Developmental trends in the effects of irrelevant information on speeded classification.

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DEVELOPMENTAL TRENDS IN THE EFFECTS OF IRRELEVANT INFORMATION ON SPEEDED CLASSIFICATION

A Thesis Presented
By
George F. Strutt

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DEVELOPMENTAL TRENDS IN THE EFFECTS OF IRRELEVANT INFORMATION ON SPEEDED CLASSIFICATION

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ABSTRACT

No study using visual stimuli has unequivocally demonstrated that irrelevant information interferes more with children's performances than it does with those of adults. Eighteen Ss in each of four age groups (six-, nine-, twelve-year olds and adults) each sorted, as quickly as possible, thirteen decks of twenty four cards apiece into two predetermined, clearly marked piles. Each deck was defined by one relevant dimension; and zero, one, or two irrelevant dimensions. Three binary dimensions were used: form, line orientation and position of a star. Additional Ss—ages seven, eight, ten and eleven—sorted decks with zero and two irrelevant dimensions. The temporal magnitude of the interference effect decreased nearly uniformly as a function of increasing age. The percent of cases of interference, however, remained high (70-80%) until age twelve, then fell to the low adult level (48%). There were significant age x relevant dimension and relevant dimension x amount of irrelevant information interaction effects. The results support the hypothesis that children younger than age twelve process more information than is necessary for task performance; with increasing age they process the information more quickly. After age twelve children are able to block out irrelevant information so that it no longer interferes with their performances.
# TABLE OF CONTENTS

List of Tables ................................................. vii
List of Figures ............................................... viii
Introduction .................................................. 1
  Overview .................................................... 1
  Dichotic Listening ......................................... 3
  Visual Search ............................................... 9
  Incidental Learning ....................................... 12
Discrimination Learning ................................. 20
Other Learning Sets ....................................... 22
Relationships Among Dimensions ..................... 24
Design and Hypotheses .................................... 26
Method ......................................................... 28
Subjects ....................................................... 28
Apparatus ...................................................... 28
Procedure ..................................................... 31
Results ........................................................ 34
  Main Study Sorting Times ............................... 34
  More Than Four Errors .................................. 46
  Analysis of Errors ...................................... 48
  One Irrelevant Dimension Data ....................... 51
  Trials Analysis .......................................... 57
  Combined: Main and Supplementary Studies ....... 59
Discussion .......................... 67
References .......................... 77
List of Appendices .................. 84
Appendices ......................... 85
LIST OF TABLES

1. Description of the Test Stimuli 30
2. The Mean Sorting Times and Their Standard Deviations (in Seconds) As a Function of Age and the Number of Irrelevant Dimensions 38
3. Description of Those Instances in Which More than Four Errors Were Made on a Given Deck 47
4. The Mean Sorting Times (in Seconds) as a Function of Stimulus Deck With One Irrelevant Dimension 52
5. The Total Number of Errors and the Mean Percent of Errors on Decks Having One Irrelevant Dimension 56
6. The Mean Sorting Times (in Seconds) Produced by Zero and Two Irrelevant Dimensions, the Amount of Interference, and the Percent of Decks on Which Interference Occurred for Each Age Group in the Study 66
# LIST OF FIGURES

1. Mean amount of interference per deck (in seconds) and per card (in milliseconds) as a function of age and the amount of irrelevant information  
   [Page 36]

2. Mean sorting times (in seconds) as a function of the age and sex of the subject  
   [Page 40]

3. Mean sorting times (in seconds) as a function of age and the relevant dimension  
   [Page 42]

4. Mean sorting times (in seconds) as a function of the relevant dimension and the number of irrelevant dimensions  
   [Page 43]

5. Mean sorting times (in seconds) as a function of sex, age and the relevant dimension  
   [Page 45]

6. The mean number of errors per deck as a function of the relevant dimension and the number of irrelevant dimensions  
   [Page 50]

7. Mean sorting times (in seconds) as a function of age and stimulus deck having one irrelevant dimension  
   [Page 54]

8. Mean sorting times (in seconds) as a function of age and trials (decks in order of presentation)  
   [Page 58]

9. Comparing by dimension, the percent of decks in which two irrelevant dimensions led to greater sorting times than zero irrelevant dimensions, as a function of age. Also, the mean difference in sorting times between two and zero irrelevant dimensions as a function of age  
   [Page 62]

10. The amount of interference per deck (in seconds) as a function of age and the relevant dimension  
    [Page 64]
INTRODUCTION

Overview. The present study concerns the development of selective attention. Since each organism is surrounded by a greater array of stimulation at any given moment than it can process and respond to, it seems clear that some process of stimulus selection is critical to the organism's effective functioning. Simon (1972, p. 3) has emphasized that "The human information processor is always struggling with the limits of his own processing and storing capabilities in the face of a wealth of information to be process and stored." The process of stimulus selection, loosely termed "attention", has been viewed by many as the central "nerve of the whole psychological system" (Titchener, 1908, p. 171). However, although William James boldly declared that "everyone knows what attention is" (1890, p. 403), investigators have come to little agreement about an adequate definition of attention or a model relating it to the more general phenomenon of perception. For James attention was "the taking possession by the mind, in clear and vivid form, of one out of what seem simultaneously possible objects or trains of thought" (1890, pp. 403-404). The success of positivistic behaviorism, however, in the late 1920's began a thirty year dearth of attempts to conceptualize the "mentalistic" phenomenon.
of attention.

With the publication of Broadbent's Perception and Communication (1958), the study of attention returned to the realm of scientific respectibility. In particular, a growing number of researchers began adopting the view that "to explain human behavior is to construct theories of the information processes that underlie behavior" (Simon, 1972, p. 22). As a product of this new perspective, a wealth of experimental data served to make more complex, rather than to clarify, our understanding of the phenomenon termed "attention". Moray (1969, p. 5) has written:

"Attention is a word with a great many very varied meanings, applicable to a very wide range of phenomena, many of them obviously central to an understanding of a human and animal behavior...."

Moray has also proposed seven subdivisions of the concept of attention: mental concentration, vigilance, selective attention, search, activation, set and the process of analysis-by-synthesis described by Neisser (1967). Moray defined selective attention (1969, p. 6) as the "problem faced by a person who is receiving several messages at once and is trying to select only one of them to accept and respond to."

This study concerns selective attention, particularly the often cited finding that irrelevant information interferes more with children's performances than it does with
those of adults; that "selective attention, focusing on the wanted information, seems to mature developmentally" (Gibson, 1969, p. 459). This conclusion has been reached through interpretation of results of numerous research paradigms, most of them borrowed from the literature involving adult subjects. Those studies that concerned the orientation of sensory receptors—e.g., eye movements—to select among various inputs, show that the ability to efficiently and strategically select information from a complex array does increase with age (Vurpillot, 1968). However, the data from studies involving less overt selection—e.g., by internal processes—are often open to numerous interpretations. It is here suggested that the only studies of selective attention which satisfy Moray's definition and which support the conclusion that children's performances suffer more interference from irrelevant information than do adults', used auditory stimuli. No unconfounded developmental evidence based on visual stimuli exists concerning the interaction of age with the effects of irrelevant information. This study investigated the possibility of this interaction.

**Dichotic Listening.** The dichotic listening paradigm has been used to demonstrate that, when receiving several simultaneous auditory messages, children are less able than are adults to select and respond to one particular message. Many of these studies present numerous simultaneous pairs of stimuli before requiring recall, thus involving both attention and short-term memory. These studies will
not be reviewed here. Treisman (1964a, 1964b) has shown that adults can easily listen selectively to one of two simultaneous messages which differ in spatial location or voice quality, but not when they differ in semantic content.

Maccoby and Konrad (1966) presented binaurally (both messages in both ears) and on another occasion dichotically (two different messages in each ear) twenty-three simultaneous pairs of words to children in kindergarten, second and fourth grades (mean ages of 5.8, 7.8 and 9.9 years, respectively). The stimulus words varied systematically in number of syllables. In the dichotic presentation, a man's voice repeated all the stimuli presented to one ear, and a woman's voice all those presented to the other ear, for each child. The first time through, the child was to repeat the word spoken by the man following each pair of words; and, on the second run, the words associated with the woman's voice. It is noteworthy that the preparatory set adopted at the beginning of a series of trials allowed the children to pair side of the head and sex of the speaker for all the trials.

The results showed that older children made more efficient use of the preparatory set in that the number of correct reports increased with age. Also, there was a decline in the number of intrusive errors as a function of age, i.e., younger children more often reported the words spoken only by the voice they were told to ignore.
For all age groups, recall scores were higher under dichotic presentation, and there was no change with age in the advantage derived from this means of presentation. For all grades combined, Ss made more correct responses when listening to multisyllable than to monosyllable words. Also, this difference was significantly greater for older children. Correct recall of monosyllabic words alone, however, improved from kindergarten (5.8 years) to grade two (7.8 years), then levelled off.

In a second study (Maccoby and Knorad, 1967) the effects of pre- vs. post-stimulus cueing were investigated. The predictions concerning developmental trends in the relative improvement associated with pre- and post-stimulus cueing followed two lines of reasoning. First, there is some evidence in the literature which suggests that younger children have greater difficulty than older children in holding and utilizing a preparatory set. From this viewpoint, the preparatory signal used in their study would not greatly improve the performances of younger children relative to their post-stimulus cueing levels (or at least the effects would not be as great as in the case of older Ss.) On the other hand, the opposite prediction is also possible. It might be emphasized that, in the post-stimulus cueing condition, S must hold in memory the entire set of messages. If younger children have more limited memory
spans, or use their memory spans less efficiently, then the post-stimulus condition should become progressively less difficult with age.

A man's voice and woman's voice were again used and sex of speaker was consistently paired with channel (ear). The stimuli were either pairs of two-syllable words varying in familiarity (Study 1) or pairs of two-word phrases classified according to their "sequential probability" or order of approximation to the English language (Study 2). These stimuli were presented over two loudspeakers rather than through earphones. The results confirmed the earlier finding in that, through the age range from kindergarten (approximate age 5) through the sixth grade (approximate age 12)¹ there was an improvement in the ability to give an accurate report of one of two simultaneous verbal messages. The improvement with age was greater for high sequentially probable phrases, suggesting that one factor underlying the improvement in selective listening is increasing familiarity with the probabilities of the language. Interestingly, the results did not reveal any differences among age groups in the extent to which familiarity of stimulus words affected performance. Ss' recall was more accurate when a

¹In order to facilitate comparisons among studies, throughout this paper, for studies in which the Ss' grade level, rather than age, was given; the ages involved have been approximated according to the formula: Grade 1 = age 6, Grade 2 = age 7...College Freshman = age 18, and so forth.
pre-stimulus rather than post-stimulus cue was presented, but the magnitude of this effect did not significantly vary with the familiarity of the stimuli, their sequential probability, or, consistently, upon the ages of the Ss. The relative stability of this phenomenon over ages was not expected, yet differences may have been masked by the stimulus variables chosen for this study. For example, a considerable portion of the children were able to reach perfect performance for one-word pairs, regardless of the presence of preparatory set. Successive retapings of the stimuli until the sounds were "somewhat blurred" was found to be necessary in order to reduce to chance performance in post-stimulus cueing.

In a third study (Maccoby and Laifer, 1968) subjects in the first, third, fifth and seventh grades were presented pairs of sequential or non-sequential phrases of varying lengths (three to five words). Again the design involved a male and a female voice, each consistently paired with channel. Ss were first asked to repeat what one voice said when the second voice was silent. The Ss were then asked to select one voice when the second voice was present. The difference between these scores was taken to indicate the magnitude of the interference effect. This difference was much greater for younger children than for older children and this was true for both the easy and the more difficult stimuli.
An interesting discrepancy within the dichotic listening results concerns sex differences in the recall of the correct voice (Maccoby and Leifer, 1968). Maccoby and Konrad (1966), presenting simultaneous pairs of single words, found that girls showed slight (non-significant) superiority, and there was no interaction of sex of subject with sex of the speaker's voice. On the other hand, Maccoby and Konrad (1967), again using pairs of single words, found that boys performed slightly better than girls, and again no interaction with the sex of the speaker's voice. In their study involving two-word phrases, Maccoby and Konrad (1967) found no over-all sex differences and no interaction with the sex of the speaker's voice. Maccoby and Leifer (1968), however, found that girls' performances were significantly superior to boys'; they also found a significant sex of subject × sex of voice interaction.

Maccoby (1967) has summarized the results of the dichotic listening studies thus:

"The ability to listen selectively (to select a wanted message when more than one message is available) increases with age through the range 5 through 12. It seems clear that an important factor in this increasing skill is the growth of language abilities."

(pp. 122-123)

Pick and Pick (1970), however, after reviewing the same literature, concluded that:
"developmental differences in selective listening may not be unequivocally interpretable since the process of selective listening is not completely understood for adults."

(p. 822)

Visual Search. A number of paradigms involving visual stimuli have yielded results interpreted as demonstrating an interaction of age with the interfering effects of irrelevant information. One such paradigm has involved visual search. In this procedure, originally designed by Neisser (1963), the S was asked to search for a specified target letter contained in rows of letters of varying similarity to the target. This kind of design made it possible to calculate the amount of time taken to process each letter and to study the effects of such variables as age, number of targets, and confusability of the contextual letters. It is of note that in these studies the variable confusability was defined by the number of distinctive features shared by the target and background items; confusability varied, by definition, directly with the number of features shared with the target, and was hypothesized to vary directly with search time.

Gibson and Yonas (1966a) used this search task with children, grades two, four and six, and with college sophomores. They hypothesized that the ability to filter incoming information from the environment increases as a function of age. Therefore, systematic search for the relevant
target and filtering-out of irrelevant contextual stimuli (or the efficient selection of critical features) would lead to shorter search times for older children. In this study, Ss searched for one or two target letters in a low confusion background—i.e., searched for G or R in lists of L, K, V, M, X and A. In a third condition Ss searched for one target letter contained in a high confusion background—i.e., searched for G in lists of B, Q, C, J and R. Search time decreased with age on all three tasks. Also, at all age levels, searching for two targets took no longer than searching for one target. Importantly, while there was a significant difference between high- and low-confusion conditions, the highly confusing visual context increased search times uniformly across all age levels. As in many developmental performance studies, individual differences between Ss, especially in the younger age groups, were marked. These differences interacted significantly with the conditions of the study, being greatest when younger Ss performed the high confusion task.

Gibson and Yonas (1966b) attempted to clarify the results of their first study. They hypothesized that younger children's greater search times may have resulted from more explicit vocalization while processing the letters. To test this possibility, they presented a high or a low confusability auditory background (male voice reading letters, heard over earphones) to these groups.
The task was basically the same as in Gibson and Yonas (1966 a) except that all subjects searched for only one target. The three conditions were: low-visual, low-auditory confusability; low-visual, high-auditory confusability; and high-visual, low-auditory confusability. The Ss were third grade children and college sophomores.

It was found that the highly confusing auditory context had little effect on either age group. In all conditions search time was greater for the children. Moreover, unlike the results of Gibson and Yonas (1966 a), the highly confusing visual context had a greater effect on younger subjects. They interpreted their results as weakening the hypothesis that visually perceived letters are encoded to acoustic representations as they are scanned. Also, they hypothesized that the results of their first study (that a highly confusing visual context had the same effect on search time at all age levels) may possibly have been due to uncontrolled order effects in that study. In their first study all Ss first searched for letters in the low-confusion condition, thus an age x confusability interaction may have been masked.

Gibson and Yonas (1966 b) interpreted their results as suggesting that the effects of visual interference on a visual scanning task were greater for children than for adults. However, Vurpillot (1968) has shown that
young children have a relatively poor ability to systematically scan a stimulus field and that significant variability exists in Ss between five and nine years of age. That Gibson and Yonas had no precise control over their Ss' search strategies allows for some doubt about their findings. Furthermore, this finding contra-indicates use of this paradigm with younger Ss.

**Incidental Learning.** A number of learning tasks, most often incidental and discrimination learning tasks, have also been used to investigate the effects of irrelevant information on the processing of visual stimuli.

In the incidental learning research it is reasoned that if the child's perception is not as selective as that of an older person, then the young child should attend to more task-irrelevant features of a stimulus display and thus do more incidental learning. Two types of incidental learning paradigms have been differentiated by Postman (1964). In type one studies, Ss are exposed to the stimulus material but given no specific instructions to learn. After this experience, Ss' retention of the stimulus materials is tested unexpectedly. In type two studies, Ss are given learning instructions concerning material relevant to the central task and then exposed during the learning period to cues which were not included in the instructions and which are not relevant to the specified task. Most incidental learning studies with
children have involved some variant of the type two paradigm. Numerous studies conducted using these procedures have produced conflicting results.

Stevenson (1954), using a type one task with children of ages three to six years found that the amount of incidental learning increased with age. This study is interesting because it involved Ss younger than those used in other incidental learning studies.

Maccoby and Hagen (1965), using an older group of children in a type two procedure, extended these findings. This often cited study served to stimulate a series of similar studies. They tested children in grades one, three, five and seven on a memory task of pictures presented on cards. Each S was shown picture cards with familiar figures (e.g. scooter) presented on distinctively colored backgrounds. The cards were then turned over and S was asked to point to the back of the card whose background color matched a color chip displayed by E (the central task). After a series of trials the child was asked to identify the pictures which appeared with each background color (the incidental recall task). Also, half the Ss in each age group were in a distraction condition. During the task (but not during incidental recall) these Ss heard a tape of piano music having a melody of high notes interrupted aperiodically by single bass notes. The Ss in this condition were required to tap the table whenever they heard
a bass note. It was argued that such a distraction would create a situation of a demanding information load which would stimulate S to give up intake of some other information. It was found that: first, recall scores on the central task increased significantly with age; second, that recall of task irrelevant (incidental) material showed essentially no change through grades one to five, but showed a sharp decline between grades five and seven; third, that distraction impaired performance on the central task to a similar degree at all age levels; fourth, that distraction had no significant effect on incidental recall at any age level; and fifth, that the central and incidental recall scores were not correlated for Ss in grades one to five but were positively correlated for Ss in grade seven. It is noteworthy that the effect of distraction on central and incidental recall was confounded by the presence of the distractor during the central but not the incidental recall. Since Stevenson (1954) reported an increase in incidental learning in Ss younger than those used in the Maccoby and Hagen study (1965), Maccoby and Hagen suggested that incidental learning increases during the early ages when children are learning to categorize, code and label objects; that is, developing processes which enable them to attend simultaneously to several features in a situation. Younger children, they contended, process more information than is necessary to adequately perform the central task
because of some deficiency in selective filtering ability. This is then followed at approximately ten to twelve years of age by a period of development of the ability to select out undesired stimuli.

Maccoby and Hagen (1965) hypothesized that under conditions demanding much information input (e.g. their distraction condition) older children should be much more efficient than younger children at giving up irrelevant, incidental information. Two aspects of this study, however, did not confirm this hypothesis: 1) distraction had no effect on incidental recall at any age, and 2) a negative correlation between central and incidental recall scores was not found for the older children.

Siegel and Stevenson (1966) used an elaborate type two paradigm involving a standard three-choice successive discrimination problem presented in three phases. Confirming the results of Maccoby and Hagen (1965), the incidental learning scores were a curvilinear function of age, increasing slightly between ages seven and twelve, then declining through ages thirteen and fourteen. Unexpectedly, however, the adults showed a significantly higher amount of incidental learning than all other groups.

Hagen (1967) used a type two procedure similar to that of Maccoby and Hagen (1965); Ss in grades one, three, five and seven, and materials of a "less child-like" nature. The recall of task relevant material increased regularly
with age level. Distraction had no effect on the recall of irrelevant information except at the highest grade level. Furthermore, the central and incidental recall scores were uncorrelated at the younger ages (approximately six to eleven); but, unlike the results of Maccoby and Hagen (1965), the recall scores were significantly negatively correlated at the seventh grade level (approximate age thirteen).

It must be noted that in both the Maccoby and Hagen (1965) and the Hagen (1967) studies, the central task (recall) was performed after each stimulus presentation; but the incidental recall was not measured until all the presentations were completed. Such a memory factor might have a differential effect with age; hence, what was considered a central-incidental variable might have been a difference in the time of the two memory measures.

Hagen and Sabo (1967), using a procedure similar to Maccoby and Hagen (1965), did not require recall of either the central or incidental material until all presentations were completed. Four grade levels were used in this study: three, five, seven and nine. Three tasks of varying difficulty (memory load) were involved. The shape of the incidental learning curve varied as a function of the task involved but in general incidental recall remained essentially unchanged over age. Contrary to the E's hypothesis, the correlation between incidental and central recall was
best for the oldest Ss.

Drucker and Hagen (1969), using a type two paradigm similar to that of Maccoby and Hagen (1965), varied the discriminability between the relevant and irrelevant stimuli. The Ss were children in grades four, six and eight. The stimulus cards contained two pictures, one of an animal and one of a household object. The discriminability between the relevant and the irrelevant aspects of the task was manipulated by varying the relationship between the pictures; spaced or contiguous, alternating or non-alternating spatial positions. A curvilinear relationship between the amount of incidental learning and age, peaking at age twelve, was found in the contiguous—alternating condition (the arrangement most closely resembling that used in previous studies). Only the spacing as a main effect was significant, and only then for the oldest two groups of children. Increasing the discriminability between the relevant and irrelevant information significantly affected only the incidental recall. Drucker and Hagen concluded that the change responsible for the development of selective information processing did not involve improved visual discrimination. Furthermore, on the basis of the results of a post-test questionnaire, they concluded that the superior encoding strategies—focused visual scanning and specific verbal labeling—of which older children were capable enabled them to focus on
task-relevant information.

Two incidental learning studies have involved the use of moving pictures (a film) as the stimulus. Both of these studies used a type one procedure; the children viewed the film casually, then were tested with specific information and evaluation questions. Adult judges rated the questions beforehand to determine whether they dealt with central or incidental content. Collins (1970) used Ss in grades three, six, seven and nine, while Hale, Miller and Stevenson (1968) used Ss in grades three to seven and a group of adults (approximate age nineteen). Both studies showed that recall of central material increased over age, while the recall of incidental material increased until approximately age twelve to thirteen, then decreased thereafter. However, in the Collins (1970) study the difference scores between the two recall measures did not vary significantly as a function of age level. Also, the results of the Hale Miller and Stevenson (1968) study showed significant sex effects, all scores tending to be higher for girls. Girls did more incidental learning at all ages except the adult level. More interestingly, the results of the Hale, Miller and Stevenson (1968) study showed that the curvilinear relationship between incidental recall and age (peaking at age twelve) was only present for recall on questions involving verbal content, such as names, verbalized content, and verbalized peripheral material. The
curvilinear developmental pattern was not evident in the results from questions dealing with visual material in the film.

Finally, Vaughan (1968) presented pictures to children in grades one, four and seven. This was a type one procedure involving stimulus lists which were either clustered or not clustered. Incidental learning increased over all the ages in this study and clustering had a significant effect for both the incidental and central recall conditions. Furthermore, there was a significant positive correlation between the recall measures at all age levels. Vaughan (1968) hypothesized that, comparing type one and type two tasks, the amount of incidental learning may actually depend upon two quite different processes. It was suggested that a curvilinear relationship between incidental recall and age may only be found using a type two procedure, because this procedure affords attention competition.

Many difficulties of interpretation arise from the results of incidental learning studies. For example, the involvement of memory and learning functions, which themselves change developmentally, might certainly modify explanations based solely on the blocking of stimulus inputs. The correlation between incidental and central recall seems to vary considerably from study to study. Furthermore, in the incidental learning studies the irrelevant material has not been shown to interfere with the
relevant material, and it is unclear that the incidental material in any way functions to distract the Ss—in other words, that the Ss' recall scores would be higher were the irrelevant information not present. The child's capability at blocking out irrelevant information is not being critically tested.

**Discrimination Learning.** A number of studies have investigated the effects of irrelevant information using discrimination learning tasks. As in incidental learning studies, the results are likely confounded by learning and memory effects.

In a study involving third and fourth grade children from eight to ten years old, Lubker (1967) presented each child with three different two-choice simultaneous discrimination problems. Form, size, and brightness were the bipolar dimensions used; form was relevant on all three problems; and each problem contained either none, one or two irrelevant dimensions. The children performed significantly better on problems containing no irrelevant dimensions and performance was about the same on problems containing one or two irrelevant dimensions. Lubker (1967, p. 125) concluded:

"The presence of one or more variable, irrelevant, within-setting, nonspatial dimensions markedly increases the difficulty of simultaneous discrimination problems for children."

This finding was also substantiated by Spiker and Lubker
(1964, experiment 4) using a similar discrimination learning problem.

Osler and Kofsky (1965, 1966) conducted two developmental studies of the effects of varying amounts of irrelevant information on discrimination learning. Using children ages four to eight; concepts of form, color, and size; and from none to two irrelevant dimensions, Osler and Kofsky (1965) failed to find that irrelevant information handicapped young children any more than it did older children. However, the fact that the subjects were exposed to the test stimuli in a pretesting period (during which the S had to make same/different judgments) biased the procedure against finding such an interaction. Moreover, following the pretesting, the Ss were pretrained using different stimuli. Ss who failed the first problem—four out of five of whom were from the youngest age group—were eliminated from the study. In a second, similar study Osler and Kofsky (1966) again used this pre-testing and pretraining procedure and in this study found a significant interaction between age and number of irrelevant dimensions, the irrelevant information affecting the performances of younger children more than those of older ones. Given that their pre-testing and pre-training procedures eliminated twelve kindergartners, one third grader and one sixth grader, this study warrants replication without these preliminary procedures.
Other Learning Sets. It must not be supposed that the experimental literature suggests that the presence of irrelevant, potentially distracting information is always debilitating to Ss performances. A number of studies using the oddity learning task have found that the presence of a distracting stimulus sometimes facilitates performance. For example, Turnure (1970) used five-and-one-half, six-and-one-half, and seven-and-one-half year old Ss with oddity learning problems accompanied by no distraction, sound distraction or mirror distraction. Compared with the performances of control Ss, the auditory distractor debilitated Ss' performances at all three age levels. Visual (mirror) distraction, on the other hand, debilitated the performance of five-and-one-half year olds, had no effect on the six-and-one-half year olds, and facilitated the performances of the seven-and-one-half year olds. Turnure (1970, p. 116) hypothesized:

"that six and seven year old children develop the ability to mobilize and direct their attention to arbitrarily assigned tasks, despite the presence of other interesting and conspicuous stimuli. This presupposes some capability in these children for inhibiting attention to irrelevant, non-task stimuli."

The results of Turnure (1970) are similar to those of Ellis et al (1963), which used an oddity learning task with seven-year old Ss; and Turnure and Zigler (1964), which
used six-year old Ss with an object assembly task. Turnure (1970) has concluded that distraction produces a decrement in the performances of young children, has no effect around age six, and facilitates performance from that age onward. It has been reported, however, that when the irrelevant information is presented on the oddity problem stimuli themselves, the irrelevant information tends to impair rather than to facilitate the performances of eight to ten-year olds (Lubker and Spiker, 1966).

Pick, Christy and Frankel (1972) measured the reaction times of children in the second and sixth grades as they made judgments, as quickly as possible, whether or not an aspect of two simultaneously presented animals were the same. In one condition, Ss were informed of the relevant aspect prior to the stimulus presentation, and in the other condition Ss were informed of the relevant aspect after stimulus presentation. All Ss first performed the pre-informed condition, then the post-informed condition. The number of irrelevant aspects which differed for a given pair of stimuli was always either one or two. The aspects were shape (six possible values), color (six possible values), and size (two possible values). The results showed that for both second and sixth graders the pre-informed condition led to shorter reaction times than the post-informed condition. Also, this difference was significantly greater for sixth graders. This result led Pick, Christy and Frankel
to conclude that older children were more capable of taking advantage of prior knowledge about what aspects of a stimulus were relevant and which irrelevant. They hypothesized that the developing selective aspect of attention operates early in the perceptual process and not in a memorial process. It must be noted that in this study there was no condition involving zero irrelevant aspects. Furthermore, the error rate was "quite high".

**Relationships Among Dimensions.** It is clear that in most of these previous studies, regardless of paradigm, little attempt has been made to systematically investigate the stimulus dimensions used or to systematically define the relationship between the relevant and irrelevant information. This issue has recently been discussed by Garner (1970). In numerous studies selective attention in adults has been investigated by using speeded classification tasks in which the amount of irrelevant information has been varied. Conflicting results have been found. Some studies have reported that the presence of irrelevant dimensions has led to interference in performance (e.g. Egeth, 1966), while others have reported no interfering effects (e.g. Imai and Garner, 1965). Egeth (1967) has argued that performance will be impeded if the task and irrelevant information evokes competing responses on the part of the S. For example, studies which involve easily discriminated and/or previously relevant, irrelevant stimuli will most
likely lead to interference effects since the irrelevant information will evoke responses which will compete with that response elicited by the relevant information which would lead to maximal performance. This hypothesis, however, is inconsistent with the data of Imai and Garner (1965), who used a card sorting task; and of Well (1971), who used a key-press speeded classification task. Garner (1970) and Well (1971) have stressed that in speeded classification tasks the relationship between the relevant and irrelevant dimensions must be considered. In particular, Garner (1970) has argued that when multidimensional stimuli are used, the dimensions which define the stimulus can be ordered on a continuum from separability to integrality. A separable dimension is one which can have an identity independent of the presence of some other dimension. Dimensions are said to be integral "if in order for a level on one dimension to be realized, there must be a dimensional level specified for the other" (Garner, 1970, p. 354). Garner and Felfoldy (1970) had adults sort cards which were defined either by two bipolar separable dimensions (Munsell chips, one color chip varying in value and another on the same card varying in chroma) or by two bipolar integral dimensions (value and chroma of single Munsell chips). The conditions included sorting by one dimension, with the other dimension 1) absent; or 2) redundant, or correlated with the first dimension; 3) or irrelevant and
orthogonal with the first dimension. Using integral colors, facilitation of sorting occurred with redundant dimensions and interference occurred with orthogonal dimensions. On the other hand, with separable dimensions, no interference was obtained when Ss sorted with orthogonal dimensions and no facilitation occurred with redundant dimensions.

**Design and Hypotheses.** The present investigation is a developmental study of the effects of various amounts of irrelevant information on speeded classification-card sorting performance. Most card sorting tasks conducted with children have concerned conceptual differentiation and the issue of breadth of categorization. In these studies the main dependent variables have usually been the number and size of categories (piles) created. In this study the stimulus cards were sorted into two predetermined categories and the collecting bins were clearly and appropriately labeled. The stimulus cards contained zero, one or two bits of irrelevant information and sorting time was the major dependent variable. Care was taken to use only separable dimensions, dimensions which, when irrelevant, are easily selectively filtered by adults.

Given that research using auditory stimuli in selective attention tasks has indicated a developmental trend in the ability to block out irrelevant auditory information; and given that a similar conclusion has been suggested in studies involving visual stimuli, the main hypothesis
of this study was that, while younger Ss would exhibit higher sorting times across all levels of irrelevant information, the younger children would be more adversely affected by increasing amounts of irrelevant information.

Also, given the results of Garner and Felfoldy (1970), it was hypothesized that the irrelevant information would have no interfering effects on the sorting speeds of adults. In this study a given value of a dimension varied in its being relevant and irrelevant, thus maximizing the possibility of competing responses. According to Egeth (1967) this would lead to stronger interference effects in all Ss.

The dimensions used in this study were form, line orientation and star location. Given that children older than five to six years have been shown to exhibit significant preferences for form rather than for dimensions such as color or size (Lee, 1955), it was hypothesized that the effects of irrelevant information would be least when form was relevant and greatest when form was irrelevant. If the interfering effects of irrelevant information do become progressively less with age, then the age x number of irrelevant dimensions interaction might also vary as a function of the dimension which was relevant.
Subjects. There were 72 subjects in this study, 18 in each of four age-defined groups: ages six, nine, twelve, and a group of adults ($\bar{x} = 19.7$ years.) Each group consisted of an equal number of boys and girls with no known visual or motor difficulties. The children, who were from upper-middle class homes, were attending summer camp at the time this study was conducted. The adult sample was a group of volunteers from an Introductory Psychology class at the University of Massachusetts. These subjects received experimental credit for their participation in the study.

In a supplementary study there were 36 subjects. There were 9 seven-year olds (6 boys, 3 girls), 9 eight-year olds (7 boys, 2 girls), 12 ten-year olds (4 boys, 8 girls) and 6 eleven-year olds (4 boys, 2 girls). These children had no known visual or motor difficulties and were drawn from the same population as those children in the main study.

Apparatus. The test stimuli were 13 decks of cards, each deck containing 24 cards. The basic card was made of white 3" x 4" six-ply posterboard. The symbols printed on the cards were centered and defined according to one, two, or three binary dimensions: form (circle or square, each ½" diameter or side length), line within the form (horizontal or vertical), and star (just above or below the form). Each deck was defined by one relevant dimen-
sion, and zero, one, or two irrelevant dimensions. A
description of each deck of cards is presented in Table
1. The symbols shown at the bottom of Table 1 are the
same size as those presented on the stimulus cards.
There was also a deck of 24 practice cards, the same
size and shape as the test stimuli; centered upon them
was either a green or a red equilateral triangle with a
side length of 3/4" and shown in one of four possible
rotations, each position occurring three times within
each color in the practice deck. In the center of each
of the cards (both practice and test stimuli) was a black
dot and on the top of each card was a black line parallel
to and 1/8" below one of the 3" sides of the card. The
stimuli were created from pressure sensitive dry transfer
symbols manufactured by the Avery Products Corporation,
Graphics Division, Leeds, Massachusetts (Circle = RDC49,
Square = RDS57, Star = TPSR333, Line = G3, and Dot = RDC2).
All of the cards were covered with Duraseal transparent
acetate adhesive film manufactured by the Morilla Com-
pany, New York, N.Y.

Eight display cards were used, similar in size and
construction to the test stimuli. The display cards for
the practice deck were solid green and solid red, while
the display cards for the test stimuli presented the value
of the relevant dimension along with a dot in the center
and line at the top of the card.
### TABLE 1
Description of the Test Stimuli.

<table>
<thead>
<tr>
<th>DECK</th>
<th>RELEVANT DIMENSION</th>
<th>IRRELEVANT DIMENSION</th>
<th>NUMBER OF DIFFERENT STIMULI</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Form</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>Line</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>Star</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>Form</td>
<td>Star</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>Form</td>
<td>Line</td>
<td>4</td>
</tr>
<tr>
<td>F</td>
<td>Star</td>
<td>Form</td>
<td>4</td>
</tr>
<tr>
<td>G</td>
<td>Star</td>
<td>Line</td>
<td>4</td>
</tr>
<tr>
<td>H</td>
<td>Line</td>
<td>Form</td>
<td>4</td>
</tr>
<tr>
<td>I</td>
<td>Line</td>
<td>Star</td>
<td>4</td>
</tr>
<tr>
<td>J</td>
<td>Form</td>
<td>Star &amp; Line</td>
<td>8</td>
</tr>
<tr>
<td>K</td>
<td>Line</td>
<td>Form &amp; Star</td>
<td>8</td>
</tr>
<tr>
<td>L</td>
<td>Star</td>
<td>Form &amp; Line</td>
<td>8</td>
</tr>
</tbody>
</table>

Form

Line

Star

Form, Line & Star

![Form](image1)

![Line](image2)

![Star](image3)

![Form, Line & Star](image4)
Two black wooden stands, 5½" wide and 6 3/4" high, supported by small back braces, were also used. On the front of these stands was a card holder which secured the display card that indicated the value of the relevant identifying dimension of the cards to be placed in front of that stand.

Lollipops and small toys were used as rewards for the children.

A stop-watch was used to time S's performances.

The materials used in the supplementary study were the same as those used in the main study, with the exception that only the practice deck, and those decks with zero and two irrelevant dimensions were used.

Procedure. Each subject was tested individually. The subject was seated before a low table upon which the two wooden stands were located 6" apart and 12" in front of Ss. Presented as a game, Ss were told to sort each deck of cards as quickly as possible without making errors. The Ss were instructed not to correct mistaken card placements, but to emphasize speed of sorting. Before each deck Ss were told the values of the relevant dimensions as the display cards, indicating these values, were placed in the holders on the stands. The instructions were of the form "If there is a _____ on the card, then put it here." No mention was made of the possible presence of extra or irrelevant information on the cards. The decks were placed face down in front of the Ss, who were instructed to place their hands
beside the deck. Given the signal "Go" by E, S turned the deck over and began sorting.

All Ss first sorted the practice deck (red and green triangles). On this sort it was important for E to notice which way Ss turned over the deck of cards so that the following test decks could be placed down before S so that after S had turned them over, the line on the top of the card was then on top as Ss held the cards. Upon completion of the practice sort, the non-adult Ss received a lollipop and the testing phase began. The 12 decks described in Table 1 were then sorted in random order by each S. For both the practice deck and test decks the cards within each deck were randomized and the position of the display cards for each S was varied randomly among Ss.

The E timed S's performances with a manually operated stop-watch, the timing beginning with the initial signal "go" and ending when the last card fell before one of the stands.

If a S made more than four errors on any given deck of cards, after all the decks were completed, S was asked to sort that deck again.

Appendix A shows the initial instructions to Ss eight years and younger; the initial instructions to Ss older than eight years are shown in Appendix B. Following completion of the practice sort and before each
subsequent deck of cards, the instructions presented in Appendix C were given to all Ss.

In the supplementary study the procedure was basically the same, with the exception that Ss in this study only sorted the practice deck and decks containing zero and two irrelevant dimensions; 7 decks total. After sorting the practice deck, the test decks were presented in random order. The instructions were the same as in the main study, the cards within each deck were in random order, and the positions of the display cards for each deck varied randomly.
RESULTS

Main Study Sorting Times. In this design, each S sorted 3 decks which contained zero irrelevant dimensions, 6 decks which contained one irrelevant dimension, and 3 decks which contained two irrelevant dimensions. In the initial analyses, the data from the one-irrelevant-dimension decks were averaged for each relevant dimension, yielding 3 one-irrelevant-dimension scores for each S. The data involved in these analyses did not include practice deck sorting time scores.

A four-way analysis of variance performed on the sorting times involved the variables age (six, nine, twelve and adult), sex, relevant dimension (form, line and star) and number of irrelevant dimensions (zero, one and two. The summary table of this analysis is presented in Appendix D. The results indicated highly significant main effects of age ($F = 95.25; \ df = 3, 64; \ p < .001$), sex ($F = 10.95; \ df = 2, 128; \ p < .005$), amount of irrelevant information ($F = 37.91; \ df = 2, 128; \ p < .001$), and the relevant dimension ($F = 68.28; \ df = 2, 128; \ p < .001$). Six-year old Ss sorted the cards in a mean of 42.02 seconds, nine-year olds in a mean of 22.61 seconds, twelve-year olds in a mean of 19.17 seconds, and adults in a mean of 14.29 seconds. Post hoc comparisons by the Scheffé test (Myers, 1966) indicated that six-year olds sorted significantly more slowly than all the other age groups, and
nine-year olds sorted significantly more slowly than did adults. Also, when combined, six-year olds and nine-year olds sorted significantly more slowly than twelve-year olds and adults. Over-all, boys sorted the decks more slowly than did girls, in means of 26.59 and 22.46 seconds, respectively. Sorting time also varied directly as a function of the number of irrelevant dimensions; in over-all means of 22.25, 25.10, and 26.23 seconds in the zero-, one-, and two-dimension conditions, respectively. Post hoc comparisons by the Scheffé test showed that zero-irrelevant-dimension conditions yielded lower sorting times than either the one- or two-irrelevant dimension conditions. The one- and two-irrelevant dimension conditions were not significantly different from one another. Finally, the relevant dimensions were ordered: form, line and star, according to the ease of sorting; over-all mean sorting times being 20.35, 25.32, and 27.91 seconds respectively. Post hoc analysis by the Scheffé test indicated that these three relevant dimensions were significantly different from one another with respect to the sorting times they elicited.

Of prime importance was the finding of a significant age x amount of irrelevant information interaction (F = 9.61; df = 6, 128; p < .001). This interaction is shown in Figure 1, which presents the mean amount of interference per deck in seconds and per card in milliseconds, as a
Figure 1. Mean amount of interference per deck (in seconds) and per card (in milliseconds) as a function of age and the amount of irrelevant information.
function of age and the amount of irrelevant information.

The amount of interference was calculated by comparing decks with the same relevant dimension and subtracting the zero-irrelevant-information sorting time score from the sorting time derived from the presence of either one or two irrelevant dimensions.

For six-year old Ss, compared to the case when no irrelevant information was present, the presence of one irrelevant dimension increased the sorting time a mean of 283.3 msec. per card, and two irrelevant dimensions increased the sorting time a mean of 411.25 msec. per card. On the other hand, the sorting times of adults were increased a mean of 29.16 msec. per card by one irrelevant dimension and a mean of 32.08 msec. by two irrelevant dimensions.

The actual mean sorting times and standard deviations (in seconds) involved in the age x amount of irrelevant information interaction are presented in Table 2. Post hoc analysis by the Scheffé test showed that, compared to their sorting times when no irrelevant information was present, the sorting times of six-year olds were significantly increased by the presence of one irrelevant information dimension, and a second irrelevant dimension significantly raised the sorting time relative to one irrelevant dimension. Between ages six and nine there occurred a significant decrease in the amount of inter-
TABLE 2

The Mean Sorting Times and Their Standard Deviations (in seconds) as a Function of Age and the Number of Irrelevant Dimensions.

<table>
<thead>
<tr>
<th>NUMBER OF IRRELEVANT DIMENSIONS</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \bar{X} )</td>
<td>S.D.</td>
<td>( \bar{X} )</td>
</tr>
<tr>
<td>AGE 6</td>
<td>36.48</td>
<td>12.73</td>
<td>43.28</td>
</tr>
<tr>
<td>9</td>
<td>21.04</td>
<td>5.09</td>
<td>23.28</td>
</tr>
<tr>
<td>12</td>
<td>17.70</td>
<td>3.37</td>
<td>19.32</td>
</tr>
<tr>
<td>Adult</td>
<td>13.80</td>
<td>2.23</td>
<td>14.50</td>
</tr>
</tbody>
</table>
ference caused by both one and two irrelevant dimensions. Relative to the condition when no irrelevant information was present, the sorting times of the three older groups were not significantly affected by irrelevant information. The irrelevant information tended to raise the sorting times of nine- and twelve-year olds more than it did those of adults. Table 2 shows that the change in sorting times as a function of age and the number of irrelevant dimensions was accompanied by a similar change in the standard deviation of the scores. The functions are the same except for the somewhat high standard deviation of twelve-year old Ss' scores when sorting decks with two irrelevant dimensions.

It is important to note that the age x amount of irrelevant information interaction did not significantly vary as a function of the dimension which was relevant.

There was a significant age x sex interaction (F = 8.05; df = 3, 64; p < .001) which is shown in Figure 2. Post hoc analysis by the Scheffé test indicated that six-year old boys sorted significantly more slowly (49.26 sec.) than did six-year old girls (35.44 sec.), and that a significant sex difference was not present in the older age groups. The decrease in sorting times between ages six and nine was significant for both sexes, though the change was slightly greater for boys. The curves are essentially the same among ages nine, twelve and adults.
Figure 2. Mean sorting times (in seconds) as a function of the age and sex of S.
There was a significant age x relevant dimension interaction ($F = 13.41; df = 6, 128; p < .001$), shown in Figure 3. Post hoc analysis by the Scheffé test indicated that at the six-year old level the three dimensions produced significantly different sorting times. At the nine- and twelve-year old levels, star yielded significantly higher sorting times than did form. At the adult level, the sorting times did not significantly vary as a function of the relevant dimension. Sorting time decreased significantly between ages six and nine, and nine to adult, with all three dimensions. However, between ages six and nine, the decrease in sorting time was significantly greater when star or line was relevant compared to when form was relevant. Comparing line-relevant to star-relevant, the change between ages six and nine was not significantly different. The change in sorting times from age nine to adult was similar for all three dimensions.

There was a significant interaction of the relevant dimension and the amount of irrelevant information ($F = 3.19; df = 4, 256; p < .025$). This interaction is shown in Figure 4. The brackets around the one-irrelevant dimension points indicate the variability dependent on the nature of the irrelevant dimension. Compared to when there was no irrelevant information, the presence of one irrelevant dimension significantly raised sorting times when line and star were relevant, but not when form was relevant.
Figure 3. Mean sorting times (in seconds) as a function of age and the relevant dimension.
Figure 4. Mean sorting times (in seconds) as a function of the relevant dimension and the number of irrelevant dimensions.

[The brackets around the one-irrelevant dimension points indicate the variability at that point as a function of the irrelevant dimension.]
Compared to when there was one irrelevant dimension, the addition of a second irrelevant dimension had no significant effect on any relevant dimension, although it nearly did so when line was relevant. When form was relevant, two irrelevant dimensions did not significantly alter the sorting times relative to when no irrelevant dimensions were present. Furthermore, when line was relevant the change in sorting times between zero and two irrelevant dimensions was significantly greater than this change when form was relevant.

There was also a significant age x sex x relevant dimension interaction ($F = 2.35; df = 6, 128; p < .050$). This interaction is shown in Figure 5. At the six-year old level boys produced higher sorting times on all three relevant dimensions, while at the older age levels no sex effect was present with any of the relevant dimensions.

For boys at the six-year old level, the dimensions produced significantly different effects, form yielding the lowest sorting times, star the highest. For six-year old girls, form yielded significantly lower sorting times than did line or star, and star and line did not significantly differ from one another. The dimensions did not differ for either sex at any of the upper age levels. When star was relevant, the decrease in sorting time between ages six and nine was significantly greater for boys than for girls. This change was not significant for
Figure 5. Mean sorting times (in seconds) as a function of sex, age and relevant dimension.
each of the other dimensions. Furthermore, older Ss showed no significant age x sex interaction with any of the relevant dimensions.

More Than Four Errors. Table 3 presents a description of those instances in which more than four errors were made on a given deck. From casual observation of the Ss, it appeared that most of these errors occurred consecutively, often when S would stop looking at the piles and inadvertently reverse the piles into which the cards were thrown. However, no quantified data was collected to substantiate this observation. Eight different Ss--four six-year old boys, two twelve-year old boys and two twelve-year old girls--produced these errors. Five Ss made nine or more errors on one deck of cards. Either line or star was the relevant dimension on all decks involved with more than four errors. No S resorted a deck more than once. For all of these Ss the corrected sorting times were lower than the original sorting times. Analysis by t-test, however, revealed no significant differences between the original and corrected scores. This was true over-all, for the younger (six-year old) Ss and for the older (twelve-year old) Ss. However, the change in the sorting times of the six-year olds was significantly greater than the change in the sorting times of the twelve-year olds (t = 2.45; df = 7; p < .050).

In a further analysis of the data the new, corrected
TABLE 3
Description of Those Instances in Which More Than Four Errors Were Made on a Given Deck of Cards.

<table>
<thead>
<tr>
<th>AGE</th>
<th>SEX</th>
<th>NO. IRREL. IN DECK</th>
<th>RELEV. DIMENSION</th>
<th>IRRELEV. DIMENSION</th>
<th>NO. OF ERRORS</th>
<th>ORIGINAL SORTING TIMES (sec.)</th>
<th>CORRECTED SORTING TIMES (sec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>M</td>
<td>2</td>
<td>Line</td>
<td>Form</td>
<td>9</td>
<td>89</td>
<td>49.5</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>1</td>
<td>Star</td>
<td>Line</td>
<td>12</td>
<td>37.5</td>
<td>33.5</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>0</td>
<td>Line</td>
<td></td>
<td>9</td>
<td>62</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>1</td>
<td>Star</td>
<td>Form</td>
<td>11</td>
<td>66</td>
<td>44</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>1</td>
<td>Star</td>
<td>Line</td>
<td>12</td>
<td>22.5</td>
<td>18</td>
</tr>
<tr>
<td>12*</td>
<td>M</td>
<td>0</td>
<td>Line</td>
<td></td>
<td>7</td>
<td>26.5</td>
<td>23</td>
</tr>
<tr>
<td>12*</td>
<td>M</td>
<td>1</td>
<td>Star</td>
<td>Form</td>
<td>5</td>
<td>26</td>
<td>21.5</td>
</tr>
<tr>
<td>12</td>
<td>F</td>
<td>2</td>
<td>Line</td>
<td>Form Star</td>
<td>6</td>
<td>24</td>
<td>21.5</td>
</tr>
<tr>
<td>12</td>
<td>F</td>
<td>1</td>
<td>Star</td>
<td>Line</td>
<td>5</td>
<td>22</td>
<td>16.5</td>
</tr>
</tbody>
</table>

* the same S
sorting times were substituted for the original, error-confounded sorting times and the data reanalyzed. A four-way analysis of variance with these data involved as the relevant variables age, sex, the relevant dimension and the number of irrelevant dimensions. A summary table showing the results of this analysis is presented in Appendix E. The results were essentially the same as those obtained with the original data, with the exception that the level of significance of the age x sex x relevant dimension interaction changed from an original p < .050 to p < .025.

Analysis of Errors. As with the sorting time data, analysis of the number of errors used an average (across each relevant dimension) of the one-irrelevant-dimension data. The number of errors committed on this task was not large. For example, the most error-prone group, six-year old boys, placed 3.5% of their cards incorrectly. A four-way analysis of variance performed on the error data involved the variables age (six, nine, twelve and adult), sex, relevant dimension (form, line and star), and number of irrelevant dimensions (zero, one and two). The summary table of this analysis is presented in Appendix F. Analysis of this error data revealed a significant age effect (F = 6.20; df = 3, 64; p < .001), sex effect (F = 6.59; df = 1, 64; p < .025) and effect of the relevant dimension (F = 12.98; df = 2, 128; p < .001). The number of
errors did not vary directly with age. Six-year olds made a mean of 0.59 errors per deck (2.46% of the cards were placed incorrectly), nine-year olds made a mean of 0.19 errors (0.79%), twelve-year olds 0.43 errors (1.79%) and adults 0.11 errors (0.46%). Post hoc analysis by the Scheffé test revealed that six-year olds made significantly more errors than did nine-year olds or adults, and that twelve-year olds made significantly more errors than did adults. Boys made a mean of 0.44 errors per deck (1.83%) while girls made a mean of 0.22 errors per deck (0.92%). A mean of 0.08 errors per deck (0.33%) were made when form was relevant, 0.51 errors per deck (2.13%) when line was relevant and 0.40 errors per deck (1.67%) when star was relevant. Post hoc analysis by the Scheffé test revealed that form yielded significantly fewer errors than either line or star and that line and star did not differ significantly in the number of errors that they elicited.

It is important to note that the number of errors did not vary significantly as a function of the number of irrelevant dimensions. However, a significant interaction between the number of irrelevant dimensions and the relevant dimension did occur, as shown in Figure 6. Clearly, the primary influence on this interaction was the data from the one-irrelevant-dimension condition, which on this curve appears as an averaged score. Excluding, for
Figure 6. The mean number of errors per deck as a function of the relevant dimension and the number of irrelevant dimensions.
a moment, the data concerning one irrelevant dimension, it can be seen that the change in the number of errors between zero and two irrelevant dimensions was essentially the same for the three relevant dimensions.

One Irrelevant Dimension Data. Since these preceding analyses involved data based on averages of results from one-irrelevant dimension decks, a finer analysis of the original one-irrelevant dimension data was performed. A three-way analysis of variance performed on the one-irrelevant-dimension sorting times involved the variables age (six, nine, twelve and adult), sex, and decks having one irrelevant dimension (six decks). The summary table of this analysis is presented in Appendix G. The results indicated, as in the original analysis, decreased sorting times with age (F = 102.18; df = 3, 64; p < .001), lower sorting times for girls (F = 9.79; df = 1, 64; p < .005) and a decrease of this sex effect with increasing age (F = 6.66; df = 3, 64; p < .001).

Furthermore, different decks elicited significantly different sorting times (F = 40.71; df = 5, 320; p < .001), shown in Table 4.

When form was relevant, sorting time was low and did not vary significantly as a function of which dimension was irrelevant. Post hoc analysis by the Scheffé test indicated that when line was relevant, the sorting time was significantly greater than when form was relevant.
TABLE 4

The Mean Sorting Time (in seconds) as a Function of Stimulus Deck With One Irrelevant Dimension.

<table>
<thead>
<tr>
<th>DECK</th>
<th>RELEVANT</th>
<th>IRRELEVANT</th>
<th>X SORTING TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Form</td>
<td>Line</td>
<td>20.51 sec.</td>
</tr>
<tr>
<td>5</td>
<td>Form</td>
<td>Star</td>
<td>20.52</td>
</tr>
<tr>
<td>6</td>
<td>Line</td>
<td>Form</td>
<td>27.44</td>
</tr>
<tr>
<td>7</td>
<td>Line</td>
<td>Star</td>
<td>24.24</td>
</tr>
<tr>
<td>8</td>
<td>Star</td>
<td>Form</td>
<td>27.15</td>
</tr>
<tr>
<td>9</td>
<td>Star</td>
<td>Line</td>
<td>30.72</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>DIMENSION</th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Combined</td>
<td>Form</td>
<td>Relevant</td>
</tr>
<tr>
<td>Combined</td>
<td>Line</td>
<td>Relevant</td>
</tr>
<tr>
<td>Combined</td>
<td>Star</td>
<td>Relevant</td>
</tr>
<tr>
<td>Combined</td>
<td>Form</td>
<td>Irrelevant</td>
</tr>
<tr>
<td>Combined</td>
<td>Line</td>
<td>Irrelevant</td>
</tr>
<tr>
<td>Combined</td>
<td>Star</td>
<td>Irrelevant</td>
</tr>
</tbody>
</table>
Also, when line was relevant, the sorting time tended to be greater when form was irrelevant compared to when star was irrelevant. When star was relevant, the sorting time was significantly greater than when either form or line were relevant. Also, when star was relevant, the sorting time was significantly greater when line was irrelevant compared to when form was irrelevant.

There was also a significant interaction of stimulus deck and age (F = 7.29; df = 15, 320; p < .001), shown in Figure 7. Post hoc analysis by the Scheffé test indicated that when form or line were relevant, the nature of the irrelevant dimension had no significant effect at any age level. However, when star was relevant, the nature of the irrelevant dimension was significant in determining sorting time only at age six. When line or star were irrelevant, then the nature of relevant dimension was not a significant factor at any age. Furthermore, when line was irrelevant, the decrease in sorting time with age was significantly greater when star was relevant than when form was relevant. In general, the effects of the relevant dimension were influenced by the nature of the irrelevant dimension and this influence changed as a function of age. Also, with increasing age the nature of both the relevant and irrelevant dimensions became less important as critical factors determining Ss' sorting times.
Figure 7. Mean sorting times (in seconds) as a function of age and stimulus deck having one irrelevant dimension.
A three-way analysis of variance performed on the number of errors which occurred on the decks containing one irrelevant dimension involved the variables age (six, nine, twelve and adult), sex, and stimulus deck (six decks). The summary table of this analysis is presented in Appendix H. This analysis revealed a significant effect of age \( (F = 6.29; \, \text{df} = 3, 64; \, p < .001) \), sex \( (F = 6.36; \, \text{df} = 1, 64; \, p < .025) \) and stimulus deck \( (F = 6.06; \, \text{df} = 5, 320; \, p < .001) \). The age x stimulus deck interaction effect was not significant. Post hoc analysis by the Scheffé test revealed that six-year old Ss (3.16% of cards thrown in error) made significantly more errors than did nine-year olds (0.54%) and adults (0.42%) but not more than twelve-year olds (2.28%). Again, boys made significantly more errors (2.28%) than did girls (0.93%).

Table 5 shows the number and mean percent of errors made as a function of the stimulus deck, as well as the combined calculations of number of errors for each dimension that was relevant and irrelevant. The total number of cards thrown on each deck was 1728 (72 Ss x 24 cards per deck). This distribution of errors is similar to the distribution of sorting times as a function of decks containing one irrelevant dimension, which is presented in Table 4. As in the over-all error data, the error rate was very low. At its highest point, when star was relevant and line irrelevant, 3.47 percent of the
### TABLE 5

The Total Number of Errors and Mean Per Cent of Errors on Decks Having One Irrelevant Dimension

<table>
<thead>
<tr>
<th>DECK</th>
<th>RELEVANT</th>
<th>IRRELEVANT</th>
<th>NO. OF ERRORS</th>
<th>X% ERRORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Form</td>
<td>Line</td>
<td>4</td>
<td>0.23</td>
</tr>
<tr>
<td>5</td>
<td>Form</td>
<td>Star</td>
<td>7</td>
<td>0.41</td>
</tr>
<tr>
<td>6</td>
<td>Line</td>
<td>Form</td>
<td>28</td>
<td>1.62</td>
</tr>
<tr>
<td>7</td>
<td>Line</td>
<td>Star</td>
<td>14</td>
<td>0.81</td>
</tr>
<tr>
<td>8</td>
<td>Star</td>
<td>Form</td>
<td>53</td>
<td>3.07</td>
</tr>
<tr>
<td>9</td>
<td>Star</td>
<td>Line</td>
<td>60</td>
<td>3.47</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th>CONDITION</th>
<th>NO. OF ERRORS</th>
<th>X% ERRORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined</td>
<td>Form</td>
<td>Relevant</td>
<td>11</td>
</tr>
<tr>
<td>Combined</td>
<td>Line</td>
<td>Relevant</td>
<td>42</td>
</tr>
<tr>
<td>Combined</td>
<td>Star</td>
<td>Relevant</td>
<td>113</td>
</tr>
<tr>
<td>Combined</td>
<td>Form</td>
<td>Irrelevant</td>
<td>81</td>
</tr>
<tr>
<td>Combined</td>
<td>Line</td>
<td>Irrelevant</td>
<td>64</td>
</tr>
<tr>
<td>Combined</td>
<td>Star</td>
<td>Irrelevant</td>
<td>21</td>
</tr>
</tbody>
</table>
cards were incorrectly placed.

The data in Table 5 helps to clarify the relevant dimension \( x \) number of irrelevant dimensions interaction effect in the errors data presented in Figure 4. The one-irrelevant-dimension points in this figure, particularly those when line and star were relevant, represent means of quite disparate data, depending on which dimension was irrelevant. Also, it must be noted that the very much elevated one-irrelevant-dimension data point when star was relevant was particularly influenced by the high error rate which occurred when star was relevant and line was irrelevant. Also, reference to Table 3 shows that among the nine cases when more than four errors occurred on a given deck, five of these cases occurred when there was one irrelevant dimension and star was relevant. These five cases accounted for 45 errors.

**Trials Analysis.** Figure 8 shows the mean sorting times as a function of age and trials. A trial was defined as a deck of stimulus cards, irrespective of the nature of the deck. A three-way analysis of variance performed on these data involved the variables age (six, nine, twelve and adult), sex, and trials. The summary table of this analysis is presented in Appendix I. The results indicated that there was a significant effect of age \((F = 99.11; \text{df} = 3, 64; p < .001)\). Post hoc analysis by the Scheffé test indicated that six-year old children
Figure 8. Mean sorting times (in seconds) as a function of age and trials (decks in order of presentation.)
had sorting times significantly greater than any other age group. The mean sorting times for six-, nine- and twelve-year olds and adults were 42.35, 22.78, 29.21 and 14.34 seconds, respectively.

Also, boys sorted the cards significantly more slowly than did girls (25.70 sec. and 22.63 sec., respectively.) This sex effect decreased as a function of increasing age, and was not significant by age nine. In general, the sorting time scores tended to decrease slightly over trials.

As can be seen in Figure 8, the six-year olds' mean sorting times were more variable across trials than those of the other age groups. Interestingly, while the rise in sorting times present in six-year olds on the ninth deck is not present in the performances of older Ss, there was no significant age x trials interaction effect.

**Combined: Main and Supplementary Studies.** The data from the supplementary study was added to the data from the main study and the sorting times reanalyzed. For this over-all analysis, the subjects from the supplementary study were combined to form two groups--ages seven and eight combined, and ages ten and eleven combined--each group containing 18 Ss. In this analysis only the data from zero- and two-irrelevant-dimension conditions could be considered since Ss in the supplementary study did not sort decks containing one irrelevant dimension.
A three-way analysis of variance performed on these combined sorting time data involved the variables age (six, seven and eight, nine, ten and eleven, twelve, and adult), relevant dimension (form, line and star) and number of irrelevant dimensions (zero and two). The summary table of this analysis is presented in Appendix J. The results showed a significant effect of age ($F = 44.78; \, df = 5, 102; \, p < .001$), relevant dimension ($F = 91.41; \, df = 2, 204; \, p < .001$) and number of irrelevant dimensions ($F = 101.55; \, df = 1, 102; \, p < .001$). Again, the sorting time became progressively shorter with increasing age.

Post hoc analysis by the Scheffé test indicated that six-year olds sorted significantly more slowly than did seven- and eight-year olds, seven- and eight-year olds sorted significantly more slowly than did nine-year olds, and ten- and eleven-year olds sorted significantly more slowly than did adults. Twelve-year olds and adults did not differ significantly in sorting times. Two irrelevant dimensions significantly raised sorting times relative to zero irrelevant dimensions and the relevant dimensions were all significantly different from one another, line leading to sorting times significantly greater than those when form was relevant and significantly less than those when star was relevant.

Analysis of the combined main and supplementary studies data also revealed a significant age $x$ amount of
irrelevant information interaction effect (F = 9.28; df = 5, 102; p < .001) as shown in Figure 9. The right-hand panel of Figure 9 shows the mean difference in seconds between two and zero irrelevant dimensions, i.e., the magnitude of the interference effect, as a function of age. As can be seen, with the exception of the data point for nine-year olds, the amount of interference associated with the presence of two irrelevant dimensions decreased smoothly and dramatically as a function of increasing age. Post hoc analysis by the Scheffé test indicated that significant interference was present at the six-year old level, seven- and eight-year old levels, and the ten- and eleven-year old levels. The left-hand panel of Figure 9 is a presentation of the percent of decks in which two irrelevant dimensions produced greater sorting time scores than zero irrelevant dimensions as a function of age. In other words, the percent of cases in which interference occurred is plotted as a function of age. Each comparison involved decks having the same relevant dimension. Interference occurred in approximately 75% of the cases in ages six through twelve; then this percentage dropped to 48% at the adult level. Compared with the curve on the right, the percent of cases of interference remained nearly constant through ages six to twelve while the magnitude of the interference effect
Figure 9. Comparing by dimension, the percent of decks in which two irrelevant dimensions led to greater sorting times than zero irrelevant dimensions, as a function of age. Also, mean difference in sorting time between two and zero irrelevant dimensions as a function of age.
decreased through this age range.

In the combined main and supplementary studies' data there was also a significant interaction of age with the relevant dimension \((F = 7.60; \text{df} = 10, 204; p < .001)\); and number of irrelevant dimensions with the relevant dimension \((F = 9.10; \text{df} = 10, 204; p < .001)\). As in the main study, the differences between the relevant dimensions decreased as a function of increasing age, and increased as a function of increased amounts of irrelevant information.

Unlike the results from the main study, the analysis of the combined data revealed that the magnitude of the age x amount of irrelevant information effect varied significantly with the relevant dimension \((F = 2.33; \text{df} = 10, 204; p < .025)\). The interaction is shown in Figure 10, which presents the mean amount of interference per deck in seconds as a function of age and the relevant dimension. Post hoc analysis by the Scheffé test indicated that most of this interaction was accountable to the performance of younger Ss. In particular, among six-year old Ss, significantly more interference occurred when line was relevant compared to when form was relevant. At the seven- and eight-year old level, there was significantly more interference when line was relevant compared to when star was relevant.
Figure 10. The amount of interference per deck (in sec.) as a function of age and the relevant dimension.
Table 6 shows, for each age group in the study, the mean sorting times in seconds produced by zero and two irrelevant dimensions, the amount of interference produced by two irrelevant dimensions, and the percent of decks on which interference occurred. This data is consistent with the pattern suggested in Figure 9, that the magnitude of the interference effect declines with age while the percent of cases of interference remains high until after age twelve.

Casual observation of Ss' performances revealed that many Ss, especially the younger ones, verbalized the relevant dimension as they placed the card in the appropriate pile. It seemed that with increasing age this verbal monitoring of performance became progressively less frequent and less overt. No systematic data, however, was collected to substantiate this observation.
TABLE 6

The Mean Sorting Times (in seconds) Produced by Zero and Two Irrelevant Dimensions, The Amount of Interference, and the Per Cent of Decks on Which Interference Occurred for Each Age Group in the Study.

<table>
<thead>
<tr>
<th>AGE</th>
<th>No. IRRELEV. DIMEN.</th>
<th>INTERFERENCE</th>
<th>% 2 IRREL. DIM.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>2</td>
<td>&gt; 0 IRREL. DIM.</td>
</tr>
<tr>
<td>6</td>
<td>36.48</td>
<td>46.35</td>
<td>9.87</td>
</tr>
<tr>
<td>7</td>
<td>30.78</td>
<td>38.15</td>
<td>7.37</td>
</tr>
<tr>
<td>8</td>
<td>27.56</td>
<td>32.96</td>
<td>5.40</td>
</tr>
<tr>
<td>9</td>
<td>21.04</td>
<td>23.50</td>
<td>2.46</td>
</tr>
<tr>
<td>10</td>
<td>21.51</td>
<td>25.71</td>
<td>4.20</td>
</tr>
<tr>
<td>11</td>
<td>19.13</td>
<td>23.53</td>
<td>4.22</td>
</tr>
<tr>
<td>12</td>
<td>20.48</td>
<td>17.70</td>
<td>2.78</td>
</tr>
<tr>
<td>Adult</td>
<td>13.80</td>
<td>14.57</td>
<td>0.77</td>
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</table>
DISCUSSION

The results of this study show that when speeded classification of a visual stimulus is required, irrelevant, separable dimensions interfere with performance; and that this interfering effect progressively diminishes as a function of increasing age. This interfering effect disappears nearly entirely between age twelve and adulthood (approximately age nineteen). Furthermore, the greatest change in the magnitude of this effect was found to occur between ages six and nine. It thus appears that, with increasing age, children become progressively better able to select a wanted visual stimulus out of a complex array of visual information. This supports the results of selective attention studies using auditory stimuli (Maccoby and Konrad, 1966, 1967; Maccoby and Leifer, 1968). Also, while this phenomenon has been suggested from the results of studies using visual stimuli, this study appears to be the first unambiguous demonstration of this phenomenon that used visual stimuli.

Significant interference with classification performance occurred at ages six, seven and eight, and ten and eleven. However, a significant interference effect did not occur with nine-year old Ss. In conjunction with this absence of significant interference, nine-year old Ss made nearly as few errors as did adults, even though they
sorted the cards significantly more slowly. The reason for this inconsistency in the otherwise regular decline of interference effects with age is unclear.

It is interesting that while the magnitude of the interference effect generally decreased as a function of increasing age, the percent of cases of interference remained nearly constant from ages six through twelve, then dropped dramatically to the low adult level. It seems plausible to account for these data on the basis of the particular characteristics of this study and two developmental trends in selective attention which have already been identified in the literature. A brief digression is necessary to clarify this interpretation.

While the results of the incidental learning studies do not uniformly suggest a singular developmental pattern, many do indicate that incidental learning increases up to early adolescence (ages twelve to thirteen), then decreases. Maccoby and Hagen (1965) have argued that, until early adolescence, children take in more information than is strictly necessary, since they are in the process of learning to code, classify and label stimuli. They are thus able to report more incidental material than are adults. At approximately age twelve, children undergo a "period of development of the ability to shut out undesired stimuli" (Maccoby and Hagen, 1965, p. 288). Results
supporting this interpretation derive primarily from type two incidental learning tasks, those in which several informations compete simultaneously for processing, and also in which the same information does not change from relevant to irrelevant, or vice versa, within the experimental session.

On the other hand, numerous selective attention studies (e.g. Maccoby and Leifer, 1968) using auditory stimuli have demonstrated, and many studies using visual stimuli (e.g. Gibson and Yonas, 1966 b) have only suggested, the following phenomenon: with increasing age, irrelevant information interferes progressively less with performance. Thus, at the same time that the ability to report incidental material is increasing, an ability to shut out irrelevant information is also increasing.

It seems reasonable to conclude that having one's performance impaired by the presence of irrelevant information (as in selection tasks) is not the same thing as being able to accurately report that information (as in incidental learning tasks). Indeed, in the dichotic listening task, younger children reported more irrelevant, incidental information (that is, made more intrusive errors) than did adults.
The task in the present study appears to involve two cognitive processes: 1) finding the relevant dimension within the information array presented (stimulus selection), and 2) selecting which response category matches the particular value of the relevant dimension shown on the card (response selection). Thus, for example, if form were relevant, S would have had to both isolate the form from the line and star, and to match the particular form presented—-for instance, square—with the appropriate pile for cards with squares. The results of many incidental learning studies suggest that before age twelve Ss process the irrelevant information to a considerable extent and it is available for recall. Given the results of the present study, it might be argued that the time taken to process and select the relevant from the irrelevant information decreases as a function of increasing age. For this reason, the magnitude of the interference effect—-that is, the difference in sorting times produced by zero and two irrelevant dimensions—decreases as a function of increasing age. However, the irrelevant information is still available for recall until approximately age twelve. Since it is available for recall, it is able to interfere with response selection; thus, the per cent of cases of interference remains high until approximately age twelve. At approximately that age, children become able to block out or filter out irrelevant information, or it is processed
so little as to be available in a very degraded form at the point of response selection. For this reason the results of this study show that the percent of cases of interference drops markedly after age twelve.

This interpretation bears out Maccoby and Haven's (1965) assertion that before age twelve children process more information than is necessary to perform the task because they are learning to code, classify and label stimuli. After age twelve, children's performances are no longer affected by irrelevant information. The particular characteristics of this study, which involved both stimulus selection and response selection, enabled two processes to be reflected in the results: 1) the magnitude of the interference effect decreased with increasing age, while 2) the percent of cases of interference remained high until approximately age twelve.

This interpretation places considerable emphasis on the percent of cases of interference. The magnitude of the interference is not reflected in this measure. Two different measures of interference—one based on the difference between sorting times and the other based on the percent of cases of one sorting time being greater than another sorting time—have been shown to vary differently as a function of age. These different functions are here interpreted as reflecting different psychological processes. However, the different functions
may simply reflect differences in the sensitivities of the measures. This remains a possibility warranting further clarification.

Girls' sorting time scores tended to be lower than those of boys, though a significant sex difference occurred only in Ss younger than nine years. At no age did the sexes differ in the number of errors committed; and, more important, at no age did the sexes differ in the amount of interference from irrelevant dimensions.

The data showing that girls tended to sort the cards more quickly than did boys is consistent with the well-documented finding that girls, from early childhood on, perform more quickly and efficiently on tasks involving manual dexterity. Girls usually sit up, crawl and walk before boys do (Hutt, 1972); learn to dress themselves earlier than do boys (Tyler, 1965); show superiority on the O'Connor Finger Dexterity Test and Purdue Pegboard (Garai and Scheinfeld, 1968); and score significantly higher on performance tasks of the Stanford-Binet (McNemar, 1942). Female superiority in manual dexterity has also been demonstrated in other cultures (Thanga, 1955). Anastasi (1958, p. 471) concluded: "Female advantage in manual dexterity and in speed and control of fine movements ... may arise initially from the developmental acceleration of girls."

While there has been considerable discussion of
sex differences in the nervous system (e.g., Nash, 1970)
o no consistent data exist in the literature which would
have predicted sex differences in the amount of inter-
ference caused by irrelevant information. While some
evidence does suggest significant female superiority
on specific abilities such as word fluency and rote
memory, and significant male superiority in abilities
involving spatial relations (e.g., Hobson, 1947; Herzberg
and Lepkin, 1954), it seems that these findings do not
readily apply to this task. On the other hand, from
the results of their selective attention task which
used simultaneous auditory inputs, Maccoby and Leifer
(1968) concluded that "it would appear that sex differ-
ences do not lie in the perceptual functions involved in
identifying a brief auditory stimulus in a noisy background."
The results of this study, which used visual stimuli, con-
firm this conclusion.

The results also showed that the nature of the relevant
dimension was very important in determining the sorting
times of younger Ss, and lost influence with increasing age.
The results, which show form more potent as a relevant dimen-
sion, especially with younger Ss, concur with results of
dimension preference studies with children (Lee, 1965) that
indicate that a preference for form emerges about age six.

Clearly, sorting time is a joint product of the
nature of both the relevant and the irrelevant dimensions.
If irrelevant information is present, knowledge of either the relevant or irrelevant information alone does not permit accurate prediction of sorting time. Furthermore, the potency of a dimension as a relevant dimension (i.e., its ability to resist interference) does not necessarily predict its potency as an irrelevant dimension (i.e., its ability to cause interference.) A logical argument derived from the results of this study demonstrates these points. When form was relevant, line and star were equally impotent as interfering dimensions. Without respect to the nature of the relevant dimension we might say that line and star were equal in their potency as irrelevant dimensions. When line was relevant, form had a greater interfering effect than did star. When star was relevant, line had a greater interfering effect than form. Referring only to the potency of the irrelevant dimension, if the interfering potency of star was the same as that of line, then form could not simultaneously have a potency both less than and greater than that of form. These results are congruent with the hypothesis of Cohen (1969) that the variables affecting the potency of a stimulus to attract attention (as, for example, an irrelevant dimension) may be different from those variables affecting the potency of a stimulus to hold attention (as, for example, a relevant dimension.) As Cohen suggested, these variables may be related to different
psychological processes.

The results of the present study also suggest that, with increasing age, the nature of both the relevant and the irrelevant information became less influential in determining sorting times. This seems to confirm a general pattern in the development of attention, that with increasing age attention is less subject to the control of specific characteristics of stimuli and more subject to control from internal information processing. Gibson (1969, p. 456-457) has expressed this as: "the tendency for attention to become more exploratory and less captive," more "voluntary" and less "wandering"; in short, a trend "toward optimizing the active search for information in the world of stimulation" (italics, mine.)

Irrelevant information did not significantly alter the performances of adult Ss. On many occasions within the experimental session, the dimensions exchanged status between relevant and irrelevant, so that the opportunity for interference from competing responses was maximal. As mentioned earlier, no evidence was found suggesting that this interference occurred. Since this study employed separable dimensions, the results confirm those of Garner and Felfoldy (1970), who found adults impervious to interference from irrelevant, separable dimensions.
The main findings of this study may seem to represent simply another demonstration of an already established phenomenon about perceptual development. Indeed, it is commonplace for parents, teachers and child psychologists to say that children are more distractable than are adults. Referring to visual perception, this phenomenon has, however, been suggested from data which are open to other interpretations. These results present a relatively unambiguous demonstration of an age x amount of irrelevant information interference effect. Also, the card sorting task used in this study is simple to set up, is easy even for the younger child to perform, yields relatively clear data, and offers considerable flexibility.

Much careful research remains to be done to discover further factors in the development of selective attention. Agan (1970, p. 832) has written:

"The acquisition of conditioned responses, the potentiation of inborn capacities and the development of cognitive structures all have been mechanisms to explain growth, yet each of these depends upon selective attention to sensory events. Better understanding of the course of development and underlying mechanisms of selective attention is important in our general understanding of the nature of psychological growth."
References


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LIST OF APPENDICES

A. Initial instructions presented to subjects eight years and younger 85
B. Initial instructions presented to subjects older than eight years 86
C. Instructions to all subjects before each deck of cards 87
D. Summary table of the analysis of variance (ANOVA) performed on the sorting times in the main study 88
E. Summary table of the ANOVA performed on the corrected sorting times in the main study 89
F. Summary table of the ANOVA performed on the error data from the main study 90
G. Summary table of the ANOVA performed on the sorting times which occurred when there was one irrelevant dimension 91
H. Summary table of the ANOVA performed on the number of errors which occurred on the decks containing one irrelevant dimension 92
I. Summary table of the ANOVA performed on the sorting times across trials 93
J. Summary table of the ANOVA performed on the sorting times of the combined main and supplementary studies 94
Initial Instructions Presented to Subjects Eight Years and Younger

This is a game. Here is a pile of cards (shown to S) and I want you to make two piles of cards. It is very important to go fast. (E turns over first card). Every card has a dot in the center and a black line at the top. Now, all the cards with red on them go here (E points to the area in front of one of the stands and inserts the red display card) and all the cards with green on them go here (E points to the area in front of the other stand and inserts the green display card). Remember, go as fast as you can but try not to make mistakes. If you put a card in the wrong pile, don't change it to the other pile, but go as fast as you can with the rest of the cards. If you do them fast enough you'll win a prize. Do you understand how the game works?

OK, let's try it with these red and green cards. (E puts the deck of cards face down in front of S). Put your hands beside the cards and when I say "Go", pick up all the cards, turn them over in your hand and put the cards in the right place as fast as you can. OK? Ready? GO!
APPENDIX B

Initial Instructions Presented to Older Subjects (older than eight years)

This is a game in which you must sort a deck of cards into two piles as quickly as you can. Each pile goes in front of one of these two stands (E points to stands). A card which will be put on the stand will tell you which cards go in that pile. (E turns over the first card.) Every card has a dot in the center and a black line at the top. With this first deck of cards, if the card has red on it, then put it in front of this stand (E points and inserts red display card). If the card has green on it, then put it in front of this stand (E points to other stand and inserts green display card). Remember, speed is very important. Work as fast as you can without making mistakes. If you do make a mistake and throw a card in the wrong pile, you can't go back and put it in the other pile. Push ahead with the other cards. Do you have any questions?

Let's try it with these red and green cards. (E puts the deck of cards face down in front of S.) Put your hands on top of the cards and when I say "Go", pick up all the cards, turn them over and begin sorting them into the right piles as fast as you can.

OK? Ready? GO!
APPENDIX C

Instructions to All Subjects
Before Each Deck of Cards

Very good. . . . Here are some different cards. (E brings out the next deck.) This time, if there is a _____ on the card (E names dimension), then it goes in this pile (E points and inserts display card); and if there is a _____ on the card (E names other value), then it goes in this pile. (E points and inserts display card.) Remember, work as fast as you can without making mistakes.

OK? Put your hands on top of the cards. Ready? GO!
## Appendix D

Summary table of the analysis of variance (ANOVA) performed on the sorting times in the main study.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
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<td>3</td>
<td>23967.4821</td>
<td>95.25</td>
<td>$p &lt; .001$</td>
</tr>
<tr>
<td>S</td>
<td>2755.5001</td>
<td>1</td>
<td>2755.5001</td>
<td>10.95</td>
<td>$p &lt; .005$</td>
</tr>
<tr>
<td>I</td>
<td>1810.0017</td>
<td>2</td>
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A = Age (six, nine, twelve and adult)  
S = Sex  
I = Number of irrelevant dimensions (zero, one and two)  
D = Relevant dimension (form, line and star)  
N = Subjects
Appendix E

Summary table of the ANOVA performed on the corrected sorting times in the main study.

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<td>p &lt; .001</td>
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A = Age (six, nine, twelve and adult)
S = Sex
I = Number of irrelevant dimensions (zero, one and two)
D = Relevant dimension (form, line and star)
N = Subjects
Appendix F

Summary table of the ANOVA performed on the error data from the main study.

<table>
<thead>
<tr>
<th>Source</th>
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<th>df</th>
<th>MS</th>
<th>F</th>
<th>Significance</th>
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A = Age (six, nine, twelve and adult)
S = Sex
I = Number of irrelevant dimensions (zero, one and two)
D = Relevant dimension (form, line and star)
N = Subjects
Appendix G

Summary table of the ANOVA performed on the sorting times which occurred when there was one irrelevant dimension.

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A = Age (six, nine, twelve and adult)
S = Sex
X = Deck containing one irrelevant dimension
Appendix H

Summary table of the ANOVA performed on the number of errors which occurred on the decks containing one irrelevant dimension.

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A = Age (six, nine, twelve and adult)
S = Sex
X = Deck containing one irrelevant dimension
Appendix I

Summary table of the ANOVA performed on the data across trials.

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A = Age (six, nine, twelve and adult)
S = Sex
B = Trials
### Appendix J

Summary table of the ANOVA performed on the sorting times of the combined main and supplementary studies.

<table>
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A = Age (six, seven and eight, nine, ten and eleven, twelve, and adult)

I = Number of irrelevant dimensions (zero, one and two)

D = Relevant dimension (Form, line and star)