RESEARCH BULLETIN

THE DEVELOPMENT OF ATTENTION IN CHILDREN

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THE DEVELOPMENT OF ATTENTION IN CHILDREN[1]

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The ability to attend selectively to critical stimulus features and ignore others is an integral part of the learning process, and it is necessary to understand the development of this ability in order to establish an adequate model of children's learning and thinking. We have examined the development of selective attention through research on children's incidental learning--that is, the acquisition of information that is extraneous or irrelevant to task performance. The original research paradigm was derived from Broadbent's (1958) model which states that a filtering mechanism causes certain information in a subject's environment to be attended to while other information is ignored. The former is held in memory briefly before being passed through filters for further processing, while the latter does not pass through the filters and fades from memory. More recent analyses by Neisser (1967), Treisman (1969), and others have expanded upon Broadbent's relatively simple filtering concept, but the essential aspect of the model, the principle of attention to selected stimulus features at the expense of others, remains useful.

We have employed a paradigm in which certain features of the stimulus are designated as relevant for task performance and others are defined as incidental. Performance on this central task is assessed as well as later recall of information about the incidental stimuli, and these two measures together provide a basis for inferring selective attention. High incidental learning is assumed to reflect a high degree of attention to incidental cues;

on the other hand, low incidental learning, in combination with high central performance, indicates selectivity in attention--that is, attention directed primarily to task-relevant rather than irrelevant stimuli. We made two developmental predictions based on the model of selective attention. First, improvement in memory with increasing age will occur at least in part because of increasing ability to attend to specific cues and to ignore others. Second, under information overload conditions, incidental information will be "given up" to maintain adequate performance on the central task, and this "trade-off" will become more evident as children grow older.

Initial Studies

In a study in collaboration with Eleanor Maccoby (Maccoby & Hagen, 1965), arrays of picture cards were used in the central-incidental task. Each card depicted a common object such as a toy train or a scooter with a background of a distinctive color. There were fourteen arrays, varying in length from four to six cards. Each array was shown briefly and was followed by presentation of a cue card in a solid color, identical to the background color of one of the cards in the array. The child's central task was to locate the position in the array of the card that matched the color of the cue card. After the fourteen picture arrays were presented and the number of correct matches was recorded, the incidental task was presented. In this task the child was asked to match the pictures which had appeared on the previous trials with the appropriate color of background. Each picture had always appeared on the same background color. The number of correct matches constituted the subject's incidental learning score.

Information overload was produced by including a distractor task. At each age level half the children performed the task in the distraction condition, which consisted of a tape recording of piano notes. Whenever a note occurred which was obviously lower in pitch than the others, the child was required to tap the table. The subjects were 7, 9, 11, and 13 years of age.

The results are easily summarized. The central memory task scores increased regularly as a function of age, but the incidental scores did not; they actually declined at the oldest age level. Thus, the hypothesized developmental improvement in selective attention was found: with increasing age, the children devoted more attention to the task-relevant than to the incidental information. The second prediction, concerning the effects of information overload, did not fare as well. This manipulation--requiring the subject to listen for an auditory stimulus--affected mainly the central scores, which were reduced by about the same amount at all ages. Incidental learning was impaired by distraction at age 13 but not at the other age levels, so that only for the oldest children was there any evidence for "giving up" of incidental information in the face of overload conditions.

In a second study (Hagen, 1967) two modifications were made to eliminate certain problems with the first study and to provide further evidence regarding the hypotheses. New stimulus materials were used, and these have served as the prototypic materials for much of the subsequent research. Each card pictured two objects, an animal and a household object (see Figure 1.) Pretesting had revealed that with the original stimuli

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Insert Figure 1 about here

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incidental learning of the background colors did not occur if the central task was to recall the objects themselves. The new stimuli permitted counterbalancing of central and incidental picture sets. For half the subjects, the central task was to recall locations of animals; for the other half, the task was to recall locations of household objects. In both cases, incidental learning was measured by asking the child to indicate the household object that had been paired with each animal during the central task.

The second modification was the inclusion of a series of trials in which only one picture appeared on a card. This condition was introduced to obtain developmental norms of task performance in the serial-position recall task, and to discover if the mere presence of the incidental pictures on the cards affected central task performance. As before, the subjects were 7-, 9-, 11-, and 13-year-old children.

As in the previous study, central task performance improved with age but incidental performance did not (see Figures 2 and 3). The effects of

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Insert Figures 2 and 3 about here

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distraction were also similar to those observed in the previous study. Central performance was lower when distraction was present than when it was absent, and this effect was about equal across age levels. Incidental performance, however, was impaired only at the oldest age level. The task with one picture per card produced higher central performance than did the standard condition at all ages, demonstrating that the presence of the incidental picture impaired central task performance. Thus, regardless of the degree to which the incidental features are processed, their mere presence makes the central recall task more difficult for children in this age range.

Several conclusions can be drawn from the results of these studies. First, the improvement in central recall with age without improvement in incidental recall indicates a developmental increase in efficiency of selective attention as hypothesized. As children approach adolescence, they tend to focus on aspects of stimuli that are critical for task performance at the expense of processing extraneous information. Second, the hypothesis about the effects of information overload may have to be reexamined, since the auditory monitoring task did not produce a greater impairment of incidental than of central performance. Thus the effects of the distractor cannot, strictly speaking, be interpreted in terms of information trade-off, a giving up of incidental information in favor of central information. Still, there is some indication that the oldest children performed most efficiently in the presence of information overload, since only these children gave up irrelevant as well as task-relevant information when the distractor was present.

In the second study, correlations were obtained between central task and incidental task scores, which indicate differences between the younger and older children's task performance. At the younger age levels, the correlations were positive, but at the oldest age level the correlation was negative. Among the younger children, then, those who performed well on the central task also showed a high degree of incidental learning, but among the oldest children, those who did well on the central task did poorly on the incidental measure. We shall return to these correlations, but at this point we note that by age 12-13 years, children's performance on the central memory task appears to be maintained in part by excluding incidental or task-irrelevant information.

Related evidence. The results of two other studies that appeared in the literature about the same time as ours provide further evidence for a developmental change in children's selective attention. Crane and Ross (1967) presented children with a visual discrimination learning task that contained both relevant and irrelevant dimensions. After the initial discrimination had been acquired, additional practice was given during which both dimensions were usable. As measured by a subsequent transfer task, second graders were found to be using both dimensions whereas sixth graders attended primarily to the originally relevant dimension. Siegel and Stevenson (1966), also using a discrimination task, found incidental learning to increase between ages 7 and 12 years but to decline between ages 12 and 14 years. It would seem that a developmental pattern can be discerned: incidental learning does not improve monotonically with increasing chronological age; rather, incidental learning either increases or remains stable up to about 12-13 years and then it declines. The initial hypothesis--that improvement with age in central task performance occurs in part because of improved skill in ignoring irrelevant information--is consistent with these findings.

The Role of Stimulus Factors

Integration of pictorial components. Having found that children's efficient use of selective attention increases with age, we began to look for the reasons behind younger children's inefficiency in deployment of attention. One hypothesis is that younger children have difficulty analyzing stimuli into components, and thus they maintain attention to all features as a global unit. In the studies discussed thus far the central and incidental features of the stimuli have been depicted together. Under such conditions young children may attend to both features together as a single unit while older children attend to the components separately. In the next studies to be considered, the relation between the central and incidental features was varied--toward lesser or toward greater integration of components. These manipulations were intended to affect the degree to which the stimuli were amenable to analysis into components. By observing variations in performance with these several types of material, it was possible to determine whether younger children's nonselective approach is induced by specific types of stimuli or whether it is a general characteristic of children's orientation to multifaceted stimuli.

In a study by Druker and Hagen (1969) the animal-and-object cards were used, but the arrangement of the central and incidental pictures was changed from that in previous studies in two ways. First, the two pictures on each card were presented spatially separated from each other, and this arrangement was compared to the usual contiguous arrangement. Second, the pictures were presented in a nonalternating fashion, such that the central picture always appeared above the incidental picture, and these stimuli were compared with the standard materials in which the central picture appeared above the incidental feature in only half the stimulus pairs. Both of these changes were intended to facilitate discrimination of the two features for the young children and to allow them to focus more exclusively on the task-relevant information, thereby reducing their level of incidental learning more than older children's. The results, while indicating an overall effect of stimulus spacing on amount of incidental learning (but no effect of nonalternation), did <u>not</u> show differential effects for children of ages 9, 11, and 13. The basic developmental results therefore were not altered by these attempts to facilitate identification of the task-relevant features.

Sabo and Hagen (in press) also tried to assist younger children in identifying the relevant information by presenting the central and incidental pictures in different colors. In comparison with the standard material, the presence of color did improve the children's simple recognition of the stimuli, but the facilitation was no greater for younger than older children. Also, the presence of color did not affect the amount of incidental learning.

Thus far we have found that attempts to reduce the integration of components and make the stimuli more amenable to analysis have had little effect on the basic developmental results. Hale and Piper (unpublished study) used stimuli in which the integration of pictorial components was increased and they also found little developmental effect. The animal and object pictures were similar to those of the studies just discussed but in two conditions these pictures were shown in various action relations. Performance in these conditions was to be compared with performance in the standard condition in which the animals and objects were pictured separately. It was reasoned that if the animal and object in each stimulus were presented together to form a unitary scene, then older as well as younger children would view the stimuli as integral wholes and would maintain attention to both features of the stimuli. Thus, the degree of incidental learning should increase with age along with the degree of central task learning. This expectation was not borne out, however. Children shown the action stimuli exhibited more incidental learning than those shown the standard materials, but this effect was more pronounced at age 8 than at ages 11 and 14 in one experiment, and was approximately equal at ages 8 and 14 in a replication experiment.

Subsequent analyses have suggested (Hagen, 1972; Maccoby, 1969) that incidental learning is determined by a two-stage sequence of information processing, such as that proposed by Neisser (1967). In the present context the first stage may be regarded as the initial discrimination of relevant and irrelevant material. Certain information is then selected for further processing, and only that material which becomes the object of one's attention is stored in memory for later retrieval. According to this model, the inefficiency of information processing attributed to young children could reflect either a failure at the initial discrimination stage or a deficiency in maintaining attention to relevant information. Although there actually may be developmental improvement at both stages, we believe that the primary changes in attention observed in the research on incidental learning reflect age differences in performance at the second stage, after the subject has performed the initial discrimination of relevant and irrelevant information. Support for this conclusion is provided by the studies on stimulus factors just discussed. The developmental trend toward greater use of selective attention remained clearly evident despite all of the attempts to increase or decrease the degree to which the stimuli were amenable to analysis into components. Thus, it is unlikely that the inefficient performance of younger children merely reflects a deficiency in initial discrimination of components.

Presence versus absence of incidental features. A second piece of evidence for this conclusion involves the effects on performance of the presence versus absence of incidental cues. If the younger child's inefficient performance were the result of difficulty in initial discrimination of relevant and incidental features, then removing the incidental cues should improve performance to a greater extent for younger than for older children. In the Hagen (1967) study, removing incidental cues did result in improved performance, but not to a greater degree at one age level than any other. Apparently, children require some time for separation of relevant and extraneous features, but the effort expended at this initial stage of information processing may not differ markedly across age levels.

Why is incidental information not ignored completely? Are incidental features noticed because they have some functional relation to central features, or are they simply picked up because they are there? Evidence bearing on this question is provided by Hagen and Frisch (1968), who examined central task performance as a function of the way in which the central and incidental pictures were paired. In the standard task, each incidental picture was paired with the same central picture across trials. In a second condition, each incidental picture was paired with a different central picture on different trials. In a third condition, the incidental pictures presented on a given trial were all identical. Thus, only in the first condition was there a consistent relation between the central and incidental pictures. No differences in central task performance were observed among these three conditions for any age group. The findings from these two studies, then, suggest that the distracting effect of incidental features can be attributed to their mere presence, and the incidental information need not have any functional relation to the central stimuli.

An anomalous result. The data discussed thus far are from tasks using pictorial materials, and the developmental results show remarkable consistency in spite of wide variation in the nature of the stimuli used. One type of material, however, has been found to produce different results. Hale and Piper (in press) used the central-incidental task with colored shapes as stimuli. The shape of each stimulus constituted the central feature and color the incidental feature. With these materials, both central and incidental scores were found to increase markedly between ages 8 and 12. When the stimuli were line drawings of animals and objects, however, incidental learning did not increase with age but remained relatively constant as found in previous experiments.

In another experiment, also with children of ages 8 and 12, the developmental increase in incidental learning was demonstrated again with colored shapes; however, no age differences were observed when the shape and color formed a figure-ground relation (Hale & Piper, in press). In the latter case, the stimuli were shape outlines on colored backgrounds, with the color visible both within and surrounding the shape. The locus of the incidental information was thus roughly equated in these two tasks, so that the differences in results cannot be attributed to factors related to orientation of sense receptors. That is, as the children viewed the shapes their gaze was necessarily directed to the color in both cases. The differences in results, therefore, appear to be a function of the relation between the central and the incidental information. For the colored shapes, the incidental information was integrally contained within the central stimulus elements, while for the shapes on colored backgrounds, the incidental information was independent of the central feature.

These unusual results may be interpreted with reference to the two-stage model discussed previously. It is assumed that pictorial stimuli of the type used in earlier studies are readily analyzable into components. That is, even when the central and incidental elements are depicted together, each still may be recognized as an entity independent of the other. The same is true of materials whose components form a figure-ground relation. When stimuli are thus readily analyzable, the initial process of discriminating task-relevant and incidental components is facilitated. The effort required at this first stage is minimized, and the subject can proceed easily to the next stage and focus his attention on the relevant information. However, when the components are attributes that are not naturally regarded as separate entities, such as the shape and color of an object, then considerable effort must be expended in the initial discrimination process. Under such conditions it actually may be more efficient to maintain attention to all features of the stimulus, whether relevant or not, than to try to discriminate the relevant and irrelevant features. Apparently the older subjects did the former, as indicated by their relatively high level of incidental performance as well as of central performance with the colored shape stimuli. In summary, it is believed that the developmental trend toward greater use of selective attention involves a stage of information processing beyond the initial discrimination of components, and this developmental change is most evident when the effort required at the discrimination stage is minimized. If these conditions are not met, as when the central and incidental features are more naturally viewed as integral parts of a unit, then even older children may find it too difficult, or perhaps too inefficient, to employ selective attention.

Degree of Training

We have shown that, with certain types of material at least, early adolescents exercise selective attention to a greater degree than younger children. Are the older children exercising selection maximally from the outset, or do they attend more selectively as the initial experience with the task indicates such an approach to be most efficient? Baker (1970) presents evidence in support of the latter alternative. She assessed incidental learning with either an eight- or sixteen-trial task and found that, for children of ages 8 and 10, the incidental learning scores were greater following sixteen than eight trials, while no difference was observed for 12-year-olds. The younger children thus maintained attention to the incidental features of the stimuli and continued to acquire information about them. The oldest children, on the other hand, acquired incidental information primarily in the first eight trials. For these early adolescent subjects, apparently, attention was least selective at the outset of the task, permitting some incidental learning to occur over the initial trials; then attention became more selective as the task progressed, allowing little learning of incidental stimulus features to take place during the latter portion of the task. It is clear, then, that these subjects do not enter a learning situation with a predisposition to attend selectively. Rather, their approach is efficient in a more general sense; they are flexible and can adapt their strategy after experience with the task dictates the most effective means of attention deployment.

Degree of training can also be defined in terms of the level of learning a subject has reached--that is, the relation between his performance and a specified criterion of learning. Defined in this manner, degree of training has received considerable theoretical emphasis (e.g., Lovejoy, 1965; Mackintosh, 1965; Trabasso & Bower, 1968), and various positions have been taken regarding changes in attention before mastery of a learning task, and regarding the effects on attention of overtraining (see Houston, 1967; James & Greeno, 1967). Hale and Taweel (1972) examined the effects of degree of training on children's performance in a component selection task--a measure related to the incidental learning task. The task consisted of two phases, an initial learning phase and a posttest. In the initial phase the children were required to learn the spatial positions of stimuli that differed on two redundant dimensions, color and shape.[2] In the posttest, the child was shown a number of cards, each containing only a shape or only a color, and was asked to identify the position in which each had appeared. All of the shapes and colors were presented in the test, and scores indicating the number correct for each of these two components were obtained. It was assumed that the amount of information retained about each stimulus component reflected the degree to which attention had been directed to that feature during learning. The paradigm was thus similar to the incidental learning task but with two critical differences. First, neither feature of the stimuli in the component selection task was defined as central or incidental, since the task was intended to measure a subject's natural disposition to attend selectively rather than his ability to attend to externally defined relevant information. Secondly, the stimuli remained in the same positions throughout the initial phase of the task, so that the subject could be trained to a specified criterion of performance before administration of the posttest.

Hale and Taweel's subjects were 4, 8, and 12 years of age; at each age level subjects were assigned to one of six different groups. These groups were given different amounts of training ranging from undertraining to overtraining on the initial phase of the task. Performance on the posttest was compared for the six groups, and two effects were of interest. First, the scores for both the shape and color components increased markedly across all degrees of undertraining, suggesting that attention was directed to both components of the stimuli as the task was learned. Second, there was little increase in these scores with overtraining, indicating that the post-criterion exposure produced a negligible amount of additional stimulus learning. This last result contradicts those models which predict that overtraining will "broaden" attention and produce increased acquisition of stimulus information (e.g, James & Greeno, 1967). Rather, the results are consistent with a model such as that of Trabasso and Bower (1968), which assumes that attention is <u>least</u> selective during the premastery stages of learning and becomes most selective during a period of overtraining. Particularly interesting from a developmental standpoint is the fact that no marked age differences were observed in the pattern of results. For learning situations of this type, then, a model assuming that attention becomes maximally selective following mastery of the task is appropriate for children throughout the range from preschool age to early adolescence.

Although methodological differences preclude a direct comparison of the two studies just discussed, some integrative remarks may be made. In Baker's study, only the oldest subjects adopted a more selective approach with increased training, in that only these subjects failed to show much incidental learning during the latter portion of the task. For all age levels in Hale and Taweel's study, however, attention was most selective during the final trials of the task. The most reasonable explanation for this difference lies in the tasks used. The latter study used a task in which a criterion of performance could be specified, and continued trials beyond that point constituted overtraining. The nature of the task changed when criterion was attained, in that the subject no longer needed to learn the correct responses (positions of the stimuli) but only to continue responding correctly. This change in the task may have been partly responsible for the children's assuming a more selective approach with extended training. The central-incidental task, on the other hand, is not actually a learning problem but a series of short-term memory measures. Since each trial is independent of the next (the stimulus arrangement is altered each time), theoretically the task could be continued indefinitely with no change in the nature of the task analogous to that associated with the attainment of criterion in a learning problem. In the absence of such changes, younger children perseverate in a nonselective approach to the stimuli. Older children, however, are able to modify their method of attention deployment on their own initiative as they determine that a selective approach is most efficient in an incidental learning task.

Component Selection versus Incidental Learning

We have stressed that employment of selective attention is the most efficient approach to use in an incidental learning task. This, of course, derives from the fact that one component of the stimuli is defined as relevant in this situation, and attention to other features is nonfunctional; children become increasingly proficient in attending selectively under these conditions as they grow older. It is of interest to ask, then, whether a similar developmental trend will be observed if children are allowed to discriminate among stimuli in whatever way they choose, rather than being required to focus on a single feature. To phrase the question in another way, is there an increase with age in children's natural inclination to exercise selective attention, or is this simply a strategy that older children employ in situations such as an incidental learning task where selective attention is functional?

In addressing this issue, Hale and Morgan (in press) used a component selection task similar to that used in the study by Hale and Taweel (1972). Children's performance on this task was compared with their performance on two variant conditions in which a single stimulus feature was designated as relevant. Colored shapes were used, and subjects in one variant condition were told at the outset to attend to the shapes of the stimuli in preparation for a subsequent test. In the second variant condition, the subjects were required to attend to shape in order to learn the initial phase of the task. In the standard condition, of course, no reference was made to the dimensions of the stimuli during the learning phase. The posttest was identical for all groups and produced two scores indicating recall for the positions of the shapes and colors, respectively.

In one portion of the study, involving 4- and 8-year-olds, the results were found to differ across the three tasks. Recall for information about the shapes was uniformly high; recall for color information increased with age for the component selection task but not for either of the variants. Thus, the developmental trend in attention to this secondary color component depended on whether this component was defined as incidental, as in the variant conditions, or was a redundant feature whose status was undefined, as in the component selection task. These results indicate that it is appropriate to view these two situations as tapping different processes. That is, it is necessary to distinguish between the process of attention to experimenter-defined relevant information, on the one hand, and the natural inclination to attend selectively, on the other. When 8- and 12-year-olds were compared no age difference was observed in the shape or color scores for either the standard or the variant conditions. Thus, this distinction appears most applicable to children in the years before middle childhood. To determine the reliability of these results, Hale and Taweel (unpublished study) focused on the 5- to 8-year age range. Using a variety of stimulus materials, they manipulated the relevance of stimulus components in a manner analogous to that of the previous study. The earlier results were essentially replicated, with a developmental increase in recall for secondary stimulus information occurring primarily where such information was redundant but not designated as incidental.

Although the research on component selection is still in its early stages, two major conclusions seem warranted at this time. The first, as already noted, is that it is useful to distinguish between attention to externally defined critical features and the natural disposition to attend selectively. The other conclusion is that this distinction is applicable to children between preschool age and middle childhood, well below the ages of children used in the incidental learning research. Thus far, we have emphasized the attentional inabilities of children in middle childhood relative to adolescence, but there is considerable development of attentional capabilities before this age as well. One might best describe the particular ability reflected in the results just discussed as the capacity to accommodate to the attentional demands of the situation. In the component selection task, a redundant secondary feature can serve as a cue for discriminating among stimuli; attention to this cue can be advantageous in such a situation. When this component is defined as incidental, however, to ignore it in favor of attention to other stimulus features is more adaptive. With increasing age children apparently become better able to differentiate between these situations and respond accordingly. Thus, older children are more likely to employ selective attention and to ignore secondary stimulus features when these features are defined as incidental than when they constitute useful redundant information. Clearly, there are developmental increases not only in children's ability to attend selectively but in their ability to determine when it is most appropriate to employ selective attention.

The Development of Task Strategies

We have considered how children react to variations of stimuli and procedures in the incidental learning task. It is apparent that these responses vary with age level and with specific stimulus properties. A possible explanation for certain cues being learned and remembered at particular age levels,when others are not, might be that older children use particular types of strategies for stimulus encoding and storage which account for their better central task performance at the expense of incidental learning.

Verbal rehearsal. The use of verbal rehearsal as a mnemonic strategy was examined by Hagen, Meacham, and Mesibov (1970). Previously, Hagen and Kingsley (1968) found that requiring children to say aloud the names of the pictures affected recall differentially at different age levels. For children in the 6-8 year age range recall was facilitated by such naming but for 10-year-olds no change in recall occurred. In Hagen et al.'s (1970) study the children were 9 through 14 years of age, a range in which changes in selective processing had been found to occur (e.g., Druker & Hagen, 1969; Hagen, 1967; Maccoby & Hagen, 1965). Hagen and Kingsley (1968) had concluded that by the age of 10 children were able to use verbal rehearsal to facilitate recall and that simply labeling the stimuli interfered with rehearsal. Thus, the children in Hagen et al.'s study were all old enough to employ verbal rehearsal; the purpose of the study was to look for further increases beyond this age in use of rehearsal, to discover if the use of such an encoding strategy played a role in the observed age differences in selective attention. At each age level, overt labeling was required for half the subjects.

The results were as follows: Labeling did not affect either central or incidental performance overall. However, the serial position curves for the central scores showed that, at all age levels, naming lowered primacy recall but increased recency recall, a pattern similar to that found for 10-year-olds by Hagen and Kingsley. It appeared that the required overt naming of the pictures interfered with spontaneous rehearsal of the to-be-remembered items; and hence, recall for primacy items, those presumably most facilitated by rehearsal, was impaired. We shall not go into detail of the rationale for the argument that verbal rehearsal plays a key role in serial recall. At this time, it is sufficient to say that, given the apparent uniformity found across the 9-14 year age range in children's use of rehearsal, the central-incidental interaction with age, once again replicated in this study, cannot be attributed simply to developmental changes in the use of such rehearsal strategies.

Correlational evidence. If the developmental trend toward greater use of selective attention is not attributable to increasing use of verbal encoding strategies, then are there other kinds of strategies that might be involved, which older children are more likely to employ in this situation? We have noted that older children tend to adjust their responses to task demands more than younger children, reflecting an adaptability or flexibility in their approach to the stimuli. Further evidence that older children are employing a task-appropriate strategy derives from the correlations available from these studies. There are two types of correlations to consider: that between central and incidental scores, and correlations of these task measures with other indices of cognitive aptitude. We have mentioned one study (Hagen, 1967) in which central and incidental scores have been found to correlate positively at younger ages and negatively at older ages. Similar effects have occurred under certain conditions in other studies as well (Druker & Hagen, 1969; Hagen et al., 1970). At the younger age levels, then, those children who perform better in one task also perform better in the other. Beyond a certain age, however, those who perform well on the central task do poorly on incidental learning and vice versa. It would appear that, for older subjects, success in task performance is accomplished partly through inhibition of attention to the incidental cues--clearly the more efficient strategy to employ in this task.

It is interesting to note that the negative correlation between central and incidental learning for the oldest subjects was most pronounced in the nondistraction conditions in the Hagen study and in the no-label condition in the Hagen, Meacham, and Mesibov study. Labeling may be considered to be a type of distractor in the latter case, in that it impaired primacy recall. Then, in general, the trade-off of central for incidental information is less evident in the presence of distraction than in its absence. In other words, although older children typically ignore incidental features in order to facilitate performance, this strategy is disrupted when external factors such as noise or imposed labeling are included.

The central and incidental scores have also been correlated with standardized measures of intelligence (e.g., Druker & Hagen, 1969; Hagen, 1967; Hagen et al., 1970). With increasing age, the correlations between central performance and intelligence have generally increased in magnitude. Incidental scores, however, have shown only very low correlations with intelligence and no discernible pattern. In Hagen et al.'s (1970) study of verbal labeling, a second experiment was conducted with college students for whom scores from the Scholastic Aptitude Test (SAT) were available. For the condition in which no verbal labeling was required, both the mathematical and verbal scales of the SAT correlated positively with central recall (Verbal, .38; Mathematical, .51) but not with incidental learning. For the labeling condition, the correlations were near zero, so that the relation between mental ability and central task performance was not apparent when verbal labeling was required. Externally imposed conditions seem to diminish whatever advantage is gained from high mental ability. In general, where significant correlations were found with measures of mental ability, they involved central and not incidental performance; and they were more likely to be found among older than younger subjects. Thus, additional evidence is provided for the notion that central task performance and incidental learning, especially for older children, involve relatively independent processes.

Attention in Retarded Children

The discussion thus far has focused on age differences in incidental learning and implications for the development of selective attention in normal children. In other studies we have looked at variation in selective attention as a function of mental age in retarded children, a population described as deficient in attention (Zeaman & House, 1963). In the first study (Hagen & Huntsman, 1971), the central-incidental task was administered in its standard form. The pattern of results observed for the retarded children was very similar to that of the normals, in that central task performance increased across _MA_ levels while incidental learning remained relatively constant. Further, when retardates were compared to normal children at equivalent _MA_ levels, no differences in performance were found. Only when comparisons were made of equivalent _CA_ groups did the retarded subjects perform more poorly than the normal subjects. It was then decided to test another sample of retarded children, those living in institutions. For this sample, evidence of an attentional deficiency was found; these institutionalized retardates showed generally lower central and higher incidental scores than either the normal or the noninstitutionalized retarded group. We now wonder whether the institutional environment itself may be responsible for the poor performance in attentional ability of its residents. Zigler (1966) has argued persuasively that deficits in retarded youngsters in institutions are more often associated with motivational and emotional factors than with retardation per se, since very few institutional environments are conducive to maximal development. At present, we must recognize that the differences found might also be due to characteristics inherent in retarded children who get placed in institutions as compared to those who do not. However, an implication of the study is that, when an attentional deficiency is found to be characteristic of the retarded child, it may be associated with his environmental conditions rather than with his intelligence level.

Can institutionalized retarded youngsters be trained to improve in performance in the central-incidental task? Hagen and West (1970) modified the task to explore this possibility, using a primary and a secondary dimension in place of the central and incidental dimensions. Pennies could be earned for recalling the pictures of either dimension, but the payoff was five times as great for recalling pictures of the primary dimension. The stimuli were simple geometric shapes and colors. As expected, recall was better for primary than for secondary pictures. At the younger MA level (8 years), the difference between recall of primary and recall of secondary pictures increased over trials; for the older MA level (10.6 years), very little change occurred. Since the older children performed better initially, they may have already been operating near their maximum level, and thus differential reward could not help. Or perhaps there is less ability to profit from such reinforcement among older retarded children. It does appear, though, that there are conditions under which retarded children are able to improve in selective attention.

Hagen and Hallahan (1972) tested severely retarded institutionalized children both on the central-incidental task and the discrimination learning task used by Zeaman and House (1963), a modified version of the Wisconsin General Test apparatus. A finding of major interest is that performance on the Zeaman-House task was positively related to performance on the central-incidental measure. It appears that similar abilities are being tapped by these tasks, abilities relating to efficiency in deployment of attention. A useful approach in future studies of attention would be to incorporate into a single battery these and other tasks purporting to measure various aspects of selective attention in order to determine the interrelations among the measures.

Cross-Cultural Evidence

Cultural differences in attention and memory processes have been explored by Daniel Wagner. In a study in Yucatan, Mexico, he used a modified version of the central-incidental task in which the pictures were taken from a popular game well known to the children and adults of that area. About 400 subjects from both urban and very rural backgrounds were included, ranging in age from 7 to 27 years. Although the data analyses are not complete, some of the more striking findings may be mentioned here.

The urban sample performed in a manner roughly similar to the American samples already described. Central task performance increased with age; incidental task performance increased from the 7-9 years until 13-16 years and then declined. Thus, the interaction between age and central versus incidental performance was replicated, although in this case the data took on a slightly different pattern, and incidental learning scores did not reach a maximum until a later age than in the earlier studies. For the rural sample, however, a different picture emerged. There was no overall increase with age in central task performance, even though the age span covered 20 years. Incidental scores increased with age up to the 20-21 year age level and then declined at 27 years; the drop-off thus occurred almost six years later than in the urban groups. Overall, performance was lower for the rural than for the urban groups.

We do not know at this time what aspects of cultural difference may be responsible for these findings. Possibly school experience is an important factor. School-age subjects in both Yucatan samples were attending classes, but the nature of the school experience was vastly different for the rural and urban settings. Furthermore, most of the adults in the rural sample had little or no formal schooling.

We have seen that two types of environmental variations, institutionalization and urban versus rural cultural settings are related to our indices of attention. Although this evidence raises many unanswered questions, it certainly suggests that environmental factors play a critical role in determining the manner in which attention is deployed.

Summary and Conclusions

We have presented evidence relating children's selective attention to a variety of factors, and although the general picture emerging from this research is complex, certain conclusions can be drawn at this time with reasonable confidence. A continually reappearing theme is that of a developmental improvement in efficiency of attention deployment. To recapitulate the evidence bearing on this point, children's incidental learning undergoes little change from middle childhood to early adolescence, whereas central performance increases markedly over this period. The suggestion is that children's ability to exercise selective attention improves with age in that, increasingly, they concentrate on task-relevant stimuli and ignore extraneous information. This conclusion came from the early studies, and more recent evidence has expanded our view of the ways in which children's use of attention becomes more efficient with increasing age. For example, older children do not simply enter a learning situation with a predisposition to employ selective attention, but rather, in performing an incidental learning task, they adopt a selective approach only as the task proceeds. By early adolescence, children are apparently quite flexible in their attention deployment, in that they modify their approach upon realizing the strategy that will maximize their performance.

The most efficient strategy in the central-incidental task, of course, is to focus upon relevant features at the expense of extraneous information. According to the correlations, such a strategy is indeed more characteristic of older than younger children. Although the relation between central and incidental learning was positive for young children, it was negative for subjects beyond early adolescence. Thus, only at the upper age levels was successful performance on the central task accompanied by an inhibition of attention to incidental features.

Another way in which children become more flexible in attention deployment is indicated in studies on component selection. With development, children increasingly tend to distinguish between situations in which it is useful to attend selectively and conditions under which attention to several stimulus features can be more advantageous. The incidental learning task, of course, demands a selective approach, and thus the developmental increase in selectivity observed with this measure indicates an increasing accommodation to task demands. When selective attention is not required, however, as in a component selection task where two or more redundant features may define the effective stimulus, a selective orientation is not evident. In general, children not only improve in ability to exercise selective attention as they grow older, but they also become better able to determine when it is appropriate to attend selectively.

We have considered Neisser's (1967) two-stage sequence of information processing and have suggested that, in the present context, the sequence consists of an initial identification of relevant cues followed by maintaining attention to those cues while ignoring irrelevant cues. It has been argued that the age differences in attention observed here reflect developmental changes in performance at the second stage, beyond the point at which the subject initially discriminates the relevant from the incidental information. As evidence for this conclusion, the younger children maintained a relatively nonselective approach despite variations in the pictorial materials designed to facilitate the initial discrimination. Further, when the incidental cues were removed, thereby obviating the need for the initial discrimination, younger children's performance on the central task did not improve to a greater degree than that of the older children. Apparently, then, the developmental differences observed involve an ability to maintain attention to relevant material and ignore extraneous features after the two types of information have been identified.

A two-stage model of this type can also account for the anomalous finding of a developmental increase in incidental learning with colored shapes. In this case, the relevant and incidental components were attributes that are not naturally viewed as separate entities. Thus, the initial discrimination of components was presumably difficult enough that even the oldest subjects were forced to maintain attention to both features of the stimuli. In general, while the use of selective attention may be the characteristic approach of an older child to an incidental learning task, this will be most clearly evident when the stimuli are readily analyzable and the effort required to separate the relevant and extraneous information is minimized.

We have identified some of the ways in which children improve with age in efficiency of attention deployment. These changes reflect the patterns of growth in the environment to which we are accustomed, and it remains to be determined whether there are particular aspects of the environment, or specific characteristics of the children in it, that are responsible for the observed results. Work on cultural differences and mental retardation has provided some initial evidence, but continued effort is needed to identify the subject factors and situational variables that determine the ways in which children process information from stimuli.

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Footnotes

[1]Invited paper presented at the Minnesota Symposia on Child Psychology, University of Minnesota, October, 1972. Also appears as Report #16, Developmental Program, Department of Psychology, University of Michigan, Ann Arbor, Michigan, 1972.

[2]This research was conducted independently of the Hale and Piper (in press) study demonstrating a functional difference between colored shapes and pictorial stimuli; given the latter results, caution is warranted in generalizing from the present findings to the more "analyzable" materials typically used in studies of incidental learning.

Figure Captions

*Fig. 1. Stimulus materials for the central-incidental task.

**Fig. 2. Central task performance at grades 1, 3, 5, and 7.

**Fig. 3. Incidental task performance at grades 1, 3, 5, and 7.

*Reprinted from J. W. Hagen, Strategies for remembering. In S. Farnham-Diggory (Ed.), Information processing in children. New York: Academic Press, 1972.

**Reprinted from J. W. Hagen, The effect of distraction on selective attention. Child Development, 1967, 38, 686-694.

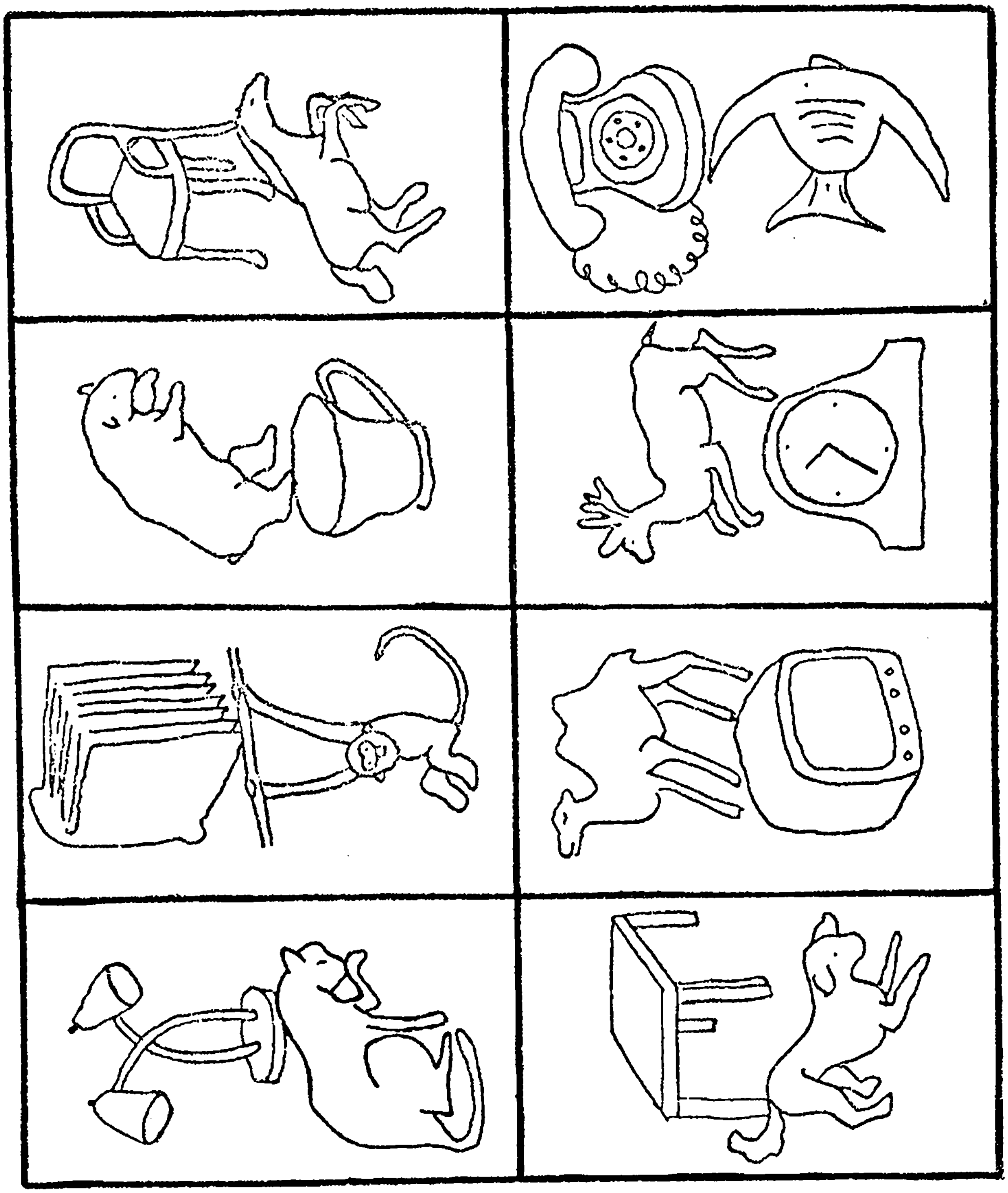

Figure 1

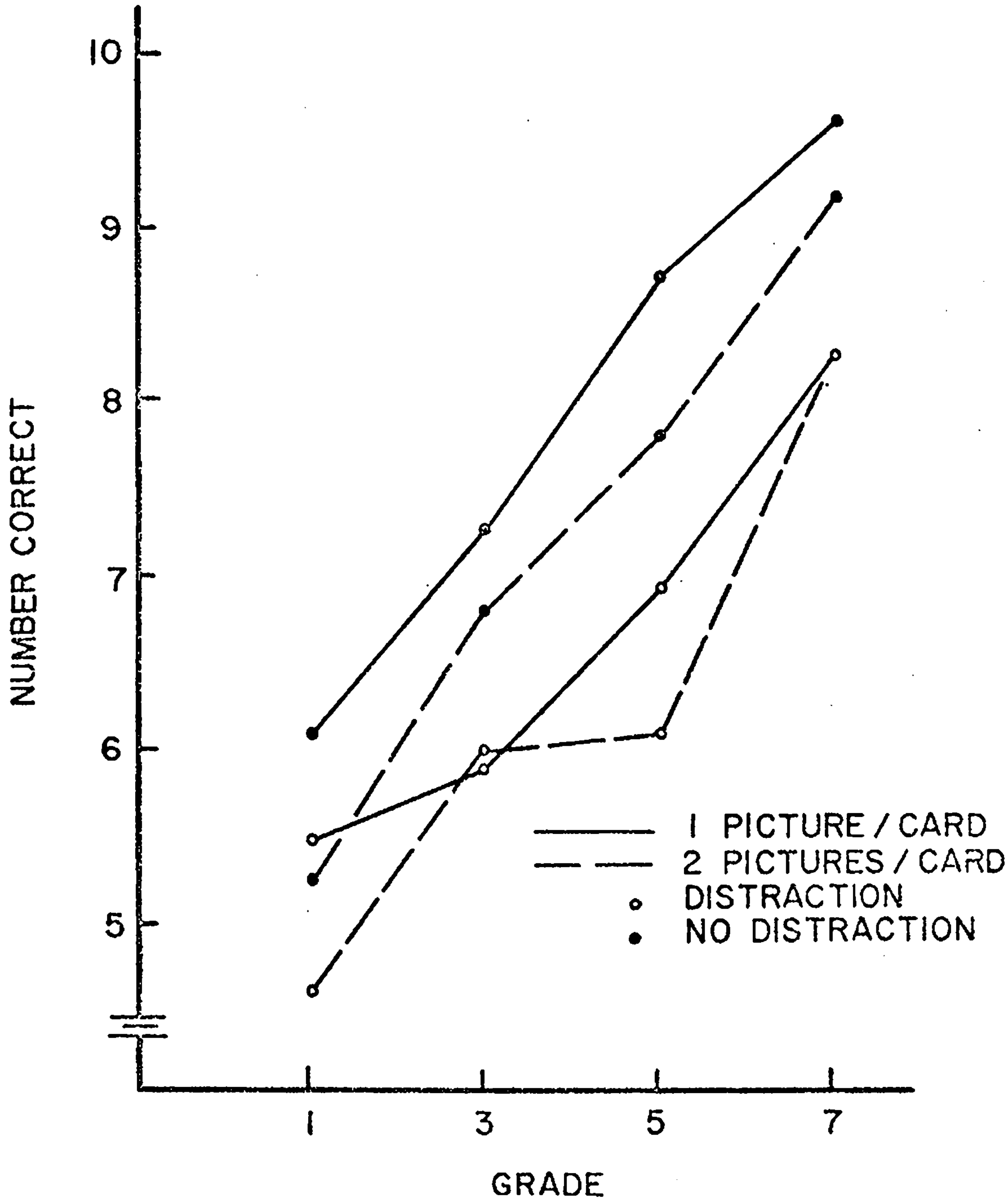
10
9
8
7
6
5
NUMBER CORRECT
1
3
5
7
GRADE
1 PICTURE / CARD
2 PICTURES / CARD
DISTRACTION
NO DISTRACTION

Figure 2

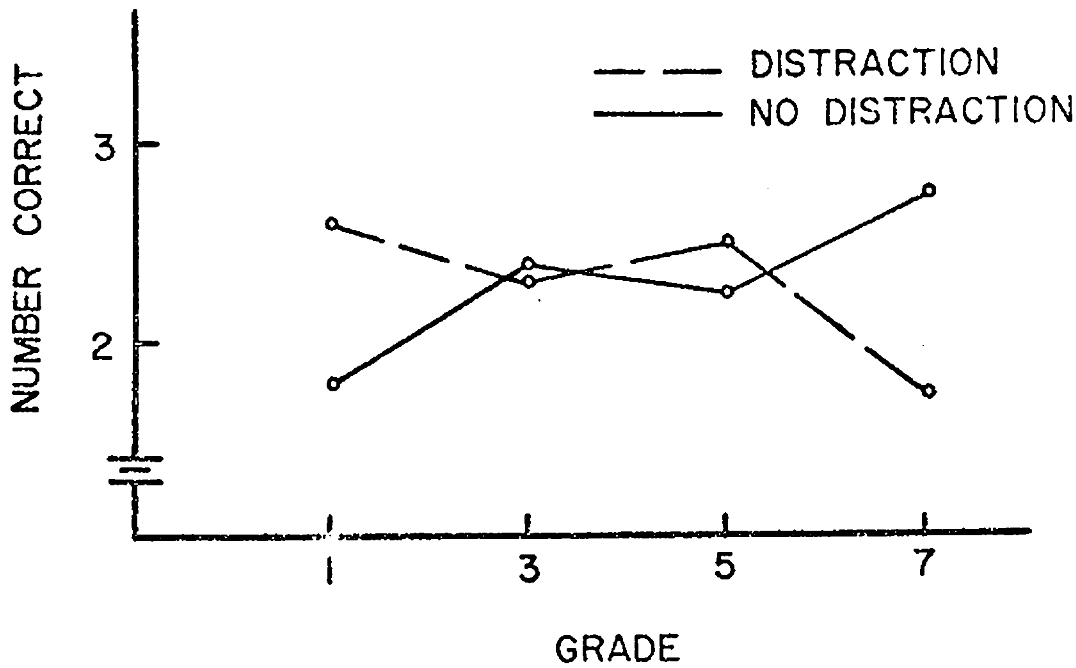

Figure 3