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Age Differences in Memory Span

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Five-year-olds recalled fewer items than adults in memory-span tasks involving both familiar and unfamiliar faces. This occurred even though the use of rehearsal and recoding strategies was minimized for adults. This residual age difference may be partially accounted for by two further processing limitations in children. The five-year-olds needed more time than adults to name a face (Experiment 1) and to encode a face (Experiment 2). In order to test whether limitations in children's initial recognition and stimulus-identification processes could account for recall performance, Experiment 3 reduced adults' exposure duration in the memory-span task. This led to a drastic reduction in the age difference. Other factors contributing to remaining age differences included adults' adaptability in using various alternative encoding and retrieval strategies which elevated their recall performance.

The goal of this paper is to isolate processes that may underlie age differences in the level of recall in a memory-span task. For example, college students typically recall twice as many digits as 5-year-olds in a digit-span task. An important theoretical question is whether developmental differences in serial recall reflect structural limitations that may change with maturation, or whether such differences reflect nonstructural factors, such as inefficient use of processing strategies. Many investigators currently assume that structural variables, such as the rate of information loss or the capacity of short-term memory, are not primarily responsible for the observed age difference (Chi, 1976).

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There are two converging methods that have been used to test the hypothesis that age differences in recall reflect differential usage of processing strategies. The first is to compare performance on tasks that are presumed to be strategy free and that involve information that is equally available to all age groups (Brown, 1975; Flavell, 1970). Such tasks should be insensitive to developmental trends. One example is a recency-judgment task where subjects judge the temporal order of a pair of items previously presented in a sequence of single items. Brown (1973) found no developmental differences in subjects' ability to discriminate temporal order. The only other task which has not shown a developmental trend is Shepard's (1967) continuous-recognition paradigm (Brown & Scott, 1971; Corsini, Jacobus, & Leonard, 1969; Nelson, 1971). Adults and children appear equally proficient at recognizing a picture that has been seen before. However, the absence of developmental trends in this task may reflect little more than a ceiling effect (Nelson & Kosslyn, 1976).

The approach of trying to verify that processing strategies are crucial to recall levels has not been very promising for at least two reasons: (a) there are very few memory tasks that do not require the use of processing strategies, and (b) both the tasks mentioned above involve a recognition paradigm. Age differences in serial recall paradigms still remain to be explained.

A second method of testing the differential-strategy usage hypothesis is to observe whether recall performance in a memory-span task is modifiable by training. The hypothesis predicts that if strategy usage is responsible for the level of performance, then training or enhancing the use of a specific strategy should reduce or eliminate age differences. In the case of digit span, performance improves with strategy training, but training alone does not completely eliminate developmental (or individual) differences. For example, Lyon (1975) placed pauses after triplets of digits to create temporal grouping, and also taught adult subjects to use a chunking strategy whereby three digits were grouped together into a single, meaningful unit. Presumably, if individuals with high digit-span scores are already using such chunking strategies, then they should profit less from the training and temporal grouping than individuals with low digit-span scores; hence training should reduce individual differences. However, individual differences in the adult population were maintained since training improved performance for all subjects. Huttenlocher and Burke (1976) also showed a similar developmental result with a temporal grouping manipulation. Significant improvements were observed for all age groups with no elimination of the initial developmental difference.

In other serial recall tasks, the training of strategies such as rehearsal has successfully elevated performance levels in the younger age groups.

However, in almost every instance[1] rehearsal training alone did not completely eliminate the adult–child difference in recall level, even under circumstances where only the immature subjects were trained. (See Belmont & Butterfield, 1971; Butterfield et al., 1973, Experiment 1; and Hagen, Hargrave, & Ross, 1973; for failure to achieve equivalent recall with only rehearsal training.)

Hence, previous training research neither confirms nor disconfirms the hypothesis that processing strategies are *entirely* responsible for differences in memory-span performance. This indeterminancy arises because span performance is modifiable by training, but age (and individual) differences still remain after training. Thus, it is necessary to isolate additional processing factors which contribute to this residual age difference. The latter is the focus of the present research.

EXPERIMENT 1

Experiment 1 is an attempt to assess the role of processing strategies in producing age differences in memory span. From the previous discussion, one can anticipate that mnemonic strategies do play a major role in affecting the level of recall performance. Furthermore, it is equally clear that other underlying processes, perhaps those that occur prior to the application of strategies, may additionally be responsible for age differences in memory span. Hence, this study also plans to identify one of these factors.

In attempting to capture the importance of processing strategies, the approach to be described here is a reversal of the training approach. In the training approach, the crucial strategies that are assumed to underlie successful adult performance are taught to the child in the hope that acquisition of these strategies will facilitate performance. In the approach employed here, the use of these critical processing strategies is minimized for adults in the hope of reducing their performance to the level of children.

Two putative strategies that give adults an advantage on recall tests are rehearsal and recoding. In this experiment, we attempted to eliminate or severely reduce the likelihood that adults could use either of these strategies. The mechanism and utility of rehearsal for serial

[1] Butterfield, Wambold, and Belmont (1973, Experiments 2 and 3) were able to elevate the recall performance of mentally retarded adolescents to the level of nonretarded adults when both acquisition and retrieval strategies were trained. However, significant losses occurred one week after the training, although additional training immediately reinstated the benefits of the original training. This result, however, can have two independent interpretations. First it suggests that previous research has failed to reduce age differences, possibly because only one or two strategies have been taught within a single experiment, whereas recall performance may require the use of a number of processing strategies. Second, the losses that occurred after training have elapsed may indicate that a more fundamental limitation exists which cannot be permanently overcome with a short period of training.

recall will not be described here (see Chi, 1976, for a discussion). In this experiment, rehearsal was minimized through rapid presentation rate.

Recoding can be defined as a process whereby two or more stimuli are chunked into a single stimulus. For example, the digits 5 and 7 can be recoded into the single number 57, where 57 now activates a new node in long-term memory, a node which is semantically distinct from 5 and 7. Hence, recoding can occur only if the concatenation of two or more stimuli produces a *familiar* third stimulus. The concept of familiarity should not be confused with recodability. A stimulus is familiar if a long-term semantic representation (a node) exists, and unfamiliar if no node exists. By this definition, any set of unfamiliar stimuli are not recodable, whereas only some sets of familiar stimuli are not recodable by any age group. To control for recoding, this experiment used faces of peers (familiar stimuli) and faces of nonpeers (unfamiliar stimuli).[2]

The two manipulations (fast presentation rate and use of nonrecodable stimuli) are assumed to minimize the use of rehearsal and recoding strategies in adults. The purpose of this study, then, was to assess the effects of such restrictions on span performance of 5-year-olds and adults. Further, in an attempt to uncover limitations beyond strategy usage, the amount of time it took subjects to name a familiar face was measured.

[2] In this experiment, one could use an alternative operational definition of a familiar stimulus (face) as one where a verbal label can be attached (name) and an unfamiliar stimulus as one where no verbal label can be attached. By this definition, controlling for recoding requires a set of stimuli such that both adults and 5-year-olds can attach a single label to a single stimulus, but neither group can attach a single label to multiple stimuli. However, the issue of stimulus familiarity in developmental research is too complicated to be defined in terms of labelability for at least two reasons. First, stimulus familiarity, in terms of the existence of a semantic representation, is independent of whether or not a label exists. A stimulus (such as a chess pattern) can be familiar and yet not have a verbal label, although it may have an internal symbolic label that can be used to access its long-term semantic representation. Conversely, some unfamiliar stimuli can elicit verbal labels from adults rather easily. Second, labelability is not a dichotomous variable. Most stimuli can elicit some sort of verbal labels, especially from adults. Here the variability lies in the ease with which one can attach a verbal label to a given stimulus. To bypass this complication, this experiment resorted to the extreme case of selecting a set of unfamiliar stimuli where no semantic representation exists. In this case, the unfamiliar stimuli (unknown faces) are presumed to have no readily accessible verbal labels, even though unfamiliarity is not synonymous with unlabelability. With regard to the familiar stimuli used here (known faces), one can only say that they are familiar in the sense that semantic representations exist, and they are also assumed to be nonrecodable. One cannot say whether the ease of labelling the familiar faces is the same between age groups. In fact, this is precisely one of the central points of this study: familiar stimuli with labels available to both age groups can nevertheless have differential accessibility of the labels. In this sense, one could also argue that another way of definding familiarity is in terms of the accessibility of the labels (see Chi, 1976).

Method

The subjects were six 5-year-olds who had been attending a preschool together for 3 years, and three adults (one faculty and two staff members) who had been in the Psychology Department at Carnegie–Mellon University for at least 3 years.

The familiar stimuli for the 5-year-olds consisted of eight color photographs of faces of peers (classmates). Familiar stimuli for the adults were eight faces of third- and fourth-year graduate students from the department. Faces within each age group were not related in any way, such as having similar sounding names, etc. Unfamiliar stimuli were faces of nonpeers, i.e., the adult faces served as the unfamiliar stimuli for the children and vice versa.

Each stimulus card contained an array of two to five pictures. Each picture was a color photograph of a face about 1 in square, and it subtended a visual angle of 3.1°. Each array of pictures was centered on the stimulus card, and started from the left margin.

Eighty stimulus cards, 40 per age group, 10 per set size, were constructed. Each face was used equally often, and appeared equally often in each serial position within an array. No stimulus card was used more than once in the experiment.

Each subject was run in three conditions, counterbalanced across subjects. All the conditions used a two-channel Polymetric tachistoscope to display the stimulus cards. Before each condition began, subjects were shown all eight faces to be used in that condition. The faces were attached to a response board by magnets in two rows of four. In the case of familiar faces, the subjects had to name each face correctly.

The first test condition consisted of overt naming. The stimuli used were 20 cards (five per set size) randomly selected from the 40 cards constructed with faces of peers. The order of presentation was randomized. The subject was told to initiate a trial by pressing a black button, focus on the left margin, overtly name each face when the array was displayed (1 sec later), and press a green button to terminate the display and stop the timer. Both naming time and errors were recorded.

The second condition was the memory-span task using the 20 cards of familiar faces not used in the naming task. The third condition was the memory-span task using 20 cards of unfamiliar faces, randomly selected from the pool of 40. For both conditions, set-size order was randomized.

For the memory-span task, the subject pressed a black button to initiate a trial. One second later, the array appeared for a duration of from 1200 to 3000 msec, depending on the set size (i.e., 600 msec per face). At the end of the exposure, the subject was required to immediately pick out the faces on the response board, and place them in correct spatial order. A grid of five blank spaces was provided on the response board. Each condition took about 20 min to run, with a break after every five trials.

Results and Discussion

The mean naming latency for each set size from the overt naming condition was used to calculate the absolute naming time per face for each age group. No errors in naming were made. Naming time was operationally defined as the slope of the linear function relating total naming latency to set size. This estimate partialed out the slow motor and decision components of children in initiating and terminating a response. The results showed that overt naming times for adults and children were 666 msec per face (intercept = 342 msec, mean R^2 = 95.3%) and 1531 msec per face (intercept = 641 msec, mean R^2 = 95.2%) respectively. Hence, it takes children more than twice as long as adults to retrieve a face name for overt naming.

The mean number of faces recalled per trial for each set size is shown in Fig. 1. The left panel illustrates the amount recalled for familiar and unfamiliar faces, using ordered scoring (i.e., both the item and position information had to be correct), and the right panel illustrates the amount recalled using free scoring (only the item information had to be correct). Separate 2 (Age) $\times$ 2 (Stimulus Familiarity) $\times$ 4 (Set Size) analyses of variance (for unequal n, with repeated measures on the last two variables) were performed for ordered and free scoring. Homogeneity of variance was not rejected, $F < 1$.

The major finding was an age main effect for both ordered and free

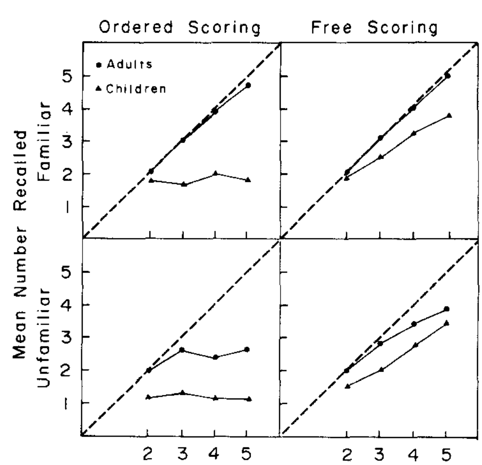

FIG. 1. Mean number of faces recalled as a function of set size under ordered and free scoring, Experiment 1.

scoring F's$(1,7) \geq 22.6, P$'s $< .005$. Thus, even when the use of rehearsal and recoding strategies was made difficult for adults, they still recalled a greater number of faces than children. In the case of familiar faces, one explanation for this superior performance is that adults had more time to process the stimuli by virtue of their faster name retrieval. Assuming that covert naming usually takes less time than overt naming,[3] this means that adults can comfortably retrieve the names of familiar faces at the exposure duration used. Children's naming time, however, far exceeds the exposure duration used. Thus, in the familiar-faces condition, adults, but not children, had the advantage of dual (verbal plus visual) coding, which has been shown to facilitate recall (Paivio & Csapo, 1969).

From anectodal evidence, this explanation can also be extended somewhat to account for the observed age differences in the case of unfamiliar faces. From subjects' introspections, it appears that adults tended to use verbal labels even for the unfamiliar faces. Each subject had sufficient time to at least dichotomize the unfamiliar array into his own idiosyncratic categories, such as glum–smile, cute–ugly, curly–straight hair, etc. It is possible that this verbal mnemonic, although not very accurate, could elevate adults' recall performance.

A second important finding was that the pattern of results differed with the method of scoring. The interactions of Age × Set Size, Familiarity × Set Size, and Age × Familiarity × Set Size were all reliable under ordered scoring, F's $(3,21) \geq 3.6$, p's $< .05$, but not under free scoring F's$(3,21) \leq 2.1$. Knowledge of position information (required under ordered scoring) has traditionally been interpreted in memory span to mean that order information has been correctly stored and retrieved. This further suggests that the reliable two-way and triple interactions arise mainly from adults' ability to increase their recall with increasing set size (linear trend for adults under the familiar-faces condition was significant, $F(1,21) = 42.7$, $p < .001$). Furthermore, this appears to be true only for familiar faces (linear trend for adults in the unfamiliar-faces condition was not significant, $F(1,21) = 1.6$). This suggests that adults maintain order information better than children at larger set sizes, but only when verbal labels are available.

In summary, the overall pattern of results is the following: First, despite the fact that rehearsal and recoding strategies were minimized, adults still recalled a greater number of faces than 5-year-olds. Second, at least from anectodal evidence, it appears that adults employed alternative strategies (such a labeling unfamiliar faces) that were not foreseen as essential to the task demands. Third, beyond the use of re-

[3] Initial pilot testing with adults showed that covert naming takes about 200 msec less per face.

tention and encoding strategies, adults were superior to children in the speed of attaching a verbal label to a familiar stimulus. Finally, for adults in the familiar-faces condition, recall under ordered scoring increased with increasing set size, suggesting that verbal mnemonic processing facilitated the preservation of order information.

EXPERIMENT 2

Experiment 1 revealed that 5-year-olds took twice as long as adults to attach a name to a familiar face. Experiment 2 pursued the question of whether the observed slow name retrieval in children reflects a limitation in the speed of recognition or a limitation in response generation that inflates the slope of the naming-time function. That is, are children slower to recognize familiar stimuli or are they slower to produce the overt naming response?

Speed of recognition has typically been assumed to be reflected by speed of encoding, which is operationally defined as the duration of stimulus presentation (followed by a mask) that is needed to identify the stimulus. It has been shown that for stimuli such as letters and random shapes, adults encode much faster than 5-year-olds (Munsinger, 1965; Welsandt, Zupnick, & Meyer, 1973). However, these differences may have resulted from differential familiarity with the stimuli. Since the stimuli used in Experiment 1 (faces of peers) satisfy the special criterion of being familiar but nonrecodable, it is of interest to see whether a limitation remains in encoding speed for these stimuli.

Method

The subjects were five 5-year-olds from the same nursery school, four of whom participated in the previous experiment, and five adults (four graduate students and one faculty member) from the psychology department. Two of the adults had participated in the previous experiment.

The stimuli were the color photographs used in the previous study, but the arrays now ranged in size from one to three faces, and these were centered on the stimulus card so that the display was within foveal view. The maximum display subtended 2°54′ visual angle. The apparatus used was a Scientific Prototype three-channel tachistoscope.

Eight stimulus cards were constructed for set size one, and 10 each for set sizes two and three. Before the experiment began each subject was shown and required to name the eight familiar faces. Each set size was run in a block design, and the blocks were counterbalanced across subjects. The entire session took about 25 min, with an intertrial interval of about one min.

Variable exposure durations, using the up-and-down method (Guilford, 1954), were used to determine the 50% identification threshold.

If the faces were correctly identified, then the exposure duration was reduced for the next trial; if not, the duration was increased. Correct identification required all names (varying from 1 to 3) in any order.

Before each trial began, the subject fixated on a dim focus point. When he was ready the stimulus card was flashed, and immediately after its termination a mask (fragments of faces) appeared for 1 sec. The subjects' task was simply to report the names of the faces he saw.

For a given set size an initial duration was chosen in the appropriate range, and the up-and-down method was continued until either the subject's performance stabilized, or until the subject fatigued (common for the children). On the average, 25 trials were run for each set size, which meant that each subject saw each stimulus card at least twice. The increments and decrements were generally in steps of 20 msec for exposure durations greater than 100 msec, and 10 msec for durations less than 100 msec.

Results and Discussion

The exposure duration at which the greatest number of correct identifications occurred (the mode) was used to estimate the 50% identification threshold for each individual subject (see Table 1). If a multimodal distribution occured for an individual subject, then the highest mode was used. Averaging across subjects, the mean exposure durations required to encode faces by adults and children respectively were: 26 and 139 msec for one face, 42 and 280 msec for two faces, and 320 and 692 msec for three faces. The differences were all significant, t's(8) ≥ 3.71, p's $< .01$.

Relative to Experiment 1, the most important results of this study were that encoding times were an order of magnitude faster than nam-

TABLE 1

INDIVIDUAL MODAL THRESHOLD DURATIONS (IN msec) FOR EXPERIMENT 2

		Children				Adults		
Set Size:		1	2	3		1	2	3
	S1	140	320	580	S6	50	90	460
	S2	140	320	840	S7	30	20	220
	S3	90	340	740	S8	20	40	600
	S4	140	160	640	S9	20	50	190
	S5	180	260	660	S10	10	10	130
	$\bar{X}$	138	280	692		26	42	320
	S.D.	31.9	73.5	100.6		15.2	31.1	200.6
	S.E.	14.3	32.9	44.9		6.8	13.9	89.7

ing times for familiar faces, and that children were slower than adults at encoding familiar faces. On the surface, it seems that even though children were significantly slower than adults at encoding faces, the difference was not great enough to account for their naming-speed difference in Experiment 1. However, it is important to note that the *exposure* time may seriously underestimate total *recognition* time. Most likely, complete recognition of the stimulus occurs subsequent to stimulus termination and mask onset. In other words, the exposure duration simply provided the opportunity to extract a sufficient number of critical features for recognition to occur after stimulus offset. Thus, recognition can be completed any time between the encoding and naming time. Hence, one could speculate that slower naming time may be a function of a more limited recognition time. Alternatively, naming and encoding could reflect two independent processes. Nevertheless, in addition to a limited speed of name retrieval, children further suffer from a limitation in the speed of encoding of a familiar stimulus.

EXPERIMENT 3

Experiments 1 and 2 have identified at least two limitations in children's processing capacities beyond the inefficient use of processing strategies. Children are much slower at retrieving the name as well as encoding a familiar face. These limitations suggest that it takes children longer to process a visual stimulus to the same stage or level of analysis as adults. It is hypothesized here that this inequality in the amount of time needed for initial processing may be responsible for the residual age difference in memory span observed in Experiment 1.

There are several ways to test this hypothesis. One obvious candidate is to increase the exposure duration for children to compensate for their slower recognition and name-retrieval times. However, the logic underlying this procedure is erroneous. It assumes that given more time, children will spontaneously process the stimulus in such a way as to make it more accessible for recall.

An alternative method is to reduce adults' exposure duration, so that they may only be permitted to process the stimuli to the same level of analysis as children. In other words, not only are adults now prohibited from using processing strategies, but further, they are unable to process the stimuli to the point that strategies can be applied. If this initial level of processing is responsible for serial recall, then age differences should be reduced when exposure duration is reduced for adults. Hence, this experiment replicates Experiment 1 (with adult subjects only), using an exposure duration of 300 msec per face, about half of their overt naming time. The original exposure duration used in Experiment 1 (600 msec) was in fact less than half of children's naming time. However, we could not reduce the exposure duration much below 300 msec for adults, since it may interfere with their eye movements in scanning the array.

Method

The subjects were six graduate students from the same psychology department. Two of them had participated in one of the previous experiments. The procedure was identical to Experiment 1, with the exception that the exposure duration for each set size was 300 msec per face, instead of 600 msec.

Results and Discussion

There are several differences between the present results and those of Experiment 1. First, when the time available for the initial processing of the stimuli was reduced for adults, age differences in memory span under free scoring were no longer significant, $F(1,10) = 4.89$. Second, with verbal coding reduced, adults no longer maintained order information for the larger set sizes. This was supported by the lack of any interactions under either type of scoring, F's$(3,30) \leq 1.85$ (see Fig. 2).

However, adults were still superior to children under ordered scoring, $F(1,10) = 19.2$, $p < .005$. This may be partially accounted for by adults' accuracy for faces in the primacy positions (and recency positions, to be elaborated below). From anecdotal evidence, we can speculate that labelling may account for this accuracy. The adults knew beforehand that there would not be enough time for them to name all the faces,

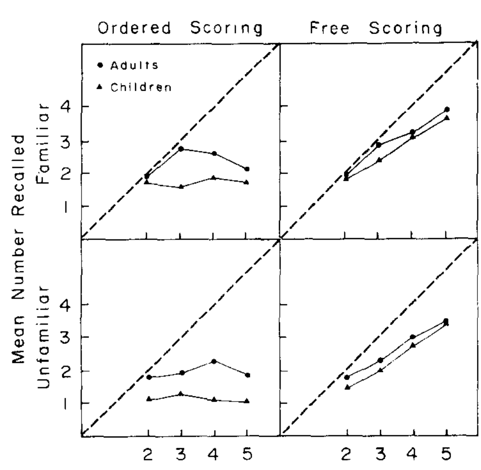

FIG. 2. Mean number of faces recalled as a function of set size under ordered and free scoring, Experiment 3.

but that there would be enough time to look at all the faces. Nevertheless, according to their introspections, it was clear that they preferred to covertly name as many faces as possible, sacrificing spending an equivalent amount of time on each face. An analysis of the amount of time available for each set size is consistent with their introspections. For example, a reasonable estimate of covert naming time for adults is about 400–450 msec per face. Hence, five faces exposed for a total of 1500 msec allow an adult to covertly name about three faces. For sets of four or three faces, adults could still name two faces, and so on. Consequently, it is not surprising that adults' recall of the first two or three faces was very accurate. A similar labelling process, though more restricted, can also function with unfamiliar faces. That is, adults can label the initial one or two unfamiliar faces by identifying them along a single dimension, such as happy–sad. Hence this labelling strategy can elevate adults' recall accuracy under ordered scoring, particularly in the primacy positions. The implicit assumption here is that verbal codes facilitate the maintenance of order information.

The third finding of this experiment was that adults exhibited a recency effect for ordered scoring (see Fig. 3). This accuracy can be explained by another strategy that adults adopted to cope with time constraints of this experiment. Every adult was observed to change the task from a serial recall to a constrained recall. Serial recall means that subjects must "reproduce the items in the order presented" (Murdock, 1974, p. 142). There was no misinterpretation or modification of this instruction in Experiment 1, either by children or adults. Constrained

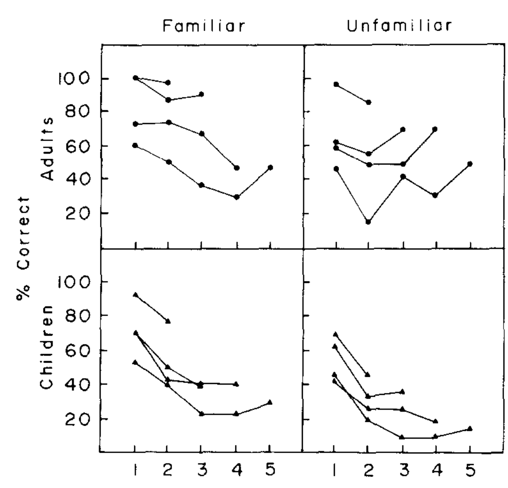

FIG. 3. Serial position curves under ordered scoring, Experiment 3, with constrained recall.

recall means that the subject can reproduce "the items in any order that he wishes, but the order of presentation must be represented in the final result" (Murdock, 1974, p. 142). Thus, adults tended to place the most salient faces in their correct positions first, followed by retrieval of the remaining faces from the array. We assume that this strategy is useful because those stimuli (presumably the ones in the primacy positions) that have verbal labels attached can be retained in short-term memory while the unlabelled faces (presumably those in the recency positions) are being retrieved. This strategy would explain the accuracy obtained in the recency positions.

Additionally, the recency effects seem to be more pronounced in the unfamiliar-faces condition. This further suggests that the two strategies reported, labelling the primacy faces and initial responding of the recency faces, were applied differentially depending on the stimuli. It is consistent with intuition that labelling should proceed for as long as time permitted when the stimuli have readily accessible names, as in the case of familiar faces. Hence, recall would consist mostly of retrieval of verbal labels. However, when labelling was made difficult, as in the case of unfamiliar faces, then adults resorted to an alternative strategy during recall, which is to retrieve first (perhaps still from an iconic storage) whichever stimulus is the most vivid.

The lack of a recency effect in children, however, was not due to their failure to scan to the end of the array. Children's ability to allocate attention properly for the entire array can be assessed by their recall under free scoring, which was better than 50% at all serial positions.

The results so far indicate that adults have adopted two strategies, labelling as many faces as time permitted and modifying the retrieval instruction, both of which can elevate their recall accuracy for position information. We can easily eliminate the use of one of these strategies by forbidding the adults to modify the instruction. Six graduate students who had not participated previously were run using the same design, with the serial recall instruction emphasized. Under such circumstances, the age difference in recall was further reduced. The age main effect was only marginally significant for ordered scoring, $F(1,10) = 6.5$, $p < .05$, but again not significant for free scoring, $F < 1$. The general pattern of results is similar to the previous results, with the exception that serial position data no longer exhibit a recency effect (see Fig. 4).

The latter finding confirms our hypothesis that modified recall strategy produced the recency effect. The remaining age difference under ordered scoring may be caused by the one final strategy that adults were still using. Had the use of this labelling strategy been eliminated also, perhaps through rapid sequential presentation, we could then speculate that the age difference would no longer be present even under ordered scoring.

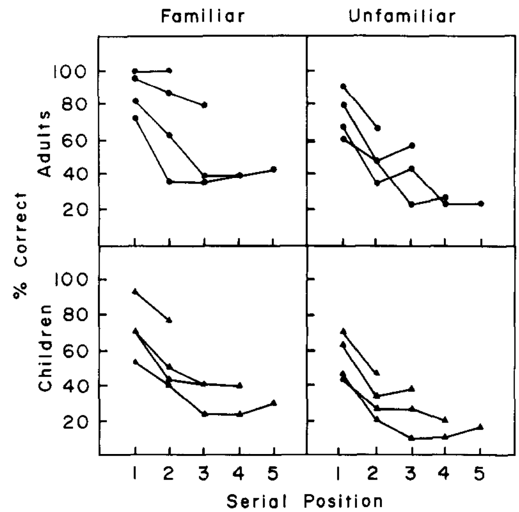

FIG. 4. Serial position curves under ordered scoring, Experiment 3, with serial recall.

SUMMARY

This research attempted to uncover processes that produce age differences in serial recall tasks such as memory span. It was assumed that processing strategies play a major role in elevating adults' recall performance. However, it is also evident from the literature that mnemonic strategies alone cannot account for all the developmental variances observed in the level of recall. It was postulated that alternative processes and limitations may be responsible for the residual age difference above and beyond the use of strategies.

Three major results were obtained. First, controlling for the use of rehearsal and recoding strategies did not substantially reduce memory-span difference between 5-year-olds and adults. Second, adults made use of various alternative strategies, depending upon the specific task. At least three strategies were identified: labelling unfamiliar stimuli, naming as many faces as time permitted rather than allocating the same proportionate amount of time to each face in the array, and modifying the instruction when the task became too demanding. Hence, it is not difficult to see how most training studies have failed to elevate children's recall performance to the level of adults' when only one or two isolated processing strategies were taught. Third, and most important, besides strategy usage, adults were superior in the speed of initial information processing, such as name retrieval and encoding. The latter result suggests that the encoding processes prior to the application of mnemonic strategies may be important components contributing toward age difference in memory span.

In conclusion, this research has shown that age differences in memory span need not be attributed to structural limitations. The level of recall in adults' performance is greatly influenced by the number of processing strategies made available to them. Furthermore, it takes children longer to encode a stimulus to a level that is accessible to processing strategies. This retardation in the speed of information processing may result from limitations in their semantic and recognition networks. All these factors collectively contribute to the commonly observed age difference in memory span.

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