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VERBAL PRODUCTION DEFICIENCIES AND THE ROLE OF MEMORY DEVELOPMENT IN CHILDREN

by

© JAMES MARK BEBKO

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF PSYCHOLOGY

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled VERBAL PRODUCTION DEFICIENCIES AND THE ROLE OF MEMORY DEVELOPMENT IN CHILDREN submitted by JAMES MARK BEBKO in partial fulfilment of the requirements for the degree of Master of Science.

Willie Runquist
Supervisor

C. Brainerd

[illegible]

Date August 3, 1973

ABSTRACT

The purpose of this study was twofold: first, to replicate studies by several other authors which indicated that young primary schoolers (grades kindergarten and one) were handicapped by a "production deficiency" (i.e., lack of the production of verbal labels at the appropriate time to be rehearsed) which negatively effected their recalling ability; and second, to determine whether it was this production deficiency alone which resulted in the poor performance, or whether other factors, such as memory differences, accounted for some of the variance.

One hundred and eighteen school children of grades kindergarten, one, three and four were shown sequences of three, four and five colors. After a fifteen second delay, they were asked to arrange colored response blocks in the same order that the colors had been presented to them. The subjects were classified as Producers or Non-producers depending on whether or not they produced and rehearsed the appropriate verbal labels, either during the stimulus presentation period or during the delay period. Half the Producers and half the Non-producers were then instructed to overtly rehearse the color sequences. The other half of each group was given an interference task to be performed during the delay period which effectively prevented

rehearsal of the items.

As predicted, it was found that the Producers recalled significantly better than the Non-producers, but when the Non-producers were instructed to verbalize the labels at the appropriate time, their recall performance increased to that of the Producers. These results served as replications of the previous findings. However, when rehearsal was prevented by the interference task, the Producers' performance did not decrease to the level of the Non-producers, which was expected if only a production deficiency differentiated the two groups. Rather, the Producers' performance dropped, but remained significantly higher than that of the Non-producers, indicating that memory differences and possibly other factors differentiated the groups as well. A suggestion was offered that production and memory deficits may simply be observable manifestations of an underlying encoding deficiency, and further research was suggested to investigate this possibility.

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Special thanks goes to my wife, Patty, for her encouragement and interest throughout, and to Merrilyn Greig and the IBM 360/67 whose assistance in the typing of this thesis was greatly appreciated.

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INTRODUCTION

In recent years there has been a great deal of research focusing on the development of intellectual functioning in children. One aspect of this research has centered on the development of the child's memory processes and capacities. Flavell, Beach and Chinsky (1966), as well as other researchers (Kendler, 1963; Spiker, 1956), have observed that older grade school children (e.g., grades 3 and 4) who are asked to remember a sequence of items for later recall, spontaneously produce the labels for those items and rehearse them continuously during the delay period. Younger children (e.g., grades 1 and kindergarten), however, tend not to produce the labels.

The present study was designed to investigate further this so-called "production deficiency" in order to determine whether it is indeed the sole factor which differentiates the recall performance of the older from the younger children, or whether there are other factors which contribute to the discrepancy as well.

One of the earliest postulations of the existence of stages in the development of the ability to use verbal labels as mediators was formulated by Kuenne (1946). She stated that:

> "...there are at least two developmental stages so far as the relation of verbal

> responses to overt choice behavior is concerned. In the first the child is able to make differential verbal responses to appropriate aspects of the situation but the verbalization does not control or influence his overt choice behavior. Later, such verbalizations gain control and dominate choice behavior." (p. 488)

More recently, Kendler, Kendler and Wells (1960) suggested:

> "Another possibility is that there is a stage in human development in which verbal responses, though available, do not readily mediate between external stimuli and overt responses." (p.87)

The interpretation of these verbal labels as being "mediating responses" between the stimulus presentation and the overt reponse was derived from the S-R literature of the Hullian tradition. A formal definition of the concept of "mediator" was undertaken by Kendler (1963). She stated that:

> "The mediator is a response, or series of responses, which intercede between the external stimulus and the overt response to provide stimulation that influences the eventual course of behavior. These responses may be overt, but they are usually assumed to be covert." (p.34)

Kendler and Kendler (1967) also observed that mediators need not be synonymous with verbal labels, but most of the literature on this topic has dealt with verbalization.

Further research on the use of mediators resulted in refinement of the "stages" of the development of this ability. Reese (1962) reviewed much of the literature on this question and suggested the term "mediational deficiency hypothesis" to describe the stage at which the child knows the verbal labels for the stimulus objects, but these names do not serve as mediators for his behavior. Kendler (1963) suggested that the development of mediational ability consisted of three stages: (1) Initially the child has no mediating response; (2) Verbal responses can occur but either appear late in a learning task or do not "necessarily and readily mediate"; (3) verbal responses occur and mediate effectively.

Studies by the Kendlers and their associates (Kendler & Kendler, 1959; Kendler, Kendler and Wells, 1960) appeared to corroborate this view of memory development. They observed that children of ages 3 and 4 years tended to respond in a non-mediating, direct S-R unit fashion, whereas children of ages 5 to 7 were nearly evenly split between those who were verbally mediating and those who were not. They concluded that increased maturity results in a higher proportion of children "whose performance is determined by some mediating system of responses." (p.36)

All of this data pointed to a developmental increase in the use of verbal labels as mediators. However a controversy developed over the intermediate processes leading from the nearly complete lack of mediating responses to effective mediation. The term "mediational deficiency hypothesis" was used by most of the investigators in discussions of this issue, but two distinct concepts were being represented by the same term. On the one hand, the findings of Kuenne (1946), Kendler et al. (1960), Luria (1961) and Kendler (1963) were interpreted as showing that in the intermediate stage, verbal responses may be elicited, but they fail to mediate the overt response. On the other hand, it was observed (Reese, 1962; Kendler & Kendler, 1962) that it is the elicitation of the verbal response which is lacking in the "mediationally deficient" children, and hence little can be concluded as to whether or not they possess a mediational deficiency. As Maccoby (1964) stated:

> "The question is, then, whether they simply fail to use the verbal labels which are presumably available to them, or whether they do use them, but for some reason the words do not serve to mediate the response." (p. 213)

It should be noted that the lack of elicitation of the verbal response presupposes that some form of knowledge of the label is necessary but that this knowledge is not a sufficient condition for its elicitation as a mediator. Maccoby further suggested that "if experimental situations are arranged so that the relevant verbalizations will be elicited (Spiker, 1963; Kendler, 1963), they will mediate the performance." (p. 2[illegible]) The implication is clear: that elicitation of an appropriate verbal label is a sufficient condition for mediation to occur.

If knowledge of the verbal label is not sufficient for its elicitation, then how can the experimental situation be arranged so that the labels are produced? Reese (1962) concluded that if the elicitation of the verbal response is a voluntary process (i.e., the child produces it), such as rehearsal, then the intermediate stage of its development may simply be that the child has not yet learned to utilize it. Instruction in the use of the process, therefore, should produce beneficial results. If, however, it is an involuntary process, then Reese concluded that instruction should have no effect. The voluntary alternative received support from a study by Weir and Stevenson (1959), in which they found that instructions to verbalize resulted in more rapid learning. Pyles (1932), Kurtz and Hovland (1953), Spiker (1963) and Kendler (1963) reported similar findings.

Flavell, Beach and Chinsky (1966) separated Maccoby's statement of the two aspects of mediation into two distinct developmental hypotheses. They restricted the name "mediational deficiency hypothesis" to the assertion that the younger child does spontaneously produce the potential verbal mediators at the appropriate time, just as the older child does, but for some reason these verbalizations do not serve to mediate the response. The second hypothesis--the "production deficiency hypothesis"--asserts that the younger child knows the relevant verbal labels (and in fact does produce them in certain situations), but in this particular task he does not _produce_ them. Thus his performance and overt behavior would be apparently nonmediational in nature. The implication is that the child's deficiency lies not in an inability to utilize words he produces as mediators, but rather in the lack of verbalization of them at the appropriate time. It would not be surpising, then, that instructions to verbalize would cause an increase in performance, such as in the earlier mentioned studies.

Flavell and his asscoiates devised an ingenious series of experiments to test their dual-hypothesis theory. Using grade school children as _Ss_, Flavell, Beach and Chinsky (1966) pointed one-by-one to sequences of from two to five easily recognizable pictures. The children were then asked to recall the sequences by pointing to the pictures in the same order that they had been presented; recall was either immediate or followed an unfilled delay of 15 sec. Having unobtrusively recorded any instances of verbalization of the appropriate labels, they reported a significant increase in the production of verbalizations, both during the presentation and delay periods, from kindergarten through grade two and up to grade five. It was further established (Keeney, Cannizzo and Flavell, 1967; Daehler, Horowitz, Wynns and Flavell, 1969) that the producers (i.e., those who spontaneously verbalized the appropriate labels) were able to recall significantly more items than the non-producing S̲s. Moreover, when Keeney, et al. instructed the non-producers to rehearse the labels cumulatively at the appropriate time, their recall performance increased to the level of the spontaneous producers. This indicated that the S̲s who were production-deficient were not also mediationally deficient. Flavell and his associates concluded that it was simply a production deficiency which accounted for the discrepancy in performance between the two groups.

It is at least possible that other factors may differentiate these groups as well, but are confounded in the above studies. The possibility exists that the distinction between production-deficient and nondeficient subjects may incorporate other factors. For example, the fact ~~that~~ the proportion of producers to non-producers increases with age, may well be a result of age-related improvements in memory span. In Flavell's studies, the placement of an S̲ into either category depends on whether or not he verbalized the presented stimuli in the same sequence that they were shown to him. If memory span increases with age, then the younger subjects would be less likely to be able even to retain all the items (particularly as the number of items increases) in order to rehearse them. In fact, a study by Flavell, Friedrichs and Hoyt (1970) showed that the memory span of children of approximately the same ages as those used in the Flavell et al. (1966) study improved from 3.6 objects for kindergarteners to 5.5 for fourth graders. This discrepancy in memorial capacity could be relevant to the explanation of the differences in performance between the two groups. If the younger children were unable to retain the sequence, then rehearsal, and thus the encoding process, would suffer.

Given that (1) older children are superior in the production of the relevant verbal mediators (Flavell, Beach and Chinsky, 1966) and that (2) the older children also have a superior memory span (Flavell, Friedrichs and Hoyt, 1970), what role could these two factors play in this sort of task? One possibility is that the older children may not have been utilizing the full potential of the mediators to assist in retention, but rather were relying in part on their superior memorial capabilities. That is, since the older Ss could readily retain more items, those items required less rehearsal in order for them to be effectively recalled. Hence the full potential of the mediators was not required. When the non-producers were instructed to repeat the labels verbally, they were intensively rehearsing the items and thus compensating for their poorer memory capabilities. The net apparent performance of the two groups could thus appear equal. On the other hand, if the producers were not utilizing their mediating capacity to its fullest extent, then on instructions identical to those given to the non-producers, one would expect the performance of the producers to increase as well. This was not observed in the Keeney _et al._ (1967) study. However, it may well be that the task was too easy for the older children. The sequences of items used in the Keeney _et al._ study were of lengths 3, 4 and 5, all of which are within the memory spans of the older children (Flavell _et al._, 1970). Thus it may have been that the task was not challenging enough for the older children to have to utilize their superior memorial capacities to any extent. They could retain the items by simple rehearsal (i.e., verbal production and repetition of the labels). Thus, when the non-producers were instructed to produce the labels, the performance of the two groups was identical because essentially the same mechanisms were being utilized by both.

The present study was designed to investigate further the production deficiency hypothesis, and specifically to determine whether or not differences in performance on this type of task can be entirely accounted for in terms of a production deficiency, or whether differences in memorial capabilities account for some of the variance.[1] Initially,

[1] It should be noted that throughout the present study, the logical distinction between mediational deficiencies and production deficiencies proposed by Flavell _et al._ (1966) is utilized.

replication of the Keeney et al. (1967) study was undertaken, using kindergarten, first, third and fourth graders as Ss. The instruction to verbalize the stimulus labels was manipulated in order to determine whether or not the non-producing Ss suffered only from a production deficiency. If so, then training in the overt verbalization of the mediators should result in an increase in the recall performance of the non-producing Ss to the level of the producers, as was the case in the Keeney et al. study.

An additional manipulation was undertaken in order to determine if all the variance between the producers and the non-producers could be accounted for by the production deficiency hypothesis. It was reasoned that if a production deficiency was the only variable on which the producers and nonproducers differed, then denial of rehearsal for the producers (i.e., the prevention of repeated production of the mediators) should equalize the recall performance of the two groups. More precisely, interference with the rehearsal of the mediators should cause the producers' performance to drop to the same level as that of the non-producers. This follows if it is assumed that the production deficiency alone can account for the previous differences in performance. However, if the Flavell et al. (1970) findings are considered, then interference with rehearsal should increase the subjects' reliance on memory alone. Hence the older children (consisting primarily of producers) should suffer a decrement in performance, but their superior memory capabilities may enable them to recall at a higher level than their younger (and non-producing) counterparts.

Several exploratory manipulations were used in order to investigate some secondary considerations. To study memorial differences between the two groups further, longer sequences of stimuli were used. The length of delay before recall was also manipulated (i.e., the length of time of interference was varied) in order to study some short-term memory characteristics. These conditions, however, were of only secondary interest.

HYPOTHESES

The major hypotheses were:

(1) As age level increases, there will be a corresponding increase in the number of subjects classified as producers.

(2) Producers will recall correctly on significantly more trials than non-producers.

(3) (a) When the non-producers are instructed to rehearse the appropriate verbal labels, their recall performance will increase to that of the producers.

(b) When the producers are instructed to rehearse the appropriate verbal labels, their recall performance will not differ from their performance prior to the instructions (i.e., on the initial classification trials).

Taken together, the above major hypotheses served as replications of the previous findings of Flavell and his associates. Of primary interest in the present study, however, was whether the production deficiency hypothesis could account for the relative performance of the producers and non-producers when rehearsal is prevented. That is, when rehearsal is prevented by the interpolation of another task between stimulus presentation and recall, one would expect according to the production deficiency hypothesis:

(4) (a) that the non-producers' recall performance will not differ from their performance on the initial classification trials;

(b) that the producers' recall performance will decrease to the same level as the non-producers'.

Alternatively, if additional factors differentiate the producers from the non-producers such as the memory-span findings of Flavell et al. (1970) indicate, then it would be expected:

(b) that the producers' recall performance will drop to a level lower than their initial performance, but that this level will remain significantly higher than the performance of the non-producers.

METHOD

Subjects

The sample consisted of a total of 118 public school children: 34 kindergarteners, 25 first graders, 31 third graders and 27 fourth graders, with an approximately equal number of boys and girls in each grade. The mean and range of ages of the children in each grade were: K--68.1 mos., range 62-75 mos.; First--80.6 mos., range 72-91 mos.; Third-- 105.4 mos., range 97-110 mos.; Fourth--116.2 mos., range 106-123 mos. The school from which the two older samples were drawn was located in a generally middle income area, but the kindergarten and first grade schools were located in slightly lower income areas. The subjects were selected one at a time at random from their classrooms, with no attempt being made to match them on any variables other than grade level.

Apparatus

A Kodak Carousel slide projector was used to display solidly colored transparencies onto a 5' 1/2" X 11" HPI side projection screen. The duration for exposure of each color was controlled by a circuit consisting of a Model 335-S Hunter Photo Relay Amplifier and a Model 11-C Hunter timer.

A manual advance mechanism was also provided.

The stimuli were 147 2" X 2" cardboard mounted slides of seven colors: red, green, blue, white, orange, purple and yellow. (Ease of identification and discriminability of these colors had been assured by pilot testing.) An approximately equal number of each color of slides was used, as they were arranged randomly in the required sequences (see Appendix I for the exact sequences utilized).

Nine 1 1/2" X 1 1/2" X 1/2" colored wooden response blocks (one of each of the stimuli colors plus one black and one brown) were randomly arranged in front of the subject and then covered by a piece of cardboard so that no cues would be available to the Ss during presentation of the stimuli. Another identical set of blocks was used by the experimenter to clarify the instructions given. These were then removed from sight. Thirty-two 2 1/2" X 2 1/2" cards [illegible] pictures of familiar objects (e.g., ball, carrot, pants, fish, etc.) mounted on them were utilized in the interference task for the kindergarten and first graders. Seven 3" X 5" filing cards with a number between 10-100 inscribed on them were used in the interference task for the third and fourth graders (pilot work and feedback from the Ss had established the similarity of these tasks for their respective age groups).

In addition, a stopwatch was used to time the delay periods between stimulus presentation and response, and Smarties candies were used to maintain the subject's interest in the task.

Procedure

Each S was brought into the room and seated across the table from E. On the table were the colored response blocks arranged randomly but covered. Slightly to S's left of the blocks was the side projection screen, and on his right was a large box with the timer, projector, photo relay, etc.

Base or Initial Classification Trials. E asked S his or her name and then said, "How would you like to play some games with me? If you try really hard and do the best that you can, then you can win some Smarties. In fact, you can have a couple now if you'd like (E gives S two Smarties).

"I'm going to show you some colors, and then after a little while, ask you to remember them. Do you know your colors very well? Can you tell me what the names of these colors are? (One slide of each color is projected until S identifies it). Now how about these? (The cardboard sheet is removed from the colored blocks and S identifies the blocks in any order.) Very good!

"Now what I'd like you to do is to watch the screen and remember the colors in the same order that I show them to you. For example, maybe I'll show you purple then orange then green. Then you have to wait for a little while. Then I'll ask you to show me these colors in that same order, like this. (E uncovers blocks and arranges them in a sequence from S's left to right: purple, orange, green. Then E returns those blocks to the others and covers them.) Now what did I just show you? (Uncovers S's blocks and S arranges them in the same order. If S can't remember, E covers up S's blocks and let's him see the sequence in front of E again. This continues until S responds correctly.) That's really good! Now do you want to try some practice slides? Watch the screen! (A sequence of three colors is shown at 5 secs. per color.) Now show me what you saw. (E uncovers S's blocks and S arranges them in the same sequrnce that he saw them, from left to right. If S is incorrect, E repeats the practice trial using the same colors.) Very good! And that's how you win Smarties. (E gives S a Smartie.) Pretty easy, isn't it?"

"Now sometimes there'll be more than 3 colors; sometimes there will be 4 or 5. And I'm always going to have you wait a little while after I show you the colors, before you show me what you saw. I have a clock here to time 15 sec., so don't show me what you saw until I take the cardboard (cover on the blocks) away. OK? Are you ready to begin?"

Each S was then given two blocks of trials. Each block consisted of a sequence of 3, 4 and 5 trials in that order. Colors were arranged randomly within each sequence by means of a random numbers table, except that no color could occur twice within any sequence. Each color was presented for five secs. and then the next color (or opaque slide to denote the end of a sequence) followed immediately. A delay of 15 secs. then ensued before recall.

During the stimulus presentation and delay period, E observed S for lip movements and/or vocalizations which could positively be identified as cumulative rehearsal of the stimuli. Cumulative rehearsal of a sequence such as blue, green and red consisted of repeating "blue, blue, blue" while the first stimulus was presented; then "blue, green, blue, green, blue, green,..."while the second was presented; and finally "blue, green, red, blue, green, red,..." during the final exposure. Rehearsal of this type was recorded both during the presentation of the stimuli and during the delay period. (In a pilot study a lip-reader was employed to do a reliability check on E's ability to detect the lip movements. There was complete agreement on every trial.)

After the delay period, the cardboard sheet covering

S's response blocks was removed and S was asked to arrange the colors in the same order as they had appeared. Regardless of S's response he was congratulated and was given a Smartie. The blocks were rearranged randomly and were covered, and the next trial began. S was always told he was doing well, whether in fact he was or not.

Approximately half way through the base condition (i.e., at the end of the first block of trials) S was asked how he was remembering the sequences, and if he had a "trick" to help him remember the colors so well. On the basis of the observation of overt lip movements and verbalization, plus the S's own reports, he was classified as a Producer (P) if he cumulatively rehearsed the sequences on more than one trial (either during stimulus presentation or during the delay) or if he reported having done so covertly. It was assumed that if S could report such cumulative rehearsal, then it was being done in such a fashion that E's gross detection procedure could not pick it up. The S was classified as a Non-producer (NP) if he cumulatively rehearsed on zero or one trial, and did not report having covertly rehearsed.

In the case of the kindergarten Ss, it was observed that the task was taking too long and as a result the children were becoming fatigued and losing interest. After the first seven Ss were tested, it was thus necessary to shorten the Base condition to one block of trials. All succeeding conditions remained the same. Classification as a P or NP was thus based on one block of trials for these Ss, as well as on their reports.

Following the Base trials, Ss within each classification (P or NP) were assigned alternately to either the Teaching (T) or the Interpolated Task (IT) condition.

Teaching Condition (T). Following the Base trials, Ss who were assigned to this condition were told that the procedure was going to change, but only a little. They were told that the colors were going to be presented exactly as before, but now they were to say each color out loud over and over again until the next color appeared. Then they were to repeat both of them in order. This cumulative rehearsal was to continue beyond the appearance of the last color, through the delay period. An example was performed by E, using the colored blocks, until S was certain of the instructions. Two blocks of trials then ensued, with E prompting S to continue rehearsing if necessary. A delay of 15 secs. followed each sequence of colors, after which S was asked to recall the colors. Recall procedure was exactly the same as in the Base condition with S being given a Smartie after each response.

Interpolated Task (IT). Following the Base trials, Ss who were assigned to this condition were told that there was going to be a change in procedure. They were told that the colors were going to appear just as before, but instead of simply waiting 15 sec. before they had to recall the colors, they were going to do something. For grades K and 1, Ss were shown the stack of picture-cards with familiar objects mounted on them. They were told that as soon as the last color disappeared from the screen, they would be given a stack of the cards to go through as fast as possible, naming the objects as they went. They were encouraged to go as fast as they could and were told that the number of cards that they named would be counted and recorded. E demonstrated to S what he was to do until he understood.

The third and fourth graders were told that after the last color disappeared, they would be given a card with a number on it. They were to say the number out loud and begin counting forward by threes (e.g., 48, 51, 54, etc.). E demonstrated with a sample card. They were encouraged to count as quickly as possible and were told that E would record the highest number they attained.

These tasks were performed during the 15 sec. delay period following which E told S to stop, removed the cards and asked S to recall the colors in the same order presented. As in the base condition, each child was given as much time as he needed to recall.

[illegible] ch trial E reshuffled the younger S's cards [illegible] ck and set aside a stack of about 20 for the next trial. (On each trial Ss usually named less than a third of the thirty-two cards, so on each successive trial S mostly saw cards which he had not seen the preceding trial.) In the case of the older children, the numbered card was set aside and not re-used for that S. The recall procedure was the same as in the Base condition, with a Smartie being given after each trial. Two blocks of trials were administered to each S.

Following either the T or the IT condition (depending on which he had been assigned to), S was thanked for having played the game and was told that he had done so well that he had earned himself a ccuple of extra Smarties. E asked S if he thought one part of the game was any easier or harder than the other, and then S returned to his classroom after asking questicns he might have had.

Throughout the experiment, no attempt was made to conceal the recording of Ss' responses, as the response sheet was upside down to S and responses were coded as they were recorded. Very few Ss expressed any interest whatsoever in the response sheets.

RESULTS

The results of eleven Ss (seven kindergarteners, three first graders, and one third grader) were discarded due to inabilities to perform the task. Most of the discards resulted from apparent color blindness or, particularly in the case of the kindergarteners, a lack of knowledge of the colors. Two children were behavioral problems and another was a recent arrival in the country and had not yet mastered the English language. Finally, two of the kindergarten Ss simply lost interest due to the length of the task (these Ss were tested prior to the shortening of the Base condition to one block of trials).

As predicted in the first hypothesis, it was found that the number of subjects classified as Producers was directly related to the age level of the subjects (see Figure 1). The increase was significant between grades one and three (X^2 using Yates correction = 18.9, df = 1, $p<.001$) but was not significant between grades K and one (X^2 using Yates correction<1.0, df = 1, $p>.25$). A ceiling appeared to have been reached sometime during or before grade three. Thus, earlier findings (e.g., Flavell *et al.*, 1966) relating to the first hypothesis were successfully replicated.

The mean proportion of trials on which correct recall was obtained for each condition across all grade levels

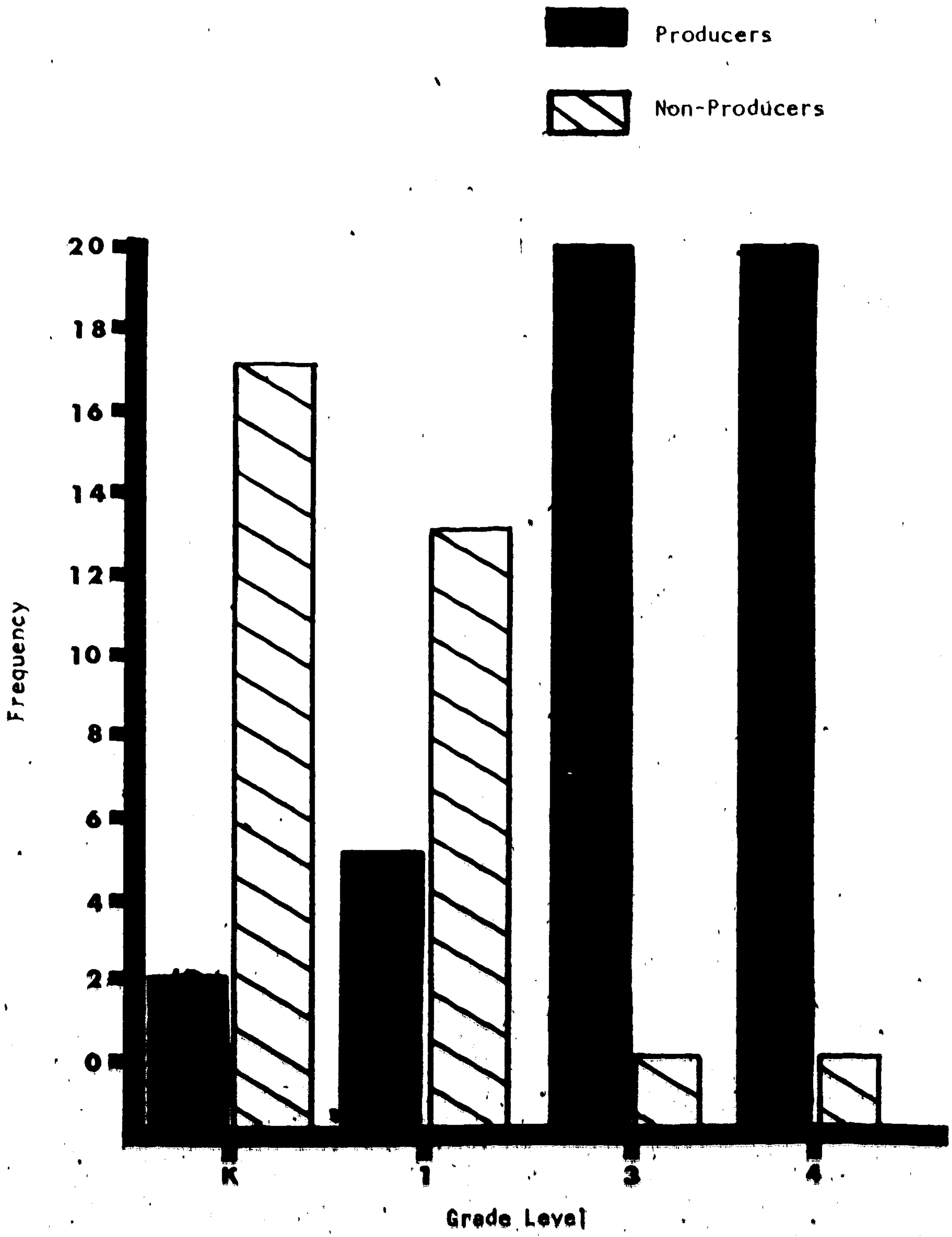

Figure 1

Number of Ss Classified as Producers and Non-Producers Across Grades.

appears in Table 1. It should be noted that there were no Non-producers in grades three and four. Correct recall was considered to have occurred if S successfully arranged the colored blocks in front of him in the same sequence that they had appeared previously. Proportion of trials correct was used to facilitate computations since some of the Ss in the kindergarten level were administered two blocks of trials, and some were only given one. The proportions were calculated as no. of correct trials/max. possible no. of correct trials. In order to determine whether there was a developmental trend for higher recall within the P or the NP groups, or whether there was no variation within each category, several one-way Analyses of Variance were performed.[2] No variation within the groups was found (see Table 2), indicating that the grade level of S does not significantly affect S's ability to perform this task correctly; rather the salient variable in terms of predicting performance on this task is whether the child is a Producer or not. It should be noted that the only condition in which a grade level variable approached significance was the T condition within the NP group (F =

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[2] In these analyses and in all those following, computations were performed on the arcsin transformed data in order to compensate for the non-independence of means and variances which occurs in data consisting of proportions. The means reported in the tables, etc. are the untransformed proportions. The statistical results, however, are those performed on the transformations.

Table 1

Trials of Correct Recall (%)

		Grade			
		K	1	2	3
P	Base Trials	75.0 (N = 2)	66.7 (N = 5)	76.7 (N = 20)	90.6 (N = 16)
	Teach	-	88.9 (N = 3)	83.3 (N = 10)	93.8 (N = 8)
	Int. Task	25.0 (N = 2)	8.4 (N = 2)	23.3 (N = 10)	35.4 (N = 8)
NP	Base Trials	11.8 (N = 17)	17.9 (N = 13)	-	-
	Teach	68.3 (N = 10)	83.4 (N = 7)	-	-
	Int. Task	4.8 (N = 7)	5.6 (N = 6)	-	-

Table 2

Results of Analyses of Variance for Age Trends

	Within P	Within NP
Base (across grades)	$F = 2.00$, $df = 3,39$, $p > .10$	$F = 1.19$, $df = 1,28$, $p > .25$
Teach (across grades)	$F = 1.33$, $df = 2,18$, $p > .25$	$F = 3.27$, $df = 1,15$, $p > .107$
IT (across grades)	$F = 0.79$, $df = 3,18$, $p > .25$	$F = 0.01$, $df = 1,11$, $p > .25$

3.27, df = 1, p=.107). This tendency towards significance may be due to the results of the kindergarten Ss in this group. Some of them had to be prodded often to continue rehearsal at the appropriate times. Most of these Ss seemed to be having difficulty remembering the stimuli even after they had just rehearsed them once and were to repeat them again. This became increasingly true as the number of stimuli to be retained increased. Unfortunately no kindergarten Producers were placed in the T condition (due to the small N) and hence no direct comparisons can be made with them. Since grade level was shown to be an irrelevant variable, Table 1 was collapsed across grades to form Table 3. As predicted in the second hypothesis, Producers were found to have correctly recalled on significantly more trials than the Non-producers in the Base condition (F = 142.56, df = 1,72, $p<.001$). It is possible that the above F-value may have been inflated beyond its true value. For example, a case could be made that since there were no grade three's or four's in the Non-producing group, their results served to increase significantly the mean of the Producers (80.6; see Table 3) disproportionately over the Non-producers. This may be true particularly of the grade four results (90.6; see Table 1). To test this possibility the Analysis of Variance on the Base condition was recalculated without the fourth graders, and was found still to be highly significant (F = 110.49, df = 1,55, $p<.001$). Similarly,

Table 3

Trials of Correct Recall (%)

	Non-Producers	Producers
Base Trials	14.4 (N = 30)	80.6 (N = 43)
Teach	74.5 (N = 17)	88.1 (N = 21)
Int. Task	5.2 (N = 13)	26.5 (N = 22)

when the third as well as the fourth grade results were eliminated, the differences remained as before ($F = 92.04$, $\underline{df} = 1,35$, $\underline{p} < .001$). A summary of the analyses between these conditions and the others with and without the third and fourth graders appears in Table 4.

When the Non-producers were instructed to produce the verbal labels at the appropriate time, their performance increased significantly from a mean of 14.4% to 74.5% ($t = 7.91$, $\underline{df} = 15$, $\underline{p} < .001$). In the case of the Producers, their performance increased from a mean of 80.6% to 88.1% but this increment was not significant ($t = 1.29$, $\underline{df} = 19$, $\underline{p} > .20$). Thus, hypothesis 3 (b) was supported. However, contrary to expectation, the Non-producers performance, while significantly increased, was still less than that of their Producing counterparts ($F = 4.44$, $\underline{df} = 1,36$, $\underline{p} < .05$). As in the Base condition, the analysis was recomputed first without the fourth graders. The result was that the performance of the Non-producers and the Producers no longer differed ($F = 1.17$, $\underline{df} = 1,28$, $\underline{p} > .25$). Similarly, when the third graders' results were dropped, the hypothesis was again supported ($F = 0.97$, $\underline{df} = 1,18$, $\underline{p} > .25$). It appears, then, that the remaining difference in performance between the P and NP groups in the T condition can be accounted for primarily by the fourth graders' performance (mean = 93.8). However, if the means within the T condition are examined

Table 4

Results of One-Way Analyses of Variance Between Producers and Non-Producers Utilizing Entire and Partial Data

	Base Levels Used		
	All (K+1+3+4)	K+1+3	K+1
Base	$F = 142.56$ ($df = 1,71$)***	$F = 110.49$ ($df = 1,55$)***	$F = 92.04$ ($df = 1,35$)***
T	$F = 4.44$ ($df = 1,36$)*	$F = 1.17$ ($df = 1,28$), $p > .25$	$F = 0.97$ ($df = 1,18$) $p > .25$
$\overline{IT}$	$F = 10.26$ ($df = 1,33$)***	$F = 5.74$ ($df = 1,25$)*	$F = 2.10$ ($df = 1,15$), $p > .10$

* denotes $p < .05$

** denotes $p < .01$

*** denotes $p < .001$

(see Table 1), it does not appear that the mean for the grade fours is that dissonant from the others. If one considers the mean for the kindergarten Non-producers (68.3) it is evident that their performance is somewhat less than all the other groups. In fact if the analysis is recalculated using all the data except that of the kindergarteners, then the difference between the P and NP groups becomes negligible ($F = 0.10$, $\underline{df} = 1,26$, $\underline{p} > .25$). Previous comments about these $\underline{S}$'s memorial capacities also applies in this case, as well as the possibility that they are encumbered by a <u>mediational</u> deficiency as well as a production deficiency. These possibilites will be discussed in greater detail below.

The above results successfully replicated the findings of Flavell <u>et al</u>. (1966) and Keeney <u>et al</u>. (1967) with the exception of the kindergarteners in the T condition and, hence, may be interpreted as supportive of the production deficiency hypothesis. When rehearsal during the delay period (intratrial interval) was prevented by the interpolation of the naming or counting task, performance for both the P and the NP groups was found to decrease from each group's respective Base trials performance. The decrement in the NP group's performance (14.4 to 5.2) was found to be significant at the .05 level ($t = 2.33$, $\underline{df} = 11$, $\underline{p} < .05$). This decrease cannot be accounted for by the theory, in that it was assumed in the production deficiency hypothesis that the NP Ss were simply not producing the verbal labels at the appropriate time and hence these labels could not mediate the response. Thus, interference with the production of the labels should have resulted in no change. If it were the case that E incorrectly identified several P's as NP's, then the decrease in this group's mean performance could be accounted for in the same manner as that of the P group below. A subject-by-subject inspection of the data was undertaken to investigate this posssibility. It was expected that if several Ss were incorrectly identified, then the observed decrement in this group's performance could be accounted for by decrements in these few Ss performance, while the remaining Ss would remain unchanged. This was not the case, however, as the performance of over half the Ss (seven) was found to have decreased. Of the remaining six Ss, five of them showed no change and one increased. It is important to note that of the five Ss whose performance did not change, all but one had achieved scores of 0 correct on the Base trials: hence their performance could not have decreased. The other S whose performance did not change had achieved a Base score of 1. Evidently the majority of the NP's were benefitting from some sort of facilitation which was deprived them in the IT condition. One can only speculate as to what sort of facilitation was occurring. It is at least possible that short-term memory faculties could have been involved, since presumably it is this storage system which is disrupted by this sort of interference task. However, other alternatives could be proposed as well, and further research is needed to investigate this phenomencn.

The decrease in performance on the IT task for the P group was of prime interest and was found to be highly significant ($t = 9.92$, $df = 20$, $p<.001$) as predicted. Furthermore, while the decrement was considerable, the performance of the P group was nonetheless found to have remained superior to that of the NP group (mean NP = 5.2; mean P = 26.5; $F = 10.26$, $df = 1,33$, $p<.001$). Consistent with the previous procedure, the analysis was recalculated, deleting the results of the grade fours. The results were still significant ($F = 5.74$, $df = 1,25$, $p<.05$), but when the third grade data was omitted the difference became insignificant ($F = 2.10$, $df = 1,15$, $p>.10$). In attempting to determine the reason for the inordinately low mean for the P grade ones, it was found that both of these Ss had been classified as P's on the basis of apparently producing the verbal labels on exactly two trials. Since the criterion for being classified as a P consisted of observing productions on more than one trial, they were included in the P group. Their reports on how they remembered were similarly not unequivocal, so it may quite possibly be that these two Ss were at a transition point between being NP's and P's, and thus the appropriate verbalizations were perhaps being elicited only occasionally. It may well be that their performance is more similar to that of the Non-producers and in fact this appears to be the case. When the analysis is performed utilizing all the data except that for the grade one Producers, the difference is highly significant ($F = 1.81$, $df = 1,31$, $p < .001$). When the fourth graders are also eliminated the difference remains ($F = 6.77$, $df = 1,23$, $p < .05$).

A final comparison was made between the Producers' IT mean and the Non-producers Base mean. According to the theory, since the NP Base score was expected to remain unchanged from their Base score, it had been predicted that the Producers' IT score would remain significantly greater than the expected Non-producers' Base/IT score. The difference between the means (Producers' IT = 26.5, Non-producers Base = 14.4) was as predicted ($t = 2.24$, $df = 20$, $p < .025$, one-tailed test; $p < .05$, two-tailed test). The above results clearly support the final, alternative hypothesis and it can thus be concluded that there are other factors differentiating the two groups then simply a production deficiency.

A post hoc analysis was performed on the data in order to compare the mean maximum length of stimuli successfully recalled by each subgroup of $\underline{S}$s. Each $\underline{S}$ was assigned a value of 3, 4, or 5 per condition depending on the longest sequence which was successfully recalled by that $\underline{S}$s. If $\underline{S}$s failed to successfully recall any sequence within that condition, an arbitrary value of 2 was assigned.[3] The mean values per condition appear in Table 5. Comparison of these values with those in Table 3 indicates the same general trend in performance. The results of the analysis of this data lends itself to even more unequivocal support of the hypotheses. The mean maximum length of colors recalled by $\underline{S}$s in the NP condition was found to be significantly less than that of $\underline{S}$s in the P condition ($t = 14.37$, $\underline{df} = 28$, $\underline{p} < .001$). In the teaching condition, performance for the P's did not change ($t = 1.48$, $\underline{df} = 19$, $\underline{p} > .10$), whereas the NP's were found to have been able to recall significantly longer sequences ($t = 11.70$, $\underline{df} = 45$, $\underline{p} < .001$). Moreover, as predicted, no difference was found between the two groups (P and NP) after the teaching instructions had been given ($t = 1.51$, $\underline{df} = 15$, $\underline{p} > .10$). In the IT condition, the NP's performance was found to have remained unchanged from the Base condition ($t = 1.27$, $\underline{df} = 41$, $\underline{p} > .20$) as predicted. However, as predicted in the alternative hypothesis, the P's

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[3] It was felt that the assignment of a two to these $\underline{S}$s would least bias the data in these conditions. It was further reasoned that there was no evidence to conclude that these $\underline{S}$s could not in fact have been able to respond correctly for lengths of two stimuli.

Table 5

Mean Maximum Sequences Length Recalled by Producers and Non-Producers Across Conditions[a]

	Non-Producers	Producers
Base	2.7	4.8
Teach	4.7	4.9
IT	2.4	3.5

[a]A value of 2 was arbitrarily assigned to any S who failed to recall any sequence whatsoever.

mean maximum length successfully recalled was found not only to have decreased significantly from the Base condition ($t = 4.88$, *df* = 20, $p < .001$), but also to have remained significantly higher than that of the NP's ($t = 3.18$, *df* = 11, $p < .01$).* These results are in clear agreement with the previous findings of this study and those of Flavell *et al.* and Keeney *et al.*

A somewhat tangential, but nonetheless important issue regearding the possible biasing effects of the different samples from which *S*s were drawn, as well as the change in procedure necessitated by the kindergarten *S*s should be considered. The fact that the kindergarten and first grade samples were drawn from lower income areas than that of the two older samples was not seen as having biased the results. The major effect this sampling differential would have on the data would be concerning the number of children classified as P's or NP's (e.g., perhaps the children drawn from the two older samples are brighter, etc.). Although this may have been the case (as may be indicated by the fact that a ceiling was reached in the present study before the grade three level whereas Flavell *et al.* found Non-producers even in grade five), the number of Producers and

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* For the sake of consistency, a comparison was also made as before between the P's IT score and the NP's Base score. The difference remained significant ($t = 2.60$, *df* = 50, $p < .02$).

Non-producers, per se, were not of significant interest. Rather, differences between these groups were the prime considerations.

Of more direct interest are the possible effects of the change in procedure wherein the majority of the kindergarten children were initially classified on the basis of one block of trials as opposed to two. Since $\underline{S}$s were classified as P's or NP's on the basis of whether or not they verbalized the appropriate mediators on more than one trial (or reported having done so), then any effect caused by decreasing the number of trials in this condition should be in the direction of decreasing the number of $\underline{S}$s classified as P's. That is, there would tend to be some P's classified incorrectly as NP's. Hence the scores of the kindergarten NP's would be generally higher than if the group consisted entirely of actual NP's, thus tending to minimize any differences between the P's and the NP's. This procedural variable does not appear to have influenced the data, however. The results of the present study agree precisely with those of the Flavell *et al.* study. In the former, only two kindergarteners were classified as P's, while 17 were classified as NP's; in the latter two were classified as P's while 18 were classified as NP's. As indicated above, if the NP group contained some Producers, then one would expect their mean performance to be superior to a group consisting solely of NP's. This did not appear to have happened, as not only is the mean for the kinderagarten NP's not significantly different from the grade one's (see Table 2), but the direction of the difference is the opposite of what would be expected. Moreover on examination of the mean maximum sequence lengths successfully recalled, it was found that the majority of the kindergarten NP's (ten) were unable to recall even the shortest sequences, another six could recall only the shortest ones, and only one could recall any sequence of length four. However, all the Producers in kindergarten and grade one, as well as those in grades three and four, recalled sequences of at least length 4, and the majority could recall those of length 5.

A final point concerns the possible effects of differing amounts of pretraining due to the procedural difference. The influence of this variable was considered to be negligible due to the design of the study. Prior to each condition, each S was given as many practice trials as were required in order that he fully understood the instructions. Hence each S was not necessarily benefitting from the previous condition, but rather from the practice trials which introduced each condition. Since there was little evidence of either biased data or misclassified Ss due to the alteration of the procedure for the kindergarteners, the salience of this variable was considered questionable, at best.

Results of the exploratory investigations undertaken are relevant to the examination of the nature of the performance difference remaining between the P's and the NP's after interference with rehearsal in the IT condition. In order to determine if the Producers were superior to the Non-producers in memorial capabilities, two blocks of trials were presented to Ss under the Teaching procedure. Each block consisted of one sequence each of 5, 6, and 7 colors, rather than the previous 3, 4 and 5. The results appear in Figure 2. No statistical analysis was performed on the data since the reliability of the results of the Non-producers is uncertain, as only three Ss are contained in that group, all of them from kindergarten. The superiority of the Producers in handling these longer strings is quite apparent. This data was combined with the data from the T conditon on lengths 3, 4 and 5 and was plotted in Figure 3. It can be observed that the Producers tend to be able to recall longer strings of stimuli indicating superior retention capacity.

Further supportive evidence of memorial differences was obtained from another exploratory manipulation involving the IT procedure, in which the length of the intratrial delay period (and hence the duration of the interference task) was manipulated. The sequence length was held constant at four items. The results of interfering with rehearsal for 0, 10,

Figure 2

Producers' and Non-Producers' Recall
as a Function of Sequence Length.

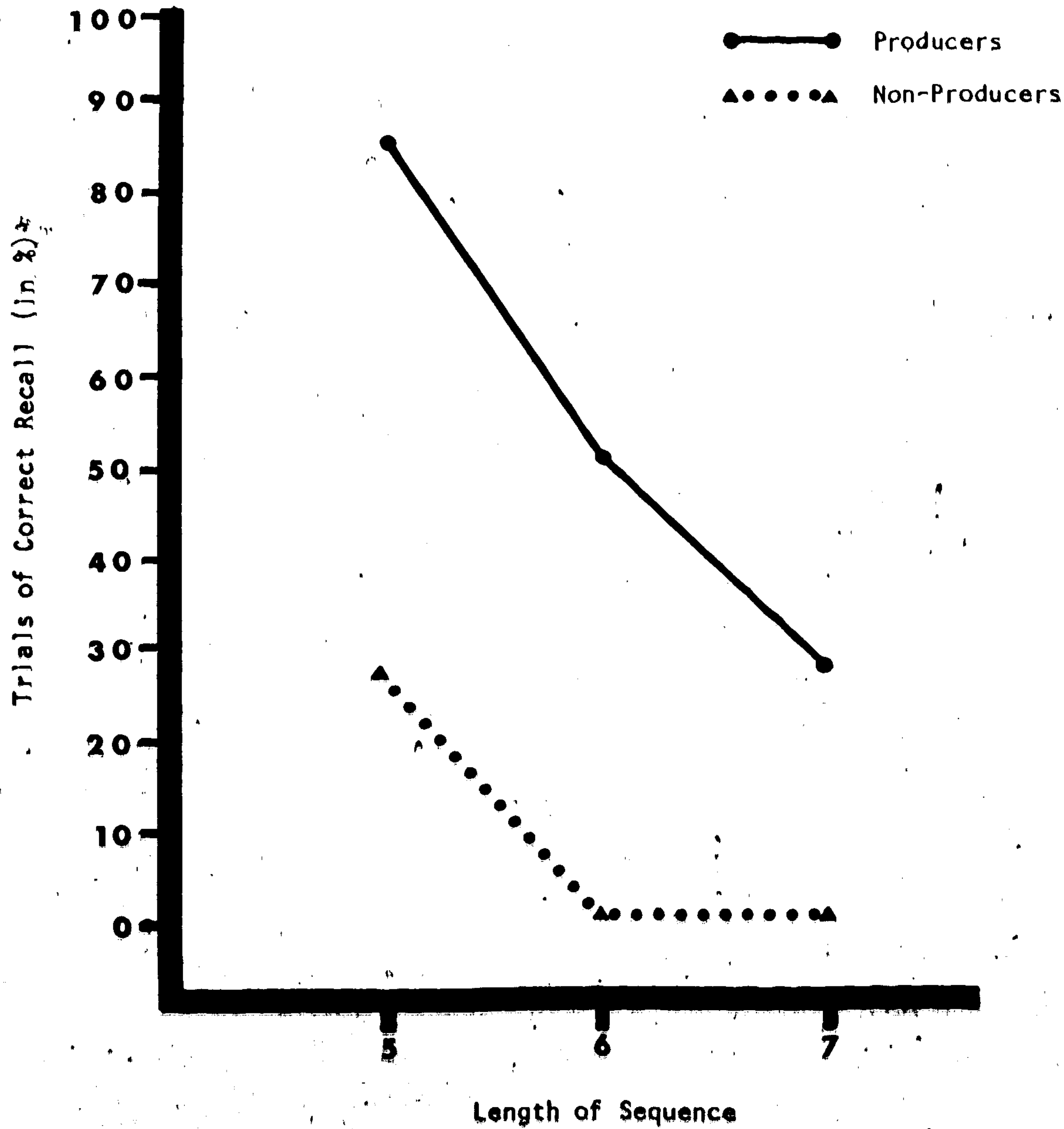
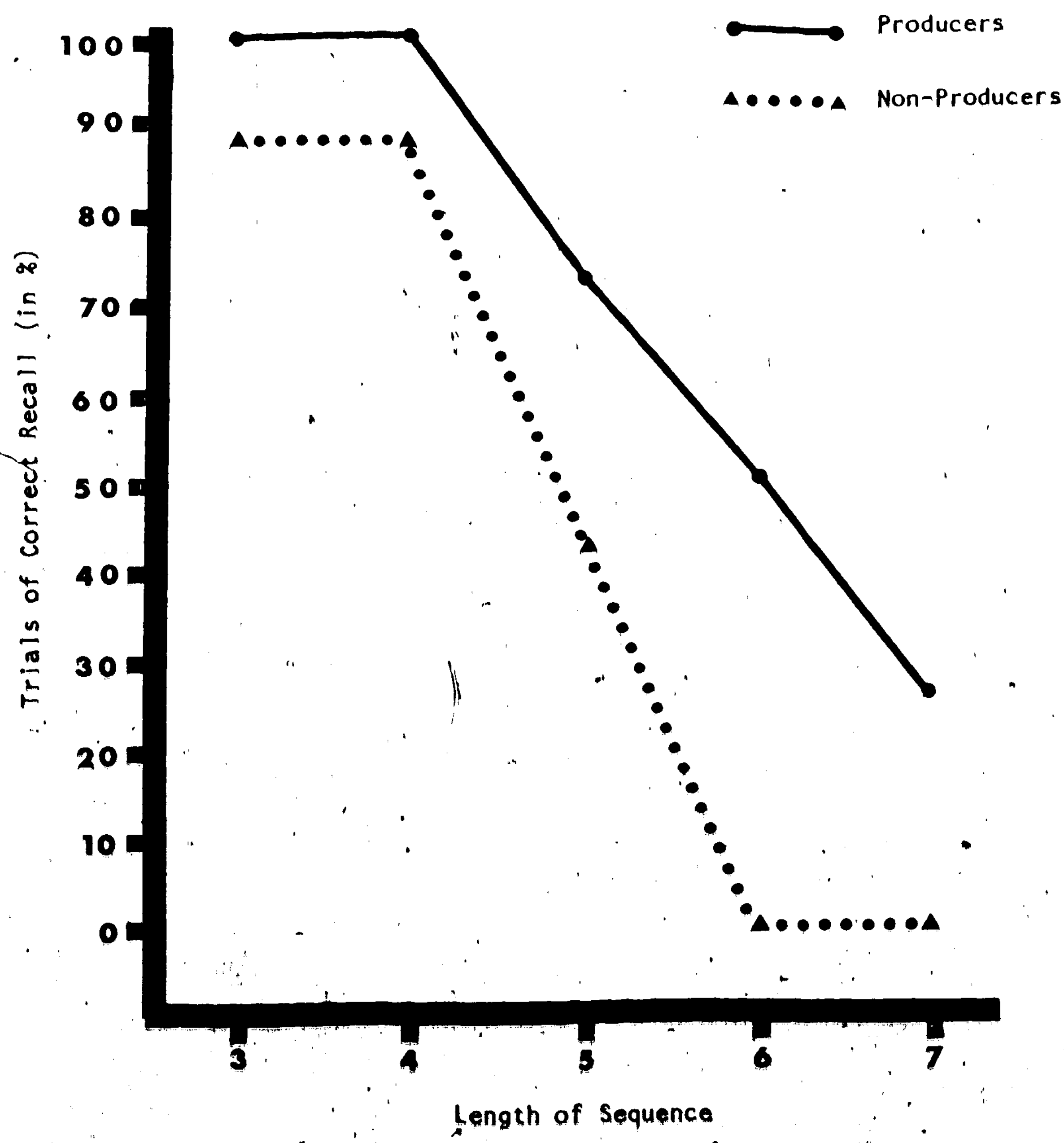


Figure 3

Producers' and Non-Producers' Recall as a Function of Sequence Length (Combined Data).



20 and 30 seconds are shown in Figure 4. It should be noted that no data was available for the Producers at 0 secs., but it was reasoned that the Producers could be assumed to be recalling at least at the level of the Base condition in the first part of the study (80.6%). In that condition, the Ss had to retain the sequence for 15 secs. before recalling. If the S can recall after a 15 second delay, then it does not seem unreasonable to assume that he could have recalled at least as well at 10 secs., 5 secs., or immediately, unless one proposes a mechanism which would increase the ability to recall correctly with time. The 0-sec. recall condition is immediate recall with no intratrial task occuring.

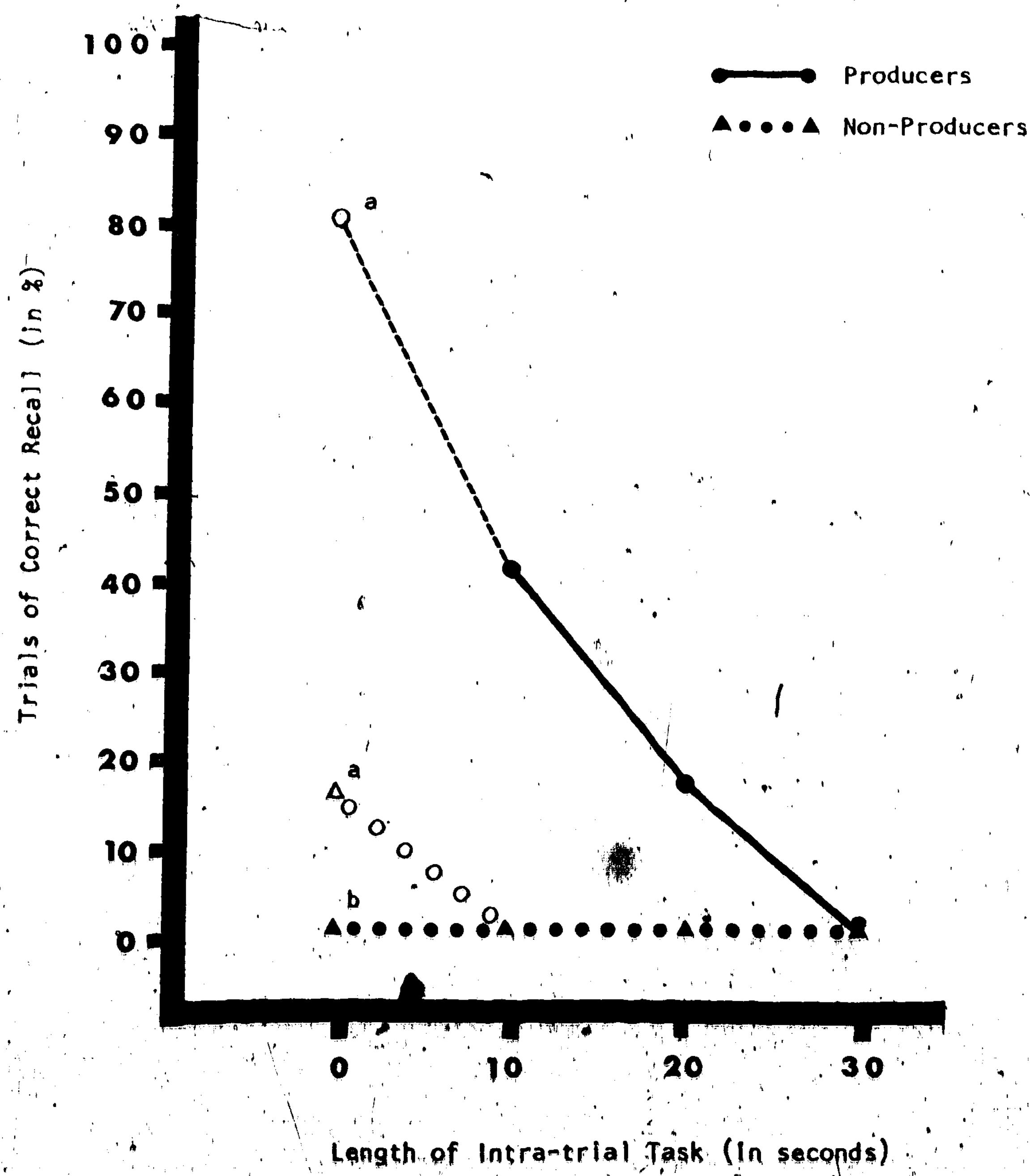
The data for 0 sec for the Non-producers in Figure 4 was based on two Ss. The value expected from the Base condition in the first part of the study is also plotted.

The reliability of these results is again in question due to the small N's (N = 10 for Producers, N = 5 for Non-producers). It could be observed from the trend of the data that the stimuli appear to be retained longer without rehearsal by the Producers than by the Non-producers. However, any conclusions based on the results of these exploratory manipulations are tentative at best, and further data is needed to clarify the questions involved.

The major findings of the study provide support for hypotheses one through four (a), thus indicating that the NP group does suffer from a production deficiency. In addition, the findings supported the alternative hypothesis, four (b), and hence were interpreted as indicating that the Producers were also superior to the Non-producers in retention ability. Additional data collected also tended to support the latter conclusion, but inferences about the specific nature of this memorial deficiency were unjustified without further research.

Figure 4

Producers' and Non-Producers' Recall as a Function of the Length of the Intra-trial Interference.



[a]Data missing. Value derived from Base trials in main body of study (see text).

[b]Actual data. May indicate a mediational deficiency.

DISCUSSION

The findings of Flavell *et al.* (1966), that the older a child the greater the probability that he will be classified as a Producer on this sort of task, were replicated in the present study. It was also evident that verbal rehearsal was extremely facilitative in recalling the stimuli. Moreover this rehearsal was no less effective a mediator of color-sequence recall for younger children than for older children, which was also observed by Keeney *et al.* (1967) and Daehler, Horowitz, Wynns and Flavell (1969). In the present study, however, it was observed that the kindergarten NP's performance was somewhat lower than that of the other groups within the Teaching condition. While increased from the Base trials, the fact that these *S*s required more prodding to continue rehearsal and that their performance was below that of the others, suggests that some additional factor may be present. In the Keeney *et al.* study, the Non-producers used in the teaching condition were all first graders, whereas in the present study this group consisted of kindergarteners. When the kindergarteners were excluded from the analysis, the two experiments were found to have produced equivalent results. This suggests that the NP kindergarteners may also have a mediational deficiency. Further support for this notion can be derived from the immediate recall data of three kindergarteners in the exploratory study involving different intervals of interference before recall. These three Ss were unable to recall correctly on all trials, including when recall was immediate. While these latter cases may be extreme, they nevertheless suggest a problem. Keeney et al. reported not having to give any more prods to their Non-producers than their Producers in order to keep them rehearsing. While no data was collected in the present study on this point, it appeared to E that most of the NP kindergarteners needed excessive prodding (almost continuous in some cases) to continue rehearsing audibly. Kendler, Kendler and Wells (1960) indicated that kindergarten may be the approximate age at which children progress from mediated to unmediated behavior. Luria (1961) claimed to have shown that there is a stage at which S's self-commands fail to regulate his motor actions (Jarvis, 1963 called these results into question in a later study). In light of these findings, it may well be that the kindergarten Ss in the Teaching condition of this study were not yet mediationally competent, and this could account for their performance. An indication of the plausibility of this argument was that in several cases, after rehearsing a sequence correctly, an S would recite the colors correctly while picking out one or more incorrect blocks and arranging them in front of him.

The Teaching condition appeared to be very easy for the

Producers, the grade fours in particular. Many of them engaged in considerable extraneous activity such as examining the apparatus, looking around the room, etc. while they rehearsed the sequences. This was more prevalent at lengths 3 and 4 and was less the case at length 5, possibly indicating that it was not really a challenge for them to remember the shorter lengths. The fact that the younger _S_s, particularly the Non-producers, had to concentrate extensively might be interpreted as reflecting a greater memorial capability on the part of the older _S_s. That the older _S_s seemed to be concentrating more on the length 5 sequences may be interpreted as reflecting more of a challenge to them. In fact the length 5 sequences approaches what Flavell _et al_. (1970) found to be the mean actual object span for fourth graders (5.50 items).

It is of interest to note that when _S_s were asked after the study whether they thought the Base or the Teaching condition was easier, nearly all _S_s reported that not only was the Base condition easier, but they felt that they had done better in that condition. The Non-producers were the most adamant about this, even though they clearly did better in the Teaching condition. (Of course, they had no actual knowledge of their results since no feedback was given to them.)

Several Producers reported that the reason they felt that they had recalled better in the Base condition was that the forced overt verbalizations in the Teaching condition sometimes confused them. The confusion resulted from their either getting "tongue-twisted" on certain sequences or from the verbalizations altering their rate of covert rehearsal. This appears to be analogous to interference and tends to corroborate evidence by Murray (1967) and Hagen and Kingsley (1968) which indicated that forced verbal rehearsal in Ss mature enough to rehearse efficiently (covertly or semi-covertly) may serve to interfere with later recall.

Contrary to predictions based on the production deficiency hypothesis alone, when rehearsal during the intra-trial delay period was interfered with, the Producers performance did not decrease to the level of the Non-producers. One possibility for explainig these results is that the interference task did not entirely prevent rehearsal during the delay period or, possibly, that the two different interference tasks were not equivalent. The interference tasks were designed based on recommendations from the children's teachers: both involved skills which the children were just developing in their curricula. The counting task for the third and fourth graders, for example, was felt by their teachers to be very challenging, but something the older children could do with effort. In both tasks the subjects were told to work as fast as possible and that their progress would be recorded. Inasmuch as the intent was to prevent overt verbal rehearsal of the items, the tasks were successful. The possibility of covert rehearsal, on the other hand, is always a recurrent issue. Concerning this, several times throughout the IT condition, after an S arranged the blocks, E expressed "amazement" at S's ability to perform this task through the interference and asked (similarly to the Base condition) how S could ever remember the colors. The majority of the children said that they did not know, even those who had reported covert rehearsal previously. Some of the children offered explanations, none of which reflected covert rehearsal. Some of the younger Ss (grades K and one) indicated, "I don't know, I just 'membered them: my mind connected them to my brain!" Another reported, "I put them in my 'membring cap before (I do the cards) and then take them out." When asked if they tried to say the colors during the interference, none of them reported affirmatively. Several of the older Ss indicated that they rehearse a sequence "real good" while it is being presented, and then try to think back to it at recall. Two of the older Ss and one of the younger ones reported using a mnemonic device (e.g., the colors of their clothes) to help them remember. But even the mnemonic-users reported not being able to rehearse covertly during the delay. The use of mnemonics, more thorough rehearsal, and a "'membring cap" all reflect a knowledge on the part of the Ss that they had to do something to "get across" the interference period. All of these techniques seem designed to store the information in short-term memory as well as possible in the hopes that at recall they could still retrieve it. This notion of bridging the interference period, as well as the Ss' own reports, indicate the efficiency of the interfering tasks with both overt and covert rehearsal. The only S who reported covert rehearsal was a fourth grader in the pilot study. However, the interference task utilized in this case was the one later restricted to the kindergarteners and first graders -- the picture naming task. She was able to name a card and then recite a color in the sequence covertly before the next card (e.g., man (out loud), blue (silently), bear (out loud), green (silently), etc.). However, when the other task, counting by threes, was introduced, she was no longer able to rehearse covertly.

A second explanation for the remaining performance difference between the Ps and the NPs in the IT condition centers on the theoretical basis for the Alternative hypothesis. As indicated above, Flavell et al. (1970) found that there is a developmental increase in the memory span of subjects from kindergarten through grade four. This increase coincides with the observed increase in the proportion of children who are classified as Producers. It may well be, then, that these factors were confounded in previous studies, and the IT condition in the present study served to divorce them. The difference in the mean maximum length successfully recalled by Producers over Non-producers reflects the confounding of these factors as well. There is little doubt that the production deficiency hypothesis can account for the data of the Base and Teaching conditions. However, it becomes clear that there is at least another factor differentiating the two groups when the effects of the production deficiency are equalized through interference. It is evident that not only are the Non-producers remembering fewer sequences in the Base condition, but the sequences they are recalling are the shortest ones. If the Flavell et al. (1970) study is considered, one would predict that the Non-producers' (which consist entirely of kindergarteners and first graders) mean maximum sequence should be between 3-4 items. The mean observed was just under three. Thus it may have been that in the Base condition the Non-producers were not even able to retain the longer sequences in order to rehearse them, whereas the older Ss were able to do both. In fact the difference, which disappears in the Teaching condition, was found to reappear if the length of the sequences is increased to 6 and 7 items. This is clearly indicative of a quantitative difference between the groups.

As in the Flavell et al. study the older children in this study seemed more knowledgeable about their own memorial capabilities than the younger Ss. This is indicated by the number of Producers who tried to rehearse "real good" prior to the imposition of the interference task. This implies a conscious knowledge that they will have to compensate for the lack of rehearsal time in order to recall at a later time.

It is quite evident that the two factors -- production deficiency and memorial deficiency -- are at least correlated in terms of developmental trends regarding the effect they have on performance. Other factors may be correlated with them as well. However, the overriding consideration involves the purpose of the child's use of the verbal rehearsal strategy. These detectable differences may only be, as it were, the tip of the iceberg. A great deal of research has been focused on various rehearsal strategies in adults, with primary emphasis being placed on the role of rehearsal in transferring information from short-term to long-term memory. For example, Atkinson and Shiffrin (1968) suggested that whenever an item is rehearsed, it is retained in the short-term store and some information about it is transferred into long-term store. The verbal rehearsal engaged in by the Ss in the present study can be interpreted as one type of rehearsal strategy. The repeated verbalizations serve to increase the probability that the information remains active in short-term memory and enters the long-term store.'

In this frame of reference, then, both the production deficiency and the memorial deficiency of the Non-producers are simply correleated to and indicative of an encoding deficiency. The deficiency in the overt production and rehearsal of the labels is thus interpreted as a manifestation of an earlier stage in the development of the encoding process. When the NPs are placed in the Teaching condition, the information is kept active in short-term memory so that at the time of recall, they can easily retrieve it from STM. When the Producers try to compress more rehearsal into the five seconds in which the last stimulus item is exposed (and hence before the interference task commences), what they accomplish is additional activation of the information in STM, so that when the interference task is completed they can still retrieve the information. The fact that not all the Producers engage in the rapid rehearsal, but can nonetheless accurately recall, may indicate that there is a concomitant quantitative change in the duration for which STM can retain information without rehearsal. One would expext, then, that if the intra-trial interference period were extended, that the Producers' performance would decrease, but at a slower rate than the

Non-producers'. This, in fact, was observed in the exploratory study.

If these deficiencies are reduced to deficiencies in encoding, then many questions arise. How extensive is the encoding deficiency and what processes are affected by it? For example, is the deficiency centered on the retention of information in STM, or does it affect the transfer of information from STM to LTM? Children are clearly capable of remembering many things for both a short and a long period of time. What sorts of information are affected: is the deficiency indigenous only to this type of task or is it more generalized? What other cognitive faculties, if any, develop synchronous with an encoding proficiency? Further research is clearly needed to develop this aspect of cognitive development.

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APPENDIX I

Exact Color Sequences Utilized

Main Study

Practice: O, B, W

Base Trials:

Block I:	G, W, R	B, Y, R, P	Y, G, R, O, B
Block II:	B, Y, P	Y, G, B, W	P, G, O, Y, B

Teach or IT Trials:

Block I:	B, G, Y	R, W, O, P	R, Y, W, G, P
Block II:	Y, O, B	R, O, W, G	W, R, P, O, B

Exploratory Studies

Practice: O, B, W

Base Trials: G, W, R B, Y, R, P Y, G, R, O, B

Varying Intervals:

Block I:	B, G, W, O	P, Y, R, B	G, P, R, Y
Block II:	W, G, Y, P	G, W, B, O	R, O, W, B

Varying Lengths:

Block I:	B, P, Y, G, W	G, R, W, O, P, B	Y, O, P, G, W, R, B
Block II:	B, P, Y, W, R	R, G, W, Y, B, P	R, B, O, P, G, W, Y

Code

Y = Yellow
O = Orange
R = Red
G = Green
B = Blue
P = Purple
W = White

APPENDIX II

# of Trials of Correct Recall

Grade K

Non-Producers

S#	Base Trials	Teach	Int. Task	Mediators Observed	Mediators Reported
1	1	4		N	N
2	3		0	N	N
3	1	4		N	N
10	2		0	N	N
23	1	3		N	N
ΣX	8	11	0		
N	5	3	2		
$\bar{X}$	1.6	3.7	0.0		
MAX/S	6	6	6		
(N x MAX) MAX TOTAL TRIALS	30	18	12		
PER CENT	8/30=26.7	11/18=61	0/12=0.0		

Non-Producers[d]

S#	Base Trials	Teach	Int. Task	Mediators Observed	Mediators Reported
8	0		2	N	N
9	0	6		N	N
11	0	3		N	N
13	0	5		N	N
16	1	3		N	N
15	1		0	N	N
17	0	5		N	N
18	0		0	N	N
19	0	4		N	N
20	0		0	N	N
24	0		0	N	N
25	0	4		N	N
ΣX	2	30	2		
N	12	7	5		
$\bar{x}$	0.17	4.3	0.4		
MAX/S	[d]3	6	6		
MAX. TOTAL	36	42	30		
PER CENT	2/36= 5.6	30/42= 7.14	2/30= 6.7		

[d]Only 3 base trials were administered per subject (see procedure for details).

Totals for All Non-Producers

ΣX	10	41	2
N	17	10	7
$\bar{x}$	.59	4.1	0.29
MAX/S	-	6	6
MAX. TOTAL	-	60	42
TOTAL PER CENT	11.8	68.3	4.8

of Trials of Correct Recall

Grade K

Producers

S#	Base Trials	Teach	Int. Task	Mediators Observed	Mediators Reported
5	4		3	Y	N [e]
22	5		0	Y	N [e]
ΣX	9		3		
N	2		2		
$\bar{X}$	4.5		1.5		
MAX/S	6		6		
(N x MAX) MAX. TOTAL	12		12		
PER CENT	9/12 = 75		3/12 = 25		

[e]Mediators observed but not unequivocally reported

of Trials of Correct Recall

Grade I

Producers

S#	Base Trials	Teach	Int. Task	Mediators Observed	Mediators Reported	
3	4	5		Y	Y	
4	5	5		N	Y	a
6	4	6		Y	Y	
9	3		0	Y	Y	c
13	4		1	N	Y	ac
x	20	16	1			
N	5	[illegible]	2			
x̄	[illegible].0	[illegible]	0.5			
MAX/S	[illegible]	[illegible]	6			
(N x MAX) MAX	[illegible]					
TOTAL TRIALS	[illegible]	18	12			
PER CENT	20/30=66.7	16/18=88.9	1/12=.837			

Non-Producers

S#	Base Trials	Teach	Int. Task	Mediators Observed	Mediators Reported
1	1	5		N	N
2	1	5		N	N
20	0	3		N	N
21	2	6		N	N
23	2	6		N	N
24	1	6		N	N
10	2		0	N	N
11	1		0	N	N
12	0		0	N	N
14	2		1	N	N
15	1		1	N	N
16	1		0	N	N
22	0	4		N	N
ΣX	14	35	2		
N	13	7	6		
X̄	1.04	5.0	0.3		
MAX/S	6	6	6		
(N x MAX) MAX					
TOTAL TRIALS	78	42	36		
PER CENT	14/78=17.9	35/42=83.4	2/36=5.6		

[a]Mediators reported but not observed

[c]Marginally classified as a producer

# of Trials of Correct Recall

Grade 3

Producers

S#	Base Trials	Teach	Int. Task	Mediators Observed	Mediators Reported	
1	6		1	Y	Y	
2	5	5		Y	Y	
3	6		4	Y	Y	
4	5	4		Y	Y	
5	5		3	N	Y	a
6	3	5		N	Y	ac
7	6		2	N	Y	a
8	5	6		Y	Y	
9	6		2	Y	Y	
10	4	5		Y	Y	
11	4		1	Y	Y	
12	3	5		N	Y	ac
13	6		0	Y	Y	
14	4	5		N	Y	a
15	4		0	Y	Y	
16	3	6		Y	Y	
17	4		0	N	Y	
18	3	4		N	Y	ac
19	6		1	Y	Y	
20	4	5		Y	Y	
Σ	92	50	14			
N	20	10	10			
$\bar{x}$	4.6	5.0	1.4			
MAX/S	(6)	(6)	(6)			
(N x MAX) MAX TOTAL TRIALS	120	60	60			
PER CENT	92/120=76.7	50/60=83.3	14/60=23.3			

Non-Producers

None

[a]Mediators reported but not observed
[c]Marginally classified as a producer

# of Trials of Correct Recall

Grade 4

Producers

S#	Base Trials	Teach	Int. Task	Mediators Observed	Mediators Reported	
1	4		4	Y	Y	b
2	6	6		N	Y	a
4	6		3	N	Y	a
3	6	5		Y	Y	
5	6		1	Y	Y	
6	5	5		Y	Y	
7	4		3	N	Y	a
8	6	6		N	Y	a
9	5		2	Y	Y	
10	5	6		Y	Y	
11	5		2	Y	Y	
12	5	6		Y	Y	
13	6		2	Y	Y	
14	6	6		N	Y	a
15	6		0	Y	Y	
16	6	5		Y	Y	
Σ	87	45	17			
N	16	8	8			
$\bar{X}$	5.4	5.6	2.1			
MAX/S	(6)	(6)	(6)			
(N x MAX) MAX TOTAL TRIALS	96	48	48			
PER CENT	87/96=90.6	45/48=93.8	17/48=35.4			

Non-Producers

None

[b]Used mnemonics in IT

[a]Production reported but not observed

APPENDIX III

Recall Scores from Exploratory Studies

Condition II (Lengths)
% of Trials Correct

Grade K

Producers

S#	Length 5	Length 6	Length 7
26	50%	0.0%	50%
29(b)	100%	50%	0.0%
ΣX	150	50	50
N	2	2	2
x	75%	25%	25%
MAX/S	100%	100%	100%
TOTAL MAX. TRIALS	200%	200%	200%
PER CENT	150/200=75%	50/200=25%	50/200=25%

Non-Producers

S#	Length 5	Length 6	Length 7
28	0.0%	0.0%	0.0%
32	50%	0.0%	0.0%
	50	0.0	0.0
	2	2	2
	25%	0.0%	0.0%
	100%	100%	100%
	200%	200%	200%
	50/200=25%	0/200=0.0%	0/200=0.0%

Condition III (Intervals)
% of Trials Correct

Grade K

Producers

None

Non-Producers (Intervals)

S#	0 Sec.	10 Sec.	20 Sec.	30 Sec.
29(a)	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0
33	0.0	0.0	0.0	0.0
ΣX	0.0	0.0	0.0	0.0
N	3	3	3	3
x	0.0	0.0	0.0	0.0
MAX/S (N x MAX)	100	100	100	100
TOTAL MAX. TRIALS	300	300	300	300
PER CENT	0/300=0.0	0/300=0.0	0/300=0.0	0/300=0.0

APPENDIX III (continued):

Condition II (Lengths)
% of Trials Correct

Grade 1

Producers

None

Non-Producers

S#	Length 5	Length 6	Length 7
17	50.0	0	0
19	50.0	50.0	.0
ΣX	100.0	50.0	0
N	2	2	2
x	50.0	25.0	0.0
MAX/S	100	100	100
TOTAL MAX. TRIALS	200.0	200.0	200.0
PER CENT	100/200=50%	50/200=25%	0/200=0.0%

Condition III (Intervals)
% of Trials Correct

Grade 1

Producers

None

Non-Producers

S#	Delay	Delay 10	Delay 20	Delay 30
25		0	0	0
18		0	0	0
ΣX		0	0	0
N		2	2	2
x		0	0	0
MAX/S		100	100	100
TOTAL MAX. TRIALS		200	200	200
PER CENT		0/20=0.0	0/200=0.0	0/200=0.0

APPENDIX IV

One Way Analyses of Variance Tables for Age Trends

		Within Producers				Within Non-Producers			
	Source	DF	SS	MS	F	DF	SS	MS	F
Base (across grades)	A	3	0.807	0.269	2.002	1	0.028	0.028	1.185
	Error	39	5.242	0.134		28	0.659	0.024	
	Total	42	6.049			29	0.687		
	p	>.10				>.25			
Teach (across grades)	A	2	0.243	0.122	1.332	1	0.450	0.450	3.271
	Error	18	1.645	0.091		15	2.064	0.128	
	Total	20	1.888			16	2.514		
	p	>.25				.107			
IT (across grades)	A	3	0.137	0.046	0.792	1	0.0001	0.0002	0.014
	Error	18	1.037	0.058		11	0.136	0.012	
	Total	21	1.174			12	0.137		
	p	>.25				>.25			

APPENDIX V

One-Way Analyses of Variance Between Groups, Within Each Condition

		Within Base				Within Teach				Within IT			
	Source	DF	SS	MS	F	DF	SS	MS	F	DF	SS	MS	F
P-NP (all grades)	A	1	14.876	14.876	142.556	1	0.562	0.562	4.442	1	0.143	0.143	10.2[illegible]
	Error	71	7.409	0.104		36	4.559	0.127		33	1.330	0.040	
	Total	72	22.285			37	5.122			34	1.743		
	p	<.001				<.05				<.001			
P-NP (minus grade 4)	A	1	8.829	8.829	110.491	1	0.148	0.148	1.166	1	0.198	0.193	5.7[illegible]
	Error	55	4.395	0.080		28	3.554	0.127		25	0.862	0.034	
	Total	56	13.224			29	3.702			26	1.060		
	p	<.001				<.25				<.05			
P-NP (minus grades 3 & 4)	A	1	2.226	2.226	92.041	1	0.148	0.148	0.973	1	0.045	0.045	2.0[illegible]
	Error	35	0.846	0.024		18	2.743	0.152		15	0.319	0.021	
	Total	36	3.073			19	2.891			16	0.364		
	p	<.001				<.25				<.10			
P-NP (minus K-NP's)	A					1	0.013	0.013	0.108				
	Error					26	3.197	0.123					
	Total					27	3.211						
	p					<.25							
P-NP (minus grade 1 P's).	A	1	0.470	0.470	11.809								
	Error	31	1.234	0.040									
	Total	32	1.704										
	p	<.001											
P-NP (minus grades 1 & [illegible] P's)	A									1	0.236	0.236	6.7[illegible]
	Error									23	0.803	0.035	
	Total									24	1.039		
	p									<.05			

APPENDIX VI

Calculated t-Values for Comparisons Between Conditions Within Each Group

% of Trials of Correct Recall

		Base	Teach	Base	IT
P	Means	80.6	88.1	80.6	26.5
	Variances	0.16	0.10	0.16	0.06
	Calculated t-values	1.29 (df = 19, p>.20)		9.92 (df = 20, p<.001)	
NP	Means	14.4	74.5	14.4	5.2
	Variances	0.02	0.16	0.02	0.01
	Calculated t-values	7.91 (df = 15, p<.001)		2.33 (df = 11, p<.05)	

Mean Maximum Length of Correct Recall (Max. = 5.0)

		Base	Teach	Base	IT
P	Means	4.8	4.9	4.8	3.5
	Variances	0.18	0.09	0.18	1.50
	Calculated t-values	1.48 (df = 19, p>.10)		4.88 (df = 20, p<.001)	
NP	Means	2.7	4.7	2.7	2.4
	Variances	0.49	0.22	0.49	0.59
	Calculated t-values	11.70 (df = 15, p<.001)		1.27 (df = 11, p>.20)	