was performed on the transformed difference scores, with salience, time-limits, dominance, age, and shift-salience as factors. A summary of the results is presented in Appendix 18. The results indicated that the main effects of shift-salience ($F(1,128) = 16.89, p < .05$) and age ($F(1,128) = 4.22, p < .05$), and the interaction between shift-salience and age ($F(1,128) = 4.28, p < .05$) were reliable. The interaction reflects differential effects of shift-salience on D-S

Table 12

Mean Number of Trials Required to Reach a Moderate Criterion
in the Shift Problem by Criterion Four Year Olds and
Ten Year Olds as a Function of Dominance and Shift-
salience. Cell Numbers are in Parentheses.

CRITERION FOUR YEAR OLDS

	Shift-nonsalient	Shift-salient
Dominant	9.30 (16)	24.44 (18)
Nondominant	9.09 (11)	38.00 (13)

TEN YEAR OLDS

	Shift-nonsalient	Shift-salient
Dominant	9.05 (20)	12.60 (20)
Nondominant	9.05 (20)	20.40 (20)

Table 13

Means and Standard Deviations of the Transformed Difference (D-S)
 Scores of Errors ($X' = \frac{X + .05}{\sqrt{X + .05}}$) for Each Condition in the
 Shift Problem of Study 1

		Nonsalient				Salient			
		1.2 sec		10 sec		1.2 sec		10 sec	
		Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient
<u>Four Year Olds</u>									
Dominant	M	.81	2.34	.71	.77	.91	1.80	.71	1.58
	SD	.23	1.58	.00	2.15	.28	1.53	.00	1.00
Nondominant	M	.71	.40	.81	1.18	.70	2.61	.71	3.80
	SD	.00	1.98	.23	2.21	.87	1.26	.00	1.08
<u>Ten Year Olds</u>									
Dominant	M	.81	1.25	.71	1.62	.71	1.22	.71	.91
	SD	.23	.41	.00	.76	.00	.52	.00	.28
Nondominant	M	.71	.94	.71	.81	.71	1.04	.71	.91
	SD	.00	1.02	.00	2.41	.00	1.12	.00	.92

difference scores in the two age groups. The error difference scores were significantly greater under salient conditions only in the four year old group ($F(1,128) = 17.58, p < .05$); the difference was not reliable in the case of the ten year olds. Further, while the difference scores of the four year olds were significantly larger than those of the ten year olds under salient conditions ($F(1,128) = 7.51, p < .05$), the age difference was not reliable under nonsalient conditions. It would appear, then, that compared to the ten year olds, the four year olds made significantly more errors on trials on which the standard and the correct matching stimulus differed with respect to the irrelevant dimension than on trials on which the two stimuli were identical, particularly under salient conditions.

Response latency. Table 14 presents the mean latency of each condition for the shift problem. An analysis of variance appropriate for a $2 \times 2 \times 2 \times 2 \times 2$ factorial design was carried out on the latency data, with salience, time-limits, dominance, age, and shift-salience as between-subject factors. A summary is presented in Appendix 19. The results indicated that the main effects of time-limits ($F(1,128) = 50.94, p < .05$), age ($F(1,128) = 176.24, p < .05$), and shift-salience ($F(1,128) = 26.63, p < .05$) were significant, in addition to the interactions between time-limits and age ($F(1,128) = 8.46, p < .05$), and between shift-salience and age ($F(1,128) = 3.998, p < .05$). Apparently the effects of the time-limits imposed during the first problem carried over to the second problem, in that both four year olds and ten year olds from the 1.2 second condition of the first problem responded considerably faster in the shift problem than those four and ten year olds from the 10 second condition of problem

Table 14

Means and Standard Deviations of Latency in the Shift
Phase of Study 1

		Nonsalient				Salient			
		1.2 sec		10 sec		1.2 sec		10 sec	
		Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient
<u>Ten Year Olds</u>									
Dominant	M	1.88	1.97	2.12	2.33	1.87	1.96	2.10	2.48
	SD	.09	.15	.11	.29	.11	.17	.06	.41
Nondominant	M	1.82	2.19	2.24	2.38	1.80	1.99	2.02	2.52
	SD	.07	.22	.25	.10	.12	.11	.25	.28
<u>Four Year Olds</u>									
Dominant	M	2.33	2.97	3.47	3.75	2.31	2.73	3.08	4.06
	SD	.14	.28	.51	.66	.35	.57	.39	1.18
Nondominant	M	2.69	3.18	2.94	3.59	2.49	3.34	3.64	3.87
	SD	.58	.37	.39	1.46	.21	1.18	.37	.61

one. The effect was stronger in the four year olds ($F(1,128) = 49.77$, $p < .05$) than in the ten year olds ($F(1,128) = 8.816$, $p < .05$). Ten year olds responded significantly faster in the shift problem than the four year olds, both for the 1.2 second condition of problem one ($F(1,128) = 52.81$, $p < .05$) and the 10 second condition ($F(1,128) = 129.17$, $p < .05$), the age difference being considerably enhanced under the 10 second condition.

The significant interaction between shift-salience and age showed that the effects of shift-salience varied according to age. Although the ten year olds responded significantly faster under shift-nonsalient conditions than under shift-salient conditions ($F(1,128) = 4.93$, $p < .01$), the difference between the two conditions of shift-salience was considerably larger in the four year olds ($F(1,128) = 25.28$, $p < .05$). In addition, ten year olds responded faster than four year olds under both shift-nonsalient ($F(1,128) = 62.70$, $p < .05$) and shift-salient conditions ($F(1,128) = 115.06$, $p < .05$).

The difference latency scores, calculated by subtracting the average latency on Same trials from the average latency on Different trials for each subject, were analyzed by means of a $2 \times 2 \times 2 \times 2 \times 2$ analysis of variance with salience, time-limits, dominance, age, and shift-salience as factors. A summary of these results is presented in Appendix 20, and the means of each condition in Table 15. The results of this analysis indicated that the main effects of time-limits ($F(1,128) = 6.71$, $p < .05$), age ($F(1,128) = 4.82$, $p < .05$), and shift-salience ($F(1,128) = 4.15$, $p < .05$) were reliable. The effects of time-limits imposed during the

Table 15

Means and Standard Deviations of D-S Difference Scores
of Latency in the Shift Phase of Study 1

		Nonsalient				Salient			
		1.2 sec		10 sec		1.2 sec		10 sec	
		Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient	Shift- Nonsalient	Shift- Salient
		M	SD	M	SD	M	SD	M	SD
<u>Four Year Olds</u>									
Dominant	M	.071	.52	-.01	.23	-.04	-.04	.34	.19
	SD	.27	.33	.31	.27	.07	.40	.27	.24
Nondominant	M	-.01	-.15	.26	.26	.04	.18	.35	.04
	SD	.19	.25	.17	.26	.16	.21	.34	.56
<u>Ten Year Olds</u>									
Dominant	M	.01	.16	-.05	.07	.00	.05	.03	.25
	SD	.12	.16	.08	.22	.33	.06	.10	.21
Nondominant	M	-.00	.09	.03	.17	-.02	.03	.03	.14
	SD	.52	.08	.08	.17	.07	.03	.02	.17

first problem apparently transferred to the shift problem, in that the D-S difference scores were larger for those subjects who operated under 10 second conditions during problem one than for those subjects who operated under 1.2 seconds in the first problem. The D-S scores of the four year olds were considerably larger than those of the ten year olds. Further, D-S scores were considerably larger under shift-salient conditions relative to shift-nonsalient conditions. Two interactions were found to be reliable: the interaction between salience of problem one, time-limits (problem one) and dominance ($F(1,128) = 10.59, p < .05$), and the interaction between salience (problem one), time-limits (problem one), dominance, and age ($F(1,128) = 4.416, p < .05$). These interactions reflect the puzzling situation that, for subjects in the nonsalient condition of problem one, the shift D-S scores are smaller for those dominant subjects who learned under 10 second conditions in problem one than for those dominant subjects who learned under 1.2 second conditions, while the opposite situation occurs for nondominant subjects. However, for those subjects from the salient condition in the first problem, the shift D-S scores of those dominant subjects operating under 10 second time-limits during the first problem, were larger than those of the subjects who performed under 1.2 second time-limits. Similarly, the D-S scores of those nondominant subjects operating under 10 second conditions were larger than for those nondominant subjects who were in the 1.2 second time-limit condition of problem one. There was also a slight variation of these patterns in the two age groups.

Correlation between mean latency and errors. The correlation coefficients between mean latency and number of errors for the four year old

and ten year old subjects in the shift-salient and shift-nonsalient conditions are presented in Table 16. None of the coefficients were significant, indicating that during the shift problem, the relation between average latency and number of errors was negligible. The correlation coefficients between the D-S latency difference score and number of errors made by a subject, for both conditions of shift-salience, are presented in Table 17. Significant correlations were found between D-S latency scores and number of errors for both four year olds ($r = .36$, $p < .05$), and ten year olds ($r = .33$, $p < .05$), from the shift-salient condition. Under shift-nonsalient conditions, the correlations were negligible, for either age group.

Hypothesis behavior. Hypothesis behavior at the beginning of the shift problem was examined to determine whether subjects were responding on the basis of the relevant or irrelevant dimension. Responses on the first four trials were examined to classify a subject as utilizing a relevant or irrelevant hypothesis. Table 18 gives the percentage of four year olds and ten year olds in each condition responding on the basis of the relevant dimension, together with the frequency of subjects in each condition attaining criterion. As was the case for the first problem, the factor of salience had a powerful influence on hypothesis behavior. The majority of both ten year old and four year old subjects responded initially on the basis of the most salient dimension rather than on the basis of the previous solution. This finding is remarkable given the situation that many of these subjects, indeed all of the ten year olds, reached criterion levels of performance on the first problem. It should also be noted that the cue of relative salience itself (that is, a

Table 16
Correlation Coefficients between Mean Latency and Number
of Errors made by Subjects in the Two Conditions
of Shift-salience during the Shift Phase
of Study 1

	Shift-nonsalient (N = 80)	Shift-salient (N = 80)
Four Year Olds	-.12	-.05
Ten Year Olds	-.13	-.14

Table 17

Correlation Coefficients between D-S Difference Latency Scores
Made by Subjects in the Two Conditions of Shift-Salience,
during the Shift Phase of Study 1

	Shift-nonsalient (N = 80)	Shift-salient (N = 80)
Four Year Olds	.07	-.36*
Ten Year Olds	-.02	-.33*

* $p < .05$

Table 18

Percentage of Subjects in Each Condition Initially Responding on the Basis of the Relevant Dimension, and the Percentage of Subjects Attaining Criterion in the Shift Problem of Study I

CONDITION		FOUR YEAR OLDS		TEN YEAR OLDS	
Problem One	Shift Problem	% Ss Responding to Relevant Dimension	% Ss Reaching Criterion	% Ss Responding to Relevant Dimension	% Ss Reaching Criterion
1.2 sec-nonsalient	Nonsalient	90	100	100	100
	Salient	40	40	20	90
10 sec-nonsalient	Nonsalient	100	100	100	100
	Salient	40	50	40	80
1.2 sec-salient	Nonsalient	90	100	100	100
	Salient	30	40	20	90
10 sec-salient	Nonsalient	80	100	100	100
	Salient	80	60	70	100

response strategy based simply on responding to dimension most salient, or less salient in the stimulus complex) was not transferred from one phase to the next, as all the ten year olds, and most of the four year olds responded immediately during shift on the basis of the more salient dimension, regardless of whether the relevant dimension in the first problem had been salient or nonsalient. Also interesting is the suggestion of reduced shift-salience differences for those conditions which performed under 10 second time-limits during the first problem compared to the magnitude of differences for those conditions operating under 1.2 second time-limits, for both the four year olds and the ten year olds (see Table 18, rows 3, 4, 7, 8). Furthermore, this difference between shift-salient and shift-nonsalient conditions appears to be especially reduced in the 10 second salient condition of the first problem.

Both four year olds and ten year olds behaved similarly in terms of initial hypothesis behavior and frequency of criterion attainment, under shift-nonsalient conditions. There are, however, several important differences in the behavior of the two age groups, which can be seen clearly from an examination of behavior under shift-salient conditions. Although both the four year olds and ten year olds respond similarly at the start of the shift problem, differences emerge between the two age groups in terms of the number of subjects reaching criterion. Of the 31 four year olds reaching criterion on problem one, 19 (or 61%) reached criterion during the shift problem. None of the four year olds failing to attain criterion on the first problem solved the second problem. Thus, only a few more than half of the four year olds solving the first problem transferred the solution to the second problem under conditions

where the irrelevant dimension was more salient. On the other hand, 36 of the 40 ten year olds (or 90%) reaching criterion on the first problem solved the second problem.

Another difference between the two age groups emerges from an examination of the probability of attaining criterion as a function of attending initially to the relevant or irrelevant dimension. Table 19 presents the frequency of four and ten year old subjects from the shift-salient condition reaching or failing to reach criterion as a function of attending initially to the relevant or irrelevant dimension. As can be seen from the data, although both four and ten year olds in the shift-salient condition responded initially to the irrelevant dimension more frequently than to the relevant, less salient dimension, most of the ten year olds (88%) responding on the basis of the irrelevant dimension switch to the relevant dimension and solve the problem. On the other hand, less than half (41%) of the four year olds switch from the irrelevant to the relevant dimension. A major difference, then, between the four year olds and the ten year olds lies in their respective probabilities of hypothesis switching behavior.

Table 19

Frequency of Subjects of Each Age Group in the Shift-salient Condition Reaching Criterion, and Frequency of Subjects Failing to Reach Criterion in the Shift Problem as a Function of Responding to the Relevant or Irrelevant Dimensions in Study 1

FOUR YEAR OLDS

	Number of <u>Ss</u> Responding Initially to Relevant Dimension	Number of <u>Ss</u> Responding Initially to Irrelevant Dimension	Totals
--	--	--	--------

Number of <u>Ss</u> Reaching Criterion	12	7	19
--	----	---	----

Number of <u>Ss</u> Not Reaching Criterion	2	10	12
--	---	----	----

Totals	14	17	31
--------	----	----	----

TEN YEAR OLDS

	Number of <u>Ss</u> Responding Initially to Relevant Dimension	Number of <u>Ss</u> Responding Initially to Irrelevant Dimension	Totals
--	--	--	--------

Number of <u>Ss</u> Reaching Criterion	14	22	36
--	----	----	----

Number of <u>Ss</u> Not Reaching Criterion	1	3	4
--	---	---	---

Totals	15	25	40
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Discussion of Study 1

The issue that was of central interest to this study centered around the notion that inferior performance of young children on concept attainment tasks is due to a deficiency in mediational ability. This deficit was hypothesized to be due to their tendency to respond impulsively (quickly) to highly salient forms of stimulation, thereby preventing any possibility of their employing longer-latency cognitive operations. Older children, however, are presumed to be relatively more reflective and capable of inhibiting this immature reactivity to highly salient dimensions of stimulation, allowing for the operation of higher-order cognitive processes.

Two specific deductions were made from this general hypothesis. First, older children who are forced to respond quickly should be prevented from employing mediational processes, and revert to simpler learning processes similar to those utilized by younger children. Thus, their behavior under short time-limits should be similar to that exhibited by younger children. Secondly, young children, who are presumed to be highly responsive to salient dimensions of information and deficient in inhibitory capacities, should be hampered in their efforts to learn under conditions where the relevant dimension is less salient than the irrelevant dimension. Older children, however, have developed the necessary inhibitory set by which they are capable of ignoring salient irrelevant information.

The results of this study did not support the above hypothesis. First, the four year olds were not impulsive, in terms of response

latency compared to the ten year olds. They consistently took longer to respond, even when their choice behavior matched that of the ten year olds in percent correct (10 second-nonsalient condition). These latency differences are interpreted as resulting from perceptual and/or motor responsiveness in the two age groups. The four year olds are more restless and distractable and generally less alert than the ten year olds. Further, the larger difference in latency on Different and Same trials on the part of four year olds suggests that they needed more time for perceptual analysis than did the older subjects. These data support the contention of Tighe and Tighe (1972) that young children are not as proficient in perceptual analysis as are older children.

The second major finding of this study indicated that although short time-limits significantly impaired the performance of the ten year olds learning a task in which the irrelevant dimension was more salient than the relevant dimension, the short time-limits did not interrupt mediated processing. No differential transfer effects were observed during shift learning as a function of the time-limits imposed during original learning. The ten year olds learned the shift task very rapidly compared to the four year olds, regardless of the conditions of original learning. They appeared to have learned and transferred a concept from one problem to the next. The effects of time-limits will be discussed in a later section.

The third major finding confirmed the prediction that relative dimensional salience influences problem-solving in young children to a greater extent than in older children. The effect of relative dimensional salience on concept attainment will be discussed in the next

section, followed by a discussion of the effects of time-limits, and finally, a summary.

Effect of Relative Dimensional Salience on Concept Attainment

As indicated earlier, the magnitude of the effects of variations in relative dimensional salience varied with the developmental level of the subjects. Ten year olds were less affected by the variations in relative salience than were four year olds, confirming earlier findings by Smiley (1972). The ten year olds required only a few more trials to acquire the solution under salient conditions than under non-salient conditions. The fact that the difference was significant during shift learning and not during the first problem is probably due to the smaller amount of subject variability present during shift learning than during original learning.

Four year olds were as proficient as were ten year olds in problem solving when the relevant dimension was salient. However, when the irrelevant dimension was more salient than the relevant dimension, the four year olds took significantly longer to reach criterion than the ten year olds. These data replicate earlier reports by Campione (1969) and Shepp and Howard (1973). Apparently the ability to process information which is not as obvious as other information in the task is related to the developmental level of the subjects.

This difference between the four year olds and the ten year olds appears to be due to the strong predisposition of the four year olds to respond only to the most salient or obvious information, rather than switching to other dimensions of information after receiving negative

feedback. In comparison to the ten year olds, four year olds tended to make considerably more errors based upon responding to the irrelevant dimension (D-S errors) in both problems under salient conditions than under nonsalient conditions.

The difference is also evident from an examination of the number of subjects reaching criterion. On the first problem, although both age groups responded initially to the more salient problem dimension, only 52.5% of four year olds in the salient condition reached criterion, compared to 92.5% in the nonsalient condition, and 100% of the ten year olds in both salient and nonsalient conditions. Similarly, during shift, only 47.5% of the four year olds in the shift-salient condition reached criterion, compared to 100% in the shift-nonsalient condition and 90% and 100% of the ten year olds in the shift-salient and shift-nonsalient conditions respectively. The four year olds, unlike the ten year olds, did not readily switch response strategies from the more salient to the less salient dimension, upon receiving negative feedback.

It is apparent from these data that young children can cognitively process information which is relevant to solution as well as older children, as long as the information is relatively salient. Developmental differences arise only when the relevant information is relatively inconspicuous.

The finding that developmental differences in concept attainment are related to perceptual factors suggests that these age differences result from differences in perceptual difference development. This approach has been advocated by Tighe and Tighe (1972). They argue

that young children have not had the same amount of experience in detecting and differentiating dimensions of stimulation as have had older children. Therefore, in a situation where the relevant dimension is not as perceptually salient as the irrelevant dimension, young children will not be as proficient in detecting the relevant dimension, and isolating the appropriate dimension-reward relations. Thus age differences, from this point of view, are due to differences in level of perceptual learning.

Additional support for this interpretation comes from an examination of the latency data of the two age groups. As stated earlier, four year olds responded more slowly than did the ten year olds, suggesting that they were not as proficient in perceptual analysis (and/or motor readiness) as were the ten year olds. In addition, however, a reliable interaction was found between the effects of relative dimensional salience and age. Although four year olds were slower than ten year olds under nonsalient conditions of irrelevant stimulation, the difference was considerably larger under salient conditions. The delay in responding under salient conditions is interpreted as an attempt by these children to identify another source of information.

Neussle (1972) has observed that subjects tend to delay longer following negative feedback. He interprets the delay as evidence of a more intense retrieval-recoding effort leading to more proficient focusing behavior. The younger subjects in the present study received considerable negative feedback in the salient condition, and it is possible that the longer latencies were due to a more intense retrieval-recoding effort on their part. However, this effort was not associated with more

proficient focusing and effective problem solving. Rather the children appeared to try to solve the problem by learning to match a particular subset of cues, a process that would require considerable memory, or by utilizing position and oddity hypotheses. Thus, increasing the response latency does not automatically ensure more proficient problem-solving, as has been pointed out by Denny (1973) in connection with impulsive children. The critical factor is that the child be capable of analyzing the stimulus complex into all its components and detecting the appropriate dimension-reward relations. If the subject has not reached the required level of perceptual learning appropriate to the task, the extra delay will not result in more efficient problem-solving.

The results of this study also support the contention of Odom and Guzman (1970, 1972) that the effect of relative dimensional salience on concept attainment is to determine the order in which the task dimensions are processed, starting from the most salient and proceeding to the least salient. In both the first problem and in shift, most subjects of the two age groups responded initially to the more salient dimension. The number of errors made by subjects responding to the irrelevant dimension was substantially larger when the irrelevant dimension was more salient than the relevant dimension. Finally, response latencies were generally longer under salient than under nonsalient conditions of irrelevant stimulation, possibly reflecting sequential processing of the task dimensions.

These data replicate the findings by Odom and Guzman (1972), and Zelniker, Oppenheimer, and Zenan (1975) suggesting that perceptual salience determines the order of processing in a problem-solving task.

These investigators observed that the number of errors made in a matching-to-sample task and the response latencies increased as the subjective preference for a dimension decreased.

The finding of significant differences as a function of relative salience of the task dimensions used in the shift phase, as well as in the first problem, extends the generalizability of the reports by Shepp and Howard (1973) and Campione (1969). These investigators reported that the magnitude of intradimensional-extradimensional shift differences depends on the relative salience of the relevant and irrelevant dimensions. Under conditions where the relevant shift dimension was more salient than the irrelevant dimension, the difference in performance on ID and ED tasks was much smaller than under the condition where the irrelevant dimension was more salient than the relevant dimension. These findings suggested that the superior performance on ID tasks compared to ED tasks was not simply the result of mediated transfer, but may have also been due to the fact that the relevant intradimensional shift dimension was more salient than the relevant dimension of the extradimensional task. The present data indicate that the relative salience of the shift dimensions does indeed influence shift learning.

As Campione (1969) and Shepp and Howard (1973) both point out, differences found in shift learning as a function of dimensional salience are contrary to predictions made by Zeaman and House (1963). Their model assumes that the probability of attending to the relevant dimension at the end of the first problem to be higher than the probability of attending to other irrelevant dimensions. Hence, these subjects should continue to respond to the same dimension during shift. Evidently any model

which purports to explain concept attainment must take into account not only changes in the probability of attending brought about by training, but also variation depending on perceptual factors such as dimensional salience, as does Lovejoy's (1968) model.

Another interesting finding was that no transfer effects were observed in shift as a function of the relative salience of the irrelevant dimension during problem one. However, examination of the initial response patterns at the beginning of the shift problem indicated that subjects from the 10 second salient condition of problem one differed somewhat from those of other conditions. Whereas data from the other conditions indicated that the percentage of subjects responding on the basis of the relevant shift dimension varied according to whether it was more salient or less salient than the irrelevant shift dimension, the data from the 10 second salient condition indicated that there was little difference in percentage of subjects responding on the basis of the relevant shift dimension as a function of relative salience of the relevant and irrelevant shift dimensions (80% and 80% for nonsalient and salient shift conditions for the four year olds, and 100% and 70% for nonsalient and salient shift conditions for the ten year olds). These data suggest that prior experience with a nonsalient relevant dimension, under normal time limits, may provide some insulation effect from the tendency to respond on a subsequent problem to a more salient yet inappropriate dimension.

The study by Johnson, Warner and Silleroy (1971), discussed earlier, provides support for this contention. They report prior training with nondominant dimensions (defined by subject preference) to facilitate

performance on a subsequent task with nondominant relevant dimensions. In the present study, although the overall frequency of subjects reaching shift criterion as a function of shift salience was about the same for all the original training conditions, examination of the criterion frequencies of those subjects who reached criterion in problem one indicates that for the four year olds, those subjects reaching criterion in the salient training conditions had a greater probability of reaching criterion during shift under salient conditions (83%) than did those subjects who attained criterion in the nonsalient original training condition (47%). It should be noted that while these data may reflect the development of inhibitory tendencies in the young children, they can also be interpreted as indicating that these subjects had reached the level of perceptual development necessary for detecting a relevant dimension which is not as salient as the irrelevant dimension.

The performance of the four year olds was very interesting from the point of view of a developmental theory of perceptual differentiation and mediation. Only 50% of the four year olds in the shift-salient conditions reached the shift criterion. Furthermore, of the criterion four year olds in the shift-salient conditions, only 61% acquired the solution to the second problem. Evidently in the case of young children, finding the solution to one problem does not guarantee success on a subsequent similar problem (with the same relevant dimension), when the relevant dimension is less salient than the irrelevant dimension. Even though the four year olds had solved the first problem, they had difficulty when the same solution was made less obvious in another problem.

This illustrates the importance of the development of perceptual differentiation abilities.

Most of the four year olds in the shift-salient condition responded initially to the more salient dimension. The factor which differentiates these younger children from the older ones is that they did not automatically switch to the alternate dimension upon receiving negative feedback. This is remarkable since many of these subjects had matched on the basis of the relevant dimension during the previous problem, when it was more salient. Apparently, when the differences between the cues were small, the four year olds simply did not consider the variation along that dimension to be of any predictive importance, that is, to be a source of information.

Effects of Time-limits on Concept Attainment

As had been predicted, short time-limits affected the performance of the ten year olds only when the irrelevant dimension was more salient than the irrelevant dimension. Fast responding by the ten year olds was detrimental to their performance only when the solution was not perceptually obvious. The results of the four year olds data, however, are at odds with earlier predictions. Short time-limits significantly impaired performance, whether or not the irrelevant dimension was salient.

Although there has been little prior research on the effects of forced fast responding in children, these data would seem to be congruent with the available research findings. White (1965) presents data from an associative interference study which shows that errors of omission are increased under short time-limits. Similarly, Castenada and Lipsitt

(1959) have demonstrated that forced fast responding increases associative interference.

It is interesting that forced fast responding by the older children resulted in increased errors only under the condition in which the possibility of associative interference was relatively high, that is, when the irrelevant dimension was more salient than the relevant dimension. Examination of correlation coefficients between errors and mean latency indicates that when the irrelevant dimension was more salient than the relevant dimension, and when the data from the 1.2 second and 10 second time-limit conditions were combined, a reliable negative relation between number of errors and mean latency occurred for both four year olds and ten year olds. That is, under salient conditions of the irrelevant dimension, fast responders tended to make more errors. Under nonsalient conditions, no relation was found between errors and latency for either the four year olds or the ten year olds.

The source of the detrimental effect of short time-limits is not readily apparent from the data. Although there was a trend for more errors to be made under short time-limits and salient conditions of the irrelevant dimension, the difference scores calculated from the number of errors made on Different and Same trials did not differ significantly as a function of time-limits. The evidence, therefore, is not conclusive that the increased errors were the result of responding on the basis of the irrelevant dimension, in either the four year olds or the ten year olds. However, the raw data do show that for both age groups, the largest difference score (D-S error difference) occurred in the salient 1.2 second condition.

Although the imposition of short time-limits during the first problem resulted in the predicted outcome, as far as the ten year olds were concerned, there was no evidence that the deleterious effects transferred to the shift problem, in neither the ten year old group nor the four year olds. There were no differences in terms of trials to criterion or errors during shift between groups which had learned under 1.2 second time-limits or under 10 second time-limits. The short time-limits used in this study and under these conditions did not interfere with mediated transfer. The only suggestion of transfer effects during shift due to time-limits imposed during original training occurs in the initial response patterns exhibited at the start of shift learning. Subjects from the 10 second conditions in problem one tended to respond on the basis of the relevant dimension more frequently than subjects from the 1.2 second condition.

The absence of transfer effects, together with the finding that four year olds took longer to respond than did ten year olds, and that short time-limits impaired performance in both the four year olds and ten year olds, makes it difficult to substantiate a theory which proposes that the inferior performance of young children is due to a mediational deficiency arising from short-latency responding. The question remains, then, as to the interpretation of the effects of short time-limits that were observed during the first problem.

Data presented earlier in the discussion of the effects of relative salience of the irrelevant dimension offered support to a proposal by Odom and Guzman (1970, 1972) that dimensional salience may determine "the order in which dimensions of a problem are processed for solution

through other cognitive mechanisms" (p. 272). From this point of view, subjects would process, on any one trial, the more salient dimension first, and then the less salient dimension. With the imposition of time limits, only the more salient dimension would be processed, while the second phase of processing would be cut short.

This interpretation is supported by the findings that under short time-limits, there was no difference in latency under salient or non-salient conditions. Further, the D-S latency scores also did not vary as a function of relative salience under 1.2 second time-limits. Thus, subjects may have had only enough time to process one dimension.

The effects of short time-limits, therefore, are interpreted as interrupting the process of perceptual analysis. When the irrelevant dimension was more salient than the relevant dimension, subjects had time only to process the irrelevant dimension, and thus took longer to reach criterion and made more errors. When the relevant dimension was more salient than the irrelevant dimension, short time-limits would not affect choice performance, since the subjects had time to process the relevant dimension, as was the case for the ten year olds.

One finding that was unexpected was the increase in errors and trials to criterion under short time-limits for the four year old subjects when the relevant dimension was more salient than the irrelevant dimension. As mentioned earlier, however, the four year olds, when allowed 10 seconds in which to respond, took longer to respond and spent relatively more time on Different trials than on Same trials compared to the older children even under nonsalient conditions. Thus, the imposition of short time-limits would have even more severe effects for

the younger children than for the older group. The increase in errors under nonsalient conditions, therefore, may have been due to an interference in perceptual analysis, resulting in decreased accuracy. Another possibility is that the short time-limits interfered with retrieval processes and led to increased confusion and decreased accuracy.

The present findings suggest that short time-limits, or forced fast responding, cuts short the amount of time available for perceptual processing with the result that only the most salient dimension is processed. It is plausible that the short time-limits also interfered with retrieval processes for the four year olds. However, the fact that the ten year olds did not make significantly more errors under short time-limits than under longer time-limits when the relevant dimension was more salient than the irrelevant dimension, argues against the notion that short time-limits interfered solely with retrieval processes. In conclusion, then, under conditions where the relevant dimension is more salient than the irrelevant dimension, and therefore processed first, short time-limits do not have any significant effect on performance, at least for ten year olds. However, when the irrelevant dimension is more salient than the relevant dimension, short time-limits cut short the time required for the analysis of the less salient, relevant dimension, with the result that more errors occur. This is due to responding on the basis of the irrelevant dimension.

Conclusions

Although the predicted interaction between salience, time-limits and age was observed in the first problem data, and the expected Shift-salience x Age interaction was found in the shift data, detailed examination

of the data does not lead to a confirmation of the original hypothesis derived from the formulations of Kendler and Kendler (1967) and White (1965). First of all, the data indicated that young children do not respond faster than older children. Secondly, although it was expected that the four year olds would perform better under nonsalient conditions and long time-limits than under salient conditions, it was not expected that they would perform equally as efficiently (virtually with no errors) as the ten year olds. In fact, the almost perfect performance of the four year olds and ten year olds on both the first and shift problems under nonsalient conditions suggests that, under these conditions, both groups of children were employing conceptual modes of problem-solving. It would appear, therefore, that under long time-limits and a relatively salient relevant dimension, young children utilize conceptual modes of learning as do older children. Thus, when the dimension of information that is relevant to the solution is readily differentiated by young children and is perceptually obvious, the four year olds are capable of abstracting the appropriate dimension-reward relations.

Finally, the probability that a dimensional concept, once attained, is transferred from one problem to another depends, in addition to prior training experience, on three factors: the relative salience of the relevant dimension, the level of perceptual learning of the subject, and the ability of a subject to inhibit responses to highly salient information. Both four year olds and ten year olds responded initially to the more salient dimension of information, during both the first problem and the shift problem. The ten year olds, however, quickly switched to the less salient dimension, indicating that they perceived that

dimension as containing predictive information, although it was located in a lower position in the response strategy hierarchy. The four year olds, on the other hand, were capable of utilizing the previously attained concept only if it remained relatively salient. It would appear, therefore, that these subjects had not reached a level of perceptual development in which less discriminable stimuli were perceived as being an important source of information. Further, it appeared that their tendency to respond to highly salient forms of stimulation prevented their processing the less salient dimensions, in that many of the four year olds perseverated in responding on the basis of the more salient dimension. It was also evident that many of the four year olds, upon receiving substantial negative feedback, attempted to solve the problems by matching specific stimuli, indicating the concurrent use of single-link modes of processing in these subjects.

In conclusion, it is felt by this author that the data are best interpreted within the framework of perceptual differentiation theory as proposed by Tighe and Tighe (1966, 1972).

STUDY 2

The majority of studies examining concept attainment and concept shift behavior have employed concepts which are based on physical stimulus similarities, i.e., dimensional concepts. Surprisingly few studies have examined parameters of concept attainment under conditions where the stimuli are functionally similar.

There are a number of reasons for preferring the use of physically similar or dimensional stimuli versus the use of functionally similar stimuli. Dimensional stimuli allow for a more precise specification of the structure of the stimulus complex. Thus, variables such as the number of irrelevant dimensions and the relative salience of the stimuli can be controlled or manipulated to determine their effect on concept attainment. On the other hand, methods using dimensional stimuli make it difficult to determine whether the solution was attained by S-R associations or by concept formation (Odom, 1966). Typically, in these studies the same stimuli are repeated many times over the course of the training.

The use of stimuli which are functionally similar, but not physically similar, provide a more clearcut method of determining which type of process was used for solution, since the same stimuli are generally not repeated many times. For example, in learning the concept of 'clothing', a variety of instances can be presented, such that a particular combination (e.g., hat-dress, shoe-glove) would occur only once or twice over the course of training. To learn the concept of clothing by means

of S-R associations would therefore be extremely difficult.

Developmental studies of concept learning using conceptually related stimuli have reported that the probability that mediational modes of learning are used increases with increasing age (Kendler, Kendler, & Marken, 1969; Odom, 1966). However, the suggestion has been made that young children might exhibit greater use of conceptually mediated behavior if the task conditions were made more conducive to such behavior (Odom, 1966). Other investigators have propounded a similar point of view. White (1965), it will be recalled, proposed that the stimulus conditions and procedural variables determine, in part, whether cognitive or associative modes will be involved in learning.

Birch and Bortner (1966, 1967) have also proposed that the apparent mediational deficiency of young children may be the result of competition of the stimulus properties inherent in the stimulus complex. They suggest that under certain conditions, young children do not abstract a higher-order concept (e.g., tools, clothing) because the probability is higher that they will attend to the primary stimulus attributes or the perceptual dimensions of the stimuli (e.g., color, size, shape). If these attributes were made less obvious, thus reducing the possibility that the young children would respond to them, the children would then respond on a conceptual basis. They argue, therefore, that the response hierarchy of young children is organized primarily according to the perceptual attributes of the stimulus complex, and then according to conceptual attributes.

As a test of their hypothesis, children of various age groups from

nursery school up to grade four were given a matching-to-sample task under two conditions. In one condition, the standard stimulus and one of the comparison stimuli resembled each other in terms of shape or color, whereas in the second condition, none of the comparison stimuli shared an obvious common stimulus property with the standard stimulus. The correct response in both conditions was the choice of a functionally similar object (e.g., bottle top and cork). Ten trials were given, with the objects differing on each trial. Their results indicated, first, a progressive increase with age in the percentage of correct matches based upon functional characteristics, and secondly, under conditions where stimulus competition was eliminated, younger children made significantly more functional matches than under conditions where stimulus competition was present (Birch & Bortner, 1966). Thus, failure to respond on the basis of functional concepts may be partially due to competing tendencies elicited by the immediate stimulus properties of the complex.

The purpose of Study 2 was to test the hypothesis that stimulus competition arising from salient primary stimulus attributes impairs functional concept identification and utilization in young children. That is, when the primary stimulus characteristics of the complex are highly salient, there is a greater tendency for young children to match on the basis of the physical similarities of the stimulus complex rather than on the basis of the functional similarities.

The concept to be learned in this study was 'clothing'. The irrelevant dimension, which was variable within trials, was that of color. A matching-to-sample procedure was used, with two comparison stimuli. Thus, one of the comparison stimuli represented an item of clothing,

while the other comparison stimulus was selected from a group of other familiar objects. One of the comparison stimuli was colored the same hue as the standard, while the other stimulus was colored a different hue. In order to examine the effects of the presence of an irrelevant primary stimulus dimension on concept identification, two levels of salience of the irrelevant dimension of color were used in the design. In one condition, the difference along the dimension of color was relatively small (the values of red and pink were used), while in the second condition, the difference along the color dimension was greater and more obvious (red and green were used). Thus, in the case where the difference in color of the stimulus objects was not obvious, the nonsalient condition, it was expected that the young children would identify and utilize the concept of clothing faster than would those children in the salient condition, for whom the color difference of the stimulus objects were quite noticeable, and thus was a highly salient dimension of information.

The second purpose of this study was to examine the effects of response time-limits on functional concept identification. Previous investigators (Peterson, 1973a, 1973b) have argued that short response time-limits should reduce the incidence of mediated behavior. It was expected, therefore, that short response time-limits would interfere with the occurrence of conceptual behavior and prolong the number of trials taken to reach criterion, particularly in the case of the older subjects in the salient condition.

Method

Subjects. Forty nursery school children were selected from several nursery schools located in a suburban area of Ottawa, Canada. The ages of these children ranged from 48 to 60 months, with a mean of 54 months. Forty fourth- and fifth-graders were selected from an elementary school in Stittsville, Ontario, a suburban community on the outskirts of Ottawa, Canada. They ranged in age from 114 to 149 months, with a mean age of 125 months. All of the subjects were experimentally naive.

Experimental design. The design was a factorial combination of three variables: age (4 and 10 year olds), salience of the irrelevant dimension (salient and nonsalient), and response time-limits (1.2 and 10 seconds). Ten subjects from each age group were randomly assigned to each of the four conditions.

Stimulus materials and apparatus. The practice stimuli used in this study were the same as were used in Study 1.

The training stimuli were photographs of combinations of three items of clothing, hat, shoes, and pants, and objects, beach ball, toy, and bell. The stimuli were traced from a children's vocabulary book, and measured 4 to 6 cm. in length and width. These were cut from white paper and covered with Pantone Color Film. Three shades, matched for saturation value, were selected: green (354-A), red (206-A), and pink (Rhodamine-red-A). All stimuli were photographed on a black background. Two stimulus sets were constructed; the salient stimulus set consisted of stimuli colored red and green, while the nonsalient stimulus set consisted of stimuli colored in red and pink.

Each training slide contained three stimuli arranged in a triad, with the standard stimulus at the apex and two comparison stimuli on the bottom row. On each slide, the standard and one of the comparison stimuli comprised an item of clothing, while the remaining comparison stimulus was selected from one of the object items. Three pairings of the three items of clothing were used: a shoe as the standard with the hat as a comparison stimulus, pants as the standard with shoes as the comparison, and hat as the standard and pants as the comparison. Thus, each object of clothing was used as a standard and a comparison stimulus an equal number of times. Each of the three stimulus pairings was combined with each of the three familiar objects, ball, toy, and bell, and arranged in such a way that each comparison stimulus occurred in the left and right positions equally often. Each stimulus was presented equally often in each of the two hues of the salience set. In total, there were seventy-two slides per stimulus set.

The same stimulus panel and apparatus as was used in Study 1 was used in Study 2.

Procedure. The procedure for Study 2 was virtually the same as that for Study 1, with the exception that no preference tests were administered.

The experiment was introduced to the children as a game. Following the practice problem, the subjects were informed that they would see new pictures, and that they were to guess which one of the pictures was the correct answer. The instructions were the same as those used in Study 1, and the children were reminded to respond before the pictures

were turned off, and to try to get a marble each time to win a prize. Training was continued until a criterion of 12 out of 12 correct, on-time responses, with an upper limit of 96 trials. The intertrial interval was 6 seconds. In addition, prior to the session, the children were required to identify the stimuli verbally.

The stimulus set for subjects assigned to the salient condition consisted of stimuli colored in red and green, while the stimulus set for those subjects assigned to the nonsalient condition consisted of stimuli colored in red and pink.

Within each stimulus set, the order of stimulus presentation of the 72 stimulus combinations was randomly determined, with certain restrictions. First, the position of the correct matching stimulus was presented equally often on the left and right windows within every block of 12 trials, in such a way that the correct stimulus did not appear in the same position on more than three trials in a row. Secondly, within each block of 12 trials, each of the three clothing stimulus pairings (e.g., shoe-hat, pant-shoes, hat-pants) was presented four times. Thirdly, slides on which the standard and correct comparison stimuli are colored the same hue, and slides on which the standard and correct comparison stimulus differ in hue were presented each six times within a block of 12 trials. Finally, within each block of 12 trials, the standard stimulus occurred equally often in both hues. Five different stimulus orders were predetermined and two subjects from each condition, at each age level, were assigned to each order.

Immediately following criterion, the subjects were given a transfer test to determine whether the concept of clothing was attained. Subjects

were presented with five cards, one at a time, on which were traced line drawings of clothing items and familiar objects. Each card contained three drawings, two of which were items of clothing. The stimulus items were different from those used in training. The subject was asked to point to the two items that belonged together.

As in the first study, subjects exchanged their marbles for prizes at the end of the session.

Results of Study 2

The data from the four response measures of trials to a moderate criterion, trials to a difficult criterion, errors, and omissions, were analyzed together by means of MANOVA, and separately by univariate analyses of variance. The analyses performed were appropriate to a $2 \times 2 \times 2 \times 5$ factorial design with relative salience of the irrelevant dimension, response time-limits, age, and order of stimulus presentation as between-subject factors. The means of each condition of salience, time-limits, and age are presented in Table 20; together with the transfer scores for each condition. The summary of the results of the MANOVA and ANOVAs are presented in Appendices 21, 22, 23, 24, and 25. The raw data are presented in Appendix 30.

The effect of age was significant according to the results of the MANOVA ($F(4,37) = 30.438, p < .001$), and of each of the ANOVAs. The main effect reflects the inferior performance of the four year olds, relative to the ten year olds, in solving the problem.

The effect of time-limits was also significant in the MANOVA results ($F(4,37) = 17.41, p < .001$), and in the results of each of the ANOVAs for each response measure. Learning under 2 second time-limits

Table 20

Means of Each Condition of Study 2, for Trials to a Moderate Criterion (TC-M),
Trials to a Difficult Criterion (TC-D), Errors,
Omissions, and Transfer Scores

	FOUR YEAR OLDS						TEN YEAR OLDS					
	Sallent			Nonsallent			Sallent			Nonsallent		
	2 sec	10 sec	2 sec	10 sec	2 sec	10 sec	2 sec	10 sec	2 sec	10 sec	2 sec	10 sec
<u>TC-M:</u>	85.1	55.0	73.1	54.5	26.2	11.6	16.2	11.0	11.0	16.2	11.0	11.0
<u>TC-D:</u>	89.0	59.4	78.4	59.5	38.4	15.3	30.6	16.2	16.2	30.6	16.2	16.2
<u>Errors:</u>	35.6	24.2	24.0	24.6	8.1	1.9	2.8	2.0	2.0	2.8	2.0	2.0
<u>Omissions:</u>	15.7	0.9	11.3	1.2	3.9	0.6	3.6	0.6	0.6	3.6	0.6	0.6
<u>Transfer:</u>	4.8	4.4	4.9	4.7	5.9	6.0	6.0	6.0	6.0	6.0	6.0	6.0

significantly impaired concept attainment.

The interaction between the effects of time-limits and age was significant in the results of the MANOVA ($F(4,37) = 8.134, p < .01$). This interaction, however, was significant only in the case of the omission data.

Figure 7 presents the means for each condition of time-limits and age for each response measure. Analyses of the simple effects of time-limits for each age group, using trials to a moderate criterion as data, indicated that in the four year old group, the difference in the number of trials required to reach criterion was significantly higher under 2 second time-limits than under 10 second time-limits ($F(1,79) = 10.44, p < .01$). In the ten year old group, however, the difference was not significant. Analyses of the simple effects of age for each condition of time-limits, indicated that the four year olds took significantly longer to acquire the solution than did the ten year olds under both 2 second time-limits ($F(1,79) = 29.20, p < .01$), and 10 second time-limits ($F(1,79) = 25.42, p < .01$).

Examination of the trials to a difficult criterion data indicates that differences as a function of time-limits were significant in the ten year old group ($F(1,79) = 6.52, p < .05$), as well as in the four year old group ($F(1,79) = 10.91, p < .01$).

Inspection of the error data revealed that neither the four year olds nor the ten year olds made significantly more errors under 2 second time-limits than under 10 second time-limits. Four year olds, however, made significantly more errors than did the ten year olds under both 2 second time-limits ($F(1,79) = 29.9, p < .01$), and 10 second time-limits ($F(1,79) = 25.42, p < .01$).

Figure 7. Time-limits X Age interaction for four response variables, Study 2.

Figure 7. (continued)

Analyses of the simple effects of time-limits for each age level, in the case of omissions, indicates that significantly more omissions were made under 2 second conditions than under 10 second conditions for both four year olds ($F(1,79) = 70.14, p < .01$) and ten year olds ($F(1,79) = 4.49, p < .05$). Further, while significantly more omissions were made by four year olds than ten year olds under 2 second time-limits ($F(1,79) = 43.1, p < .01$), under 10 second conditions the age differences were not reliable.

Although neither the main effect of salience nor the interaction between the factors of salience, time-limits, and age was significant in the MANOVA results, examination of the means in Table 20 for each condition suggests a consistent trend for the effects of time-limits to be strongest under conditions where the irrelevant dimension is highly salient. This trend is observed for both four year olds, and ten year olds. For example, in the case of trials to a difficult criterion, the effects of time-limits are significant only under the salient condition for both four year olds ($F(1,79) = 8.13, p < .01$), and ten year olds ($F(1, 79) = 4.95, p < .01$).

Order of stimulus presentation had no reliable effect on any of the response measures, and did not interact with any other factors.

Analysis of the transfer data, presented in Appendix 26, indicates that only the main effect of age was significant ($F(1,40) = 20.83, p < .01$). Four year olds performed more poorly on the transfer task than did the ten year olds.

Errors as a function of trial type. The distribution of errors on the two types of trials was examined by subtracting the number of errors

made by a subject on trials on which the correct matching stimulus and standard stimulus were identical in colour (Same trials) from the number of errors made on trials on which the standard and correct matching stimulus differed in colour (Different trials). The mean transformed difference scores ($X' = \sqrt{X + .5}$) for each condition are presented in Table 21. A 2 X 2 X 2 analysis of variance was performed on the transformed error scores, and a summary of the results are presented in Appendix 27. The main effects of age ($F(1,72) = 6.21, p < .05$), time-limits ($F(1,72) = 8.45, p < .05$), and salience of the irrelevant dimension ($F(1,72) = 21.81, p < .05$) were reliable, although none of the interactions between these factors were statistically significant. Considerably more errors were made by four year olds than ten year olds on Different trials than on Same trials. This difference in errors was significantly larger under 2 second time-limits than under 10 second time-limits; further, the D-S scores were significantly larger under conditions of a salient irrelevant dimension than under conditions of a nonsalient irrelevant dimension.

Response latency. The mean latency and standard deviation of each treatment condition for both age groups are presented in Table 22. The latency data were subjected to a 2 X 2 X 2 analysis of variance with relative salience of the irrelevant dimension, time-limits and age as between-subject factors. A summary of the analysis is shown in Appendix 28. The results indicated that the effects of time-limits ($F(1,72) = 77.70, p < .05$), age ($F(1,72) = 44.713, p < .01$), and the interaction between time-limits and age ($F(1,72) = 22.41, p < .01$) were reliable. Response latencies under 10 second time-limits were longer than under 2

Table 21

Means and Standard Deviations of Transformed Difference
Scores (D-S) of Errors for Each Condition in Study 2

		FOUR YEAR OLDS	
		2 seconds	10 seconds
Salient	M	3.44	1.86
	SD	1.81	1.18
Nonsalient	M	1.53	.43
	SD	1.09	1.60
		TEN YEAR OLDS	
		2 seconds	10 seconds
Salient	M	2.08	1.01
	SD	1.29	.87
Nonsalient	M	.46	.84
	SD	1.15	1.05

Table 22
Means and Standard Deviations of Latency in Study 2

		FOUR YEAR OLDS	
		2 seconds	10 seconds
Nonsalient	M	2.12	3.69
	SD	.19	1.11
Salient	M	2.16	3.72
	SD	.24	.70
		TEN YEAR OLDS	
		2 seconds	10 seconds
Nonsalient	M	1.90	2.56
	SD	.16	.48
Salient	M	1.93	2.22
	SD	.17	.17

second conditions, in both four year olds ($F(1,72) = 74.93, p < .01$) and ten year olds ($F(1,72) = 8.36, p < .01$). Four year olds, however, took significantly longer to respond than did ten year old subjects under 10 second time-limits ($F(1,72) = 65.19, p < .01$), although under 2 second time-limits, no age differences were observed.

Response latencies were also examined as a function of trial type. The means and standard deviations of the D-S latency scores are presented in Table 23. Analysis of variance of the data indicated that the main effect of time-limits ($F(1,72) = 9.03, p < .01$) and the interaction between time-limits and salience ($F(1,72) = 6.54, p < .01$) were reliable. Under salient conditions of the irrelevant dimension, the difference in magnitude of D-S latency scores was not reliable. Under nonsalient conditions, the D-S scores were significantly larger under 10 second time-limits than under 2 second time-limits ($F(1,27) = 15.47, p < .01$). Furthermore, while the difference in magnitude of D-S scores as a function of relative salience of the irrelevant dimension was not reliable under 2 second time-limits, under 10 second time-limits, D-S scores were significantly larger under nonsalient conditions than under salient conditions ($F(1,72) = 9.80, p < .01$). A summary is presented in Appendix 29.

Correlation between latency and errors. The correlation coefficients between mean latency and number of errors made by a subject for each condition and age group are given in Table 24. The only significant coefficients occur in the data of the ten year olds, under 2 second salient conditions and when the data from both the 2 second and 10 second salient condition were combined. Thus, for ten year olds, a significant negative relationship occurred between response latency and number of errors when

Table 23

Means and Standard Deviations of D-S Latency Scores in Study 2

		FOUR YEAR OLDS	
		2 seconds	10 seconds
Nonsalient	M	.017	.221
	SD	.089	.331
Salient	M	.019	-.027
	SD	.054	.276
		TEN YEAR OLDS	
		2 seconds	10 seconds
Nonsalient	M	.020	.250
	SD	.100	.231
Salient	M	.043	.127
	SD	.054	.136

Table 24

Correlation Coefficients Between Mean Latency and Number
of Errors Made by Subjects in Each Condition in Study 2

FOUR YEAR OLDS			
	2 seconds (N = 10)	10 seconds (N = 10)	Both (N = 20)
Nonsalient	.04	-.28	-.20
Salient	-.08	-.01	-.28
TEN YEAR OLDS			
	2 seconds (N = 10)	10 seconds (N = 10)	Both (N = 20)
Nonsalient	.13	.76*	.32
Salient	-.56*	-.49	-.56*

*p < .05

the irrelevant dimension was relatively salient. It should also be noted that a positive relationship between response latency and number of errors was found in the 10 second nonsalient condition.

The correlation coefficients between D-S latency scores and number of errors are presented in Table 25. Again, the only significant correlations occurred in the data of the ten year olds, who showed positive significant correlations under both salient and nonsalient conditions of the irrelevant dimension. Apparently, larger D-S scores were correlated with higher error scores for these ten year olds.

Hypothesis behavior. Responses on the first four trials were examined to classify the initial hypothesis of each subject (e.g., clothing, color, or positions responding). The frequency of subjects employing the various types of hypotheses is presented in Table 26. It is evident that the salience of the irrelevant dimension influenced the initial probability of responding to that dimension, especially in the case of the four year olds. Under salient conditions, over half of the subjects initially matched on the basis of color. Under nonsalient conditions, however, fewer than half chose the color dimension. It is interesting that whereas many of the ten year olds select clothing as a basis for matching, the four year olds tend to select position hypotheses or respond in some unsystematic fashion. The concept of clothing, in the case of the four year olds, was not high in their repertoire of hypotheses. The effect of time-limits was negligible for each age group and salience condition.

Discussion of Study 2

The major finding of this study was that reducing the salience of the irrelevant features of the stimulus complex was not especially

Table 25

Correlation Coefficients between D-S Latency Scores and
the Number of Errors Made by a Subject in Each
Condition of Study 2

FOUR YEAR OLDS			
	2 seconds (N = 10)	10 seconds (N = 10)	Both (N = 20)
Nonsalient	.17	-.06	-.04
Salient	.35	-.48	-.23
TEN YEAR OLDS			
	2 seconds (N = 10)	10 seconds (N = 10)	Both (N = 20)
Nonsalient	.59*	.71*	.45*
Salient	-.39	.68*	-.15

*p < .05

Table 26

Frequency of Subjects Initially Employing Color, Clothing,
Position, or Unsystematic Response Strategies
in Each Condition of Study 2

CONDITION	HYPOTHESES			
	Color	Clothing	Position	Unsystematic
<u>Four Year Olds</u>				
2 sec-salient	8	0	1	1
10 sec-salient	7	1	2	0
2 sec-nonsalient	3	1	4	2
10 sec-nonsalient	2	3	5	0
<u>Ten Year Olds</u>				
2 sec-salient	6	4	0	0
10 sec-salient	5	5	0	0
2 sec-nonsalient	3	7	0	0
10 sec-nonsalient	3	7	0	0

effective in easing identification development of a higher-order concept in young children. Under 10 second time-limits, there was no difference in terms of trials to criterion, errors and omissions between salient conditions and nonsalient conditions of the irrelevant dimension, for either the four year olds or ten year olds. There was, however, a suggestion that under 2 second time-limits, performance was hampered when the irrelevant dimension was salient, for both four year olds and ten year olds. Further, examination of the number of four year olds reaching criterion in the 2 second-salient, 10 second-salient, 2 second-nonsalient and 10 second-nonsalient conditions (20%, 40%, 60% and 60%, respectively) also suggests that there is a slight tendency for non-salient conditions to be slightly easier than salient conditions. All of the ten year olds reached criterion.

Contrary to earlier predictions, the imposition of short time-limits had a significant effect on the performance of the four year olds as well as on that of the ten year olds. Indeed, the effect of short time-limits appears to be greater in the performance of the four year olds. Since the mean latency of the four year olds was longer than that of the ten year olds, these data do not confirm the hypothesis that short-latency responding on the part of the four year olds prevents the use of mediational modes of behavior. Exactly what effect short time-limits has on performance is difficult to determine. Response latencies were significantly decreased under 2 second time-limits, especially in the four year olds. The D-S latency scores also indicate that differences normally observed as a function of trial type are eliminated under 2 second

time-limits. The correlation data suggest that when the irrelevant dimension is salient, the quicker the response, the larger the number of errors for both the four year olds and ten year olds.

One interpretation of these data is that the short time-limits interfered with the perceptual analysis of the stimulus complex, in the sense that there was only enough time to process one dimension of information, this being the most salient one to the subject. Since the initial response strategies of the subjects in the 2 second and 10 second time-limit conditions were similar for both the four year olds and ten year olds, the longer solution time, and larger number of errors by subjects in the 2 second condition must be due to an inability to adequately analyze the stimulus complex. That is, both perceptual analysis and decision processes were interrupted, with the result that performance deteriorated. Both age groups made more errors on Different trials than on Same trials under 2 second time-limits than under 10 second time-limits, suggesting that when subjects had to process more than one dimension of variation, short time-limits significantly increased errors.

Although the interactions between salience and time-limits, and between salience, time-limits, and age, were not reliable, there was a suggestion in both age groups that the combination of short time-limits and a salient irrelevant dimension was most detrimental to concept attainment. Errors and trials to criterion were greatest for this condition in both age groups. Further, significantly more errors were made on Different trials than on Same trials under salient conditions than under nonsalient conditions, with the source of the effect arising mainly from

the data of the 2 second-salient conditions. Again, there is the suggestion that perceptual processing is interrupted under short time-limits, and that responses tend to be made to the highly salient dimension.

Examination of the initial hypothesis data and criterion frequency data gives a clue as to the source of the age differences found in this study. The salience of the color dimension influenced both initial response strategies and the number of four year olds reaching criterion. When color was salient, most of the four year olds initially chose to match on the basis of color. Furthermore, only 30% of the four year olds under salient conditions reached criterion.

When color differences were not obvious, thus lowering the salience value of color as a dimension of information, less than half of the four year olds matched on the basis of color. However, it should be noted that the remaining subjects did not select the clothing dimension as the relevant dimension; rather many of the four year olds responded on the basis of position. The concept of clothing, therefore, was not dominant in their hierarchies of response strategies, nor was it a dimension to be easily perceived as a basis of responding by these young children under these conditions. However, since more four year olds (60%) reached criterion under the nonsalient conditions than under salient conditions (30%), reducing the salience of an irrelevant, but highly dominant dimension of information, did increase the probability that these young children would abstract the concept of clothing as the correct basis of matching.

The relatively low frequency of four year olds reaching criterion in general, however, suggests that, under these experimental conditions,

the perception and classification of these stimuli as instances of a permanent category was beyond the capacity of most of these children. The transfer data also support the contention that the younger children have not reached the level of readily categorizing stimuli along a functional continuum. Only 40% of the four year olds scored perfectly on the transfer task (in which outline drawings of clothing stimuli and furniture were presented for matching); the figure rose to 70% when a criterion of 5 out of 6 correct responses was employed.

Salience of the color dimension also had an influence on initial hypothesis behavior in the ten year olds, although not to the same extent as in the four year olds. The frequency of ten year olds initially matching on the basis of color increased as the salience of color increased, although not to the same extent as for the four year olds. The major difference between the two age groups, however, lies in the behavior of those subjects who did not match initially on the basis of color. The remaining ten year olds chose to match on the basis of the clothing concept. Thus, for the ten year olds, the concept of clothing was as readily perceived as the concept of color. Further, all of the ten year olds reached criterion, and more quickly, than did the four year olds. Obviously, the ten year olds initially responding on the basis of color were capable of isolating another dimension of information and switching response strategies, an operation which appears to elude the four year olds.

The data from this second study suggest that the average subject approaches problem-solving with a repertoire of hypotheses and strategies which are arranged hierarchically according to level of abstraction

required (e.g., perceptual or conceptual), and within a level, according to salience of preference. From this point of view, age differences in concept attainment are due to differences in the level of mediation which a subject chooses to utilize, and to differences in the level of perceptual learning which a subject has reached. The four year olds appeared to find dimensions based on perceptual similarities more salient than those based on functional similarities. In this case, relative salience of the Irrelevant dimension (that of a perceptual dimension, color) did not have a substantial influence in increasing the amount of conceptual behavior exhibited by the four year olds.

Functional similarities, on the other hand, appeared to have increased in salience value for the ten year olds. When color was low in salience value, most of the ten year olds responded on the basis of clothing. However, when color was fairly salient as a dimension of information, about 50% of the subjects responded to color, while the remaining 50% responded to clothing. Both dimensions were thus approximately equal in salience value, for the ten year olds. Furthermore, both dimensions were "usable" (Silleroy & Johnson, 1973) and available to the older children, since, upon receiving negative feedback to responses made on the basis of color, these children switched to the dimension of clothing. On the other hand, the dimension of clothing was neither available nor usable to most of the four year olds under these conditions, since few were capable of reaching criterion.

Finally, short time-limits appear to interrupt perceptual processing. The effects of short time-limits were more severe on the performance of four year olds than on the ten year olds. Since the dimension of color

appeared to be more salient for the younger children, it is probable that these children processed color first, and then possibly examined the complex for other dimensions of variation. However, under short time-limits, these children may have had only enough time to analyze color, and thus would make a large number of errors. The effect of short time-limits on the performance of the ten year olds was less severe, possibly because many of these children analyzed the clothing dimension first, and thus made fewer errors.

GENERAL DISCUSSION

The major interest of this research project was to investigate the hypothesis, proposed by White (1965) and Peterson (1973) that short latency response patterns exhibited by young children might account for the mediational deficiency thought to be the basis of the age differences observed in concept attainment. The results of the two studies reported here did not confirm that aspect of the hypothesis relating to the effects of short-latency responses on mediation and transfer. First, the findings indicated that response latencies of the four year olds from both studies were significantly longer than those of the ten year olds, under relatively long time limits. The younger children were not impulsive in responding compared to the older children. Secondly, the data from the first study indicated that time-limits imposed during the first problem did not differentially influence shift performance. It would appear, therefore, that the imposition of short time-limits during learning does not necessarily result in the use of 'single-link' modes of learning.

On the surface, there would appear to be a discrepancy between these data and those reported by Peterson (1973) and White (1965). The discrepancy, however, may be due to the nature of the experimental paradigms used by these researchers. Both investigators found that time-limits imposed during the transfer phase of an acquired equivalence design, or an associative interference design, influenced the probability of occurrence of a mediated response. For example, in Peterson's (1973) study,

although the majority of college students had employed mediational modes of learning during the actual training phase, the actual occurrence of a mediated response occurring during transfer depended on the amount of time the subjects had in which to respond. The purpose of the present studies, on the other hand, was to examine the possibility of whether imposing time-limits during learning would influence the modes of learning used by a particular subject in solving a problem.

It is also interesting that the four year old children in the present studies took longer to respond than did the older children. Kagan (1966) has reported that there are reliable individual differences in the cognitive tempo by which children solve problems, but that there is a tendency for older children to become increasingly 'reflective' in their approach to such tasks. However, as Bush and Diveck (1975) point out, efficiency of performance depends also on the task characteristics. For example, the tasks used by Kagan tend to demand highly complex perceptual analysis from the subjects, and thus, it might be expected that longer latencies would be associated with superior performance. In the present studies, the tasks were relatively simple with high intraproblem transfer. According to Bush and Diveck (1975), reflective children might be expected to respond faster and more efficiently on such tasks.

The differences in response latencies found between the four year olds and the ten year olds in these studies are interpreted as reflecting, in part, differences in perceptual abilities of the two age groups. Gibson (1969) has proposed that human beings do not immediately detect the properties and distinctive features of stimulation; rather, she proposes that perception begins as crudely differentiated and grossly

selective. / With continued exposure to environmental stimulation, perception becomes better differentiated and more precise. It is suggested, therefore, that the ten year olds in these studies were more adept in analyzing and detecting the distinctive features of the stimulus complex than were the younger children.

Recently, Cole and Medin (1973) have suggested that rather than concentrate on demonstrating the existence of mediational processing in young children, it may be more reasonable to assume that young children can mediate, and to concentrate our efforts on examining the conditions under which mediation does occur in young children. Certainly the evidence of relational learning (oddity and matching to sample) in young children (House, Brown, & Scott, 1974) reinforces this point of view. The findings reported here are also pertinent to this suggestion. Evidence of mediation or conceptual learning was observed in young children under certain conditions; however, under other conditions, conceptual behavior was not observed.

The results of this research project suggest that there are three important factors that are related to the age differences observed in concept attainment. The first factor relates to the level of perceptual development reached by children of varying ages. The data from the 10 second-nonsalient conditions of Study 1 indicate that both four year olds and ten year olds solved the task with almost perfect performance. This would seem to indicate that both age groups were using conceptual modes of processing. However, the data from the same study also demonstrated that, when the relevant dimension was less salient than the irrelevant dimension, a majority of four year olds did not acquire the concept.

Thus, it would appear that although young children can attain a relational concept when a highly salient and differentiated perceptual dimension is used, the probability is much lower that young children will attain a relational concept when the relevant dimension is relatively less salient. The findings of Study 2 extend this generalization to a higher level of abstraction. While all the ten year olds attained the concept of 'clothing', less than half of the four year olds attained the concept. Rather, the four year olds responded on the basis of a variety of perceptual dimensions, such as color and position.

It is proposed here that the differences in conceptual behavior observed in these two studies between the two age groups are related to individual differences in perceptual learning. By the age of four, children have had substantial experience in differentiating between widely spaced values on a physical dimension. The attainment of a perceptual concept based on a highly salient dimension is therefore within the capabilities of young children. However, it is probable that their limited experience in differentiating fairly small differences along a physical dimension reduces the probability that they will identify variation along a less salient dimension with the reward contingencies. Furthermore, the limited experience in differentiating and categorizing stimuli along functional or linguistic dimensions would account for the inability of four year olds to identify the 'clothing' concept.

The second factor which is proposed to be important in accounting for the age differences observed in concept attainment is the development of inhibitory control. The data from both studies suggest that the younger children lack the necessary inhibitory control to solve somewhat

difficult tasks. The results of Study 1 indicate that subjects of both age groups responded initially first on the basis of the most salient dimension, thereby confirming the contention by Odom and Guzman (1970, 1972) that the order in which the task dimensions are processed depends on the relative dimensional salience, from highest to lowest. The data also show, however, that the four year olds continued to respond on the basis of the more salient dimension longer than did the ten year olds, and had difficulty switching to other response strategies. Sanders (1971) observed somewhat similar findings in that she reports that older and younger children differ in the readiness with which they give up previously reinforced responses.

The lack of inhibitory control on the part of younger children, combined with their concentration on the more salient dimension would prevent them from processing the less salient dimensions of the task, thereby hampering problem solving. There is some evidence that prior practice in identifying a relatively nonsalient dimension as the basis of solution increases the probability that young children will attain the solution of a subsequent problem in which the relevant dimension is less obvious than the irrelevant dimension.

Finally, it is evident that procedural and task variables also determine the probability that conceptual behavior will or will not occur. Time-limits on responding appeared to prolong concept attainment, possibly because the time restrictions interrupted perceptual analysis, and only allowed subjects enough time to process one dimension, the most salient one. Performance on tasks in which the relevant dimension was less salient than the irrelevant dimension was therefore hampered.

Another task variable which influences the probability of conceptual behavior is the relative salience of the relevant dimension. Dimensional salience appears to determine the order in which the task dimensions are processed, not only during original training but also in shift learning. Furthermore, depending on the level of perceptual development of an individual subject, concept attainment performance varies with the relative salience of the relevant dimension.

Another task variable which influences the probability of conceptual behavior is the nature of the stimuli in the task and the type of concept to be acquired. As has been noted, the attainment of a functional concept, or concepts based on a linguistic classification, depends, in part, on the level of perceptual learning of the subject. Since decreasing the salience of the more preferred dimension of color in Study 2 increased only slightly the probability that young children will attain a functional concept, it is apparent that the necessary requirement for the attainment of these higher-order concepts is the availability of an appropriate cognitive structure which is based on prior experience in differentiating and classifying objects in the environment along functional and linguistic dimensions.

The conclusions that have been reached from these studies suggest that there is an orderly progression in the concept attainment capabilities of young children which is based on their increasing awareness and analysis of their surrounding environment. In the context of this research project, the most primitive form of concept attainment occurs with physical dimensions along which the values are grossly spaced. As has been noted, all of the four year olds attained the relevant concept

under these conditions with almost perfect performance. As perception becomes more differentiated, children become increasingly proficient in detecting dimension-reward relations along dimensions which are not perceptually salient. With increasing maturity, and more intensive verbal and perceptual experience, children become capable of attaining 'higher' order concepts, such as those based on functional similarities and common class inclusion. In addition to increased perceptual abilities, other processes related to inhibitory control and memory processes become more finely developed to increase the ease and efficiency of concept attainment.

The results of the present research project do not support the contention of Kendler and Kendler (1968) that there is a transition, occurring between the ages of five and seven years of age, in the modes of learning processes used by young children. The present data indicate that under specific conditions, four year old children were capable of learning a relational concept.

There is also some difficulty in interpreting these data within the framework of an attentional theory. Although the results relating to the salience effects and age differences from the first problem of Study 1 can be interpreted by attentional theory (i.e., the higher the salience value of the relevant dimension, the higher the probability of an attending response to that dimension, and the faster the rate of learning), the shift data do not agree with the predictions made by Zeaman and House (1963). Shift differences were found in both age groups as a function of the relative salience of the relevant dimension.

Another difficulty arises from the results of Study 2. Decreasing the

sallence of the more dominant dimension of color, and thereby indirectly increasing the sallence of the clothing dimension, did not have any substantial effect on the frequency of four year olds attaining the concept of clothing. Hence, increasing the sallence of the clothing dimension did not increase the probability that the four year olds would attend to that dimension. The problem seems to lie in the assumption of attentional theory that dimensions of information are immediately perceived as such. However, these data suggest that prior to a discussion of attending responses, it is necessary to examine how and when young children perceive variation in stimulation as being members of the same class; that is, when and under what conditions do young children come under dimensional control.

In conclusion, it is the view of this author that the role of perceptual learning, as propounded by Gibson (1969) and Tighe and Tighe (1972), is an important aspect of concept attainment, and should receive more experimental attention than it has in the past. However, it should be noted that no one theory adequately handles every feature underlying the mechanism responsible for the ontogenetic trend in concept attainment. Rather, each of these theories has contributed important knowledge to our understanding of the development of conceptual behavior and it is likely that the most powerful explanation will incorporate assumptions of each of these theoretical positions.

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APPENDIX 1

Trials to a Moderate Criterion (TC-M), Trials to a Difficult Criterion (TC-D), Errors (Err), Omissions (Omm), and Response Latency (Lat) Data from the First Problem and the Shift Problem for Each Subject from Study 1

First Problem			Shift Problem							
TC-M	TC-D	Err	Omm	Lat		TC-M	TC-D	Err	Omm	Lat
Ten Year, Nonsalient; 1.2 seconds, Shift-nonsalient Condition										
Dominant Subjects:										
1.	9	12	0	0	1.889	9	12	0	0	1.999
2.	9	12	0	0	1.919	9	12	0	0	1.924
3.	14	17	1	3	1.884	9	12	0	0	1.881
4.	9	12	0	0	1.736	9	12	0	0	1.733
5.	13	19	1	1	1.851	10	18	1	0	1.886
Nondominant Subjects:										
1.	20	34	2	2	1.825	9	12	0	0	1.784
2.	31	45	11	3	1.979	9	12	0	0	1.737
3.	9	12	0	0	1.786	9	12	0	0	1.786
4.	32	37	7	0	1.741	10	21	2	0	1.846
5.	11	23	1	1	1.809	9	12	0	0	1.926
Ten Year, Nonsalient, 1.2 seconds, Shift-salient Condition										
Dominant Subjects:										
1.	20	23	1	7	2.064	10	12	1	0	2.222
2.	16	19	2	0	1.750	10	13	1	0	1.966
3.	12	15	1	2	1.731	13	20	4	0	1.892
4.	10	15	1	0	1.716	48	48	27	0	1.830
5.	29	32	3	3	1.800	9	12	0	0	1.946

APPENDIX 1 (continued)

First Problem			Shift Problem			Lat			
TC-M	TC-D	Err	Omm	TC-M	TC-D		Err	Omm	
Nondominant Subjects:									
1.	11	17	2	0	18	25	5	0	2.245
2.	10	13	0	1	12	27	3	0	2.372
3.	9	12	0	0	30	33	14	0	1.837
4.	22	36	6	3	10	41	7	0	2.361
5.	34	63	10	0	10	13	1	0	2.146
Ten Year, Nonsalient, 10 seconds, Shift-nonsalient Condition									
Dominant Subjects:									
1.	9	12	0	0	9	12	0	0	2.276
2.	9	12	0	0	9	12	0	0	1.983
3.	49	52	17	0	9	12	0	0	2.061
4.	10	13	1	0	9	12	0	0	2.185
5.	9	12	0	0	9	12	0	0	2.121
Nondominant Subjects:									
1.	13	16	2	1	9	12	0	0	2.113
2.	10	13	1	0	9	12	0	0	2.107
3.	31	34	4	0	9	12	0	0	2.566
4.	9	12	0	0	9	12	0	0	1.973
5.	9	12	0	0	9	12	0	0	2.337

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APPENDIX 1 (continued)

		First Problem			Shift Problem						
		TC-M	TC-D	Err	Omm	Lat	TC-M	TC-D	Err	Omm	Lat
Ten Year, Nonsalient, 10 seconds, Shift-salient Condition											
Dominant Subjects:											
1.	10	15	1	0	0	2.230	9	12	0	0	2.144
2.	9	12	0	0	0	2.530	9	12	0	0	2.144
3.	9	12	0	0	0	2.325	12	20	1	0	2.309
4.	9	12	0	0	0	2.224	11	35	4	0	2.957
5.	10	13	1	0	0	2.324	10	20	1	0	2.010
Nondominant Subjects:											
1.	9	12	0	0	0	2.356	48	48	25	0	2.279
2.	9	12	0	0	0	2.050	12	48	7	0	2.276
3.	10	15	1	0	0	2.860	11	20	2	0	2.419
4.	9	12	0	0	0	2.049	10	13	1	0	2.409
5.	10	13	1	0	0	2.243	48	48	22	0	2.520
Ten Year, Salient, 1.2 seconds, Shift-nonsalient, Condition											
Dominant Subjects:											
1.	15	18	4	1	1	1.870	9	12	0	0	1.906
2.	13	23	3	0	0	1.780	9	12	0	0	1.693
3.	13	17	2	1	1	1.902	9	12	0	0	1.693
4.	44	48	12	4	4	1.882	9	12	0	0	1.903
5.	38	52	10	0	0	1.884	9	12	0	0	1.869

APPENDIX 1 (continued)

	First Problem			Shift Problem			Lat
	TC-M	TC-D	Err	TC-M	TC-D	Err	
Nondominant Subjects:							
1.	11	15	1	9	12	0	1.797
2.	53	58	22	9	12	0	1.839
3.	49	63	18	9	12	0	1.991
4.	21	25	5	9	12	0	1.717
5.	19	22	3	9	12	0	1.675
Ten Year, Sallent, 1.2 seconds, Shift-sallent Condition							
Dominant Subjects:							
1.	92	95	39	10	13	1	1.874
2.	18	34	3	12	16	3	2.031
3.	15	21	2	11	21	2	1.708
4.	27	40	5	9	12	0	2.123
5.	17	21	2	18	25	6	2.059
Nondominant Subjects:							
1.	12	15	2	9	12	0	2.104
2.	95	98	27	13	29	5	2.104
3.	21	24	4	48	48	23	1.965
4.	12	18	2	30	33	6	1.878
5.	21	36	8	10	13	1	1.893

APPENDIX 1 (continued)

		First Problem			Lat		Shift Problem			Lat	
		TC-M	TC-D	Err	Omm		TC-M	TC-D	Err	Omm	
Ten Year, Sallent, 10 second, Shift-nonsallent Condition											
Dominant Subjects:											
1.	15	18	4	0	0	2.817	9	12	0	0	2.109
2.	11	19	2	0	0	2.158	9	12	0	0	2.039
3.	10	13	1	0	0	2.263	9	12	0	0	2.079
4.	17	24	4	0	0	2.152	9	12	0	0	2.201
5.	9	12	0	0	0	2.183	9	12	0	0	2.073
Nondominant Subjects:											
1.	10	13	1	0	0	2.971	9	12	0	0	2.409
2.	17	21	5	0	0	2.618	9	12	0	0	2.032
3.	17	23	5	0	0	1.977	9	12	0	0	1.728
4.	10	13	1	0	0	2.136	9	12	0	0	1.839
5.	10	13	1	0	0	2.206	9	12	0	0	2.049
Ten Year, Sallent, 10 second, Shift-nonsallent Condition											
Dominant Subjects:											
1.	9	12	0	0	0	2.909	9	12	0	0	2.634
2.	44	50	18	0	0	2.096	10	15	1	0	2.374
3.	12	18	3	0	0	2.064	16	19	3	0	2.115
4.	14	23	3	0	0	3.161	9	12	0	0	3.119
5.	74	77	13	0	0	2.334	10	15	1	0	2.147

APPENDIX 1 (continued)

		First Problem			Lat		Shift Problem			Lat	
		TC-M	TC-D	Err	Omm			TC-D	Err	Omm	Lat
Nondominant Subjects:											
1.	19	22	3	0	0	2.477	42	48	18	0	2.448
2.	10	15	1	0	0	2.209	9	12	0	0	2.400
3.	10	13	0	0	0	3.238	14	20	3	0	3.010
4.	11	16	2	0	0	2.718	10	18	1	0	2.430
5.	10	13	1	0	0	1.938	14	17	0	0	2.315
Four Year, Nonsalient, 1.2 seconds, Shift-nonsalient Condition											
Dominant Subjects:											
1.	13	26	0	4	2.091	9	12	0	0	0	2.339
2.	78	80	13	12	2.238	10	17	1	0	0	2.280
3.	14	34	2	3	2.186	9	12	0	0	0	2.530
4.	56	77	20	3	1.873	10	25	2	0	0	2.363
5.	19	33	4	5	2.181	9	12	0	0	0	2.144
Nondominant Subjects:											
1.	54	65	6	15	2.280	9	12	0	0	0	2.554
2.	13	22	1	2	2.105	9	12	0	0	0	1.997
3.	10	35	0	3	2.219	9	12	0	0	0	2.339
4.	96	96	23	29	2.359	9	12	0	0	0	3.351
5.	96	96	21	22	2.257	10	21	2	0	0	3.225

APPENDIX 1 (continued)

		First Problem		Lat		Shift Problem		Lat	
TC-M	TC-D	Err	Omm	TC-M	TC-D	Err	Omm	TC-M	TC-D
Four Year, Nonsalient, 10 seconds, Shift-nonsalient Condition									
Dominant Subjects:									
1.	20	17	7	0	3.540	12	0	9	3.164
2.	11	14	0	0	3.144	12	0	9	4.188
3.	9	12	0	0	3.526	12	0	9	2.870
4.	9	12	0	0	2.981	12	0	9	3.750
5.	9	25	3	0	3.807	16	2	11	3.387
Nondominant Subjects:									
1.	10	13	1	0	3.121	17	0	10	3.057
2.	10	15	1	0	3.402	12	0	9	3.103
3.	9	12	0	0	3.018	12	0	9	2.703
4.	9	12	0	0	3.238	12	0	9	3.414
5.	10	21	1	0	2.320	12	0	9	2.416
Four Year, Nonsalient, 10 seconds, Shift-salient Condition									
Dominant Subjects:									
1.	17	21	5	0	2.914	48	0	48	2.704
2.	9	12	0	0	2.519	48	0	48	3.891
3.	11	30	3	0	3.055	12	0	9	3.871
4.	9	12	0	0	3.044	15	0	10	4.554
5.	9	12	0	0	3.038	12	0	9	3.743

APPENDIX 1 (continued)

	First Problem			Lat	Shift Problem			Lat ^a	
	TC-M	TC-D	Err		Omm	TC-M	TC-D		Err
Nondominant Subjects:									
1.	10	13	1	0	4.066	9	12	0	3.646
2.	10	19	1	0	2.494	48	48	28	2.249
3.	9	12	0	0	2.455	10	13	1	2.373
4.	9	12	0	0	2.604	48	48	26	3.811
5.	9	12	0	0	3.979	48	48	24	5.858
Four Year, Sallent, 1.2 seconds, Shift-nonsallent Condition									
Dominant Subjects:									
1.	63	95	17	20	2.258	9	12	0	2.176
2.	96	96	43	6	2.043	14	34	3	2.104
3.	96	96	20	36	2.515	10	13	0	2.894
4.	91	96	41	6	1.958	9	12	0	2.362
5.	43	58	13	8	2.073	10	20	1	2.004
Nondominant Subjects:									
1.	96	96	44	19	2.311	23	30	6	2.396
2.	96	96	10	40	2.319	9	12	5	2.324
3.	96	96	49	27	2.272	9	12	0	2.331
4.	96	96	48	6	2.192	12	38	3	2.786
5.	96	96	53	10	2.257	10	14	1	2.637

APPENDIX 7 (continued)

		First Problem			Lat		Shift Problem			Lat	
		TC-M	TC-D	Err	Omm		TC-M	TC-D	Err	Omm	
Four Year, Salient, 1.2 seconds, Shift-salient Condition											
Dominant Subjects:											
1.	96	96	48	2	2.081		48	48	28	0	2.299
2.	56	64	10	14	2.179		13	15	2	0	2.148
3.	73	91	30	8	2.300		48	48	25	1	3.533
4.	66	70	24	6	2.180		9	12	0	0	2.599
5.	34	48	13	5	2.063		26	31	14	0	3.065
Nondominant Subjects:											
1.	96	96	37	12	2.156		48	48	27	0	2.246
2.	96	96	27	40	2.442		48	48	22	0	5.342
3.	96	96	37	15	2.127		48	48	17	0	3.160
4.	29	34	5	5	2.347		38	43	12	0	3.156
5.	96	96	51	7	2.235		48	48	25	0	2.805
Four Year, Salient, 10 seconds, Shift-nonsalient Condition											
Dominant Subjects:											
1.	57	65	16	5	3.696		9	12	0	0	2.872
2.	96	96	48	0	3.777		9	12	0	0	3.382
3.	96	96	45	0	2.253		10	19	2	0	2.597
4.	25	34	8	0	3.666		9	12	0	0	2.963
5.	68	81	32	5	3.946		9	12	0	0	3.564

APPENDIX 1 (continued)

First Problem																													
TC-M						TC-D						Err						Omm						Lat					
Nondominant Subjects:																													
1.		9		41		4		0		3.493		9		12		0		0		3.309									
2.		9		12		0		0		4.851		9		12		0		0		3.504									
3.		96		96		47		0		4.103		9		12		0		0		4.167									
4.		62		67		23		2		4.329		99		12		0		0		3.353									
5.		96		96		43		1		4.613		15		24		4		0		3.890									
Four Year, Sallent, 10 seconds, Shift-sallent Condition																													
Dominant Subjects:																													
1.		63		66		31		2		3.595		10		17		1		0		2.780									
2.		25		30		5		1		4.318		25		27		7		0		5.734									
3.		9		12		0		0		4.360		48		48		26		0		3.084									
4.		36		40		15		0		4.989		9		12		0		0		4.379									
5.		10		25		3		0		3.818		31		35		10		0		4.320									
Nondominant Subjects:																													
1.		96		96		53		1		3.636		48		48		28		1		4.098									
2.		45		49		20		0		5.553		41		43		12		0		4.764									
3.		60		63		24		0		3.124		28		40		13		0		3.131									
4.		96		96		48		4		3.984		48		48		26		0		3.652									
5.		96		96		45		2		3.602		48		48		24		0		3.700									

Multivariate Analysis of Variance, using Trials to a Moderate Criterion (TC-M), Trials to a Difficult Criterion (TC-D), Errors, and Omissions as Criterion Variables, First Problem, Study 1

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APPENDIX 2 (continued)

Source	df Hypotheses	df Error	U _{stat}	Standardized Discriminant TC-M	TC-D	Function Coefficients Errors	Omissions
Shift-salience X Dominance	1	128	.9967	1.894	-1.228	-.933	.547
Shift-salience X Age	1	128	.9335	-1.240	2.062	-.331	.432
Dominance X Age	1	128	.9370	1.469	-2.281	1.088	.910
Salience X Time-limits X Shift-salience	1	128	.9888	.086	2.084	-2.052	-1.075
Salience X Time-limits X Dominance	1	128	.9569	2.670	-3.420	.583	.465
Salience X Time-limits X Age	1	128	.9185*	-.171	2.006	-1.305	-1.164
Salience X Shift-salience Salience X Dominance	1	128	.9785	1.615	-1.109	.178	.498
Salience X Shift-salience Salience X Age	1	128	.9902	-.516	2.096	-.691	-.537
Salience X Dominance X Age	1	128	.9562	-1.727	1.206	1.366	.454
Time-limits X Shift- Salience X Dominance	1	128	.9453	.033	-1.069	1.695	.771
Time-limits X Shift- Salience X Age	1	128	.9603	-.928	.030	1.117	1.232

APPENDIX 2 (continued)

Source	df Hypotheses	df Error	U**	Standardized Discriminant TC-M	Function Errors	Coefficients Omissions
Time-limits X Dominance X Age	1	128	.9093*	-.686	-1.199	-1.123
Shift-sallence X Dominance X Age	1	128	.9797	-.223	-.900	-.598
Sallence X Time-limits Shift-sallence X Dominance	1	128	.9751	-2.037	2.152	.294
Sallence X Time-limits X Shift-sallence X Age	1	128	.9595	.776	-2.093	-.895
Sallence X Time-limits X Dominance X Age	1	128	.9729	1.318	-2.257	-1.188
Sallence X Shift-sallence X Dominance X Age	1	128	.9602	.109	.380	.416
Time-limits X Shift-sallence X Dominance X Age	1	128	.9703	1.184	.739	.196
Sallence X Time-limits X Shift-sallence X Dominance X Age	1	128	.9752	.400	-.325	-.957

*p < .05

**Wilks' Lambda Criterion

APPENDIX 3

Analysis of Variance of Trials to a Moderate Criterion, with Saliency (Sal), Time-limits (Time), Shift-saliency (Grp), Dominance (Dom), and Age as Factors, First Problem, Study 1

Source	df	SS	MS	F	Sig
Sal	1	29866.	29866.	66.92	.000
Time	1	10890.	10890.	24.40	.000
Sal Time	1	102.40	102.40	.23	.633
Grp	1	532.90	532.90	1.19	.277
Sal Grp	1	152.10	152.10	.34	.560
Time Grp	1	189.23	189.23	.42	.516
Sal Time Grp	1	.25000E-01	.25000E-01	.00	.995
Dom	1	624.10	624.10	1.40	.239
Sal Dom	1	435.60	435.60	.98	.325
Time Dom	1	255.03	255.03	.57	.451
Sal Time Dom	1	3.0250	3.0250	.01	.935
Grp Dom	1	2.0250	2.0250	.00	.946
Sal Grp Dom	1	931.22	931.22	2.09	.151
Time Grp Dom	1	1562.5	1562.5	3.50	.064
Sal Time Grp Dom	1	6.4000	6.4000	.01	.905
Age	1	29268.	29268.	65.58	.000
Sal Age	1	13323.	13323.	29.85	.000
Time Age	1	2480.6	2480.6	5.56	.020
Sal Time Age	1	390.62	390.62	.88	.351
Grp Age	1	1428.0	1428.0	3.20	.076
Sal Grp Age	1	308.03	308.02	.69	.408
Time Grp Age	1	448.90	448.90	1.01	.318
Sal Time Grp Age	1	324.90	324.90	.73	.395
Dom Age	1	931.23	931.23	2.09	.151
Sal Dom Age	1	1380.6	1380.6	3.09	.081
Time Dom Age	1	136.90	136.90	.31	.581

APPENDIX 3 (continued)

Source	df	SS	MS	F	Sig
Sal Time	1	40.000	40.000	.09	.765
Grp	1	640.00	640.00	1.43	.233
Sal	1	2192.5	2102.5	4.71	.032
Time	1	1476.2	1476.2	3.31	.071
Sal Time	1	469.22	469.23	1.05	.307
Within Cells	128	57129.			
Total	159	.15783E+06	446.32		

APPENDIX 4 (continued)

Source	df	SS	MS	F	Sig
Sal	1	479.56	479.56	1.26	.264
Time	1	61.256	61.256	.16	.689
Dom	1	735.31	735.31	1.93	.167
Grp	1	1802.3	1802.3	4.73	.032
Age	1	975.16	975.16	2.56	.112
Sal	1	438.91	438.91	1.15	.285
Time	128	48808.	381.31		
Dom	159	.14977E+06			
Grp					
Age					
Within Cells					
Total					

Analysis of Variance of Errors, with Sallence (Sal), Time-limits (Time), Shift-sallence (Grp), Dominance (Dom), and Age as Factors, First Problem, Study 1

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APPENDIX 6

Analysis of Variance of Omissions, with Sallence (Sal), Time-limits (Time),
Shift-sallence (Grp), Dominance (Dom), and Age, as Factors,
First Problem, Study 1

Source	df	SS	MS	F	Sig
Sal	1	234.50	234.50	9.54	.002
Time	1	1511.1	1511.1	61.47	.000
Sal	1	147.65	147.65	6.01	.016
Grp	1	80.798	80.798	3.29	.072
Sal	1	2.4256	2.4256	.10	.754
Time	1	64.643	64.643	2.63	.107
Sal	1	2.4255	2.4255	.10	.754
Time	1	67.211	67.211	2.73	.101
Sal	1	4.1279	4.1279	.17	.683
Time	1	77.980	77.980	3.17	.077
Sal	1	5.5132	5.5132	.22	.637
Time	1	7.0980	7.0980	.29	.592
Sal	1	29.156	29.156	1.19	.278
Time	1	20.808	20.808	.85	.359
Sal	1	14.581	14.581	.59	.443
Time	1	866.30	866.30	35.24	.000
Sal	1	141.19	141.19	5.74	.018
Time	1	657.32	657.32	26.74	.000
Sal	1	70.623	70.623	2.87	.093
Time	1	112.73	112.73	4.59	.034
Sal	1	.42935E-03	.32935E-03	.00	.997
Time	1	99.698	99.698	4.06	.046
Sal	1	.85404E-01	.85404E-01	.00	.953
Time	1	73.306	73.306	2.98	.087
Sal	1	5.7381	5.7381	.23	.630
Age	1	14.581	14.581	.59	.443
Age	1	866.30	866.30	35.24	.000
Age	1	141.19	141.19	5.74	.018
Age	1	657.32	657.32	26.74	.000
Age	1	70.623	70.623	2.87	.093
Age	1	112.73	112.73	4.59	.034
Age	1	.42935E-03	.32935E-03	.00	.997
Age	1	99.698	99.698	4.06	.046
Age	1	.85404E-01	.85404E-01	.00	.953
Age	1	73.306	73.306	2.98	.087
Age	1	5.7381	5.7381	.23	.630

APPENDIX 7

Analysis of Variance of Trials to a Moderate Criterion Data
of Criterion Four Year Olds and Ten Year Olds with
Sallience, Time-limits and Age as Factors,
First Problem, Study 1

Source	df	MS	F
Age	1	5584.15	29.15*
Sallience	1	11214.47	58.53*
Time-limits	1	5430.36	28.34*
Age X Sallience	1	3037.21	15.88*
Age X Time-limits	1	646.27	3.37**
Sallience X Time-limits	1	397.48	2.07
Sallience X Time-limits X Age	1	42.33	.22
Within Cells	130	191.59	

*p < .05

**p < .10

APPENDIX 8

Analysis of Variance of Transformed Difference Scores of Errors
Made on Different and Same Trials during Original Training,
with Saliency, Time-limits, Dominance, and Age as
Factors, Study 1

Source	df	MS	F
Age	1	12.70	4.69*
Saliency	1	46.07	17.00*
Time-limits	1	5.02	1.85
Dominance	1	17.40	6.42*
Age X Saliency	1	8.79	3.24*
Age X Time-limits	1	.31	.11
Age X Dominance	1	.01	.00
Saliency X Dominance	1	2.52	.93
Saliency X Time-limits	1	4.56	1.69
Time-limits X Dominance	1	.02	.01
Age X Saliency X Time-limits	1	.08	.03
Age X Dominance X Saliency	1	1.56	.58
Age X Time-limits X Dominance	1	.40	.15
Saliency X Time-limits X Dominance	1	.94	.35
Age X Saliency X Time-limits X Dominance	1	1.94	.72
Within Cells	144	2.71	

*p < .05

APPENDIX 9

Analysis of Variance of Latency Data from the
First Problem of Study 1

Source	df	MS	F
Sallience	1	3.12	21.68*
Time-limits	1	36.16	251.61*
Dominance	1	.15	1.08
Age	1	22.20	154.47*
Shift-sallience	1	.01	.05
Sallience X Time-limits	1	1.95	13.58*
Sallience X Dominance	1	.10	.69
Sallience X Age	1	1.67	11.59*
Sallience X Shift-sallience	1	.33	2.30
Time-limits X Dominance	1	.07	.49
Time-limits X Age	1	5.83	40.60*
Time-limits X Shift-sallience	1	.08	.54
Dominance X Age	1	.00	.00
Dominance X Shift-sallience	1	.01	.07
Sallience X Time-limits X Dominance	1	.16	1.08
Sallience X Time-limits X Age	1	1.13	7.84*
Sallience X Time-limits X Shift-sallience	1	.42	2.92
Time-limits X Dominance X Age	1	.00	.04
Time-limits X Dominance X Shift-sallience	1	.08	.53

APPENDIX 9 (continued)

Source	df	MS	F
Saliency X Dominance X Shift-saliency	1	.16	1.12
Saliency X Age X Shift-saliency	1	.04	.32
Time-limits X Age X Shift-saliency	1	.001	.04
Saliency X Time-limits X Dominance X Age	1	.07	.48
Saliency X Time-limits X Dominance X Shift-saliency	1	.40	2.76
Saliency X Dominance X Shift-saliency X Age	1	.41	2.82
Time-limits X Dominance X Shift-saliency X Age	1	.02	.12
Saliency X Time-limits X Age X Shift-saliency	1	.01	.08
Saliency X Time-limits X Dominance X Age X Shift-saliency	1	.80	5.60*
Within Cells	128	.14	

*p < .05

APPENDIX 10

Analysis of Variance of D-S Latency Scores from
the First Problem of Study 1

Source	df	MS	F
Sallience	1	.003	.02
Time-limits	1	3.52	32.31*
Dominance	1	.14	1.32
Age	1	.24	2.24
Sallience X Time-limits	1	.05	.42
Sallience X Dominance	1	.00	.00
Sallience X Age	1	.03	.23
Time-limits X Dominance	1	.01	.06
Time-limits X Age	1	.47	4.31*
Dominance X Age	1	.05	.42
Sallience X Time-limits X Dominance	1	.03	.27
Sallience X Time-limits X Age	1	.04	.40
Sallience X Dominance X Age	1	.03	.25
Time-limits X Dominance X Age	1	.10	.88
Sallience X Time-limits X Dominance X Age	1	.02	.21
Within Cells	144	.11	

*p < .05

APPENDIX 11

Multivariate Analysis of Variance, using Trials to a Moderate Criterion,
Trials to a Difficult Criterion, Errors, and Omissions
as Criterion Variables, Shift Phase of Study 1

Source	df Hypotheses	df Error	U**	Standardized Discriminant Function Coefficients		
				TC-M	TC-D	Errors
Sallence	1	128	.9885	3.083	-.805	-2.286
Time-limits	1	128	.9757	-.799	1.167	.442
Shift-sallence	1	128	.5404*	.384	.636	.025
Dominance	1	128	.8901*	.081	.821	.118
Age	1	128	.7745*	1.125	.036	-.384
Sallence X Time-limits	1	128	.9687	.693	.397	-1.251
Sallence X Shift-sallence	1	128	.9835	-2.366	1.818	.835
Sallence X Dominance	1	128	.9628	2.845	.422	-3.035
Sallence X Time-limits X Age	1	128	.9672	-.106	.490	.088
Sallence X Shift-sallence X Dominance	1	128	.9470	2.977	.082	-3.011
Sallence X Shift-sallence X Age	1	128	.9881	-2.383	.766	2.261

APPENDIX 11 (continued)

Source	df Hypotheses	df Error	U**	Standardized Discriminant Function Coefficients			Omissions
				TC-M	TC-D	Errors	
Sallence X Dominance X Age	1	128	.9732	.991	1.739	-2.348	-.177
Time-limits X Shift-sallence X Dominance	1	128	.9697	-1.886	-.912	3.060	-.208
Time-limits X Shift-sallence X Age	1	128	.9936	.451	-1.211	1.349	.325
Time-limits X Dominance X Age	1	128	.9803	3.068	-.373	-2.263	-.154
Sallence X Age	1	128	.9471	-1.668	1.824	.443	-.010
Time-limits X Shift-sallence	1	128	.9734	.820	-1.813	1.296	.181
Time-limits X Dominance	1	128	.9696	-1.977	-1.007	3.141	.060
Time-limits X Age	1	128	.9816	-.498	1.390	-.206	.405
Shift-sallence X Dominance	1	128	.8874*	.100	.631	.123	.409
Shift-sallence X Age	1	128	.7853*	1.712	-.950	-.020	.111
Dominance X Age	1	128	.9756	.599	-1.321	1.209	.421
Sallence X Time-limits X Shift-sallence	1	128	.9984	.543	-.094	.144	-.915

APPENDIX 11 (continued)

Source	df Hypotheses Error	df	U**	Standardized Discriminant Function		
				TC-M	TC-D	TC-D Coefficients Errors Omissions
Sallence X Time-limits X Dominance	1	128	.9931	2.772	-1.036	-1.459 .357
Sallence X Time-limits X Age	1	128	.9672	-.106	.490	.088 -.983
Sallence X Shift-sallence X Dominance	1	128	.9740	2.977	.082	-3.011 .183
Sallence X Shift-sallence X Age	1	128	.9881	-2.383	.766	2.261 -.230
Sallence X Dominance X Age	1	128	.9732	.991	1.739	-2.348 -.177
Time-limits X Shift-sallence X Dominance	1	128	.9697	-1.886	-.912	3.060 -.208
Time-limits X Shift-sallence X Age	1	128	.9936	.451	-1.211	1.349 .325
Time-limits X Dominance X Age	1	128	.9803	3.068	-.373	-2.263 -.154
Shift-sallence X Dominance X Age	1	128	.9474	.127	-.859	.875 .871

APPENDIX 11 (continued)

Source	df	Hypotheses	df	U**	Standardized Discriminant Function Coefficients		
					TC-M	TC-D	Errors Omissions
Sallience X Time-limits X Shift-sallience X Dominance	1	128	.9646	1.422	-.59	-.675	.889
Sallience X Time-limits X Shift-sallience X Age	1	128	.9665	-.167	1.912	-1.134	.331
Sallience X Time-limits X Dominance X Age	1	128	.9820	1.625	-1.200	.227	-.337
Sallience X Shift-sallience X Dominance X Age	1	128	.9884	1.517	1.379	-2.753	.241
Time-limits X Shift-sallience X Dominance X Age	1	128	.9857	2.865	-.001	2.426	.184
Sallience X Time-limits X Shift-sallience X Dominance X Age	1	128	.9556	.498	-.068	.234	-.879

*p < .05

**Wilks' Lambda Criterion

APPENDIX 12

Analysis of Variance of Trials to a Moderate Criterion, with
Saliency (Sal), Time-limits (Time), Shift-saliency
(Grp), Dominance (Dom), and Age as Factors
Shift Problem, Study 1

Source					df	SS	MS	F	SIG
Sal					1	11.556	11.556	.11	.737
	Time				1	158.01	158.01	1.54	.216
Sal	Time				1	.30625	.30625	.00	.956
		Grp			1	10033.	10033.	98.04	.000
Sal		Grp			1	.15625	.15625	.00	.969
	Time	Grp			1	88.506	88.506	.86	.354
Sal	Time	Grp			1	3.9063	3.9063	.04	.845
			Dom		1	1339.8	1339.8	13.09	.000
Sal			Dom		1	51.756	51.756	.51	.478
	Time		Dom		1	6.8063	6.8062	.07	.797
Sal	Time		Dom		1	28.056	28.056	.27	.601
		Grp	Dom		1	1182.7	1182.7	11.56	.001
Sal		Grp	Dom		1	18.906	18.906	.18	.668
	Time	Grp	Dom		1	12.656	12.656	.12	.726
Sal	Time	Grp	Dom		1	18.906	18.906	.18	.668
				Age	1	3431.8	3431.8	33.53	.000
Sal				Age	1	85.556	85.556	.84	.362
	Time			Age	1	85.556	85.556	.84	.362
Sal	Time			Age	1	21.756	21.756	.21	.646
		Grp		Age	1	2797.3	2797.3	27.33	.000
Sal		Grp		Age	1	23.256	23.256	.23	.634
	Time	Grp		Age	1	45.156	45.156	.44	.508
Sal	Time	Grp		Age	1	61.256	61.256	.60	.441
			Dom	Age	1	146.31	146.31	1.43	.234
Sal			Dom	Age	1	23.256	23.256	.23	.634
	Time		Dom	Age	1	85.556	85.556	.84	.362
Sal	Time		Dom	Age	1	127.81	127.81	1.25	.266
		Grp	Dom	Age	1	97.656	97.656	.95	.330
Sal		Grp	Dom	Age	1	3.9063	3.9063	.04	.845
	Time	Grp	Dom	Age	1	68.906	68.906	.67	.413
Sal	Time	Grp	Dom	Age	1	150.16	150.16	1.47	.228
Within Cells					128	13099.			
Total					159	33309.			

APPENDIX 13

Analysis of Variance of Trials to a Difficult Criterion, with
Saliency (Sal), Time-limits (Time), Dominance (Dom),
Shift-saliency (Grp), and Age as Factors,
Shift Problem, Study 1

Source	df	SS	MS	F	SIG
Sal	1	.22500	.22500	.00	.962
Time	1	260.10	260.10	2.69	.103
Sal Time	1	4.2250	4.2250	.04	.835
Grp	1	10049.	10049.	104.03	.000
Sal Grp	1	50.625	50.625	.52	.470
Time Grp	1	1.6000	1.6000	.02	.898
Sal Time Grp	1	2.0250	2.0250	.02	.885
Dom	1	1512.9	1512.9	15.66	.000
Sal Dom	1	27.225	27.225	.28	.596
Time Dom	1	.10000	.10000	.00	.975
Sal Time Dom	1	3.0250	3.0250	.03	.860
Grp Dom	1	1299.6	1299.6	13.45	.000
Sal Grp Dom	1	3.0250	3.0250	.03	.860
Time Grp Dom	1	1.6000	1.6000	.02	.898
Sal Time Grp Dom	1	.22500	.22500	.00	.962
Age	1	2496.4	2496.4	25.84	.000
Sal Age	1	390.63	390.63	4.04	.046
Time Age	1	168.10	168.10	1.74	.189
Sal Time Age	1	30.625	30.625	.32	.574
Grp Age	1	1020.1	1020.1	10.56	.001
Sal Grp Age	1	55.225	55.225	.57	.451
Time Grp Age	1	14.400	14.400	.15	.700
Sal Time Grp Age	1	216.23	216.23	2.24	.137
Dom Age	1	36.100	36.100	.37	.542
Sal Dom Age	1	93.025	93.025	.96	.328
Time Dom Age	1	22.500	22.500	.23	.630
Sal Time Dom Age	1	27.225	27.225	.28	.596
Grp Dom Age	1	25.600	25.600	.27	.608
Sal Grp Dom Age	1	18.225	18.225	.19	.665
Time Grp Dom Age	1	32.400	32.400	.34	.564
Sal Time Grp Dom Age	1	87.025	87.025	.90	.344
Within Cells	128	12364.			
Total	159	30314.			

APPENDIX 14

Analysis of Variance of Errors, with Sallience (Sal), Time-
limits (Time), Shift-sallience (Grp), Dominance (Dom),
and Age as Factors, Shift Problem, Study 1

Source

Sal				1	.62500E-02	.62500E-02	.00	.990	
	Time			1	.74.256	74.256	1.84	.177	
Sal	Time			1	1.0563	1.0562	.03	.872	
		Grp		1	3792.8	3792.8	93.92	.000	
Sal		Grp		1	3.3063	3.3062	.08	.775	
	Time	Grp		1	39.006	39.006	.97	.328	
Sal	Time	Grp		1	1.4063	1.4063	.03	.852	
			Dom	1	529.26	529.26	13.11	.000	
Sal			Dom	1	.62500E-02	.62500E-02	.00	.990	
	Time		Dom	1	26.406	26.406	.65	.420	
Sal	Time		Dom	1	3.9062	3.9062	.10	.756	
		Grp	Dom	1	465.81	465.81	11.54	.001	
Sal		Grp	Dom	1	1.0563	1.0562	.03	.872	
	Time	Grp	Dom	1	31.506	31.506	.78	.379	
Sal	Time	Grp	Dom	1	1.4063	1.4063	.03	.852	
			Age	1	1118.3	1118.3	27.69	.000	
Sal			Age	1	58.806	58.806	1.46	.230	
	Time		Age	1	35.156	35.156	.87	.353	
Sal	Time		Age	1	9.5062	9.5063	.24	.628	
		Grp	Age	1	888.31	888.31	22.00	.000	
Sal		Grp	Age	1	24.806	24.806	.61	.435	
	Time	Grp	Age	1	20.306	20.306	.50	.480	
Sal	Time	Grp	Age	1	17.556	17.556	.43	.511	
			Dom	Age	1	63.756	63.756	1.58	.211
Sal			Dom	Age	1	.75625	.75625	.02	.891
	Time		Dom	Age	1	8.5562	8.5562	.21	.646
Sal	Time		Dom	Age	1	41.006	41.006	1.02	.316
		Grp	Dom	Age	1	47.306	47.306	1.17	.281
Sal		Grp	Dom	Age	1	.30625	.30625	.01	.931
	Time	Grp	Dom	Age	1	7.6562	7.6562	.19	.664
Sal	Time	Grp	Dom	Age	1	56.406	56.406	1.40	.239
Within Cells				128	5168.8	40.381			
Total				159	12538.				

APPENDIX 15

Analysis of Variance of Omissions, with Salience (Sal), Time-
limits (Time), Shift-salience (Grp), Dominance (Dom),
and Age as Factors, Shift Problem, Study 1

Source					df	SS	MS	F	SIG
Sal					1	.56250E-01	.56250E-01	.14	.713
	Time				1	.30625	.30625	.74	.391
Sal	Time				1	1.4063	1.4063	3.41	.067
		Grp			1	.75625	.75625	1.83	.178
Sal		Grp			1	.62500E-02	.62500E-02	.02	.902
	Time	Grp			1	.56250E-01	.56250E-01	.14	.713
Sal	Time	Grp			1	.56250E-01	.56250E-01	.14	.713
			Dom		1	.30625	.30625	.74	.391
Sal			Dom		1	.62500E-02	.62500E-02	.02	.902
	Time		Dom		1	.62599E-02	.62500E-02	.02	.902
Sal	Time		Dom		1	.56250E-01	.56250E-01	.14	.713
		Grp	Dom		1	2.2563	2.2563	5.47	.021
Sal		Grp	Dom		1	.56250E-01	.56250E-01	.14	.713
	Time	Grp	Dom		1	.56250E-01	.56250E-01	.14	.713
Sal	Time	Grp	Dom		1	1.4063	1.4063	3.41	.067
				Age	1	3.3062	3.3062	8.02	.005
Sal				Age	1	.56250E-01	.56250E-01	.14	.713
	Time			Age	1	.30625	.30625	.74	.391
Sal	Time			Age	1	1.4063	1.4063	3.41	.067
		Grp		Age	1	.75625	.75625	1.83	.178
Sal		Grp		Age	1	.62500E-02	.62500E-02	.02	.902
	Time	Grp		Age	1	.56250E-01	.56250E-01	.14	.713
Sal	Time	Grp		Age	1	.56250E-01	.56250E-01	.14	.713
			Dom	Age	1	.30625	.30625	.74	.391
Sal			Dom	Age	1	.62500E-02	.62500E-02	.02	.902
	Time		Dom	Age	1	.62500E-02	.62500E-02	.02	.902
Sal	Time		Dom	Age	1	.56250E-01	.56250E-01	.14	.713
		Grp	Dom	Age	1	2.2562	2.2563	5.47	.021
Sal		Grp	Dom	Age	1	.56250E-01	.56250E-01	.14	.713
	Time	Grp	Dom	Age	1	.56250E-01	.56250E-01	.14	.713
Sal	Time	Grp	Dom	Age	1	1.4062	1.4063	3.41	.067
	Within Cells				128	52.800	.41250		
	Total				159	69.694			

APPENDIX 16

Analysis of Variance of Unweighted Means of Shift Performance
by Criterion and Noncriterion Four Year Olds as a
Function of Shift-salience, Study 1

Source	df	MS	F
Shift-salience	1	12825.82	112.69*
Performance on first problem (Criterion vs. Noncriterion)	1	1571.65	13.83*
Shift-salience X Performance on first problem	1	949.27	8.38*
Within Cells	76	113.68	

*p < .05

APPENDIX 17

Analysis of Variance of Unweighted Means of Number of Trials
 Required to Reach a Moderate Criterion by Noncriterion
 Four Year Olds and Ten Year Olds, with Age,
 Dominance, and Shift-salience as Factors,
 Shift Problem, Study 1

Source	df	MS	F
Age	1	1812.63	18.71*
Dominance	1	914.62	9.44*
Shift-salience	1	7155.42	73.85*
Age X Dominance	1	64.16	.66
Age X Shift-salience	1	1739.92	17.96*
Dominance X Shift-salience	1	953.11	9.84*
Age X Dominance X Shift-salience	1	75.01	.77
Within Cells	130	96.89	

*p < .05

APPENDIX 18

Analysis of Variance of Transformed D-S Scores of Errors
from the Shift Phase of Study 1

Source	df	MS	F
Saliency	1	2.08	2.02
Time-limits	1	.02	.02
Dominance	1	.13	.13
Shift-saliency	1	17.40	16.89*
Age	1	4.35	4.22*
Saliency X Time-limits	1	.01	.01
Saliency X Dominance	1	3.31	3.21
Saliency X Shift-saliency	1	2.33	2.26
Saliency X Age	1	3.79	3.68
Time-limits X Dominance	1	1.54	1.50
Time-limits X Shift-saliency	1	.04	.04
Time-limits X Age	1	.04	.04
Dominance X Shift-saliency	1	.01	.01
Dominance X Age	1	.56	.54
Shift-saliency X Age	1	3.41	3.31**
Saliency X Time-limits X Shift-saliency	1	.02	.02
Saliency X Time-limits X Dominance	1	.22	.21
Saliency X Time-limits X Age	1	.28	.26

APPENDIX 18 (continued)

Source	df	MS	F
Time-limits X Dominance X Shift-salience	1	.70	.68
Time-limits X Dominance X Age	1	2.04	1.98
Time-limits X Shift-salience X Age	1	.02	.02
Dominance X Shift-salience X Age	1	.70	.68
Salience X Dominance X Shift-salience	1	3.64	3.53
Salience X Shift-salience X Age	1	3.50	3.40
Salience X Dominance X Age	1	.98	.96
Salience X Time-limits X Dominance X Shift-salience	1	.14	.14
Salience X Time-limits X Dominance X Age	1	.82	.79
Salience X Time-limits X Shift-salience X Age	1	1.60	1.56
Salience X Dominance X Shift-salience X Age	1	1.41	1.37
Time-limits X Dominance X Shift-salience X Age	1	2.37	2.30
Salience X Time-limits X Dominance X Shift-salience X Age	1	.02	.02
Within Cells	128	1.03	

*p < .05

APPENDIX-19

Analysis of Variance of Latency Data from the
Shift Phase of Study 1

Source	df	MS	F
Sallience	1	.03	.12
Time-limits	1	12.74	50.96*
Dominance	1	.25	.99
Shift-sallience	1	6.66	26.64*
Age	1	44.06	176.24*
Sallience X Time-limits	1	.36	1.44
Sallience X Dominance	1	.14	.56
Sallience X Shift-sallience	1	.05	.20
Sallience X Age	1	.09	.36
Time-limits X Dominance	1	.46	1.84
Time-limits X Shift-sallience	1	.01	.04
Time-limits X Age	1	2.12	8.48*
Dominance X Shift-sallience	1	.02	.08
Dominance X Age	1	.12	.48
Shift-sallience X Age	1	1.00	4.00*
Sallience X Time-limits X Dominance	1	.12	.48
Sallience X Time-limits X Shift-sallience	1	.11	.44
Sallience X Time-limits X Age	1	.12	.48

APPENDIX 19 (continued)

Source	df	MS	F
Saliency X Dominance X Shift-saliency	1	.09	.36
Saliency X Dominance X Age	1	.42	1.68
Saliency X Shift-saliency X Age	1	.04	.16
Time-limits X Dominance X Shift-saliency	1	.10	.40
Time-limits X Dominance X Age	1	.44	1.76
Dominance X Shift-saliency X Age	1	.05	.20
Time-limits X Dominance X Shift-saliency	1	.00	.00
Saliency X Time-limits X Dominance X Shift-saliency	1	.71	2.84
Saliency X Time-limits X Dominance X Age	1	.11	.44
Time-limits X Dominance X Shift-saliency X Age	1	.44	1.76
Saliency X Time-limits X Shift-saliency X Age	1	.04	.16
Saliency X Dominance X Shift-saliency X Age	1	.01	.04
Saliency X Dominance X Age X Time-limits X Shift-saliency	1	.24	.96
Within Cells	128	.25	

*p < .05

APPENDIX 20

Analysis of Variance of D-S Latency Scores
from the Shift Phase of Study 1

Source	df	MS	F
Sallience	1	.00	.00
Time-limits	1	.33	6.71*
Dominance	1	.02	.39
Age	1	.24	4.82*
Shift-sallience	1	.20	4.15*
Sallience X Time-limits	1	.13	2.72
Sallience X Dominance	1	.02	.46
Sallience X Age	1	.00	.05
Sallience X Shift-sallience	1	.14	2.90
Time-limits X Dominance	1	.10	2.07
Time-limits X Age	1	.08	1.67
Time-limits X Shift-sallience	1	.03	.58
Dominance X Age	1	.01	.21
Dominance X Shift-sallience	1	.16	3.25
Age X Shift-sallience	1	.08	1.57
Sallience X Time-limits X Dominance	1	.52	10.57*
Sallience X Time-limits X Age	1	.00	.01
Sallience X Time-limits X Shift-sallience	1	.02	.46

APPENDIX 20 (continued)

Source	df	MS	F
Saliency X Dominance X Age	1	.11	2.25
Saliency X Dominance X Shift-saliency	1	.09	1.78
Saliency X Age X Shift-saliency	1	.10	2.01
Time-limits X Dominance X Age	1	.03	.63
Time-limits X Dominance X Shift-saliency	1	.00	.00
Time-limits X Age X Shift-saliency	1	.14	2.76
Dominance X Age X Shift-saliency	1	.08	1.61
Saliency X Time-limits X Dominance X Age	1	.22	4.42
Saliency X Time-limits X Dominance X Shift-saliency	1	.11	2.20
Saliency X Time-limits X Age X Shift-saliency	1	.09	1.81
Saliency X Dominance X Age X Shift-saliency	1	.12	2.44
Time-limits X Dominance X Age X Shift-saliency	1	.00	.00
Saliency X Time-limits X Dominance X Age X Shift-saliency	1	.04	.61
Within Cells	128	.05	

*p < .05

APPENDIX 21

Multivariate Analysis of Variance, using Trials to a Moderate Criterion (TC-M),
Trials to a Difficult Criterion (TC-D), Errors, and
Omissions as Criterion Variables, Study 2

Source	df Hypotheses	df Error	U**	Standardized Discriminant Functions Coefficients			
				TC-M	TC-D	Errors	Omissions
Sallence	1	40	.8760	.369	-1.223	1.542	.949
Time-limits	1	40	.3471*	-.093	.463	.164	.917
Order	4	40	.6905	1.027	-.079	-1.456	-1.087
Age	1	40	.2331*	1.103	-.411	.219	.624
Sallence X Time-limits	1	40	.8573	-.597	-.534	1.821	.964
Sallence X Order	4	40	.6299	1.896	.072	-1.676	-.781
Sallence X Age	1	40	.9320	-1.451	-.148	2.011	.999
Time-limits X Order	4	40	.7682	.700	-.098	.102	.846
Time-limits X Age	1	40	.5321*	1.789	-1.738	.228	.985
Order X Age	4	40	.6763	2.497	-2.164	-.119	.798
Sallence X Time-limits X Order	4	40	.6945	-.551	-.536	1.758	.997

APPENDIX 21 (continued)

Source	df Hypotheses	df Error	U**	Standardized Discriminant Functions Coefficients			
				TC-M	TC-D	Errors	Omissions
Sallence X Time-limits X Age	1	40	.9117	-.998	-.602	1.984	1.033
Sallence X Order X Age	4	40	.7469	-1.474	-.355	2.118	.959
Time-limits X Order X Age	4	40	.6662	2.298	-1.630	-.092	.712
Sallence X Time-limits X Order X Age	4	40	.6298	1.452	-1.408	.819	.607

*p < .05

**Wilk's Lambda Criterion

APPENDIX 22

Analysis of Variance of Trials to a Moderate Criterion,
with Saliency (Sal), Time-limits (Time), Order (Ord),
and Age as Factors, Study 2

Source	df	SS	MS	F	SIG
Sal	1	667.01	667.01	1.17	.285
Time	1	5865.3	5865.3	10.33	.003
Sal Time	1	546.01	546.01	.96	.333
Ord	4	557.07	139.27	.25	.911
Sal Ord	4	4817.4	1204.4	2.12	.096
Time Ord	4	2062.9	515.72	.91	.469
Sal Time Ord	4	1960.9	490.23	.86	.494
Age	1	51359.	51359.	90.43	.000
Sal Age	1	4.5130	4.5130	.01	.929
Time Age	1	1044.0	1044.0	1.84	.183
Sal Time Age	1	5.5117	5.5117	.01	.922
Ord Age	4	515.83	128.96	.23	.922
Sal Ord Age	4	2441.2	610.29	1.07	.382
Time Ord Age	4	3562.9	890.73	1.57	.201
Sal Time Ord Age	4	5095.2	1273.8	2.24	.081
Within-Cells	40	22717.	567.91		
Total	79	.10322E+06			

Appendix 23

Analysis of Variance of Trials to a Difficult Criterion,
with Saliency (Sal), Time-limits (Time),
Order (Ord), and Age as Factors,
Study 2

Source				df	SS	MS	F	SIG
Sal				1	378.45	378.45	.70	.407
	Time			1	9245.0	9245.0	17.16	.000
Sal	Time			1	470.46	470.46	.87	.356
		Ord		4	1115.6	278.89	.52	.723
Sal		Ord		4	3252.7	813.17	1.51	.213
	Time	Ord		4	2276.9	569.22	1.06	.391
Sal	Time	Ord		4	2182.2	545.54	1.01	.413
			Age	1	43152.	43152.	80.08	.000
Sal			Age	1	16.199	16.199	.03	.863
	Time		Age	1	151.26	151.26	.28	.599
Sal	Time		Age	1	4.9912	4.9912	.01	.924
		Ord	Age	4	209.57	52.394	.10	.933
Sal		Ord	Age	4	2323.2	580.79	1.08	.380
	Time	Ord	Age	4	1911.9	477.97	.89	.481
Sal	Time	Ord	Age	4	2959.9	729.97	1.37	.260
Within Cells				40	21554.	538.85		
Total				79	91204.			

Appendix 24

Analysis of Variance of Errors, with Sallence (Sal),
Time-limits (Time), Order (Ord),
and Age as Factors, Study 2

Source					df	SS	MS	F	SIG
Sal					1	337.02	337.02	1.70	.200
	Time				1	395.16	395.16	1.99	.166
Sal	Time				1	379.32	379.32	1.91	.174
		Ord			4	615.76	153.94	.78	.547
Sal		Ord			4	1008.5	252.12	1.27	.297
	Time	Ord			4	410.19	102.55	.52	.723
Sal	Time	Ord			4	990.43	247.61	1.25	.306
			Age		1	10947.	10947.	55.21	.000
Sal			Age		1	45.294	45.294	.23	.635
	Time		Age		1	17.863	17.863	.09	.766
Sal	Time		Age		1	54.778	54.778	.28	.602
		Ord	Age		4	133.68	33.419	.17	.953
Sal		Ord	Age		4	758.11	189.53	.96	.442
	Time	Ord	Age		4	451.69	112.92	.57	.686
Sal	Time	Ord	Age		4	1635.9	408.97	2.06	.104
		Within Cells			40	7931.0	198.28		
		Total			79	26111.			

Appendix 25

Analysis of Variance of Omissions, with Sallence (Sal),
Time-limits (Time), Order (Ord), and Age
as Factors, Study 2

Source				df	SS	MS	F	SIG
Sal				1	24.200	24.200	1.10	.302
	Time			1	1216.8	1216.8	55.06	.000
Sal	Time			1	31.250	31.250	1.41	.241
		Ord		4	148.70	37.175	1.68	.173
Sal		Ord		4	91.800	22.950	1.04	.399
	Time	Ord		4	108.20	27.050	1.22	.316
Sal	Time	Ord		4	87.501	21.875	.99	.424
			Age	1	520.20	520.20	23.54	.000
Sal			Age	1	18.050	18.050	.82	.372
	Time		Age	1	432.45	432.45	19.57	.000
Sal	Time		Age	1	24.200	24.200	1.10	.302
		Ord	Age	4	105.80	26.450	1.20	.327
Sal		Ord	Age	4	33.200	8.3000	.38	.825
	Time	Ord	Age	4	104.30	26.075	1.18	.334
Sal	Time	Ord	Age	4	31.299	7.8248	.35	.840
	Within Cells			40	884.00	22.100		
	Total			79	3862.0			

Appendix 26

Analysis of Variance of the Transfer Scores, with
Sallence (Sal), Time-limits (Time), Order (Ord),
and Age as Factors, Study 2

Source	df	MS	F
Sallence	1	.05	.03
Time-limits	1	.80	.53
Order	4	1.05	.70
Age	1	31.25	20.83*
Sallence X Time-limits	1	.05	.03
Sallence X Order	4	.99	.66
Sallence X Age	1	.00	.00
Time-limits X Order	4	3.49	2.32
Time-limits X Age	1	1.25	.83
Order X Age	4	1.19	.79
Sallence X Time-limits X Order	4	.30	.20
Sallence X Order X Age	4	.88	.58
Time-limits X Order X Age	4	3.38	2.25
Sallence X Time-limits X Order X Age	4	.38	.26
Within Cell	40	1.5	

*p < .05

Appendix 27

Analysis of Variance of Transformed D-S Error Scores
($X' = \sqrt{X + .05}$) from Study 2

Source	df	MS	F
Sallience	1	36.21	21.81*
Time-limits	1	14.13	8.45*
Age	1	10.31	6.21*
Sallience X Time-limits	1	1.30	.78
Sallience X Age	1	.34	.21
Time-limits X Age	1	4.93	2.97
Sallience X Time-limits X Age	1	4.48	2.70
Within Cells	72	1.66	

*p < .05

Appendix 28

Analysis of Variance of Response Latency
Data of Study 2

Source	df	MS	F
Saliency	1	.07	.26
Time-limits	1	20.75	77.70*
Age	1	11.94	44.71*
Saliency X Time-limits	1	.19	.69
Saliency X Age	1	.21	.77
Time-limits X Age	1	5.98	22.41*
Saliency X Time-limits X Age	1	.15	.55
Within Cells	72	.27	

* $p < .05$

Appendix 29

Analysis of Variance of D-S Latency Scores
from Study 2

Source	df	MS	F
Saliency	1	.12	3.49
Time-limits	1	.32	9.03*
Age	1	.07	.211
Saliency X Time-limits	1	.23	6.54*
Saliency X Age	1	.02	.44
Time-limits X Age	1	.02	.53
Saliency X Time-limits X Age	1	.02	.67
Within Cells	72	.04	

* $p < .05$

Appendix 30

Trials to a Moderate Criterion (TC-M), Trials to a Difficult
Criterion (TC-D), Errors (Err), Omissions (Omm),
Transfer Scores (Trans), and Response Latency
(Lat) for Each Subject in Study 2

	TC-M	TC-D	Err	Omm	Trans	Lat
--	------	------	-----	-----	-------	-----

Four Year, Nonsalient, 10 seconds Condition

Subjects:

1.	51	59	20	1	1	2.951
2.	96	96	58	5	5	3.653
3.	9	12	0	0	6	3.583
4.	10	29	6	0	6	6.623
5.	69	80	32	0	5	3.043
6.	96	96	41	1	0	4.066
7.	96	96	44	1	2	2.662
8.	9	12	0	0	5	3.078
9.	96	96	45	0	6	3.643
10.	13	19	3	0	6	3.594

Four Year, Nonsalient, 1.2 seconds Condition

Subjects:

1.	96	96	49	5	4	1.954
2.	75	79	23	22	6	2.464
3.	96	96	43	16	0	2.235
4.	96	96	29	4	5	2.192
5.	42	44	0	14	6	2.104
6.	78	96	34	15	6	2.295
7.	37	53	9	4	6	1.810
8.	19	32	3	6	6	2.106
9.	96	96	5	10	4	1.968
10.	96	96	40	12	6	2.079

Four Year, Salient, 1.2 seconds Condition

Subjects:

1.	96	96	37	27	5	2.325
2.	96	96	46	24	6	2.447
3.	25	50	6	10	6	2.142

Appendix 30 (continued)

	TC-M	TC-D	Err	Omm	Trans	Lat
4.	96	96	39	3	4	1.869
5.	96	96	45	3	5	2.069
6.	96	96	45	16	5	2.211
7.	96	96	49	16	6	2.051
8.	58	72	2	18	6	2.029
9.	96	96	26	34	4	2.607
10.	96	96	56	1	3	1.877

Four Year, Salient, 10 seconds Condition

Subjects:

1.	76	85	33	0	5	2.866
2.	19	23	4	0	5	4.738
3.	11	16	1	1	6	3.631
4.	46	60	20	1	5	3.872
5.	96	96	49	2	4	3.242
6.	96	96	49	0	0	4.577
7.	30	35	13	0	6	3.068
8.	67	70	28	0	4	3.002
9.	13	17	4	0	5	3.640
10.	96	96	36	0	4	4.589

Ten Year, Nonsalient, 1.2 seconds Condition

Subjects:

1.	20	23	0	0	6	1.972
2.	20	25	1	6	6	2.055
3.	13	35	2	4	6	1.905
4.	35	41	15	1	6	1.669
5.	15	31	1	0	6	1.925
6.	32	36	6	5	6	1.806
7.	77	83	35	0	5	1.763
8.	13	27	3	2	6	2.044
9.	24	62	11	5	6	1.887
10.	14	21	2	1	6	2.287

Ten Year, Nonsalient, 10 seconds Condition

Subjects:

1.	10	13	1	0	6	2.148
2.	11	15	1	1	6	1.991
3.	10	13	1	0	6	2.210

Appendix 30 (continued)

	TC-M	TC-D	Err	Omni	Trans	Lat
4.	9	12	0	0	6	2.096
5.	9	12	0	0	6	2.558
6.	9	12	0	0	6	2.372
7.	9	12	0	0	6	2.360
8.	11	17	2	0	6	2.172
9.	26	31	7	0	6	2.041
10.	12	16	2	0	6	2.204

Ten Year, Salient, 1.2 seconds Condition

Subjects:

1.	21	25	3	2	6	1.824
2.	12	36	3	3	6	1.764
3.	10	13	0	1	6	1.660
4.	12	36	3	3	6	1.768
5.	22	52	6	6	6	1.987
6.	13	17	0	4	6	1.884
7.	13	47	3	4	6	1.884
8.	12	18	0	0	6	1.929
9.	32	50	5	10	6	2.108
10.	10	13	0	1	6	2.167

Ten Year, Salient, 10 seconds Condition

Subjects:

1.	9	12	0	0	6	2.221
2.	24	33	9	0	6	3.149
3.	9	12	0	0	6	2.153
4.	9	12	0	0	6	2.638
5.	11	30	4	0	6	3.457
6.	9	12	0	0	6	2.152
7.	9	12	0	0	6	2.528
8.	9	12	0	0	6	2.298
9.	9	12	0	0	6	2.075
10.	9	12	0	0	6	2.914

END

04

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FIN