DEVELOPMENTAL CHANGES IN ATTENTION TO REDUNDANT AND IRRELEVANT CUES: THE ROLE OF PERCEPTUAL LEARNING

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This thesis has been read and approved by:

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Abstract

The experiment was designed to determine if attention to redundant and irrelevant information decreases during development, and whether perceptual learning may account for changes in attention to such information.

The 180 subjects consisted of equal numbers of Grade one children, Grade four children, and adults, and equal numbers of males and females. All were administered a form-discrimination task. For an equal number of subjects in each age group, the relevant dimension was accompanied by an additional correlated cue (redundant condition), an additional uncorrelated cue (irrelevant condition), or no additional cue (nonredundant condition). In the redundant and irrelevant conditions, the learning task was followed by a post-test trial in which the cards were sorted on the basis of the additional cue rather than the previously-relevant form dimension.

For Grade four children and adults, there were no differences between conditions in sorting times or errors over trials. While there was no difference between the redundant and nonredundant conditions in Grade one children, sorting times were significantly longer in the irrelevant condition, but primarily on the first few trials. Sorting time increased on the post-test trial relative to the last learning trial in both conditions, but only in Grade one children. Errors increased on the post-test trial only in the irrelevant condition, and primarily in Grade one children.

The results were taken to indicate that attention to irrelevant cues decreases not only during development but also as a result of short-term perceptual learning. The failure to obtain a difference between the redundant and nonredundant conditions was discussed, and several variables warranting further research were indicated.

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Chapter 1

Statement of problem

The fact of response selection--that organisms learn to make certain responses and not others--has traditionally been the overriding concern of theories of behavior. The less obvious fact of stimulus selection--that organisms respond to certain stimuli but not others--has a much more recent history in the study of behavior.

When the behaviorist school revolutionized the study of behavior, the concept of stimulus selection, or selective attention, was rejected as a violation of behaviorist principles. At that time, attention was conceived of as an attribute of consciousness and studied by means of the analysis of introspective reports.

Nevertheless, some such concept as attention seemed necessary in order to explain failures of discrimination in situations of differential reinforcement, and so attention found its way into the continuity-noncontinuity controversy of the 1930's and 1940's. Later, the fact of limited-capacity information processing again necessitated an attention concept, and in the 1950's attention regained some degree of respectability as a construct in the explanation of behavior. Since that time, interest in the problem of attention has grown steadily, and the amount of theoretical and research effort directed towards it continues to increase.

Interest in the developmental history of selective attentional processes is relatively recent. It has been established that the ability to attend selectively increases with development (e.g., Maccoby & Konrad, 1966). Along with the increase in ability to focus on critical information, the ability to ignore noncritical, or unnecessary, information also develops. Hence, redundant and irrelevant cues tend to be ignored by older children but not by younger children (e.g., Maccoby & Hagen, 1965; Osler & Kofsky, 1965).

The present study was concerned with the role of perceptual learning in attention to redundant and irrelevant cues. Maccoby (1969) has suggested that discrimination learning underlies the development of selectivity. Extended discriminative experience permits immediate discrimination, and hence selection, between relevant and irrelevant stimuli. The present study postulated that, in older children and adults with a long history of discriminative experience, irrelevant and redundant cues would be ignored, while younger children would attend to these cues. It was expected, however, that young children would learn to ignore these cues as a result of immediate perceptual experience with them.

Since the role of attention in performance and in discrimination learning, as well as the effect of redundant and irrelevant information on stimulus selection, are relevant to the concerns of the present study, research on these topics will be reviewed briefly before considering the research relevant to the development of selectivity. The concluding section of the introduction will deal specifically with the purpose of the present study.

Attention in performance

Attention is usually defined as the "control of behavior by only selected aspects of a complex stimulus" (Hilgard &

Bower, 1966, p. 528). Thus, the central problem of attention is the question of the extent to which rejected information is not processed by the nervous system. Two lines of research provide information bearing on this question.

The main body of literature on attention concerns the role of attention in human information processing. Cherry (1953) found that when a subject is presented a different spoken message to each ear simultaneously and required to shadow one of the messages, only very gross characteristics, such as the sex of the voice of the other, "rejected," message could be reported. To explain this remarkable lack of ability to report anything about the rejected message, Broadbent's (1958) early filter model postulated that, while all stimulus inputs are received and enter short-term storage, only one input is selected for further analysis and processing. According to this model, then, unwanted information is eliminated almost immediately.

Later experiments, however, showed that properties as complex as meaning, linguistic features, and the "importance" of the stimulus (e.g., Gray & Wedderburn, 1960; Moray, 1959; Treisman, 1960, 1964a, 1964b) can influence the selection of inputs, implying that the rejected input, far from being filtered immediately, is analyzed at a high level in the nervous system. A number of theorists (e.g., Deutsch & Deutsch, 1963; Treisman, 1966) have attempted to account for these findings and thereby determine at what level in the nervous system selection occurs. Treisman (1966) postulates that rejected, or secondary, material is attenuated rather than eliminated completely. While secondary material has a higher threshold for recognition and identification, such material will be perceived whenever the criterion is sufficiently low. Deutsch and Deutsch (1963), on the other hand, maintain that selection occurs on the response rather than the stimulus side. The Deutsches postulate a "specific alerting mechanism," whereby each incoming signal is compared to a fluctuating standard. Depending on its weighting, a signal will or will not switch in further processes, such as motor output and memory storage. While Treisman and Geffen (1967) found evidence in favour of perceptual selectivity, Moray (1969) has noted that the shadowing task typically used is inadequate to decide between perceptual and response selection, since delayed responding confounds the role of attention in memory with its role in performance.

To date, then, research on selective listening has had limited success in understanding how attention affects the processing of nonselected inputs. Nevertheless, it is clear that, wherever the precise locus of selectivity may be, attention is a central cognitive process.

Attention in discrimination learning

The second line of research to be reviewed also deals with the question of the fate of nonattended inputs. Theories of attention in discrimination learning (e.g., Mackintosh, 1965a; Sutherland, 1964; Zeaman & House, 1963) postulate that discrimination learning involves two processes: learning to attend to the relevant dimension, and learning to attach appropriate choice responses to the specific values of this dimension. The concept of attention in discrimination learning implies that organisms will learn more about some cues than others. The decision as to the extent to which learning is selective revolves around research on multiple-cue or redundant-cue learning, and incidental learning.

Early research on the additivity of cues indicated that the presence of additional relevant cues increases the rate of discrimination learning (e.g., Hara & Warren, 1961; Warren, 1953). Sutherland and Holgate (1966), however, suggested that the effect of stimulus additivity on learning rate reflects simply the greater probability that each subject will attend to a relevant dimension. Using single-cue transfer tests on individual subjects, Sutherland and Holgate (1966) found that rats tend to learn multiple-cue discrimination problems in terms of one cue. Other experiments in which multiple-cue training was followed by transfer tests to single cues have corroborated Sutherland and Holgate's findings with rats (e.g., Kamin, 1968), pigeons (e.g., Born & Peterson, 1969; Eckerman, 1967; Johnson & Cumming, 1968; Newman & Baron, 1965; Reynolds, 1961), and human adults (e.g., Trabasso & Bower, 1968). There is little responding during single-cue tests to cues that were redundant during original learning.

Warren and McGonigle (1969), however, have marshalled evidence to suggest that single-cue transfer tests are not a valid measure of what was learned in a multiple-cue discrimination problem. Mumma and Warren (1968, Exp. I), for example, found no correlation between degree of preference for a cue on a single-cue test and rate of learning in a subsequent transfer task with that cue. Warren and McGonigle (1969) suggest that performance on single-cue tests, in which responses are not differentially reinforced, reflects merely the subject's preference for a particular cue and not the amount learned about each cue. That transfer tests with differential reinforcement can demonstrate previous learning of an incidental cue is suggested by Kamin's (1968) finding that, in single-cue training to a previously-redundant cue, savings occur. Moreover, even in single-cue tests (e.g., Eckerman, 1967; Johnson & Cumming, 1968) it has been found that multiple cues can share control over behavior, though such sharing is unequal.

Thus, it may be concluded that, while equal learning of each cue is unlikely, so also is complete lack of learning of incidental cues. As Mackintosh (1965a) has noted, unequal learning of multiple cues must be considered a graded phenomenon: the more that is learned about one cue, the less that is learned about another cue. While it is not clear to what extent and by what mechanism there is attenuation or filtering of information by the nervous system, it is certain that selection of some sort occurs. Parenthetically, it is reasonable to suppose that the degree of selectivity in learning may depend largely on task variables. Mackintosh (1965b), for example, found that the amount learned about an incidental cue introduced during overtraining varied directly with the difficulty of the original discrimination task.

<u>Effect of redundant and irrelevant information on stimulus selection</u>

As the research on selectivity in multiple-cue learning

(Born & Peterson, 1969; Eckerman, 1967; Johnson & Cumming, 1968; Kamin, 1968; Newman & Baron, 1965; Reynolds, 1961; Trabasso & Bower, 1968) has shown, one stimulus characteristic influencing selection is redundancy. Redundant cues provide surplus, unnecessary information, and tend to be ignored or filtered out. Irrelevance is another stimulus characteristic influencing attention. Irrelevant cues, like redundant cues, are not needed for problem solution. A number of studies demonstrate that, in animal discrimination learning, irrelevant stimuli come to be ignored. In rats (e.g., Wagner, Logan, Haberlandt, & Price, 1968, Exp. I) and pigeons (e.g., Newman & Baron, 1965) there is little responding during single-cue testing to component cues that were nondifferentially reinforced during discrimination learning. The ability of human adults to ignore or filter out irrelevant material is attested to by the large body of research on selective listening. There is also evidence that, in discrimination and concept learning, adults learn to ignore cues found to be irrelevant. Trabasso and Bower (1968) have found that, in concept learning, a previously-irrelevant cue is not learned when it is made relevant and redundant during overtraining, suggesting that this cue came to be ignored during original learning. Supporting evidence is provided by Fishbein, Haygood, and Frieson's (1970) experiment on the effect of relevant and irrelevant saliency in concept learning. Their finding that performance was better when the irrelevant dimensions were highly salient than when neither the relevant nor irrelevant dimensions were highly salient further supports the notion that adults learn to ignore irrelevant cues during concept learning.

In stimulus selection, then, redundant and irrelevant stimuli function to "inhibit" attention. Attention is nonselective to the extent that it is directed to such stimuli.

The literature reviewed thus far reveals that, while multiple inputs seem to be processed at a fairly high level of the nervous system, and multiple-cue learning can occur, selection among competing messages is very efficient and learning is quite selective.

The development of these selective capacities and characteristics has recently been investigated, and several developmental trends have emerged.

Development of selectivity

It has been established that the ability to attend selectively, i.e., the ability to filter out irrelevant information, increases with experience. Maccoby and Konrad (1966) found that the ability to report correctly one of two dichotically-presented words improved in children from kindergarten through Grade four. In a concept attainment task in which either zero, one, or two dimensions were irrelevant, Osler and Kofsky (1965) found that errors made by children aged 4, 6, and 8 years increased as the number of irrelevant dimensions increased. The increase was greater for 4- and 6-year-olds than for 8-year-olds.

A paradoxical trend is the development of the ability to process more than one stimulus input simultaneously and to learn multiple cues. Siegel (1968) found that Grade six children were significantly better than Grade four children in an information processing task requiring consideration of two dimensions simultaneously. Eimas (1969), using children in kindergarten, Grade two, and Grade four, administered a simultaneous discrimination task in which the relevant cue was accompanied by either one, two, or three redundant cues. Single-cue transfer tests revealed that, while multiple-cue learning occurred in all age groups, the number of cues about which something was learned increased with age. Studies of incidental learning have shown that there is a curvilinear relation between age and amount of incidental learning. Stevenson (1954) found that the amount of incidental learning increased between the ages of 3 and 6 years, while Maccoby and Hagen (1965) found that incidental learning remains constant between grades one and five, and declines between grades five and seven. Siegel and Stevenson (1966) found an increase in incidental learning between ages 7 and 12, and a decrease between ages 12 and 14.

In an attempt to resolve the apparent contradiction that incidental learning increases simultaneously with the increase in selectivity, Maccoby (1969) suggests that incidental learning will not decline until selectivity is sufficiently developed to permit rapid discrimination of wanted from unwanted information. In Maccoby's view, rapid discrimination is required to prevent unwanted material from being identified and stored.

During the period when multiple cue processing is increasing, reduction of information has been found to have a detrimental effect on perceptual performance. Gollin (1960) presented incomplete line drawings of common objects to children between the ages of 2 1/2 and 5 1/2, and college students. The ability to identify the incomplete drawings increased up to the age of 5 1/2 years. In a similar experiment employing colour photographs of common scenes in varying focus from very blurred to clear, Potter (1966) found that the ability to recognize blurred pictures increased between the ages of 4 and 19, with the greatest and most rapid improvement occurring between the ages of 4 and 4 1/2. Spitz (1969), using a task requiring the subjects to locate a target piece in a puzzle, found that when the information value of the target piece was reduced, the consequent increase in search time was greater for children in Grade four than for children in Grade seven.

In summary, it would appear that young children attend to and process as much information as they can, with the result that performance suffers in situations involving irrelevant or reduced information. Older children and adults, on the other hand, process information selectively: they filter out irrelevant information, exhibit little learning of incidental information, and are less reliant on the presence of multiple cues.

Attempts have been made to specify the processes underlying the development of selectivity. Maccoby (1969), for example, reports that the development of selective listening cannot be attributed to response organization, peripheral masking, or preparatory set. Her finding that selectivity does not improve when peripheral masking is eliminated by having the two voices alternate, is consistent with the existing evidence that selective attention is a central process. Since the role of response competition was not investigated, there is no developmental evidence bearing on the question of whether selectivity occurs on the perceptual or the response side of the nervous system, and whether or not the locus of selectivity changes during development.

Maccoby (1969) suggests that the ability to discriminate relevant from irrelevant material underlies the development of selectivity. Extended experience with a variety of discriminations increases the range of cues available for discriminating relevant from irrelevant material. In support of this notion, Maccoby and Konrad (1967) found that the greater the difference in familiarity between two competing inputs, the greater the ease of shadowing one of them.

It appears, then, that with experience children learn to differentiate between critical cues and irrelevant or redundant cues, i.e., between necessary and unwanted or unnecessary information. If learning to ignore irrelevant and redundant cues is a process of perceptual learning, it should occur not only in the course of the development of the organism, but also as a result of practice during a limited experimental session. Research cited earlier (e.g., Born & Peterson, 1969; Newman & Baron, 1965; Wagner, Logan, Haberlandt, & Price, 1968, Exp. I) showing that animals tend not to learn redundant and irrelevant cues in discrimination learning, suggests that such may be the case.

In summary, it has been seen that, while the locus of selective attentional processes is uncertain, selection is a central cognitive process determining how much of, and to what extent, the available stimulus information is processed. As such, it influences the amount of information that is learned in multiple-cue tasks. It has also been seen that the ability to attend to selected aspects of incoming information increases developmentally, and may depend on experience in discriminating relevant from irrelevant material.

Purpose of the present study

The aim of the present study was to investigate the notion that, during development, children learn to ignore redundant and irrelevant cues, and that this learning is evident not only in the perceptual learning that occurs in the course of development, but also in the specific perceptual learning experiences of children. It was hypothesized that, in a perceptual learning task, younger children would attend to redundant and irrelevant cues, while older children and adults would ignore such cues. It was expected, however, that with practice the younger children would come to ignore the cues.

A second concern of the present study was the use that may be made of redundant information. Once a cue is identified as being redundant, it may be used to reduce the amount of information that must be processed, or to facilitate performance by providing a choice between dimensions which may differ in salience, or which may differentially affect task difficulty. A study by Paraskevopoulos (1968) suggests that the ability to use redundancy to reduce the amount of information to be processed increases with age. Paraskevopoulos (1968) found that symmetrical redundancy facilitated the reproduction of dot patterns in children between the ages of 6 and 12, but not in children between 5 1/2 and 6 years of age. Moreover, in children younger than 11 years of age, the effect of symmetry depended on the orientation of the axis of symmetry. Presumably, some forms of symmetry are more distinctive than others, and younger children were able to utilize only the more distinctive forms.

Paraskevopoulos' (1968) study suggests that, from the age of about 6 years, children can not only detect redundancy but also use it to code information. Presumably, the types of redundancy that can be detected and used increase with experience.

In the present study, it was hypothesized that if younger children attended to the redundant cue, they might also use it to facilitate performance, since it would reduce task difficulty. Older children and adults, however, were not expected to attend to the redundant cue, and it was hypothesized that there would be no facilitation of performance by redundancy in these subjects.

The aim of the present study, then, was to investigate the notion that, developmentally, children learn to ignore redundant and irrelevant cues, and that the change represents a process of perceptual learning which occurs over short-term as well as long-term periods of experience. During short-term perceptual learning, however, it was expected that younger children would not learn to ignore a redundant cue, since it could be used to facilitate performance.

The perceptual learning task used in the present study involved improvement in speed of discrimination. The presence of multiple cues was manipulated in a form-discrimination task involving card-sorting. While form was the relevant dimension, an additional dimension was correlated with the form dimension. In one condition (nonredundant condition), form was the only dimension on which the discrimination could be made. In the redundant condition, an additional dimension was correlated with the relevant dimension, while in the irrelevant condition, the additional dimension was not correlated with the relevant dimension. If the tendency to ignore redundant and irrelevant cues increases with age, then the sorting time of young children would be expected to differ when a redundant or irrelevant dimension was added. It was expected that, when an irrelevant dimension was added, sorting time would be longer than when no additional cue accompanied the forms to be discriminated. When a redundant dimension was added, it was expected that sorting time would decrease relative to the nonredundant condition if the redundant cue was used to facilitate discrimination, or increase if the cue was attended to but not used. No significant differences in sorting times were expected for older children and adults.

If the tendency to ignore redundant and irrelevant cues is a result of perceptual learning, it was also expected that, on a post-test sorting trial in which the subject was required to sort the same cards on the basis of a redundant or irrelevant cue rather than the previously-critical dimension of form, sorting time for all subjects would increase relative to the last learning trial. For subjects who had ignored, or had learned to ignore, redundant and irrelevant cues, the stimuli in the post-test task would be relatively "unfamiliar," and sorting time should be longer on this trial than on the previous trial. In the younger children, however, it was expected that, if the redundant cue had been used to facilitate sorting, then no increase in sorting time would occur on the post-test trial.

Table 1

Means and Standard Deviations of the Ages (in months) of Grade 1 and Grade 4 Children, and Adults

	Conditions			
	Redundant	Nonredundant	Irrelevant	
Grade 1				
Mean				81.00 (n=60)
SD				4.02
Males				
Mean	82.60	81.30	80.00	81.30 (n=30)
SD	5.27	3.59	4.39	4.45
Females				
Mean	79.10	81.60	81.40	80.70 (n=30)
SD	2.56	2.50	4.97	3.60
Grade 4				
Mean				119.10 (n=60)
SD				3.53
Males				
Mean	116.70	117.90	121.10	118.60 (n=30)
SD	3.06	3.11	2.35	3.35
Females				
Mean	120.00	119.70	118.90	119.50 (n=30)
SD	3.79	4.08	3.48	3.69
Adults				
Mean				240.87 (n=60)
SD				38.99
Males				
Mean	229.40	240.30	242.20	237.30 (n=30)
SD	35.09	40.50	38.27	37.01
Females				
Mean	246.30	226.00	261.00	244.43 (n=30)
SD	40.15	32.41	45.98	36.74

in each age group, subdivided according to sex and the conditions to which they were assigned. A two-way analysis of variance of age was performed, separately for each age group. The two factors were Sex (male and female), and Conditions (redundant, nonredundant, and irrelevant). While no main effects or interactions were significant for Grade one children or adults, there was a significant Sex-by-Conditions interaction in Grade four children. It should be noted, however, that even small mean differences may produce significant F values, given the small variability inherent in ages within a grade. The summary table of the analysis of variance of age in Grade four children appears in Table 2. Newman-Keuls multiple comparisons (Ferguson, 1971) of the means in the interaction of Sex-by-Conditions showed that, in the redundant condition, girls were significantly older than boys ($p < .05$). Boys in the irrelevant condition were significantly older than boys in the redundant ($p < .01$) and nonredundant ($p < .05$) conditions.

Stimuli

In each condition, the stimuli consisted of eight squares and eight rectangles, each drawn in black outline on a 5.73-cm. x 9.55-cm. white card, the size of an ordinary playing card. Squares measured 2.54 cm. x 2.54 cm., and rectangles measured 2.54 cm. x 3.02 cm.. There was a total of 16 cards in each pack.

Examples of the stimuli used in all conditions appear in Figure 1. In the nonredundant condition, the stimuli consisted of a square and rectangle in black outline. In the redundant and irrelevant conditions, an additional cue, consisting of

Table 2

Analysis of Variance of the Ages of Grade Four Children as a Function of Sex and Conditions

Source of Variation	*df*	*MS*	*F*
Total	59		
Sex (S)	1	14.01	1.33
Conditions (C)	2	14.55	1.38
S x C	2	61.98	5.87*
Error	54	10.51	

*$p < .005$

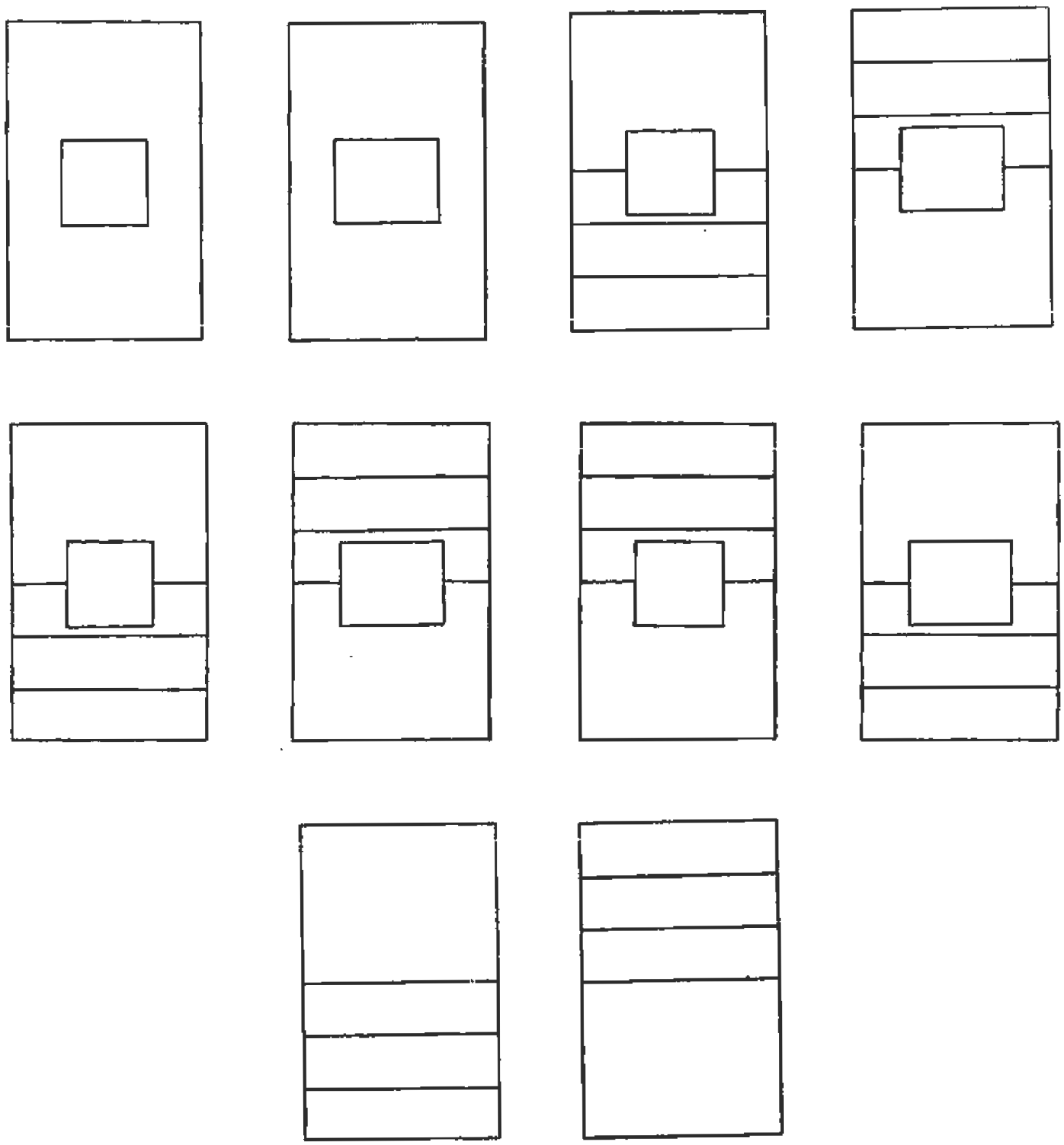

Fig. 1. Examples of stimuli used in the three conditions. On the top row, sample stimuli used in the nonredundant condition are shown on the left, and sample stimuli used in the redundant condition are shown on the right. Examples of the stimuli used in the irrelevant condition are shown in the second row, while the model cards used in the redundant and irrelevant conditions are illustrated in the bottom row.

three horizontal lines placed 1.58 cm. apart on the top or bottom half of the card, accompanied the forms to be discriminated. In the redundant condition, the additional cue was correlated with the relevant form dimension. The lines were always on the bottom if the form was a square, and always on the top if it was a rectangle. In the irrelevant condition, the additional cue varied within but remained constant across forms of the two classes. For both squares and rectangles, the lines were at the bottom on half the cards, and at the top on half the cards.

In each condition, the subject sorted the cards to two model cards. In all conditions, the model cards were identical to the cards in the nonredundant condition. For the post-test sorting trial in the redundant and irrelevant conditions, however, the model cards consisted of the additional cue alone, with the forms absent. The model cards used in the post-test trial are illustrated in Figure 1.

Two packs of cards were used to provide subjects with practice in sorting cards. One pack consisted of 16 ordinary playing cards. A second pack of 16 cards was constructed in which eight cards bore the number "1" and eight bore the number "2". All the numbers were in black outline. The cards in this pack were sorted to two model cards identical to the cards to be sorted.

A Heuer Leonidas SA stopwatch was used to measure the sorting time of each subject.

<u>Procedure</u>

Each child sat at a table facing the experimenter, and was introduced to the experiment. The experimenter told the child that he would be playing a game of cards. First, he was given 16 cards from an ordinary pack of playing cards, and asked to deal them out as if he were going to play cards with one other person, but to deal them out side by side.

The child was then given a pack of 1's and 2's. As with all the cards subsequently given the child, the model cards were placed beside each other, approximately 5.08 cm. apart, and at a distance of approximately 25.40 cm. from the child. The child was free to hold the cards in whichever hand he preferred, and to deal them out in the way he found most comfortable. As he was given the cards, the child was asked to deal them out so that all the 1's would go into a pile below the card with the "1" on it and all the 2's would go into a pile below the card with the "2" on it. The child sorted this pack of cards twice. Before the second sorting, which was a timed practice trial, he was shown the stopwatch and told that the aim of the game was to see how fast he could deal the cards without making any mistakes.

Following practice sorting the numbers "1" and "2", the child was asked to show the difference between squares and rectangles by drawing an example of each of them. If the child was not able to do this, the experimenter drew them herself and showed the child how rectangles differ from squares. Each child was then shown the model cards for the pack of squares and rectangles, and asked to indicate, by pointing, which was the square, and then which the rectangle, or vice versa. All children were able to do this correctly before being presented with the pack to be sorted.

When the child was presented a pack of cards under one of the three conditions, he was again told that the experimenter would time him to see how fast he could deal the cards correctly. In each condition, the child sorted the pack of cards ten times. The experimenter attempted to maintain the child's motivation and interest at an optimal level by providing continual praise and encouragement.

Immediately following the tenth trial in the redundant and irrelevant conditions, the child was required to sort the same cards on the basis of the additional cue rather than the previously-critical dimension of form.

The procedure followed for adults was similar to that for children.

The sorting time, to the nearest second, and number of errors for each trial were recorded. There was an inter-trial interval of approximately five seconds. The subjects were tested individually, each testing session lasting from 15 to 20 minutes. All subjects were tested privately in a room free from noise and other distractions.

Design

The independent variables in the present study were age and sex of the subjects, the three conditions (redundant, nonredundant, and irrelevant), and the ten perceptual learning trials.

There were six dependent variables in the present study. Sorting time and errors were scored separately for the ten trials. Sorting time and errors were also the dependent variables for the analysis of the practice trial and trial one.

For the analysis of performance on trial ten and the post-test trial, sorting time and errors again constituted the two dependent variables.

Each dependent variable was analyzed by a four-way analysis of variance for a mixed design. For the analyses of sorting time and errors on trials one through ten, the between-subjects factors were Age (Grade one, Grade four, and adults), Sex (male and female), and Conditions (redundant, nonredundant, and irrelevant). The within-subjects factor was Trials (trials one through ten). For the analyses of sorting time and errors on the practice trial and trial one, the between-subjects factors were Age (Grade one, Grade four, and adults), Sex (male and female), and Conditions (redundant, nonredundant, and irrelevant), while the within-subjects factor was Trials (practice trial and trial one). For the analyses of sorting time and errors on trial ten and the post-test trial, the between-subjects factors were Age (Grade one, Grade four, and adults), Sex (male and female), and Conditions (redundant and irrelevant). The within-subjects factor was Trials (trial ten and the post-test trial). Means for each of the six dependent variables, for each cell in the analysis of variance classification, were calculated.

In all analyses of variance performed, the .05 level of significance was the cut-off for accepting a difference as significant. Where significant effects were found, Newman-Keuls multiple comparisons (Ferguson, 1971) of individual means were performed to determine where the difference lay. The .05 level of significance was also accepted for Newman-Keuls comparisons.

Chapter 3

Results

The raw data may be found in Appendix A. The means of all six dependent variables are located in Appendix B, while the results of all Newman-Keuls comparisons are presented in Appendix C.

Trials one through ten: sorting time

The summary table of the analysis of variance of sorting times on trials one through ten is shown in Table 3. The main effects of Age, Conditions, and Trials were significant. The interactions of Age-by-Trials, Conditions-by-Trials, and Age-by-Conditions-by-Trials were also significant.

The main effect of Age revealed that sorting time decreased with age. Comparisons of the mean sorting times for the three age groups showed that each age group differed significantly from each of the other two age groups ($p < .01$).

Comparisons of the means for the three conditions revealed that sorting time was significantly shorter in the redundant and nonredundant conditions than in the irrelevant condition ($p < .05$). There was no significant difference in sorting time between the redundant and nonredundant conditions.

Comparisons of the means in the main effect of Trials showed that sorting time had reached an asymptotic level by trial four. Sorting time for each of trials two through ten was significantly shorter than for trial one ($p < .01$). Sorting times for trials five through ten were significantly shorter than for trials one through three. All differences were signi-

Table 3

Analysis of Variance of Sorting Times on Trials 1-10 as a Function of Age, Sex, Conditions, and Trials

Source of Variation	*df*	*MS*	*F*
Between Subjects	179		
Age (A)	2	21175.25	169.56**
Sex (S)	1	1.68	.01
Conditions (C)	2	520.53	4.17*
A x S	2	21.47	.17
A x C	4	144.77	1.16
S x C	2	180.74	1.45
A x S x C	4	39.92	.32
Error (between)	162	124.88	
Within Subjects	1620		
Trials (T)	9	316.75	38.82**
A x T	18	30.97	3.80**
S x T	9	18.49	2.27
C x T	18	16.91	2.07**
A x S x T	18	11.69	1.43
A x C x T	36	13.63	1.67**
S x C x T	18	8.99	1.10
A x S x C x T	36	9.72	1.19
Error (within)	1458	8.16	

*$p < .05$
**$p < .001$

ficant at $p < .01$, except the difference between trials three and five, which was significant at $p < .05$.

Multiple comparisons of the means in the Age-by-Trials interaction showed that, while sorting time decreased over trials in all age groups, the greatest decrease occurred during the first four trials in Grade one children. In Grade four children and adults, there were no significant differences in sorting time across trials beyond trial two, which decreased significantly from trial one ($p < .01$). In Grade one children, however, sorting time decreased between each of trials one, two, three, and four. Only the difference between trials two and three was nonsignificant. All significant differences were at $p < .01$, with the exception of the difference between trials three and four, which was significant at $p < .05$. There were no significant differences in sorting time across trials beyond trial four.

Multiple comparisons of means also revealed that the Conditions-by-Trials interaction could be attributed primarily to the sharp decrease in sorting time that occurred over trials one through four in the irrelevant condition. There were no significant differences in sorting time in the redundant and nonredundant conditions on any trial. Sorting time was significantly longer in the irrelevant condition than in the other two conditions primarily on the first three trials ($p < .01$). Sorting time in the irrelevant condition was also significantly longer than in the other conditions on trials six ($p < .05$) and ten ($p < .01$). On trials four and seven, sorting time in the irrelevant condition was significantly longer than in the nonredundant condition ($p < .05$), while the differences between the redundant and irrelevant conditions were not significant.

The Age-by-Conditions-by-Trials interaction is shown in Figure 2. Multiple comparisons of means showed that this interaction was primarily a function of the sharp decrease in sorting time over trials one through four of the irrelevant condition in Grade one children. There were no significant differences over trials between any of the conditions within the two older age groups. In Grade one children, however, sorting time in the irrelevant condition was significantly longer than in the redundant and nonredundant conditions on trials one through three ($p < .01$) as well as on trials six and ten ($p < .05$). There were no significant differences in Grade one children between the redundant and nonredundant conditions.

Trials one through ten: errors

The analysis of errors revealed results similar to those for sorting time. Table 4 shows that the main effects of Age, Sex, and Trials were significant. The interactions of Age-by-Trials and Sex-by-Trials were also significant.

Multiple comparisons of the mean number of errors for the three age groups showed that, while there was no significant difference in errors between children in Grade four and adults, both age groups made significantly fewer errors than did children in Grade one. The difference between Grade one children and adults was significant at $p < .01$, while the difference between Grade one and Grade four children was significant at $p < .05$.

The main effect of Sex revealed that females made more

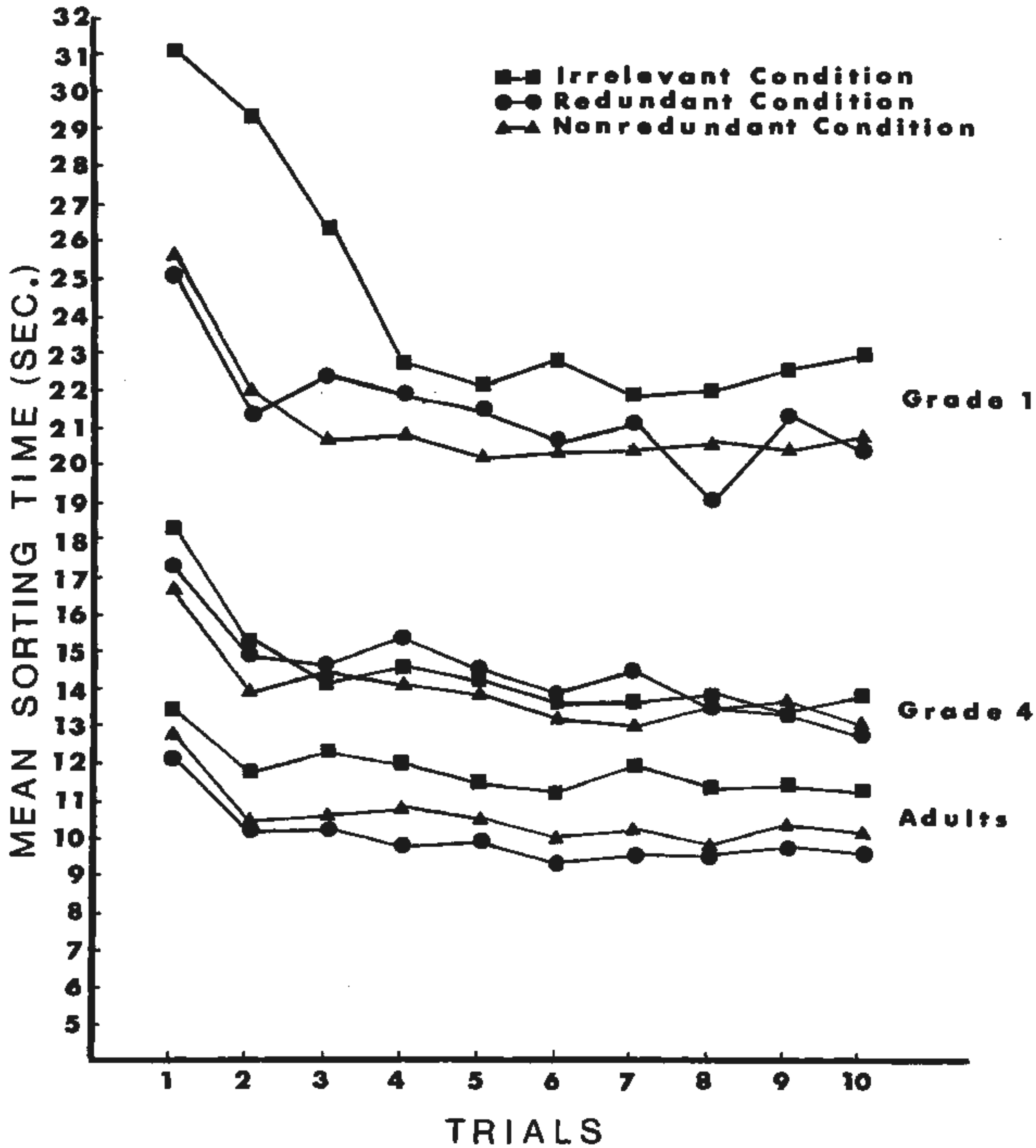

Fig. 2. Interaction between age, conditions, and trials for the analysis of variance of sorting times on trials one through ten.

Table 4

Analysis of Variance of Errors on Trials 1-10 as a Function of Age, Sex, Conditions, and Trials

Source of Variation	*df*	*MS*	*F*
Between Subjects	179		
Age (A)	2	19.02	7.36**
Sex (S)	1	9.98	3.86*
Conditions (C)	2	2.51	.97
A x S	2	4.12	1.60
A x C	4	3.26	1.26
S x C	2	.22	.09
A x S x C	4	4.90	1.90
Error (between)	162	2.58	
Within Subjects	1620		
Trials (T)	9	15.05	16.36**
A x T	18	1.52	1.66*
S x T	9	1.95	2.12*
C x T	18	1.14	1.24
A x S x T	18	.70	.76
A x C x T	36	1.06	1.15
S x C x T	18	1.03	1.12
A x S x C x T	36	.60	.65
Error (within)	1458	.92	

$*p < .05$

$**p < .001$

errors than did males. The nonsignificant Age-by-Sex interaction indicated that this effect occurred in all age groups.

Multiple comparisons of the mean number of errors on trials one through ten revealed that there were significantly fewer errors on each of trials two through ten than on trial one ($p < .01$). There were no significant differences in errors between any of trials two through ten.

The Age-by-Trials interaction is shown in Figure 3. Comparisons of the means in this interaction showed that there were differences in errors between the age groups only on the first few trials. Grade four children made more errors than adults only on trial one ($p < .05$). Grade one children made more errors than Grade four children ($p < .05$) and adults ($p < .01$) only on trials one, two, and four.

The Sex-by-Trials interaction revealed a similar trend. Females made more errors than did males only on trials one and two ($p < .01$).

Practice trial and trial one

The analyses of sorting times and errors on trials one through ten both revealed a significant main effect of Trials. While this may be interpreted as evidence of learning, the improvement with practice may have been motoric rather than perceptual. Accordingly, performance on trial one was compared to performance on the practice trial, which differed from each other only in the stimuli to be sorted. It was reasoned that an increase in sorting time and errors from the practice trial to trial one would reflect the perceptual nature of the subsequent improvement in performance.

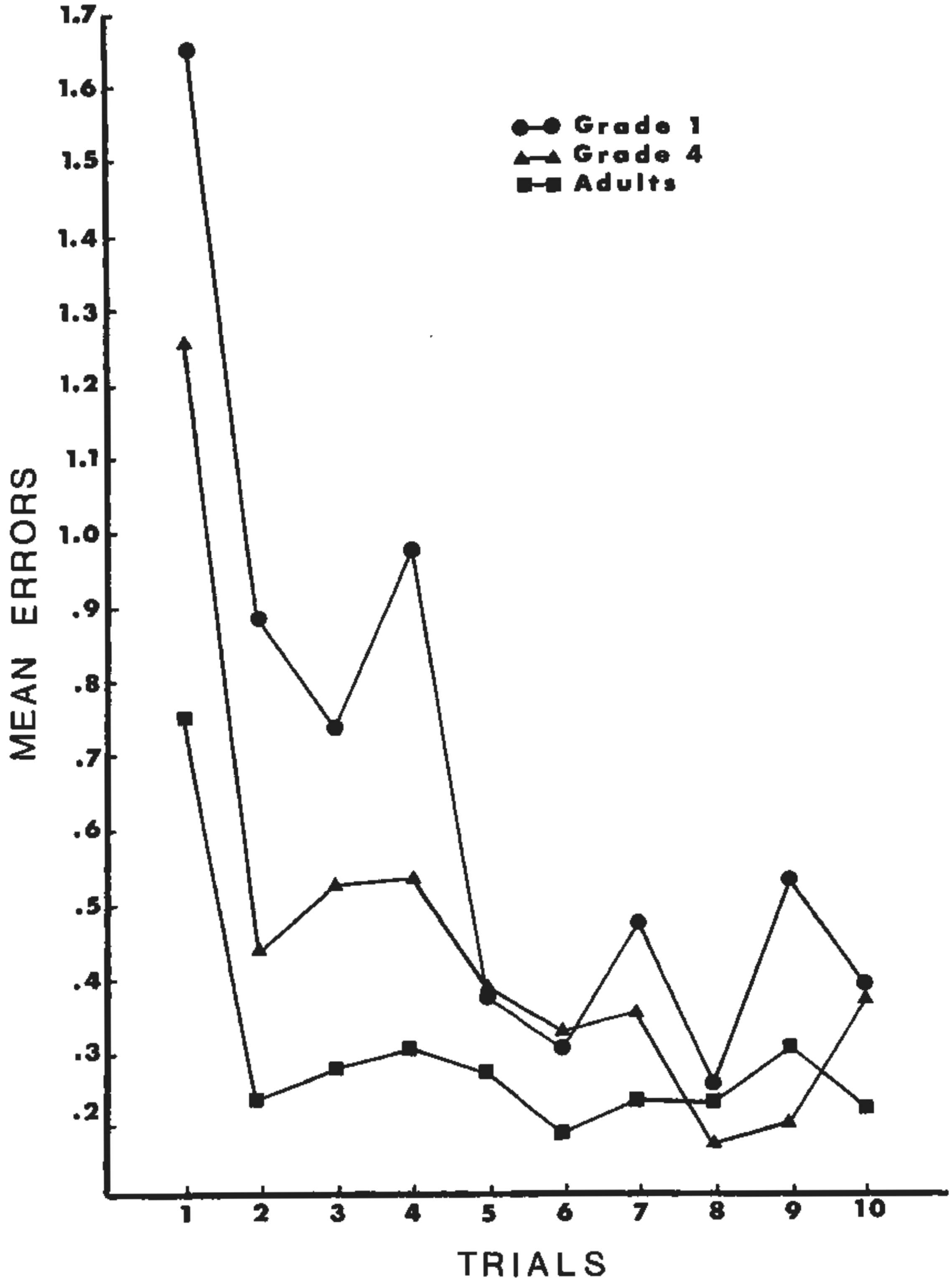

Fig. 3. Interaction between age and trials for the analysis of variance of errors on trials one through ten.

Sorting time. The summary table of the analysis of variance of sorting times on the practice trial and trial one is shown in Table 5. The main effects of Age, Conditions, and Trials were significant, as were the interactions of Sex-by-Conditions, Age-by-Trials, Sex-by-Trials, and Conditions-by-Trials.

No comparisons of the means in the main effect of Conditions and in the interaction of Sex-by-Conditions were made, since these effects were confounded by the effect of trials.

Comparisons of the means in the main effect of Trials showed that sorting time on trial one was significantly longer than on the practice trial. Multiple comparisons of the means in the interaction of Age-by-Trials, shown in Figure 4, revealed that, in each age group, sorting time on trial one was significantly longer than on the practice trial ($p < .01$). This interaction also indicated that sorting time was longer for Grade one children than for Grade four children ($p < .01$), and longer for Grade four children than for adults ($p < .01$) in both the practice trial and trial one.

Multiple comparisons of the means in the interaction of Sex-by-Trials indicated that the sorting times of females were longer than those of males on trial one ($p < .05$), but not on the practice trial. Comparisons of the means in the interaction of Conditions-by-Trials revealed that subjects in the irrelevant condition were significantly slower at sorting the cards than were subjects in the redundant and nonredundant conditions both on the practice trial ($p < .05$) and on trial one ($p < .01$).

Errors. Table 6 presents the summary table of the analysis of variance of errors on the practice trial and trial one. The

Table 5

Analysis of Variance of Sorting Times on the Practice Trial and Trial 1 as a Function of Age, Sex, Conditions, and Trials

Source of Variation	*df*	*MS*	*F*
Between Subjects	179		
Age (A)	2	3439.86	153.63***
Sex (S)	1	9.34	.42
Conditions (C)	2	115.73	5.17**
A x S	2	3.12	.14
A x C	4	32.74	1.46
S x C	2	71.64	3.20*
A x S x C	4	20.97	.94
Error (between)	162	22.39	
Within Subjects	180		
Trials (T)	1	4608.18	385.93***
A x T	2	499.12	41.80***
S x T	1	62.50	5.23*
C x T	2	39.21	3.28*
A x S x T	2	18.92	1.58
A x C x T	4	21.38	1.79
S x C x T	2	32.70	2.74
A x S x C x T	4	19.18	1.61
Error (within)	162	11.94	

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

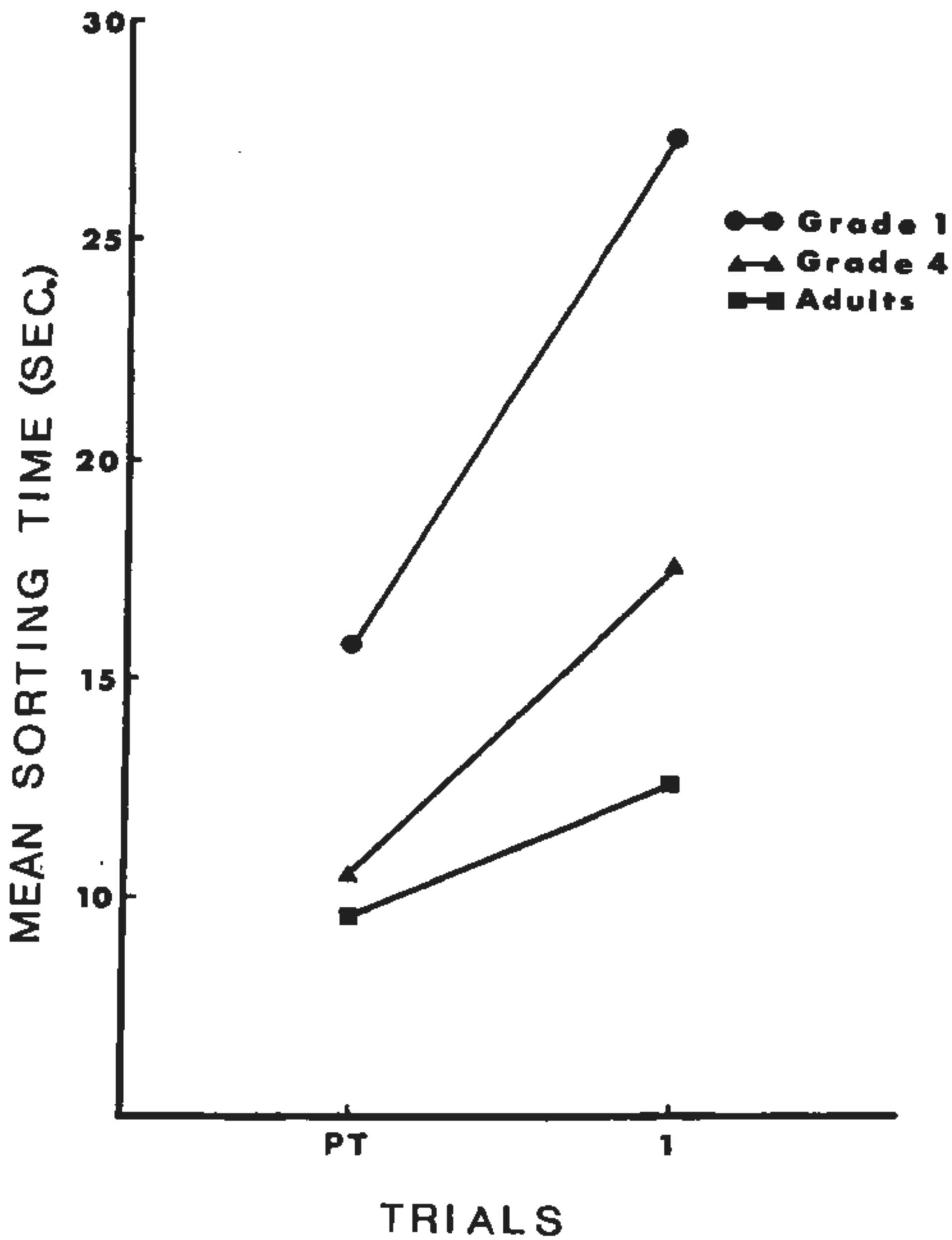

Fig. 4. Interaction between age and trials for the analysis of variance of sorting times on the practice trial and trial one.

Table 6

Analysis of Variance of Errors on the Practice Trial and Trial 1 as a Function of Age, Sex, Conditions, and Trials

Source of Variation	df	MS	F
Between Subjects	179		
Age (A)	2	6.77	4.12*
Sex (S)	1	8.71	5.30**
Conditions (C)	2	1.11	.67
A x S	2	.20	.12
A x C	4	.33	.20
S x C	2	1.77	1.08
A x S x C	4	1.51	.92
Error (between)	162	1.64	
Within Subjects	180		
Trials (T)	1	129.60	78.27***
A x T	2	5.47	3.31*
S x T	1	8.10	4.89*
C x T	2	1.11	.67
A x S x T	2	.16	.10
A x C x T	4	.33	.20
S x C x T	2	2.36	1.42
A x S x C x T	4	1.37	.83
Error (within)	162	1.66	

*$p < .05$

**$p < .01$

***$p < .001$

main effects of Age, Sex, and Trials were significant. The interactions of Age-by-Trials and Sex-by-Trials were also significant.

The main effect of Trials revealed that significantly more errors were made on trial one than on the practice trial. Multiple comparisons of the means in the interaction of Age-by-Trials, shown in Figure 5, indicated that, in each age group, significantly more errors occurred on trial one than on the practice trial ($p < .01$). Moreover, Grade one children made more errors than adults on trial one ($p < .01$), while there was no difference between Grade one and Grade four children, or Grade four children and adults. There were no differences among the three age groups on the practice trial.

Multiple comparisons of the means in the interaction of Sex-by-Trials showed that females made more errors than males on trial one ($p < .01$), but not on the practice trial.

Trial ten and post-test trial: sorting time

The analysis of variance of sorting times on trial ten and the post-test trial is summarized in Table 7. The main effects of Age, Conditions, and Trials were significant. The interaction of Age-by-Trials was also significant.

While the main effect of Conditions indicated that sorting time was significantly longer in the irrelevant condition than in the redundant condition, this effect was not meaningful since it was confounded by the effect of trials. Comparisons of the means in the main effect of Trials revealed that sorting time on the post-test trial was significantly longer than the sorting time on trial ten. Multiple comparisons of the means in the

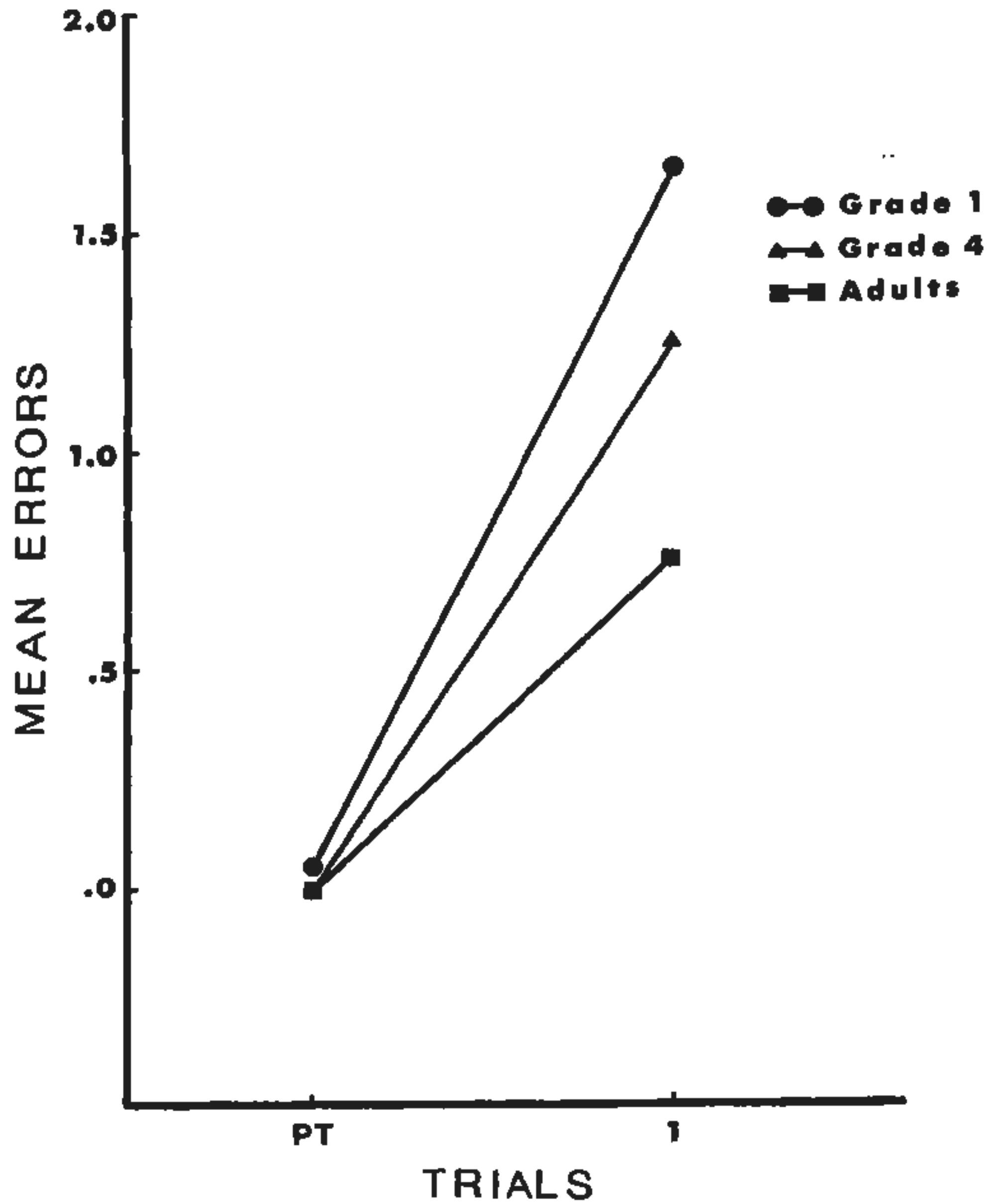

Fig. 5. Interaction between age and trials for the analysis of variance of errors on the practice trial and trial one.

Table 7

Analysis of Variance of Sorting Times on Trial 10 and the Post-Test Trial as a Function of Age, Sex, Conditions, and Trials

Source of Variation	*df*	*MS*	*F*
Between Subjects	119		
Age (A)	2	3946.28	94.46***
Sex (S)	1	4.27	.10
Conditions (C)	1	205.35	4.92*
A x S	2	22.28	.53
A x C	2	12.41	.30
S x C	1	68.27	1.63
A x S x C	2	2.33	.06
Error (between)	108	41.78	
Within Subjects	120		
Trials (T)	1	101.40	7.52**
A x T	2	138.01	10.23***
S x T	1	.15	.01
C x T	1	2.40	.18
A x S x T	2	.91	.07
A x C x T	2	.46	.03
S x C x T	1	30.82	2.28
A x S x C x T	2	17.18	1.27
Error (within)	108	13.49	

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

Age-by-Trials interaction showed that the difference between the two trials was a function of age: sorting time increased on the post-test trial only in Grade one children ($p < .01$). The Age-by-Trials interaction is shown in Figure 6.

Trial ten and post-test trial: errors

Table 8 presents the table of analysis of variance of errors on trial ten and the post-test trial. The only significant main effect was that of Conditions. The significant interactions were Age-by-Conditions and Conditions-by-Trials.

The mean number of errors on trial ten and the post-test trial, in each condition and for each age group, are shown in Figure 7. The main effect of Conditions showed that more errors occurred in the irrelevant condition than in the redundant condition, though this effect was confounded by the effect of trials.

Multiple comparisons of the means in the Age-by-Conditions interaction revealed that more errors occurred in the irrelevant condition than the redundant condition, and primarily in Grade one children. The difference between the redundant and irrelevant conditions was significant only for children in Grade one ($p < .01$).

Multiple comparisons of the means in the Conditions-by-Trials interaction further revealed that the increase in errors on the post-test trial occurred only in the irrelevant condition ($p < .05$). While there was no difference in mean number of errors on trial ten and the post-test trial in the redundant condition, there were significantly more errors on the post-test trial than on trial ten in the irrelevant condition ($p < .01$).

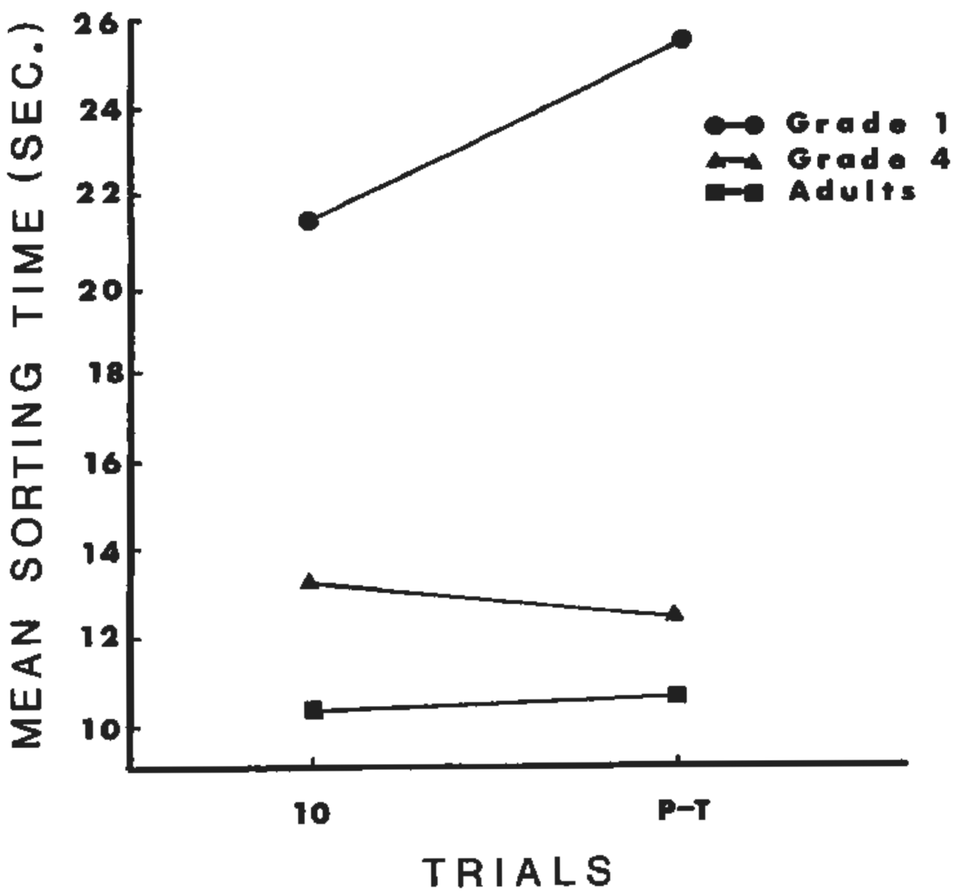

Fig. 6. Interaction between age and trials for the analysis of variance of sorting times on trial ten and the post-test (P-T) trial.

Table 8

Analysis of Variance of Errors on Trial 10 and the Post-Test Trial as a Function of Age, Sex, Conditions, and Trials

Source of Variation	*df*	*MS*	*F*
Between Subjects	119		
Age (A)	2	4.93	3.01
Sex (S)	1	.07	.04
Conditions (C)	1	8.82	5.38*
A x S	2	.38	.23
A x C	2	5.78	3.52*
S x C	1	.00	.00
A x S x C	2	.01	.01
Error (between)	108	1.64	
Within Subjects	120		
Trials (T)	1	.60	.37
A x T	2	4.29	2.65
S x T	1	.02	.01
C x T	1	9.60	5.92*
A x S x T	2	.55	.34
A x C x T	2	2.74	1.69
S x C x T	1	.02	.01
A x S x C x T	2	.25	.16
Error (within)	108	1.62	

*$p < .05$

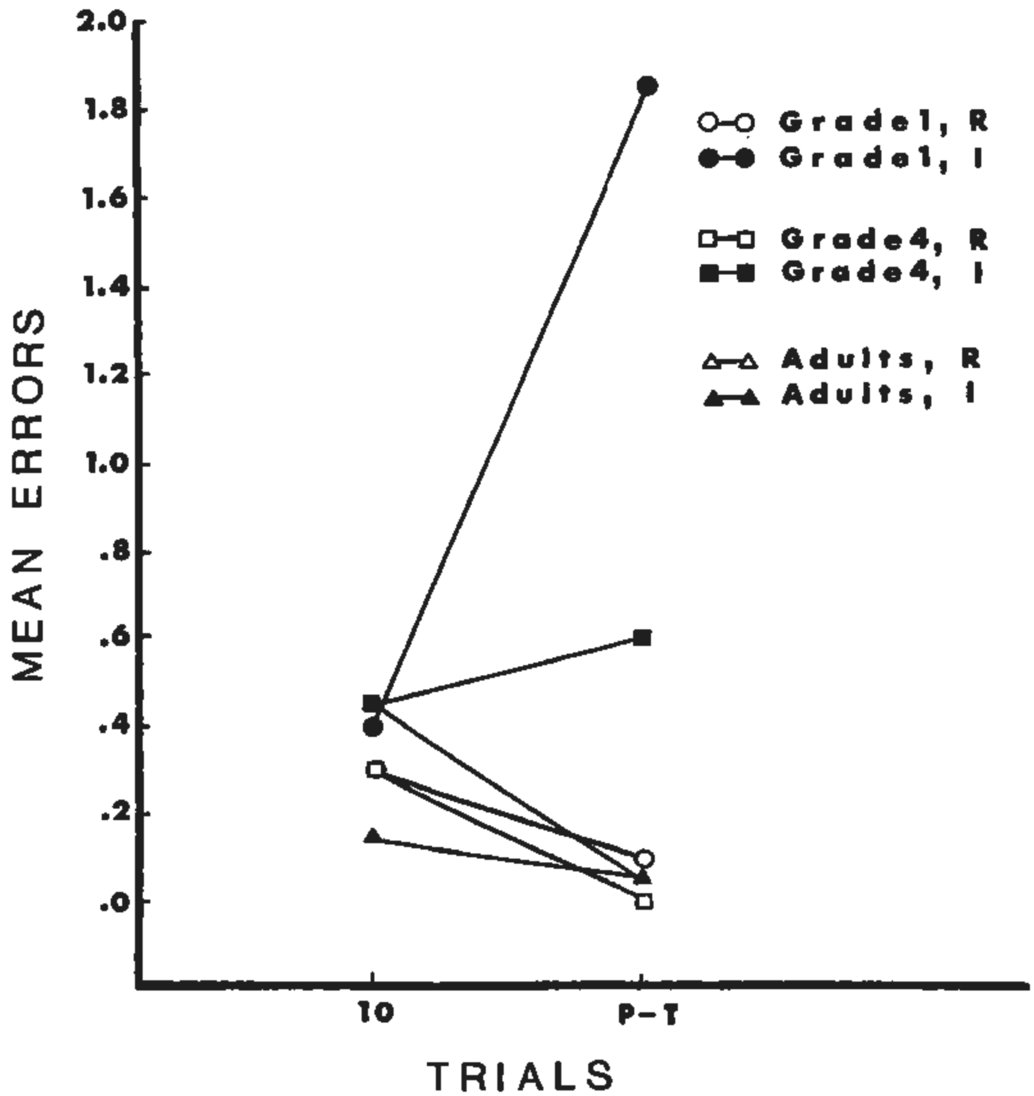

Fig. 7. Mean number of errors on trial ten and the post-test (P-T) trial, for the three age groups and the redundant (R) and irrelevant (I) conditions.

In summary, the results of the present study indicated that, while there was no difference in sorting time between the redundant and nonredundant conditions in any of the three age groups, children in Grade one were significantly slower in the irrelevant condition during early trials. There was no difference over trials between the irrelevant condition and the other two conditions in Grade four children or adults. On the first trials, Grade one children made more errors than older children and adults, and females made more errors than males. The analyses of sorting times and errors on the practice trial and trial one revealed significantly longer sorting times and more errors on trial one than on the practice trial, and longer sorting times on both trials for subjects in the irrelevant condition. Sorting time on the post-test trial in the redundant and irrelevant conditions increased relative to the last learning trial only in Grade one children. Errors increased on the post-test trial only in the irrelevant condition, while an increase in errors in the irrelevant condition occurred primarily in Grade one children.

Chapter 4

Discussion

The present study hypothesized that younger children attend to redundant and irrelevant cues, but will come to ignore them as a result of perceptual learning. Older children and adults, on the other hand, ignore redundant and irrelevant cues, and no attentional changes during perceptual learning were predicted for subjects in these age groups.

Evidence that subjects in all age groups experienced perceptual, and not simply motoric learning is provided by the finding that sorting time and errors increased from the practice trial to trial one for subjects of all ages. As argued earlier, this increase suggests that the subsequent improvement in performance reflected perceptual learning. It may be concluded, then, that the decrease in sorting time over the first four trials, and the decrease in errors from trial one to trial two, indicates that perceptual learning occurred in all age groups.

With reference to irrelevant cues, the hypothesis that young children attend to, but learn to ignore, additional cues was confirmed in the present study. The Age-by-Conditions-by-Trials interaction revealed that, on the first three trials, the sorting times of Grade one children in the irrelevant condition were significantly longer than in the other two conditions, but primarily over the first three trials. While the Conditions main effect showed that subjects in all age groups sorted more slowly in the irrelevant condition, the interaction of Age-by-Conditions-by-Trials revealed that the detriment in performance was greater for the younger children. In Grade four children and adults, there were no significant differences among the conditions in sorting time over trials. While the Conditions-by-Trials interaction in the analysis of sorting time on the practice trial and trial one indicated that subjects in the irrelevant condition were generally slower at sorting to begin with, the difference between these subjects and subjects in the other conditions was greater on trial one than on the practice trial. It may be concluded, then, that subjects in the irrelevant condition were influenced by the additional cue, and were not simply slower at sorting in general.

As noted in the method section, Grade four girls were significantly older than the boys in the redundant condition, and the boys in the irrelevant condition were significantly older than the boys in the other two conditions. That these differences do not account for the results of the present study is attested to by the finding that no similar interactions between sex and conditions were observed for the dependent variables in this study. Therefore, these age differences, as mentioned previously, should be considered simply an artifactual result of the small age variance observed in grade selection.

It appears, then, that as a result of experience with specific stimuli, accompanying irrelevant cues come to be ignored by younger children. Further evidence that inattention to irrelevant stimuli results from perceptual learning is provided by the results of the post-test sorting trial. The interaction of Age-by-Trials showed that, for both the redundant and irrelevant conditions in Grade one children, sorting times were longer on the post-test trial than on trial ten of perceptual learning. The interaction of Conditions-by-Trials revealed that errors increased significantly on the post-test trial in the irrelevant condition but not in the redundant condition. These results suggest that, by trial ten, Grade one children had learned to ignore the irrelevant cue such that when the relevant and irrelevant cues were switched, the requirement to stop ignoring the previously-irrelevant cue and start ignoring the previously-relevant cue necessitated new learning.

The results of the post-test trial, however, should not be regarded as conclusive. It is important to note that perceptual learning appears to have reached asymptotic level by trial four in Grade one children, and by trial two in Grade four children and adults. Therefore, it can be argued that the subsequent trials constituted overtraining. In view of this overtraining, it is suggested that post-test performance may have been different had the post-test been administered immediately after performance had reached asymptotic level. In Grade one children, it has been seen that sorting time and errors increased on the post-test trial in the irrelevant condition. Overtraining has repeatedly been found to facilitate the making of reversal shifts (e.g., Eimas, 1966), which occur between two values of a single dimension. In the present study, the post-test trial involved a nonreversal shift, since the dimensions themselves were switched. It has been found (e.g., Mackintosh, 1962) that overtraining retards nonreversal learning, presumably by strengthening the attentional response to the relevant dimension, which is no longer relevant during the nonreversal shift.

In the present study, it may be concluded that in the irrelevant condition overtraining strengthened attention to the relevant form dimension. In Grade four children and adults, there was no change in sorting time or errors on the post-test trial. While such a result had been considered to imply that attention had been directed to the additional cues during perceptual learning, another explanation is evident. Since Grade four children and adults received eight overtraining trials prior to the post-test trial, it would be predicted that they would be slower to shift to the new relevant dimension. Overtraining appears, however, to have had a different effect in these subjects. Since learning occurred in one trial, it may be suggested that the task was too easy for older children and adults. As a result, they may have attended to other characteristics of the stimuli during overtraining trials, and the results of the post-test trial may be attributed to this possibility. Thus, the results of the present study provide no information about the strength of the attentional response to the relevant dimension prior to overtraining, and suggest that the role of stimulus complexity may interact with that of overlearning in influencing attention during perceptual learning.

The hypothesis that young children attend to, but learn to ignore, redundant cues was not confirmed in the present study. As predicted, there were no differences between the redundant and nonredundant conditions in Grade four children and adults. For Grade one children, it was predicted that, if these subjects attended to the redundant cue without using it to facilitate discrimination, attention to redundancy would be characterized by longer sorting times in the redundant than the nonredundant condition. If, on the other hand, the redundant cue was utilized, attention to redundancy would be reflected by shorter sorting times in the redundant than the nonredundant condition. In the present study, however, there were no differences between the redundant and nonredundant conditions in Grade one children. From these results it would appear that the ability to ignore redundant cues may appear earlier in development than the ability to ignore irrelevant cues.

Alternatively, it is possible that attention to the redundant cue occurred without a corresponding increase in sorting time. When the relevant and redundant cues are totally correlated and adjacent to one another, as in the present study, decision time may be the same whether attention is directed to both cues or to only one. Alternatively, the difference in decision time may have been so slight as to have no measurable effect on sorting time. This interpretation assumes that the redundant cue, while attended to, was not used to facilitate sorting. In view of the uncertainty of the present results, no conclusion can be reached regarding the use of redundancy.

Equally plausible is the possibility that the use of a separate groups design for the conditions may have obscured an effect of redundancy. Models of multidimensional stimulus processing recognize the role of individual differences in information processing (Stone, 1971). In the present study, it is possible that some subjects took advantage of the redundant cue, while others attended to the cue but did not detect its redundancy. Relative to the nonredundant condition, sorting time would decrease in subjects who used the redundant cue, but increase in those who attended to but did not use the cue. It may be suggested, therefore, that the question of whether or not young children ignore redundant cues may be clarified by a repeated measures design in which each subject experiences all conditions.

The increase in sorting time on the post-test trial suggests that Grade one children had ignored the redundant cue. Since the results of the present study are not clear as to whether or not the redundant cue had been attended to before learning had occurred, and in view of the overlearning that had occurred prior to the post-test, no conclusion can be drawn from the results of the post-test trial.

That individual differences in attentional styles, mentioned earlier, is an important factor to consider in studies of attention is attested to by the sex difference that emerged in the present study. While there were no differences in sorting time between males and females, the latter made more errors. This finding is consistent with Witkin's (1959) finding that girls tend to be more field-dependent than boys, and with studies of sex differences in attentional styles (Silverman, 1970), which find that females are more distractible and more responsive to contextual stimuli. In the present study, the sex difference in number of errors made disappeared after trial two, as evidenced by the significant interaction of Sex-by-Trials.

In sum, the results of the present study demonstrate that the ability to ignore irrelevant cues is a function of perceptual learning. Moreover, the influence of perceptual learning on attention to irrelevant cues occurs not only as a result of the perceptual learning that occurs in the course of the development of the organism, but also as a result of practice during a limited experimental session.

The results of the present study suggest that the tendency to ignore redundancy may appear earlier in development than the tendency to ignore irrelevant cues. This finding, however, is not consistent with studies of multiple-cue learning (e.g., Eimas, 1969) and incidental learning (e.g., Maccoby & Hagen, 1965; Stevenson, 1954), which indicate that young children attend to and learn about as many cues as they can. As suggested earlier, an experimental design in which each subject is tested under all stimulus conditions may allow a more decisive conclusion regarding age changes in attention to additional cues.

As noted in the introduction, Maccoby (1969) suggests that the ability to discriminate between relevant and irrelevant stimuli, and consequently to attend selectively to them, develops as a result of discrimination learning. The discriminative experience of older children and adults is sufficient to enable them to recognize immediately which cues are relevant and which irrelevant or redundant. Since there is no need to learn to discriminate between what are probably old cues in a new context, selection occurs immediately in individuals with extended discriminative experience, unless the stimuli are very unfamiliar and perhaps also complex.

The results of the present study are consistent with Maccoby's (1969) hypothesis regarding the role of discrimination learning, and demonstrate that in children of limited discriminative experience, selectivity occurs once the child has had perceptual experience with the cues involved. Studies of stimulus control in animals (e.g., Reynolds, 1961; Wagner, Logan, Haberlandt, & Price, 1968) demonstrate that stimuli which are not differentially reinforced fail to acquire control over behavior. It may be suggested, therefore, that the process by which irrelevant and redundant stimuli come to be ignored is one in which responses to these stimuli are extinguished simply because they are not differentially associated with the occurrence and nonoccurrence of reinforcement, and so do not have differential consequences for behavior. The present study, however, provides no evidence on this question, and research is suggested.

The results of the present study point to several areas of concern for future research. It has been noted that overlearning can bring about further changes in attention beyond those which occur during original learning. It is suggested, therefore, that in future studies of the role of perceptual learning in attention, tests of the strength of attentional responses to critical and noncritical cues should be administered immediately after performance has reached asymptotic level. Using separate groups, the parameter of amount of learning may then be varied in order to determine what changes in attentional response strength may occur as a result of overtraining.

Stimulus complexity has also been suggested to be an important variable in comparing the effects of perceptual learning across age groups. While it is difficult, if not impossible, to equate stimulus complexity across age, the number of additional cues may be varied at each age level, and the effects compared both within and across age groups. It has also been suggested that the parameters of stimulus complexity and amount of learning may interact, and this function should also be investigated.

Finally, it has been noted that individual differences in attentional styles may be an important variable in studies of selective attention, and the use of a repeated measures design, in which each subject experiences all stimulus conditions, has been suggested.

In conclusion, it has been seen that perceptual learning has an effect on selective attention. Several variables have been suggested to play an important role in this effect, and indicate fruitful areas for further research.

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Appendix A

Table 1

Sorting times (ST) and errors (E) of Grade 1 boys on the practice trial (PT), trials 1-10, and the post-test (P-T) trial in the redundant condition; and subjects' ages (in months)

Subjects		Trials												Age
		PT	1	2	3	4	5	6	7	8	9	10	P-T	
S_1:	ST	11	31	15	15	15	13	12	15	13	14	15	19	85
	E	0	0	0	0	0	0	0	0	0	0	2	0	
S_2:	ST	17	19	18	16	19	19	15	24	19	16	19	20	80
	E	0	0	0	0	0	0	0	2	0	0	0	0	
S_3:	ST	15	23	20	21	23	20	18	22	15	18	18	26	85
	E	0	1	0	2	2	0	1	1	0	1	0	0	
S_4:	ST	15	15	25	22	21	20	20	21	19	18	18	18	88
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_5:	ST	17	29	22	24	22	20	25	20	20	18	22	29	87
	E	0	3	0	0	1	0	0	0	0	0	0	0	
S_6:	ST	19	34	21	29	26	31	24	20	27	18	17	44	76
	E	0	1	0	0	1	0	0	0	1	0	0	0	
S_7:	ST	23	31	24	24	34	23	40	27	27	38	32	27	76
	E	0	4	0	0	0	0	1	0	0	1	0	0	
S_8:	ST	18	31	22	31	29	31	22	26	26	27	19	31	87
	E	0	2	0	1	0	0	0	1	0	0	0	0	
S_9:	ST	14	17	15	16	16	20	17	18	15	15	22	18	87
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_{10}:	ST	16	28	22	18	23	26	18	23	22	29	22	33	75
	E	0	1	0	1	0	2	0	0	0	0	1	1	

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Table 2

Sorting times (ST) and errors (E) of Grade 1 boys on the practice trial (PT) and trials 1-10 in the nonredundant condition; and subjects' ages (in months)

Subjects		Trials											Age
		PT	1	2	3	4	5	6	7	8	9	10	
S_1:	ST	10	15	16	11	11	11	10	15	16	16	12	79
	E	0	0	0	0	0	0	0	0	0	0	0	
S_2:	ST	15	20	22	19	25	20	21	17	16	16	21	83
	E	0	4	0	0	0	0	0	0	0	0	0	
S_3:	ST	23	32	25	29	22	25	24	23	23	26	25	86
	E	0	5	0	0	0	0	0	0	0	0	0	
S_4:	ST	14	25	15	18	15	15	18	16	17	18	18	78
	E	0	0	0	1	0	0	0	0	0	0	0	
S_5:	ST	17	22	23	22	21	26	21	23	25	20	33	82
	E	0	0	0	0	1	0	0	1	0	1	0	
S_6:	ST	16	33	22	27	29	21	20	21	22	24	23	75
	E	0	0	0	0	0	0	0	0	0	0	0	
S_7:	ST	13	24	24	27	20	27	22	25	28	23	25	83
	E	0	2	0	0	0	2	0	1	0	0	1	
S_8:	ST	18	33	29	26	29	32	38	27	37	26	30	78
	E	0	0	0	0	3	2	0	0	0	2	1	
S_9:	ST	20	29	26	26	23	27	21	18	21	20	20	84
	E	0	0	0	0	0	0	0	0	0	0	0	
S_{10}:	ST	14	25	20	21	22	22	17	21	19	17	17	85
	E	0	0	0	0	0	1	0	1	0	0	0	

Appendix A

Table 3

Sorting times (ST) and errors (E) of Grade 1 boys on the practice trial (PT), trials 1-10, and the post-test (P-T) trial in the irrelevant condition; and subjects' ages (in months)

Subjects		Trials												Age
		PT	1	2	3	4	5	6	7	8	9	10	P-T	
S_1:	ST	18	22	18	22	19	19	17	15	15	19	15	24	75
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_2:	ST	11	28	25	20	16	14	18	18	16	19	18	20	76
	E	0	0	1	0	0	0	0	0	0	2	1	0	
S_3:	ST	17	28	19	26	21	17	17	16	26	21	28	28	77
	E	0	0	2	6	11	0	1	0	1	0	0	14	
S_4:	ST	16	36	30	30	19	19	29	24	31	34	40	30	86
	E	0	4	3	2	0	1	1	0	0	3	1	0	
S_5:	ST	21	21	30	29	25	28	28	26	25	27	26	35	77
	E	0	1	0	1	1	0	0	0	0	0	0	0	
S_6:	ST	16	21	21	17	18	19	20	19	17	20	20	21	79
	E	0	1	1	0	0	0	0	0	0	0	0	0	
S_7:	ST	19	32	24	24	29	20	26	31	20	28	25	29	77
	E	0	0	2	0	7	2	0	1	0	2	2	0	
S_8:	ST	15	26	20	17	21	23	21	17	14	17	16	28	82
	E	0	2	2	1	2	1	0	0	0	0	0	3	
S_9:	ST	23	40	69	40	37	38	36	30	46	35	33	36	84
	E	0	8	0	0	0	0	0	0	0	0	0	0	
S_{10}:	ST	12	14	16	19	20	14	13	17	19	14	19	17	87
	E	0	0	0	0	0	0	1	0	2	1	1	0	

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Table 4

Sorting times (ST) and errors (E) of Grade 1 girls on the practice trial (PT), trials 1-10, and the post-test (P-T) trial in the redundant condition; and subjects' ages (in months)

Subjects		Trials												Age
		PT	1	2	3	4	5	6	7	8	9	10	P-T	
S_1:	ST	16	23	23	31	30	25	24	19	22	21	30	21	81
	E	1	2	1	0	1	0	2	1	0	0	0	0	
S_2:	ST	18	29	25	27	21	30	27	27	22	25	33	33	77
	E	0	0	0	0	0	0	0	0	0	0	1	0	
S_3:	ST	23	43	30	44	30	28	43	31	36	32	29	41	76
	E	0	6	4	1	1	2	2	0	1	5	2	0	
S_4:	ST	13	24	29	24	26	21	17	17	17	19	18	34	77
	E	0	1	1	1	1	0	0	0	0	0	0	1	
S_5:	ST	21	20	20	17	20	19	18	17	16	21	17	22	77
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_6:	ST	10	19	14	11	12	11	10	12	11	11	10	10	83
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_7:	ST	12	28	21	22	16	20	20	29	17	27	16	13	78
	E	0	3	0	2	1	1	1	3	0	0	0	0	
S_8:	ST	11	15	16	17	18	14	11	14	15	13	13	13	79
	E	0	0	0	0	0	0	0	1	0	0	0	0	
S_9:	ST	12	16	20	17	14	15	13	18	16	23	13	15	83
	E	0	3	1	0	4	0	2	1	0	0	0	0	
S_{10}:	ST	16	27	26	24	24	24	21	21	24	22	23	22	80
	E	0	1	2	0	2	1	0	1	0	0	0	0	

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Table 5

Sorting times (ST) and errors (E) of Grade 1 girls on the practice trial (PT) and trials 1-10 in the nonredundant condition; and subjects' ages (in months)

Subjects		Trials											Age
		PT	1	2	3	4	5	6	7	8	9	10	
S_1:	ST	10	28	18	15	17	15	17	16	16	15	14	82
	E	1	0	0	0	0	0	0	0	0	4	0	
S_2:	ST	15	40	27	25	25	28	28	24	26	23	20	77
	E	0	3	0	0	3	2	2	5	1	2	1	
S_3:	ST	14	29	19	19	21	21	16	19	18	21	17	83
	E	0	3	3	0	2	1	1	4	0	1	1	
S_4:	ST	16	22	28	20	26	20	17	20	23	23	26	85
	E	0	6	2	4	2	0	0	0	1	0	1	
S_5:	ST	11	27	33	14	17	16	19	25	17	28	19	82
	E	0	1	6	2	0	0	0	1	0	3	1	
S_6:	ST	13	17	17	19	16	15	14	18	14	15	17	81
	E	0	1	1	0	0	0	1	1	0	0	1	
S_7:	ST	14	18	16	16	17	16	17	16	16	19	17	83
	E	0	0	0	0	0	0	0	0	0	1	0	
S_8:	ST	15	24	20	27	21	21	24	22	21	21	19	78
	E	0	1	0	0	0	0	1	0	0	0	0	
S_9:	ST	17	29	20	17	20	15	25	21	18	18	20	81
	E	0	0	0	0	0	0	1	0	0	0	2	
S_{10}:	ST	15	21	18	16	18	18	18	19	17	20	18	84
	E	0	3	0	1	0	1	0	0	2	0	0	

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Table 6

Sorting times (ST) and errors (E) of Grade 1 girls on the practice trial (PT), trials 1-10, and the post-test (P-T) trial in the irrelevant condition; and subjects' ages (in months)

Subjects		Trials												Age
		PT	1	2	3	4	5	6	7	8	9	10	P-T	
S_1:	ST	13	24	18	16	17	17	22	17	16	15	15	19	77
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_2:	ST	19	44	31	17	19	18	17	17	18	17	17	18	85
	E	0	1	1	0	1	0	0	1	0	0	0	0	
S_3:	ST	18	26	23	29	22	25	20	23	19	23	21	26	80
	E	0	1	0	2	0	3	0	0	0	0	0	8	
S_4:	ST	20	34	47	31	28	26	25	35	29	21	27	21	86
	E	0	3	2	1	0	0	0	0	0	0	0	0	
S_5:	ST	17	45	22	27	27	32	31	26	23	28	34	59	81
	E	0	1	0	0	0	0	0	0	0	0	0	3	
S_6:	ST	18	45	51	39	27	30	26	24	22	26	25	35	76
	E	0	0	0	0	0	0	0	0	0	0	0	7	
S_7:	ST	12	45	57	52	30	23	33	24	23	27	17	31	77
	E	0	7	7	8	0	0	0	0	0	0	0	0	
S_8:	ST	16	45	24	30	23	22	19	21	19	21	24	18	89
	E	0	3	1	1	1	0	0	0	1	1	0	0	
S_9:	ST	15	24	20	29	21	21	22	19	24	22	19	28	76
	E	0	5	6	3	9	0	0	0	1	2	1	0	
S_{10}:	ST	16	21	25	17	17	16	17	16	16	15	17	21	87
	E	0	5	4	3	1	0	0	1	4	0	2	2	

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Table 7

Sorting times (ST) and errors (E) of Grade 4 boys on the practice trial (PT), trials 1-10, and the post-test (P-T) trial in the redundant condition; and subjects' ages (in months)

Subjects		PT	1	2	3	4	5	6	7	8	9	10	P-T	Age
S_1:	ST	10	17	15	21	15	14	15	13	14	15	13	16	120
	E	0	3	0	0	0	0	0	0	0	0	0	0	
S_2:	ST	12	13	13	13	13	13	14	12	13	12	14	15	113
	E	0	0	2	0	0	0	1	0	0	0	0	0	
S_3:	ST	9	13	13	11	12	12	11	11	12	13	12	12	120
	E	0	2	0	0	0	1	0	1	0	1	0	0	
S_4:	ST	10	12	15	13	11	12	10	12	9	10	10	9	115
	E	0	0	1	0	0	0	0	0	0	0	0	0	
S_5:	ST	11	15	19	17	17	17	15	15	16	17	17	15	115
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_6:	ST	12	16	15	17	15	17	14	15	15	20	15	12	116
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_7:	ST	14	18	16	19	20	13	15	17	15	14	14	15	117
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_8:	ST	11	22	14	13	16	15	15	14	14	16	14	10	112
	E	0	3	0	2	1	0	2	1	0	1	1	0	
S_9:	ST	14	24	14	14	15	15	12	15	13	14	13	12	121
	E	0	0	0	0	0	0	0	0	0	1	0	0	
S_{10}:	ST	9	17	15	13	11	12	10	12	16	11	13	9	118
	E	0	0	0	0	0	0	0	0	0	0	0	0	

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Table 8

Sorting times (ST) and errors (E) of Grade 4 boys on the practice trial (PT) and trials 1-10 in the nonredundant condition; and subjects' ages (in months)

Subjects		Trials											Age
		PT	1	2	3	4	5	6	7	8	9	10	
S_1:	ST	12	17	15	14	13	16	13	14	14	15	13	118
	E	0	0	0	0	0	0	0	0	0	0	0	
S_2:	ST	11	16	18	13	12	13	13	13	13	13	11	121
	E	0	0	0	0	0	1	0	0	0	0	0	
S_3:	ST	11	16	17	15	13	13	12	15	13	17	14	114
	E	0	0	0	0	1	0	0	0	0	0	1	
S_4:	ST	10	18	12	13	13	11	11	13	12	11	11	118
	E	0	4	0	0	0	1	0	0	0	1	0	
S_5:	ST	12	22	16	16	20	15	14	14	17	15	20	115
	E	0	0	1	0	2	0	0	0	0	0	0	
S_6:	ST	9	18	13	13	14	13	12	11	13	11	12	116
	E	0	1	0	1	1	1	0	0	1	0	0	
S_7:	ST	10	15	13	14	16	12	14	14	15	16	14	115
	E	0	4	1	1	6	0	2	1	0	0	0	
S_8:	ST	11	16	15	15	15	14	13	11	16	14	12	118
	E	0	0	1	0	0	1	0	1	0	0	0	
S_9:	ST	12	15	15	16	17	16	16	14	14	14	16	120
	E	0	0	0	2	1	2	0	0	0	0	0	
S_{10}:	ST	11	20	14	15	13	14	15	13	12	12	11	124
	E	0	5	0	1	0	2	3	1	0	0	1	

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Table 9

Sorting times (ST) and errors (E) of Grade 4 boys on the practice trial (PT), trials 1-10, and the post-test (P-T) trial in the irrelevant condition; and subjects' ages (in months)

Subjects		Trials												Age
		PT	1	2	3	4	5	6	7	8	9	10	P-T	
S_1:	ST	10	21	14	14	15	13	13	14	12	12	16	12	120
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_2:	ST	12	25	16	14	14	13	13	12	11	12	11	14	121
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_3:	ST	12	18	20	21	16	16	18	17	18	16	16	16	119
	E	0	1	2	2	3	0	1	0	3	2	1	6	
S_4:	ST	12	15	13	15	14	14	12	14	14	16	12	14	120
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_5:	ST	11	25	19	18	18	20	20	17	18	18	17	15	126
	E	0	1	1	0	0	0	1	0	2	0	0	0	
S_6:	ST	9	17	13	12	13	11	13	14	11	14	13	11	120
	E	0	3	1	0	2	0	0	5	0	1	1	0	
S_7:	ST	11	14	15	15	16	15	14	12	15	19	13	10	121
	E	0	0	0	2	0	1	3	0	0	1	0	0	
S_8:	ST	8	11	10	11	10	10	10	9	11	10	9	11	122
	E	0	0	1	0	0	0	1	0	1	0	0	0	
S_9:	ST	10	18	12	11	17	12	11	13	13	11	11	8	118
	E	0	4	0	0	0	0	0	0	0	0	0	0	
S_{10}:	ST	13	15	13	15	14	14	14	13	12	13	14	12	124
	E	0	0	0	1	0	0	0	0	0	0	1	0	

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Table 10

Sorting times (ST) and errors (E) of Grade 4 girls on the practice trial (PT), trials 1-10, and the post-test (P-T) trial in the redundant condition; and subjects' ages (in months)

Subjects		Trials												Age
		PT	1	2	3	4	5	6	7	8	9	10	P-T	
S_1:	ST	13	20	15	14	15	14	21	14	14	13	13	13	120
	E	0	0	0	0	0	0	0	0	0	0	1	0	
S_2:	ST	10	12	12	11	13	11	11	12	11	13	12	10	125
	E	0	1	0	2	0	0	0	0	0	0	0	0	
S_3:	ST	8	20	16	22	27	32	25	40	25	15	9	9	123
	E	0	0	1	0	6	1	0	0	0	1	0	0	
S_4:	ST	11	25	21	17	26	15	14	17	16	16	20	16	115
	E	0	9	4	2	0	1	0	1	0	0	2	0	
S_5:	ST	10	23	14	15	13	14	17	12	13	12	10	12	118
	E	0	0	0	1	0	0	2	1	0	0	0	0	
S_6:	ST	11	14	16	13	12	17	10	13	10	12	12	10	116
	E	0	0	1	1	1	1	0	1	0	0	0	0	
S_7:	ST	9	13	10	12	11	9	9	11	9	11	10	13	121
	E	0	0	1	0	1	0	1	1	0	1	2	0	
S_8:	ST	10	22	18	15	14	12	11	10	10	10	10	9	123
	E	0	4	0	0	0	0	0	0	0	0	0	0	
S_9:	ST	11	21	19	16	20	20	20	18	19	13	17	16	115
	E	0	2	1	1	0	0	0	1	0	0	0	0	
S_{10}:	ST	8	11	8	9	11	9	8	10	8	10	9	8	124
	E	0	0	0	0	0	0	0	0	0	0	0	0	

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Table 11

Sorting times (ST) and errors (E) of Grade 4 girls on the practice trial (PT) and trials 1-10 in the nonredundant condition; and subjects' ages (in months)

Subjects		Trials											Age
		PT	1	2	3	4	5	6	7	8	9	10	
S_1:	ST	10	15	12	16	13	12	15	13	12	12	12	120
	E	0	4	4	4	0	0	0	0	0	0	0	
S_2:	ST	9	21	13	15	13	11	13	14	14	13	13	114
	E	0	0	0	2	0	0	0	0	0	0	0	
S_3:	ST	11	19	14	15	12	13	13	13	14	15	15	121
	E	0	2	1	0	0	0	0	0	0	1	0	
S_4:	ST	12	18	13	14	14	19	12	12	14	12	11	119
	E	0	0	0	0	1	3	0	0	0	0	0	
S_5:	ST	13	14	14	12	14	11	11	11	12	11	11	127
	E	0	0	0	0	0	0	0	0	0	0	0	
S_6:	ST	13	16	14	14	14	15	14	15	16	13	12	116
	E	0	0	0	0	0	0	0	0	0	0	0	
S_7:	ST	11	13	12	13	14	13	13	13	12	13	12	122
	E	0	0	0	1	0	1	1	0	0	0	0	
S_8:	ST	9	14	12	14	11	12	11	12	12	15	13	122
	E	0	1	0	1	0	1	0	3	1	0	4	
S_9:	ST	12	18	15	17	15	17	13	12	15	18	13	122
	E	0	4	0	0	0	2	1	0	0	0	1	
S_{10}:	ST	11	13	12	12	15	14	12	12	12	12	12	114
	E	0	0	0	1	0	0	0	0	0	0	0	

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Table 12

Sorting times (ST) and errors (E) of Grade 4 girls on the practice trial (PT), trials 1-10, and the post-test (P-T) trial in the irrelevant condition; and subjects' ages (in months)

Subjects		Trials												Age
		PT	1	2	3	4	5	6	7	8	9	10	P-T	
S_1:	ST	10	16	11	14	14	13	12	14	19	11	14	17	119
	E	0	0	0	0	2	0	0	0	0	0	0	0	
S_2:	ST	11	17	15	14	14	17	16	17	15	17	13	22	121
	E	0	4	0	0	0	1	0	0	1	0	1	2	
S_3:	ST	11	13	19	14	20	14	17	13	17	12	16	12	120
	E	0	1	0	0	0	0	0	1	1	0	1	0	
S_4:	ST	10	13	12	13	13	14	14	13	12	13	12	13	112
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_5:	ST	9	22	19	15	12	13	11	11	11	11	13	11	114
	E	0	1	0	0	0	0	0	0	0	1	1	0	
S_6:	ST	10	13	13	12	13	16	13	13	15	12	13	15	124
	E	0	1	1	2	2	1	0	0	0	0	0	0	
S_7:	ST	12	28	19	14	17	16	15	17	14	15	17	13	121
	E	0	1	0	0	0	0	0	0	0	0	1	0	
S_8:	ST	9	22	14	12	12	12	10	14	11	10	13	12	119
	E	0	7	1	0	1	1	0	2	0	0	3	3	
S_9:	ST	14	28	22	17	17	16	17	15	13	13	18	15	120
	E	0	0	0	0	1	0	0	0	0	0	0	0	
S_{10}:	ST	9	14	15	13	12	14	12	13	13	12	15	11	119
	E	0	2	0	1	0	0	0	0	0	0	0	0	

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Table 13

Sorting times (ST) and errors (E) of male adults on the practice trial (PT), trials 1-10, and the post-test (P-T) trial in the redundant condition; and subjects' ages (in months)

Subjects		Trials												Age
		PT	1	2	3	4	5	6	7	8	9	10	P-T	
S_1:	ST	12	13	11	10	10	10	10	10	10	10	11	9	215
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_2:	ST	9	11	9	10	10	12	10	10	10	10	10	10	210
	E	0	0	0	1	0	0	0	0	0	0	1	0	
S_3:	ST	9	9	10	8	8	9	7	8	8	9	8	7	197
	E	0	0	0	0	0	0	0	0	0	1	0	0	
S_4:	ST	9	13	11	11	10	10	9	10	10	10	10	10	228
	E	0	2	1	0	0	0	0	0	0	1	0	0	
S_5:	ST	9	12	10	9	9	9	10	9	10	10	10	10	215
	E	0	1	0	3	1	2	0	1	0	0	0	0	
S_6:	ST	9	19	12	11	11	9	9	10	9	9	9	10	252
	E	0	3	0	0	0	1	0	2	0	0	1	0	
S_7:	ST	8	11	9	10	9	10	9	10	9	9	9	9	320
	E	0	0	0	0	0	0	0	1	0	0	1	0	
S_8:	ST	8	10	11	10	13	9	9	8	10	10	9	7	230
	E	0	0	0	0	0	0	1	0	0	0	1	0	
S_9:	ST	7	11	9	12	9	9	8	10	11	10	9	17	211
	E	0	0	0	0	0	0	0	1	1	2	0	0	
S_{10}:	ST	9	13	13	14	15	13	14	13	13	14	13	11	216
	E	0	3	3	2	0	2	1	2	5	0	2	0	

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Table 14

Sorting times (ST) and errors (E) of male adults on the practice trial (PT) and trials 1-10 in the nonredundant condition; and subjects' ages (in months)

Subjects		Trials											Age
		PT	1	2	3	4	5	6	7	8	9	10	
S_1:	ST	12	14	10	11	10	10	10	11	9	9	9	211
	E	0	0	0	0	0	0	0	0	0	0	0	
S_2:	ST	11	16	13	14	13	13	13	12	12	12	13	236
	E	0	0	0	0	0	0	0	0	0	0	0	
S_3:	ST	7	11	9	9	12	11	9	8	9	10	9	224
	E	0	2	0	0	2	0	0	0	0	2	0	
S_4:	ST	11	14	11	11	9	10	11	9	10	12	10	218
	E	0	0	0	0	0	0	0	0	1	1	0	
S_5:	ST	9	13	12	10	11	12	9	10	10	12	9	228
	E	0	1	1	0	2	1	1	1	0	2	0	
S_6:	ST	9	10	11	11	10	10	10	9	9	9	9	351
	E	0	0	0	0	0	0	0	0	0	0	0	
S_7:	ST	8	19	11	10	11	11	11	10	9	10	9	248
	E	0	0	0	0	1	0	0	0	0	0	1	
S_8:	ST	10	11	9	9	11	9	9	9	10	10	10	216
	E	0	0	0	0	0	0	0	0	0	0	0	
S_9:	ST	8	9	8	8	11	8	8	8	8	11	9	239
	E	0	0	0	1	0	0	0	0	0	0	0	
S_{10}:	ST	11	12	11	11	11	13	12	11	10	9	12	232
	E	0	0	0	0	0	0	1	0	0	0	0	

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Table 15

Sorting times (ST) and errors (E) of male adults on the practice trial (PT), trials 1-10, and the post-test (P-T) trial in the irrelevant condition; and subjects' ages (in months)

Subjects		Trials												Age
		PT	1	2	3	4	5	6	7	8	9	10	P-T	
S_1:	ST	8	11	9	12	10	9	9	11	8	8	7	9	216
	E	0	0	1	1	0	0	0	0	1	0	0	0	
S_2:	ST	7	9	10	10	14	13	12	9	16	10	11	9	198
	E	0	0	0	0	0	0	1	0	0	3	0	0	
S_3:	ST	9	11	11	11	11	9	9	10	9	10	11	9	214
	E	0	0	0	0	0	0	1	0	0	0	1	0	
S_4:	ST	8	11	9	9	9	9	8	9	8	9	9	11	225
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_5:	ST	11	13	10	12	11	11	10	10	10	10	11	12	257
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_6:	ST	11	14	13	13	15	12	12	13	12	14	12	11	238
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_7:	ST	10	13	11	12	10	11	10	9	9	9	10	9	247
	E	0	0	1	0	0	0	0	0	0	0	0	1	
S_8:	ST	9	9	8	10	8	8	8	8	9	8	9	9	330
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_9:	ST	12	15	15	12	15	11	9	15	14	12	14	16	275
	E	0	0	0	0	0	0	0	0	0	0	1	0	
S_{10}:	ST	13	14	11	12	12	11	14	11	12	12	10	12	222
	E	0	0	0	0	1	0	0	0	0	0	0	0	

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Table 16

Sorting times (ST) and errors (E) of female adults on the practice trial (PT), trials 1-10, and the post-test (P-T) trial in the redundant condition; and subjects' ages (in months)

Subjects		Trials												Age
		PT	1	2	3	4	5	6	7	8	9	10	P-T	
S_1:	ST	8	10	10	9	9	9	8	9	8	10	9	11	216
	E	0	1	0	0	0	0	0	0	0	0	0	0	
S_2:	ST	11	16	13	10	10	10	10	9	12	9	9	9	209
	E	0	0	1	0	0	0	0	2	0	0	1	0	
S_3:	ST	9	13	12	11	10	11	11	12	9	9	12	9	230
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_4:	ST	10	14	12	11	10	10	9	10	8	8	8	9	228
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_5:	ST	11	12	10	10	11	12	10	10	10	13	10	9	231
	E	0	2	0	0	0	0	0	0	0	0	0	0	
S_6:	ST	9	11	9	10	9	10	9	9	9	8	9	8	326
	E	0	0	0	2	0	0	0	0	0	0	0	1	
S_7:	ST	7	9	8	8	7	8	7	7	8	8	8	8	313
	E	0	0	0	0	0	1	0	0	0	1	0	0	
S_8:	ST	8	10	10	9	8	8	8	9	9	9	8	8	223
	E	0	0	0	0	0	0	0	0	2	0	1	0	
S_9:	ST	8	8	9	9	9	10	8	9	9	9	9	7	242
	E	0	0	1	0	0	4	0	1	0	0	0	0	
S_{10}:	ST	9	16	8	15	10	11	9	11	11	10	11	12	245
	E	0	0	0	0	0	0	0	0	1	0	1	0	

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Table 17

Sorting times (ST) and errors (E) of female adults on the practice trial (PT) and trials 1-10 in the nonredundant condition; and subjects' ages (in months)

Subjects		Trials											Age
		PT	1	2	3	4	5	6	7	8	9	10	
S_1:	ST	9	15	12	11	10	10	9	9	11	10	11	210
	E	0	1	0	0	0	0	0	0	0	0	0	
S_2:	ST	8	9	9	10	9	9	9	11	9	9	9	217
	E	0	0	0	0	0	0	0	0	0	0	0	
S_3:	ST	9	13	9	9	10	9	9	11	10	11	9	225
	E	0	5	0	3	1	0	0	0	0	1	0	
S_4:	ST	11	12	11	11	11	10	11	10	11	14	10	210
	E	0	3	2	0	0	0	0	0	3	0	0	
S_5:	ST	9	15	10	10	10	11	9	10	11	9	11	223
	E	0	2	0	0	0	1	1	2	0	0	0	
S_6:	ST	9	12	12	14	12	14	10	13	10	11	10	213
	E	0	0	0	0	0	1	0	1	0	0	0	
S_7:	ST	6	9	9	8	8	8	8	8	7	7	9	316
	E	0	0	0	0	0	0	0	0	0	0	0	
S_8:	ST	9	18	10	12	11	11	10	13	11	11	13	228
	E	0	1	0	0	0	0	0	0	0	0	0	
S_9:	ST	8	11	10	10	10	9	11	8	9	9	9	209
	E	0	0	0	0	0	0	1	0	0	0	0	
S_{10}:	ST	11	13	12	12	12	11	11	11	11	11	10	209
	E	0	0	0	0	0	0	0	0	0	0	0	

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Table 18

Sorting times (ST) and errors (E) of female adults on the practice trial (PT), trials 1-10, and the post-test (P-T) trial in the irrelevant condition; and subjects' ages (in months)

Subjects		Trials												Age
		PT	1	2	3	4	5	6	7	8	9	10	P-T	
S_1:	ST	15	18	14	16	14	15	15	20	14	15	14	23	232
	E	0	0	0	0	8	0	0	0	0	1	0	0	
S_2:	ST	9	12	11	11	12	11	10	14	11	10	9	10	258
	E	0	5	0	0	0	1	0	0	0	0	0	0	
S_3:	ST	10	14	11	10	10	9	10	9	10	9	9	9	231
	E	0	4	0	0	1	0	0	0	0	0	0	0	
S_4:	ST	10	14	16	12	13	13	13	13	12	11	12	16	314
	E	0	0	0	0	0	1	0	0	0	0	0	0	
S_5:	ST	13	18	14	15	16	15	13	14	15	14	13	13	237
	E	0	2	0	0	1	0	0	0	0	0	0	0	
S_6:	ST	8	13	10	11	10	12	9	13	9	10	10	10	364
	E	0	0	0	1	0	0	1	0	0	2	0	0	
S_7:	ST	10	13	10	12	10	11	11	12	11	12	11	11	236
	E	0	0	0	0	0	0	0	0	0	0	0	0	
S_8:	ST	10	13	12	13	11	13	11	12	12	15	11	12	255
	E	0	1	2	0	0	0	1	0	0	0	0	0	
S_9:	ST	13	19	12	15	13	13	11	12	10	13	12	11	211
	E	0	4	0	0	0	0	0	0	0	1	0	0	
S_{10}:	ST	9	18	20	17	15	16	17	15	13	14	16	13	272
	E	0	2	1	2	0	1	1	0	0	0	1	0	

Appendix B

Table 1

Means for the dependent variable of sorting time on trials one through ten, classified by age, sex, conditions (R, N, and I), and trials

Age Sex Conditions	Trials									
	1	2	3	4	5	6	7	8	9	10
Grade 1										
Males										
R	25.80	20.40	21.60	22.80	22.30	21.10	21.60	20.30	21.10	20.40
N	25.80	22.20	22.60	21.70	21.60	21.20	20.60	22.40	20.60	22.40
I	26.80	27.20	24.40	22.50	21.10	22.50	21.30	22.90	23.40	24.00
Females										
R	24.40	22.40	23.40	21.10	20.70	20.39	20.50	19.60	21.40	20.20
N	25.50	21.60	18.80	19.80	18.50	19.50	20.00	18.60	20.30	18.70
I	35.30	31.80	28.70	23.10	23.00	23.20	22.20	20.90	21.50	21.60
Grade 4										
Males										
R	16.70	14.90	15.10	14.50	14.00	13.10	13.60	13.70	14.20	13.50
N	17.30	14.80	14.40	14.60	13.70	13.30	13.20	13.90	13.80	13.40
I	17.90	14.50	14.60	14.70	13.80	13.80	13.50	13.50	14.10	13.20
Females										
R	18.10	14.90	14.40	16.20	15.30	14.60	15.70	13.50	12.50	12.20
N	16.10	13.10	14.20	13.50	13.70	12.70	12.70	13.30	13.40	12.40
I	18.60	15.90	13.80	14.40	14.50	13.70	14.00	14.00	12.60	14.40
Adults										
Males										
R	12.20	10.50	10.50	10.40	10.00	9.50	9.80	10.00	10.10	9.80
N	12.90	10.50	10.40	10.90	10.70	10.20	9.70	9.60	10.40	9.90
I	12.00	10.70	11.30	11.50	10.40	10.10	10.50	10.70	10.20	10.40
Females										
R	11.90	10.10	10.20	9.30	9.90	8.90	9.50	9.30	9.30	9.30
N	12.70	10.40	10.70	10.30	10.20	9.70	10.40	10.00	10.20	10.10
I	15.20	13.00	13.20	12.40	12.80	12.00	13.40	11.70	12.30	11.70

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Table 2

Means for the dependent variable of errors on trial one through ten, classified by age, sex, conditions (R, N, and I) and trials

Age / Sex / Conditions	Trials 1	2	3	4	5	6	7	8	9	10
Grade 1										
Males										
R	1.20	.00	.40	.40	.20	.20	.40	.10	.20	.30
N	1.10	.00	.10	.40	.50	.00	.30	.00	.30	.20
I	1.60	1.10	1.00	2.10	.40	.30	.10	.30	.80	.50
Females										
R	1.60	.90	.40	1.00	.40	.70	.70	.10	.50	.30
N	1.80	1.20	.70	.70	.40	.60	1.10	.40	1.10	.70
I	2.60	2.10	1.80	1.20	.30	.00	.20	.60	.30	.30
Grade 4										
Males										
R	.80	.30	.20	.10	.10	.30	.20	.00	.30	.10
N	1.40	.30	.50	1.10	.80	.50	.30	.10	.10	.20
I	.90	.50	.50	.50	.10	.60	.50	.60	.40	.30
Females										
R	1.60	.80	.70	.80	.30	.30	.50	.00	.20	.50
N	1.10	.50	.90	.10	.70	.20	.30	.10	.10	.50
I	1.70	.20	.30	.60	.30	.00	.30	.20	.10	.60
Adults										
Males										
R	.90	.40	.60	.10	.50	.20	.70	.60	.40	.60
N	.30	.10	.10	.50	.10	.20	.10	.10	.50	.10
I	.00	.20	.10	.10	.00	.20	.00	.10	.30	.20
Females										
R	.30	.20	.20	.00	.50	.00	.30	.30	.10	.30
N	1.20	.20	.30	.10	.20	.20	.30	.30	.10	.00
I	1.80	.30	.30	1.00	.30	.30	.00	.00	.40	.10

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Table 3

Means for the dependent variable of sorting time on the practice trial and trial one, classified by age, sex, conditions (R, N, and I), and trials

Age / Sex / Conditions	Trials: Practice Trial	Trials: Trial One
Grade 1		
Males		
R	16.50	25.80
N	16.00	25.80
I	16.80	26.80
Females		
R	15.20	24.40
N	14.00	25.50
I	16.40	35.30
Grade 4		
Males		
R	11.20	16.70
N	10.90	17.30
I	10.80	17.90
Females		
R	10.10	18.10
N	11.10	16.10
I	10.50	18.60
Adults		
Males		
R	8.90	12.20
N	9.60	12.90
I	9.80	12.00
Females		
R	9.00	11.90
N	8.90	12.70
I	10.70	15.20

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Table 4

Means for the dependent variable of errors on the practice trial and trial one, classified by age, sex, conditions (R, N, and I), and trials

Age / Sex / Conditions	Practice Trial	Trial One
Grade 1		
Males		
R	.00	1.20
N	.00	1.10
I	.10	1.60
Females		
R	.10	1.60
N	.10	1.80
I	.00	2.60
Grade 4		
Males		
R	.00	.80
N	.00	1.40
I	.00	.90
Females		
R	.00	1.60
N	.00	1.10
I	.00	1.70
Adults		
Males		
R	.00	.90
N	.00	.30
I	.00	.00
Females		
R	.00	.30
N	.00	1.20
I	.00	1.80

Appendix B

Table 5

Means for the dependent variable of sorting time on trial ten and the post-test trial, classified by age, sex, conditions, (R and I), and trials

Age / Sex / Conditions	Trial Ten	Post-Test Trial
Grade 1		
Males		
R	20.40	26.50
I	24.00	26.80
Females		
R	20.00	22.40
I	21.60	27.60
Grade 4		
Males		
R	13.50	12.50
I	13.20	12.30
Females		
R	12.20	11.60
I	14.40	14.10
Adults		
Males		
R	9.80	10.00
I	10.40	10.70
Females		
R	9.30	9.00
I	11.70	12.80

Appendix B

Table 6

Means for the dependent variable of errors on trial ten and the post-test trial, classified by age, sex, conditions (R and I), and trials

Age / Sex / Conditions	Trial Ten	Post-Test Trial
Grade 1		
Males		
R	.30	.10
I	.50	1.70
Females		
R	.30	.10
I	.30	2.00
Grade 4		
Males		
R	.10	.00
I	.30	.60
Females		
R	.50	.00
I	.60	.60
Adults		
Males		
R	.60	.00
I	.20	.10
Females		
R	.30	.10
I	.10	.00

Appendix C

Table 1

Newman-Keuls multiple comparisons between means for the interaction of Sex-by-Conditions on age in Grade 4 children

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{10.51/10}} = \frac{\bar{X}_L - \bar{X}_S}{1.02} \qquad \underline{df}=54$$

BOYS

Conditions	Redundant	Nonredundant	Irrelevant
Means	116.70	117.90	121.10
Redundant	------	1.18	4.31**
Nonredundant		----	3.14*
Irrelevant			----

GIRLS

Conditions	Irrelevant	Nonredundant	Redundant
Means	118.90	119.70	120.00
Irrelevant	------	.78	1.08
Nonredundant		---	.29
Redundant			---

*$p < .05$

**$p < .01$

Appendix C

Table 1 (cont'd)

REDUNDANT CONDITION

Sex	Boys	Girls
Means	116.70	120.00
Boys	------	3.24*
Girls		----

NONREDUNDANT CONDITION

Sex	Boys	Girls
Means	117.90	119.70
Boys	------	1.76
Girls		----

IRRELEVANT CONDITION

Sex	Girls	Boys
Means	118.90	121.10
Girls	------	2.16
Boys		----

*$p < .05$

Appendix C

Table 2

Newman-Keuls multiple comparisons between means for the main effect of Age on sorting times on trials 1-10

$$\underline{q}_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{124.88/600}} = \frac{\bar{X}_L - \bar{X}_S}{.46} \qquad \underline{df}=162$$

Age		Adults	Grade 4	Grade 1
	Means	10.77	14.30	22.36
Adults		-----	7.67**	25.20**
Grade 4			----	17.52**
Grade 1				-----

$^{**}\underline{p}<.01$

Appendix C

Table 3

Newman-Keuls multiple comparisons between means for the main effect of Conditions on sorting times on trials 1-10

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{124.88/600}} = \frac{\bar{X}_L - \bar{X}_S}{.46} \qquad df=162$$

Conditions		Nonredundant	Redundant	Irrelevant
	Means	15.16	15.38	16.87
Nonredundant		-----	.48	3.72*
Redundant			---	3.24*
Irrelevant				----

*p <.05

Appendix C

Table 4

Newman-Keuls multiple comparisons of the means in the main effect of Trials (T) on sorting times on trials 1-10

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{8.16/180}} = \frac{\bar{X}_L - \bar{X}_S}{.23} \qquad \underline{df}=1458$$

Trials	T_{10}	T_8	T_6	T_9	T_7	T_5	T_4	T_3	T_2	T_1
Means	14.87	14.88	14.97	15.08	15.12	15.34	15.76	16.24	16.61	19.18
T_{10}	---	.05	.45	.95	1.14	2.14	4.05	6.23	7.91	19.59
T_8		---	.41	.91	1.09	2.09	4.00	6.18	7.86	19.55
T_6			---	.50	.68	1.68	3.59	5.77	7.45	19.14
T_9				---	.18	1.18	3.09	5.27	6.95	18.64
T_7					---	1.00	2.91	5.09	6.77	18.45
T_5						----	1.91	4.09	5.77	17.45
T_4							----	2.18	3.86	15.55
T_3								----	1.68	13.36
T_2									----	11.68
T_1										-----

Trials	T_{10}	T_8	T_6	T_9	T_7	T_5	T_4	T_3	T_2	T_1
T_{10}								**	**	**
T_8								**	**	**
T_6								**	**	**
T_9								**	**	**
T_7								**	**	**
T_5								*	**	**
T_4									*	**
T_3										**
T_2										**
T_1										

*$\underline{p}<.05$

**$\underline{p}<.01$

Appendix C

Table 5

Newman-Keuls multiple comparisons of the means in the interaction of Age-by-Trials on sorting times on trials 1-10

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{8.16/60}} = \frac{\bar{X}_L - \bar{X}_S}{.37} \qquad \underline{df}=1458$$

GRADE 1

Trials	T_8	T_7	T_5	T_{10}	T_6	T_9	T_4	T_3	T_2	T_1
Means	20.78	21.03	21.20	21.22	21.32	21.38	21.83	23.25	24.27	27.27
T_8	---	.68	1.14	1.19	1.46	1.62	2.83	6.68	9.43	17.54
T_7		---	.46	.51	.78	.95	2.16	6.00	8.76	16.86
T_5			---	.05	.32	.49	1.70	5.54	8.30	16.41
T_{10}				---	.27	.43	1.65	5.49	8.24	16.35
T_6					---	.16	1.38	5.22	7.97	16.08
T_9						---	1.22	5.05	7.81	15.92
T_4							----	3.84	6.59	14.70
T_3								----	2.76	10.86
T_2									----	8.11
T_1										----

Trials	T_8	T_7	T_5	T_{10}	T_6	T_9	T_4	T_3	T_2	T_1
T_8								**	**	**
T_7								**	**	**
T_5								**	**	**
T_{10}								**	**	**
T_6								**	**	**
T_9								**	**	**
T_4								*	**	**
T_3										**
T_2										**
T_1										

*$\underline{p}<.05$

**$\underline{p}<.01$

Appendix C

Table 5 (cont'd)

GRADE 4

Trials	T_{10}	T_9	T_6	T_8	T_7	T_5	T_3	T_4	T_2	T_1
Means	13.18	13.43	13.53	13.65	13.78	14.17	14.42	14.65	14.68	17.45
T_{10}	---	.68	.95	1.27	1.62	2.68	3.35	3.97	4.05	11.54
T_9		---	.27	.59	.95	2.00	2.68	3.30	3.38	10.86
T_6			---	.32	.68	1.73	2.41	3.03	3.11	10.59
T_8				---	.35	1.41	2.08	2.70	2.78	10.27
T_7					---	1.05	1.73	2.35	2.43	9.92
T_5						----	.68	1.30	1.38	8.86
T_3							---	.62	.70	8.19
T_4								---	.08	7.57
T_2									---	7.49
T_1										----

Trials	T_{10}	T_9	T_6	T_8	T_7	T_5	T_3	T_4	T_2	T_1
T_{10}										**
T_9										**
T_6										**
T_8										**
T_7										**
T_5										**
T_3										**
T_4										**
T_2										**
T_1										

**$p < .01$

Appendix C
Table 5 (cont'd)

ADULTS

Trials	T_6	T_{10}	T_8	T_9	T_7	T_5	T_4	T_2	T_3	T_1
Means	10.07	10.20	10.22	10.42	10.55	10.67	10.80	10.87	11.05	12.82
T_6	---	.35	.41	.95	1.30	1.62	1.97	2.16	2.65	7.43
T_{10}		---	.05	.59	.95	1.27	1.62	1.81	2.30	7.08
T_8			---	.54	.89	1.22	1.57	1.76	2.24	7.03
T_9				---	.35	.68	1.03	1.22	1.70	6.49
T_7					---	.32	.68	.86	1.35	6.14
T_5						---	.35	.54	1.03	5.81
T_4							---	.19	.68	5.46
T_2								---	.49	5.27
T_3									---	4.78
T_1										----

Trials	T_6	T_{10}	T_8	T_9	T_7	T_5	T_4	T_2	T_3	T_1
T_6										**
T_{10}										**
T_8										**
T_9										**
T_7										**
T_5										**
T_4										**
T_2										**
T_3										**
T_1										

**$p < .01$

Appendix C

Table 6

Newman-Keuls multiple comparisons of the means in the interaction of Conditions-by-Trials on sorting times on trials 1-10

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{8.16/60}} = \frac{\bar{X}_L - \bar{X}_S}{.37} \qquad \underline{df}=1458$$

TRIAL 1

Conditions	Redundant	Nonredundant	Irrelevant
Means	18.18	18.38	20.97
Redundant	-----	.54	7.54**
Nonredundant		---	7.00**
Irrelevant			----

TRIAL 2

Conditions	Nonredundant	Redundant	Irrelevant
Means	15.43	15.53	18.85
Nonredundant	-----	.27	9.24**
Redundant		---	8.97**
Irrelevant			----

TRIAL 3

Conditions	Nonredundant	Redundant	Irrelevant
Means	15.18	15.87	17.67
Nonredundant	-----	1.86	6.73**
Redundant		----	4.86**
Irrelevant			----

TRIAL 4

Conditions	Nonredundant	Redundant	Irrelevant
Means	15.13	15.72	16.43
Nonredundant	-----	1.59	3.51*
Redundant		----	1.92
Irrelevant			----

*$p < .05$

**$p < .01$

Appendix C

Table 6 (cont'd)

TRIAL 5

Conditions Means	Nonredundant 14.73	Redundant 15.37	Irrelevant 15.93
Nonredundant	-----	1.73	3.24
Redundant		----	1.51
Irrelevant			----

TRIAL 6

Conditions Means	Nonredundant 14.43	Redundant 14.60	Irrelevant 15.88
Nonredundant	-----	.46	3.92*
Redundant		---	3.46*
Irrelevant			----

TRIAL 7

Conditions Means	Nonredundant 14.43	Redundant 15.12	Irrelevant 15.82
Nonredundant	-----	1.86	3.76*
Redundant		----	1.89
Irrelevant			----

TRIAL 8

Conditions Means	Redundant 14.40	Nonredundant 14.63	Irrelevant 15.62
Redundant	-----	.62	3.30
Nonredundant		---	2.68
Irrelevant			----

*$p < .05$

Appendix C

Table 6 (cont'd)

TRIAL 9

Conditions	Redundant	Nonredundant	Irrelevant
Means	14.77	14.78	15.68
Redundant	-----	.03	2.46
Nonredundant		---	2.43
Irrelevant			----

TRIAL 10

Conditions	Redundant	Nonredundant	Irrelevant
Means	14.23	14.48	15.88
Redundant	-----	.68	4.46**
Nonredundant		---	3.78**
Irrelevant			----

**$p < .01$

Appendix C

Table 7

Newman-Keuls multiple comparisons of means in the interaction of Age-by-Conditions-by-Trials on sorting times on trials 1-10

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{8.16/20}} = \frac{\bar{X}_L - \bar{X}_S}{.64} \qquad df=1458$$

TRIAL 1

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	N	R	I	R	N	I
Means	12.05	12.80	13.60	16.70	17.40	18.25	25.10	25.65	31.05
Adults									
R	-----	1.17	2.42	7.27	8.36	9.69	20.39	21.25	29.69
N		----	1.25	6.09	7.19	8.52	19.22	20.08	28.52
I			----	4.84	5.94	7.27	17.97	18.83	27.27
Grade 4									
N				----	1.09	2.42	13.13	13.98	22.42
R					----	1.33	12.03	12.89	21.33
I						----	10.70	11.56	20.00
Grade 1									
R							-----	.86	9.30
N								---	8.44
I									----

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	N	R	I	R	N	I
Adults									
R				**	**	**	**	**	**
N				**	**	**	**	**	**
I				**	**	**	**	**	**
Grade 4									
N							**	**	**
R							**	**	**
I							**	**	**
Grade 1									
R									**
N									**
I									

**$p < .01$

Appendix C

Table 7 (cont'd)

TRIAL 2

Age / Conditions / Means	Adults R 10.30	Adults N 10.45	Adults I 11.85	Grade 4 N 13.95	Grade 4 R 14.90	Grade 4 I 15.20	Grade 1 R 21.40	Grade 1 N 21.90	Grade 1 I 29.50
Adults									
R	-----	.23	2.42	5.70	7.19	7.66	17.34	18.13	30.00
N		---	2.19	5.47	6.95	7.42	17.11	17.89	29.77
I			----	3.28	4.77	5.23	14.92	15.70	27.58
Grade 4									
N				----	1.48	1.95	11.64	12.42	24.30
R					----	.47	10.16	10.94	22.81
I						---	9.69	10.47	22.34
Grade 1									
R							----	.78	12.66
N								---	11.88
I									-----

Age / Conditions	Adults R	Adults N	Adults I	Grade 4 N	Grade 4 R	Grade 4 I	Grade 1 R	Grade 1 N	Grade 1 I
Adults									
R				**	**	**	**	**	**
N				**	**	**	**	**	**
I					*	**	**	**	**
Grade 4									
N							**	**	**
R							**	**	**
I							**	**	**
Grade 1									
R									**
N									**
I									

*$p<.05$

**$p<.01$

Appendix C
Table 7 (cont'd)

TRIAL 3

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	I	N	R	N	R	I
Means	10.35	10.55	12.25	14.20	14.30	14.75	20.70	22.50	26.55
Adults									
R	-----	.31	2.97	6.02	6.17	6.88	16.17	18.98	25.31
N		---	2.66	5.69	5.86	6.57	15.86	18.67	25.00
I			----	3.05	3.20	3.91	13.20	16.02	22.34
Grade 4									
I				----	.16	.86	10.16	12.97	19.30
N					---	.70	10.00	12.81	19.14
R						---	9.30	12.11	18.44
Grade 1									
N							----	2.81	9.14
R								----	6.33
I									----

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	I	N	R	N	R	I
Adults									
R				**	**	**	**	**	**
N				**	**	**	**	**	**
I							**	**	**
Grade 4									
I							**	**	**
N							**	**	**
R							**	**	**
Grade 1									
N									**
R									**
I									

**$p < .01$

Appendix C
Table 7 (cont'd)

TRIAL 4

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	N	I	R	N	R	I
Means	9.85	10.60	11.95	14.05	14.55	15.35	20.75	21.95	22.80
Adults									
R	----	1.17	3.28	6.56	7.34	8.59	17.03	18.91	20.23
N		----	2.11	5.39	6.17	7.42	15.86	17.73	19.06
I			----	3.28	4.06	5.31	13.75	15.63	16.95
Grade 4									
N				----	.78	2.03	10.47	12.34	13.67
I					---	1.25	9.69	11.56	12.89
R						----	8.44	10.31	11.64
Grade 1									
N							----	1.88	3.20
R								----	1.33
I									----

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	N	I	R	N	R	I
Adults									
R				**	**	**	**	**	**
N				**	**	**	**	**	**
I						**	**	**	**
Grade 4									
N							**	**	**
I							**	**	**
R							**	**	**
Grade 1									
N									
R									
I									

**$p < .01$

Appendix C

Table 7 (cont'd)

TRIAL 6

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	N	I	R	N	R	I
Means	9.20	9.95	11.05	13.00	13.75	13.85	20.35	20.75	22.85
Adults									
R	----	1.17	2.89	5.94	7.11	7.27	17.42	18.05	21.33
N		----	1.72	4.77	5.94	6.09	16.25	16.88	20.16
I			----	3.05	4.22	4.38	14.53	15.16	18.44
Grade 4									
N				----	1.17	1.33	11.47	12.11	15.38
I					----	.16	10.31	10.94	14.22
R						---	10.16	10.78	14.06
Grade 1									
N							-----	.63	3.91
R								---	3.28
I									----

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	N	I	R	N	R	I
Adults									
R				**	**	**	**	**	**
N				*	**	**	**	**	**
I					*	*	**	**	**
Grade 4									
N							**	**	**
I							**	**	**
R							**	**	**
Grade 1									
N									*
R									*
I									

*$p < .05$

**$p < .01$

Appendix C

Table 7 (cont'd)

TRIAL 7

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	N	I	R	N	R	I
Means	9.65	10.05	11.95	12.95	13.75	14.65	20.30	21.05	21.75
Adults									
R	----	.63	3.59	5.16	6.41	7.81	16.64	17.81	18.91
N		---	2.97	4.53	5.78	7.19	16.02	17.19	18.28
I			----	1.56	2.81	4.22	13.05	14.22	15.31
Grade 4									
N				----	1.25	2.66	11.48	12.66	13.75
I					----	1.41	10.23	11.41	12.50
R						----	8.83	10.00	11.09
Grade 1									
N							----	1.17	2.27
R								----	1.09
I									----

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	N	I	R	N	R	I
Adults									
R				**	**	**	**	**	**
N				*	**	**	**	**	**
I						*	**	**	**
Grade 4									
N							**	**	**
I							**	**	**
R							**	**	**
Grade 1									
N									
R									
I									

*$p < .05$

**$p < .01$

Appendix C

Table 7 (cont'd)

TRIAL 8

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	N	R	I	R	N	I
Means	9.65	9.80	11.20	13.60	13.60	13.75	19.95	20.50	21.90
Adults									
R	----	.23	2.42	6.17	6.17	6.41	16.09	16.95	19.14
N		---	2.19	5.94	5.94	6.17	15.86	16.72	18.91
I			----	3.75	3.75	3.98	13.67	14.53	16.72
Grade 4									
N				----	.00	.23	9.92	10.78	12.97
R					---	.23	9.92	10.78	12.97
I						---	9.67	10.55	12.73
Grade 1									
R							----	.86	3.05
N								---	2.19
I									----

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	N	R	I	R	N	I
Adults									
R				**	**	**	**	**	**
N				**	**	**	**	**	**
I							**	**	**
Grade 4									
N							**	**	**
R							**	**	**
I							**	**	**
Grade 1									
R									
N									
I									

**$p < .01$

Appendix C
Table 7 (cont'd)

TRIAL 9

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	R	I	N	N	R	I
Means	9.70	10.30	11.25	13.35	13.35	13.60	20.45	21.25	22.45
Adults									
R	----	.94	2.42	5.70	5.70	6.09	16.80	18.05	19.92
N		---	1.48	4.77	4.77	5.16	15.86	17.11	18.98
I			----	3.28	3.28	3.67	14.38	15.63	17.50
Grade 4									
R				----	.00	.39	11.09	12.34	14.22
I					---	.39	11.09	12.34	14.22
N						---	10.70	11.95	13.83
Grade 1									
N							-----	1.25	3.13
R								----	1.88
I									----

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	R	I	N	N	R	I
Adults									
R				**	**	**	**	**	**
N				*	*	**	**	**	**
I							**	**	**
Grade 4									
R							**	**	**
I							**	**	**
N							**	**	**
Grade 1									
N									
R									
I									

*$p < .05$

**$p < .01$

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Table 7 (cont'd)

TRIAL 10

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	R	N	I	R	N	I
Means	9.55	10.00	11.05	12.85	12.90	13.80	20.30	20.55	22.80
Adults									
R	----	.70	2.34	5.16	5.23	6.64	16.80	17.19	20.70
N		---	1.64	4.45	4.53	5.94	16.09	16.48	20.00
I			----	2.81	2.89	4.30	14.45	14.84	18.36
Grade 4									
R				----	.08	1.48	11.64	12.03	15.55
N					---	1.41	11.56	11.95	15.47
I						----	10.16	10.55	14.06
Grade 1									
R							-----	.39	3.91
N								---	3.52
I									----

Age	Adults			Grade 4			Grade 1		
Conditions	R	N	I	R	N	I	R	N	I
Adults									
R				**	**	**	**	**	**
N				*	*	**	**	**	**
I						*	**	**	**
Grade 4									
R							**	**	**
N							**	**	**
I							**	**	**
Grade 1									
R									*
N									*
I									

*$p < .05$

**$p < .01$

Appendix C

Table 8

Newman-Keuls multiple comparisons of means in the main effect of Age on errors on trials 1-10

$$\underline{q}_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{2.58/600}} = \frac{\bar{X}_L - \bar{X}_S}{.06} \qquad \underline{df}=162$$

Age	Adults	Grade 4	Grade 1
Means	.30	.45	.65
Adults	---	2.50	5.83**
Grade 4		----	3.33*
Grade 1			

*$\underline{p}$<.05

**$\underline{p}$<.01

Appendix C

Table 9

Newman-Keuls multiple comparisons of means in the main effect of Trials on errors on trials 1-10

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{.92/180}} = \frac{\bar{X}_L - \bar{X}_S}{.10} \qquad \underline{df}=1458$$

Trials	T_8	T_6	T_{10}	T_9	T_5	T_7	T_3	T_2	T_4	T_1
Means	.22	.27	.32	.34	.34	.35	.51	.52	.60	1.22
T_8	---	.50	1.00	1.20	1.20	1.30	2.90	3.00	3.80	10.00
T_6		---	.50	.70	.70	.80	2.40	2.50	3.30	9.50
T_{10}			---	.20	.20	.30	1.90	2.00	2.80	9.00
T_9				---	.00	.10	1.70	1.80	2.60	8.80
T_5					---	.10	1.70	1.80	2.60	8.80
T_7						---	1.60	1.70	2.50	8.70
T_3							----	.10	.90	7.10
T_2								---	.80	7.00
T_4									---	6.20
T_1										----

Trials	T_8	T_6	T_{10}	T_9	T_5	T_7	T_3	T_2	T_4	T_1
T_8										**
T_6										**
T_{10}										**
T_9										**
T_5										**
T_7										**
T_3										**
T_2										**
T_4										**
T_1										

**$\underline{p}$ < .01

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Table 10

Newman-Keuls multiple comparisons of means in the interaction of Age-by-Trials on errors on trials 1 10

$$q_r = \frac{\overline{X}_L - \overline{X}_S}{\sqrt{MS/n}} = \frac{\overline{X}_L - \overline{X}_S}{\sqrt{.92/60}} = \frac{\overline{X}_L - \overline{X}_S}{.14} \qquad \underline{df}=1458$$

TRIAL 1

Age	Adults	Grade 4	Grade 1
Means	.75	1.25	1.65
Adults	---	3.57*	6.43**
Grade 4		----	2.86*
Grade 1			----

TRIAL 2

Age	Adults	Grade 4	Grade 1
Means	.23	.43	.88
Adults	---	1.43	4.64**
Grade 4		----	3.21*
Grade 1			----

TRIAL 3

Age	Adults	Grade 4	Grade 1
Means	.27	.52	.73
Adults	---	1.79	3.29
Grade 4		----	1.50
Grade 1			----

TRIAL 4

Age	Adults	Grade 4	Grade 1
Means	.30	.53	.97
Adults	---	1.64	4.79**
Grade 4		----	3.14*
Grade 1			----

*$\underline{p}<.05$

**$\underline{p}<.01$

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Table 10 (cont'd)

TRIAL 5

Age	Adults	Grade 1	Grade 4
Means	.27	.37	.38
Adults	---	.71	.79
Grade 1		---	.07
Grade 4			---

TRIAL 6

Age	Adults	Grade 1	Grade 4
Means	.18	.30	.32
Adults	---	.86	1.00
Grade 1		---	.14
Grade 4			---

TRIAL 7

Age	Adults	Grade 4	Grade 1
Means	.23	.35	.47
Adults	---	.86	1.71
Grade 4		---	.86
Grade 1			---

TRIAL 8

Age	Grade 4	Adults	Grade 1
Means	.17	.23	.25
Grade 4	---	1.14	.57
Adults		----	.14
Grade 1			---

TRIAL 9

Age	Grade 4	Adults	Grade 1
Means	.20	.30	.53
Grade 4	---	.71	2.36
Adults		---	1.64
Grade 1			----

TRIAL 10

Age	Adults	Grade 4	Grade 1
Means	.22	.37	.38
Adults	---	1.07	1.14
Grade 4		----	.15
Grade 1			---

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Table 11

Newman-Keuls multiple comparisons of means in the interaction of Sex-by-Trials on errors on trials 1-10

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{.92/90}} = \frac{\bar{X}_L - \bar{X}_S}{.10} \qquad \underline{df}=1458$$

	TRIAL 1		TRIAL 2		TRIAL 3		TRIAL 4		TRIAL 5	
Sex	M	F	M	F	M	F	M	F	M	F
Means	.91	1.52	.32	.71	.39	.62	.59	.61	.30	.37
M	---	6.10**	---	3.90**	---	2.30	---	.20	---	.70
F		----		----		----		---		---

	TRIAL 6			TRIAL 7			TRIAL 8			TRIAL 9			TRIAL 10	
Sex	F	M		M	F		M	F		F	M		M	F
Means	.26	.28		.29	.41		.21	.22		.32	.37		.28	.37
F	---	.20	M	---	1.20	M	---	.10	F	---	.50	M	---	.90
M		---	F		----	F		---	M		---	F		---

**$p < .01$

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Table 12

Newman-Keuls multiple comparisons between means for the interaction of Age-by-Trials on sorting times on the practice trial and trial 1

$$\underline{q}_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{11.94/60}} = \frac{\bar{X}_L - \bar{X}_S}{.20} \qquad \underline{df}=162$$

GRADE 1

Trials	Practice Trial	Trial 1
Means	15.82	27.27
Practice Trial	-----	57.25**
Trial 1		-----

GRADE 4

Trials	Practice Trial	Trial 1
Means	10.77	17.45
Practice Trial	-----	33.40**
Trial 1		-----

ADULTS

Trials	Practice Trial	Trial 1
Means	9.48	12.82
Practice Trial	----	16.70**
Trial 1		-----

**$\underline{p}$<.01

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Table 12 (cont'd)

PRACTICE TRIAL

Age	Grade 1	Grade 4	Adults
Means	9.48	10.77	15.82
Grade 1	----	6.45**	31.70**
Grade 4		----	25.25**
Adults			-----

Age	Grade 1	Grade 4	Adults
Means	12.82	17.45	27.27
Grade 1	-----	23.15**	72.25**
Grade 4		-----	49.10**
Adults			-----

**$p < .01$

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Table 13

Newman-Keuls multiple comparisons between means for the interaction of Sex-by-Trials on sorting times on the practice trial and trial 1

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{11.94/90}} = \frac{\bar{X}_L - \bar{X}_S}{.36} \qquad df=162$$

PRACTICE TRIAL

Sex	Females	Males
Means	11.77	12.28
Females	-----	1.42
Males		----

TRIAL 1

Sex	Males	Females
Means	18.60	19.76
Males	-----	3.22*
Females		----

*$p < .05$

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Table 14

Newman-Keuls multiple comparisons between means for the interaction of Conditions-by-Trials on sorting times on the practice trial and trial 1

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{11.94/60}} = \frac{\bar{X}_L - \bar{X}_S}{.20} \qquad df=162$$

PRACTICE TRIAL

Conditions	Nonredundant	Redundant	Irrelevant
Means	11.75	11.82	12.50
Nonredundant	-----	.35	3.75*
Redundant		---	3.50*
Irrelevant			----

TRIAL 1

Conditions	Redundant	Nonredundant	Irrelevant
Means	18.18	18.38	20.97
Redundant	-----	1.00	8.95**
Nonredundant		----	7.95**
Irrelevant			----

*$p < .05$

**$p < .01$

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Table 15

Newman-Keuls multiple comparisons between means for the interaction of Age-by-Trials on errors on the practice trial and trial 1

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{1.66/60}} = \frac{\bar{X}_L - \bar{X}_S}{.17} \qquad df=162$$

GRADE 1

Trials	Practice Trial	Trial 1
Means	.05	1.65
Practice Trial	---	9.41**
Trial 1		----

GRADE 4

Trials	Practice Trial	Trial 1
Means	.00	1.25
Practice Trial	---	7.35**
Trial 1		----

ADULTS

Trials	Practice Trial	Trial 1
Means	.00	.75
Practice Trial	---	4.41**
Trial 1		----

**$p < .01$

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Table 15 (cont'd)

PRACTICE TRIAL

Age	Adults	Grade 4	Grade 1
Means	.00	.00	.05
Adults	---	.00	.29
Grade 4		---	.29
Grade 1			---

TRIAL 1

Age	Adults	Grade 4	Grade 1
Means	.75	1.25	1.65
Adults	---	2.94	5.29**
Grade 4		----	2.35
Grade 1			----

**$p < .01$

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Table 16

Newman-Keuls multiple comparisons between means for the interaction of Sex-by-Trials on errors on the practice trial and trial 1

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{1.66/90}} = \frac{\bar{X}_L - \bar{X}_S}{.14} \qquad \underline{df}=162$$

PRACTICE TRIAL

Sex	Males	Females
Means	.01	.02
Males	---	.07
Females		---

TRIAL 1

Sex	Males	Females
Means	.91	1.52
Males	---	4.36**
Females		----

**$p < .01$

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Table 17

Newman-Keuls multiple comparisons of means in the interaction of Age-by-Trials on sorting times on trial 10 and the post-test trial

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{13.49/60}} = \frac{\bar{X}_L - \bar{X}_S}{.47} \qquad df=108$$

GRADE 1

Trials		Trial 10	Post-Test Trial
	Means	21.55	25.83
Trial 10		-----	9.11**
Post-Test Trial			----

GRADE 4

Trials		Post-Test Trial	Trial 10
	Means	12.63	13.33
Post-Test Trial		-----	1.49
Trial 10			----

ADULTS

Trials		Trial 10	Post-Test Trial
	Means	10.30	10.63
Trial 10		-----	.47
Post-Test Trial			---

**$p < .01$

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Table 18

Newman-Keuls multiple comparisons of means in the interaction of Age-by-Conditions on errors on trial 10 and the post-test trial

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{1.64/40}} = \frac{\bar{X}_L - \bar{X}_S}{.20} \qquad df=108$$

GRADE 1

Conditions	Redundant	Irrelevant
Means	.20	1.13
Redundant	---	4.65**
Irrelevant		----

GRADE 4

Conditions	Redundant	Irrelevant
Means	.15	.53
Redundant	---	1.90
Irrelevant		----

ADULTS

Conditions	Irrelevant	Redundant
Means	.10	.25
Irrelevant	---	.75
Redundant		---

**$p<.01$

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Table 19

Newman-Keuls multiple comparisons of means in the interaction of Conditions-by-Trials on errors on trial 10 and the post-test trial

$$q_r = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{MS/n}} = \frac{\bar{X}_L - \bar{X}_S}{\sqrt{1.62/60}} = \frac{\bar{X}_L - \bar{X}_S}{.17} \qquad \underline{df}=108$$

REDUNDANT CONDITION

Trials		Post-Test Trial	Trial 10
	Means	.05	.35
Post-Test Trial		---	1.76
Trial 10			----

IRRELEVANT CONDITION

Trials		Trial 10	Post-Test Trial
	Means	.33	.83
Trial 10		---	2.94*
Post Test Trial			----

*$p < .05$