LONG-TERM MEMORY IMPROVEMENT: CONFIRMATION OF A FINDING BY PIAGET

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Piaget has recently reported results indicating that children's memories of a patterned array of sticks improve over a 6-month period. Results reported here first of all confirm this finding, though not to the full extent Piaget found. Second, the improvement is apparently not due to a particular feature of the experimental procedure: E's focusing attention upon the size of the sticks during an intermediary session. Third, the improvement seems linked to the fact that the array is ordered and patterned. Several possible explanations of the phenomenon are discussed.

In a recent address at the University of Minnesota, Piaget (1967) described a rather striking finding obtained during his current studies of memory processes. Young children (ages 3–8) were shown a patterned array of sticks and asked to memorize the configuration. Then, 1 week later, they were asked to describe (either verbally, through gestures, or through a drawing) the sticks they had seen. Finally, 6 months later, the children were again asked to describe the sticks. Piaget found that 74 percent of his subjects had *better* memories of the array 6 months later than they had had 1 week after seeing the sticks. The rest of the children showed no change; none had gotten worse. Piaget wittily advised the students in his audience to study for their exams 6 months, rather than 1 week, before taking them.

Piaget did not suggest, of course, that all or even many memories improve over time. In this instance, however, he thought they did because the manner (or structure) wherein the information was encoded changed over time—largely because the child's increased experience over time with ordered, patterned arrays facilitated his ability to conceptualize such arrays.

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Reflexive skepticism—less with the explanation than the phenomenon itself—prompted us to attempt replication and extension of the findings. It may be reported at the outset that our data substantially confirm Piaget's results and that further explorations yield results which in no way oppose his explanation.

PROCEDURE

Approximately 100 kindergarten children from the public school in a small midwestern town served as subjects. None of the children was known to the researchers prior to a meeting 2 days before the first experimental session, when *Es* spent an hour playing with the children in the kindergarten. The sticks were shown to the children 2 days later.

Group A

Three experimental conditions were created. The first ("Group A") condition sought to recreate Piaget's experimental procedures. Subjects were called individually into a familiar room and seated across a small table from *E*. Then *E* began conversation in a friendly manner, saying "Hi. My name is Dan [Kent]. What is your name? What are you doing in school today? How do you like school?" When *E* was satisfied the child was at ease, he said, "I am going to show you something now, and I want you to take a good look at it. Try to remember it, because I am going to come back some time and ask you about it." The child was then shown (for 30 seconds) the patterned array of sticks Piaget had used (fig. 1), which were ¼-inch dowel pins glued to a piece of blue construction paper. This was the only time any of the children in any of the three conditions ever saw the sticks.

One week later, *E* returned to the kindergarten and met with each child again, saying, "Hi. I am ——— and you are ———, right?" Then *E* gave the child a blank piece of white 8½ × 11-inch paper and a pencil and asked, "Would you draw me a picture and show me how *big* the sticks we looked at were?" Some emphasis was laid on the word "big" in this request.

After the child had drawn his picture, with general encouragement to draw all he remembered but no hints of any kind from *E*, he was thanked for his drawing and returned to the kindergarten. Six months after the day the sticks were shown to the children, *Es* again returned and followed exactly the procedure (just described) they had used 5 months and 3 weeks earlier.

Group B

It was hypothesized that, if the phenomenon Piaget had described

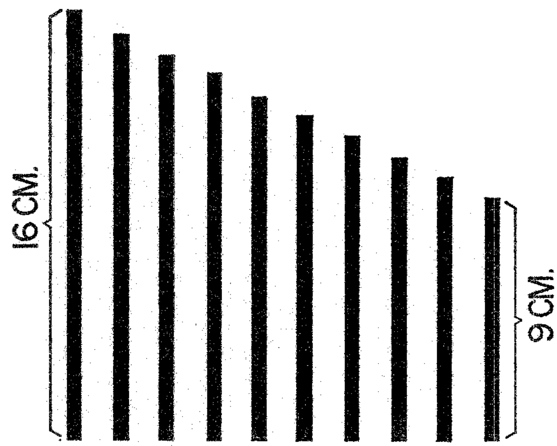


FIG. 1.—Array of sticks shown to Groups A and B

was found in our Group A Ss, it might be due to *E*'s behavior at the meeting 1 week after the child was shown the sticks. Specifically, we thought that *E*'s questioning the child about the *size* of the sticks—as opposed to their color, composition, the color of the background paper, or some other aspect of the experience—might cause the memory of the array to be revived or restructured with an emphasis on size. Thus, that aspect of the memory would be better represented in the drawings 6 months later. We wondered if an improvement would result if the size of the sticks was not emphasized during the first recall session.

Accordingly, Group B Ss were treated identically with Group A children, except that *E*'s questioning at the 1-week meeting was altered. After the usual preliminaries about names, *E* said, "When I was here before, what did we look at? What were they made of? What color were they? Would you draw me a picture of what you saw?" Thus *E* avoided any reference to the size of the sticks as a salient feature of the array.

Group C

We wondered about the limits of memory improvement, if any was to be found, in this situation. Does memory of *any* array of sticks improve, or is the patterning and ordering of the array of crucial importance, as Piaget suggested? A third group of children therefore experienced the same procedure as Ss in Group A but was shown instead the completely unorganized array illustrated in figure 2. Should memories of *this* array improve, it was reasoned, it would be a tour de force of the phenomenon, though perhaps a strike against Piaget's explanation of it.

A summary of the three experimental conditions is given in table 1. The Ss were randomly assigned to the two *E*s. Each *E* ran half of the

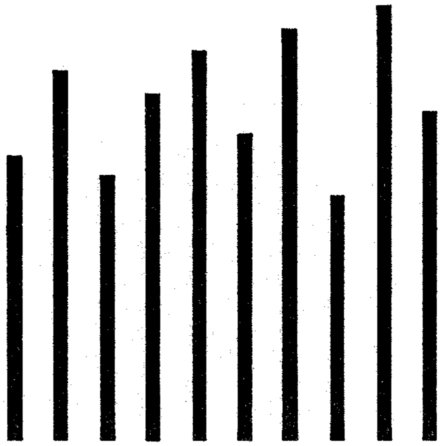


FIG. 2.—Array of sticks shown to Group C

three experimental groups. Each *S* had the same *E* for all three sessions. Except for a visit a few weeks later when *Es* ran the classic Piaget water-conservation experiment, *Ss* did not see the researchers for the next half-year.

TABLE 1

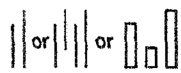
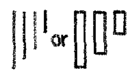
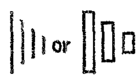
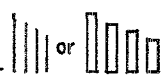
SUMMARY OF EXPERIMENTAL CONDITIONS

Group	*N*	Pattern Seen on First Day	Instructions during First Recall Session, 1 Week Later	Instructions during Second Recall Session 6 Months Later
A.......	34	Patterned and ordered (fig. 1)	Focus on size	Focus on size
B.......	31	Patterned and ordered (fig. 1)	Avoid mentioning size	Focus on size
C.......	29	Nonpatterned and nonordered (fig. 2)	Focus on size	Focus on size

Scoring

A major difficulty to be overcome in studying the questions Piaget raised is the development of an objective system for scoring the *Ss'* drawings. Our *Ss* produced quite a variety of sketches, including one dinosaur, several bullet holes, and an incredibly varied depiction of "sticks." We found the (five-category) system used by Piaget inappropriate for many of our drawings (e.g., a blank paper or a single stick) and also somewhat unresponsive to some differences among our drawings which we thought important. Accordingly, the nine-category ordinal scale, outlined in table 2 was developed for scoring the Group A and Group B drawings. Table 2 also lists appropriate correspondences with Piaget's scoring system.

Table 2. Scoring System Used to Evaluate Subjects Drawings

Piaget's Approximate Category		Our Category	Description of Drawing	Examples
	Unordered and unpatterned	0	Blank or large figures (man, frame around edge of paper.	
		1	Scribbles: several wildly intersecting lines.	
		2	One stick.	
1		3	Equal or approximately equal-sized sticks; any number greater than 1.	
2 & 3*		4	A number of different-sized sticks, but no ordered progression.	
4	Ordered and patterned	5	Ordered: "inverted pattern;" any number greater than two.	
4		6	Ordered: "arrowhead;" any number greater than two.	
4		7	Ordered: "mirror-image;" any number greater than two.	
4		8	Ordered: correct shape but wrong number of sticks: any number greater than two except 10.	
5		9	Ordered: correct shape and number.	See Figure 1.

* Piaget's second category is given exclusively to drawings containing two, and only two, different–sized sticks. His third category has three different-sized sticks, but no progression. Either of these is a "4" in our system. Most of our "4's" are what Piaget would call a "3".

This system was developed after the figures had been collected but without reference to the date of collection. The outline given in table 2 is necessarily brief; numerous subrules were necessary for further differentiating the categories from one another. A scoring manual (copies of which may be obtained from the senior author) was devised and practice drawings scored until the three writers were independently in unanimous agreement over 90 percent of the time. All of the Group A and Group B drawings were then scored independently by the authors. There was perfect agreement on 84 percent of the Group A and 89 percent of the Group B drawings. In the remaining cases, only two of the three judges were in agreement.

Scoring the Group C drawings presented a uniquely difficult problem: the best drawings are the most nonordered, unpatterned ones. It is difficult to score heterogeneity systematically. A different approach was therefore used. Each child's pair of drawings was stapled together (with all identifying symbols removed), and each writer independently judged which of the drawings—if either—was more like the array represented in figure 2. For one-half of the pairings, the 6-month drawing preceded, and for the other half followed, the drawing obtained after 1 week. It should be emphasized that this procedure does not match that used for scoring the Group A and Group B drawings in objectivity and rigor, nor does it reveal much about the quality of the sketches. Unanimous agreement in scoring was reached on only 79 percent of the pairs of drawings.

As will be seen later, the Group C sketches were also scored (for other reasons) according to the system developed for Groups A and B. Perfect agreement among the three judges was obtained in 86 percent of the cases.

RESULTS

Groups A and B

One would predict, on the basis of common experience, that kindergarten children would remember very little of a minute's experience 6 months later and that, compared with memories a week old, those obtained a half-year later would be quite inferior. Yet our data (table 3)

TABLE 3

CHANGES IN DRAWINGS FROM 1 WEEK TO 6 MONTHS, GROUPS A AND B

Group	*N*	Improved	No Change	Got Worse
A...........	34	16	9	9
B...........	31	12	12	7
Total.......	65	28	21	16

show that, on the whole, memories had improved over time for both Groups A and B. Whether tested against a null hypothesis that memories stayed the same or that they got worse, the results are highly significant (Kolmogorov-Smirnov one-sample test, $p < .001$). It should be mentioned that the imperfections of the scoring system play no role in producing this result. The maximum damage that could be done to the "improvement score" in each group by using the minority opinion on those drawings for which there was scoring disagreement is a loss of one. That is, Group A would show 15 improvements and Group B, 11. Nearly all of the scoring disagreements affect the size of the change and not the direction.

There is virtually no difference between the performance of the two groups ($\chi^2 = 1.1$; $p < .60$). Thus the improvement in memory over time does not appear to be a function of *E*'s focusing the *S*'s attention upon the size of the sticks during the second experimental session.

The data in table 3 reveal very little about the nature of the changes that occurred in our *Ss*' drawings. In fact, the "improvements" could be artifactual: if the children were timid when the drawings were first requested, they might have produced a lot of blanks; then, if for some reason they were more relaxed when the drawings were requested a second time, their "improvement score" would be quite high, although their memories of the array might actually be worse. A high improvement count does not necessarily mean anything about memories.

Table 4 presents the combined scores, by category, for the two sets of drawings. (The overall pattern of responses within Groups A and B are quite similar and permit combination.) It can be seen that the most typical scores of the 1-week drawings are categories 2, 4, and 3—which are nonordered, unpatterned drawings—while the most frequent scores on the 6-month drawings are categories 6, 8, and 0. Categories 6 and 8

TABLE 4

COMBINED FREQUENCIES OF GROUPS A AND B FOR EACH DRAWING, BY CATEGORIES

Category	Drawings Obtained after 1 Week	Drawings Obtained after 6 Months
0	6	10
1	5	2
2	13	9
3	9	5
4	13	7
5	7	2
6	6	14
7	0	4
8	6	12
9	0	0
Total	65	65

are ordered and patterned. Thus, on the group level of analysis, the typical response on the two drawings shifts from a nonordered, unpatterned drawing at 1 week to an ordered, patterned one 6 months later.

The same result can be reported for individual scores. Most (65 percent) of the 28 improvements in Groups A and B are changes from nonordered, unpatterned drawings (categories 0–4) to ordered, patterned ones (categories 5–9). Nearly all of these improvements represent scores at least two categories higher than before.

The losses in Groups A and B have their own story to tell. Most (62 percent) represent nonordered, unpatterned responses that got worse, and most of the losses showed a decrease of two or fewer categories.

Seventy-two percent of the "no-change" scores occur among nonordered, unpatterned drawings.

Seen from different perspective, the data from Groups A and B yield the following picture. Of 65 Ss, most (46) drew nonordered, unpatterned pictures a week after seeing the array. Of these 46, about one-half (22) showed improvement 6 months later. Usually the improvement was substantial; 15 of the 22 raised their score by at least three categories, into the ordered, patterned range. Another 15 of the 46 low starters showed no change in scores; these tended to be bunched in the lowest three scoring categories (0–2). The remaining nine of the 46 low starters got worse over time, but the drop was usually small and often not as great as it could have been.

The overall trend among the low starters, then, was toward marked improvement in drawings by the time 6 months had passed.

The other 19 of the 65 A and B Ss were high starters (categories 5–9 at 1 week). Their scores, on the balance, did not change over time.

Thus the overall trend among the 65 Ss shown Piaget's original array was toward improvement in memory; and this effect is entirely attributable to the marked improvement in the responses of children who originally produced nonordered, unpatterned drawings and later produced ordered, patterned ones.

Group C

Table 5 presents the changes in Group C's performance as measured by two different scoring systems. The first section (*a*) presents the results of the paired-comparison judgment technique described earlier. It can be seen that again a certain (and hence surprising) percentage (31 percent) of the Ss showed "improvement" over time. In the case of Group C Ss, however, it is difficult to distinguish what appears to be an improvement in memory from a loss of memory that would also produce drawings of random-sized sticks. But, on the whole, the group's memories at the 6-month testing were the same or worse than they had been earlier, in contrast to Groups A and B. Scoring disagreements play a larger role in shaping this result than in the other groups, however: the number of improvements can vary from 7 to 10. On the balance, though, there is no evidence that memories improved over time.

The second section (*b*) of table 5 presents the results obtained when

TABLE 5

CHANGES IN DRAWINGS FROM 1 WEEK TO 6 MONTHS, GROUP C

(*a*) When Scored according to Paired-Comparison Method

N	Improved (Became *Less* Ordered and Patterned)	No Change	Got Worse (Became *More* Ordered and Patterned)
29.........	9	7	13

(*b*) When Scored by System for Groups A and B

N	Improved (Became *More* Ordered and Patterned)	No Change	Got Worse (Became *Less* Ordered and Patterned)
29.........	12	12	5

Group C drawings were scored according to the system developed for Groups A and B. Such an analysis is patently inappropriate for comparing memories of the disorganized array, of course. Yet its results are instructive, for comparison with table 3 reveals virtually *no difference* between these Group C scores and those of the other two groups. Thus, even though Group C Ss did not see an ordered, patterned array, their drawings of the sticks 6 months later were *also* more ordered and patterned than they had been earlier. This clearly is not attributable to the array seen but, rather, suggests that something happened over time to the memories themselves (i.e., the information stored) and/or to the cognitive processes involved in transferring memories to paper. Whatever the explanation, the results found in table 5(*b*) suggest that what we and Piaget have called an improvement in the memory of the patterned array may have little to do with the array itself. It appears more likely that certain ongoing (and perhaps developmental) processes may have produced more patterned responses for Ss in all our conditions at the 6-month testing. In the case of Groups A and B, such an effect appears to be an "improvement." For Group C, of course, it is not—but apparently it is just as prevalent.

Is Memory Involved At All?

The finding with Group C immediately suggests an interpretation of all our data which has nothing whatsoever to do with memory. Suppose there is a tendency for children's spontaneous drawings to become more patterned as they grow older. If so, the drawings at the 6-month recall session would be more patterned than earlier, even if the child had completely forgotten the experimental array. The improvement, then, would hardly be one of memory.

We tested this possibility by asking children of various ages to draw us "some sticks." Subjects were 78 children from the kindergarten, first, and second grade of a public school in a community near the first. The children in this and the following experiment were tested in the spring of 1968, at the same time Groups A, B and C of the preceding experiment were given the 6-month recall test. The different classes were tested within a few minutes of one another and had no chance to interact. The first grade was tested first, then the kindergarten, then the second grade. Each class was tested as a group, with *E* being introduced by the regular teacher as "a visitor to our school today who wants to play a game with you." Then *E* explained the game three times as follows: "The purpose of the game is to see if you can tell what I'm thinking about. I have a picture of something in my mind, and I would like you to guess what it looks like and draw a picture of it. I will give you a hint before you start, but mostly you will have to guess. Do you want to play this game?" The children always agreed enthusiastically to play. Then *E* distributed blank sheets of white 8½ × 11-inch paper and gave the following (twice repeated) hint: "OK. Listen carefully, here is the hint. *I am thinking about some sticks.* . . . Now draw me a picture of some sticks. Mostly you will have to guess, of course. So don't worry. Just draw me a picture of some sticks." Papers were collected after 2 minutes of drawing time. The drawings were scored according to the scoring system for Groups A and B outlined in table 2.

As can be seen from the data in table 6, the hypothesis underlying the "no memory" explanation was not supported by this experiment. To begin, children of the ages tested do not seem to draw many patterned

TABLE 6

CLASSIFICATION OF SPONTANEOUSLY DRAWN STICKS

Grade	*N*	Unpatterned (Categories 1–4)	Patterned (Categories 5–9)
Kindergarten	21	17	4
First	25	20	5
Second	32	31	1
Total	78	68	10

arrays on their own. Groups A and B of the preceding study drew a significantly greater number at each testing ($p < .025$ in each case by χ^2 test). Nor is there evidence that older children spontaneously draw more patterned arrays than younger ones ($\chi^2 = 4.4$; $p < .10$). The tendency would seem to be the reverse, if anything. Finally, there was little similarity between the drawings these children produced—relatively few of which had the sticks lined up side by side, for example—and the sketches Groups A, B, and C produced. All in all, the evidence against the "no memory" explanation is rather strong. It seems more likely that at the times of their testings our three experimental groups were guided by at least *some* memory of the array seen earlier. Clearly, however, the memories were not always accurate (e.g., Group C).

DISCUSSION

Two Possible Explanations

While our data do not reveal improvement of the magnitude Piaget found, many of our subjects' abilities to reproduce the patterned array did improve, without apparent practice, over the space of half a year. It is also true that many of our subjects did not show improvement. But compared with the general deterioration of performance we fully expected, the results were surprising and provocative.

Simply seen, the task of drawing a picture of an array seen earlier involves two different cognitive systems: the information (storage/hold/retreival) system (i.e., "memory") and the central systems that regularly process information regardless of the source: past or present, real or imagined. Seen this way, the task put to a child in our first experiment requires locating the "image" of the array stored in memory and then processing that information, much as the child would if he were copying an array left in plain sight.

These processes are not necessarily fixed and unchanging over time. One child might see the sticks in figure 1 essentially one at a time (if he described them relationally at all) and describe them as "a stick, and then a littler stick next to it, and then a littler stick," etc; while a second, older child might describe the array as most adults would, as a *series* of increasingly smaller sticks. The first child is perceptually bound to the array: if the last stick of the array were very large, for instance, he might not particularly notice the change. The second child, however, can be said to be operating conceptually; he has abstracted a principle and can reproduce the sticks better than the first child when they are not in sight—or even if they have never seen them, one might think. The second child can generate the patterned array through memory of a simple rule, rather than through memory of the whole array. Piaget of course has documented many such shifts from purely perceptual to increasingly conceptual operations in the cognitive development of children.

We have some evidence from one more study which supports this line of reasoning. Ninety-two children from yet another community near the first were asked—after preliminaries about playing a game—to draw a picture of the sticks based on the following (thrice read) description: "I [*E*] am thinking of some sticks. There are many sticks, standing in a row. They are all standing up straight. The stick on the end is the tallest, and *from then on each stick is shorter than the one that came before it.*"

The children were tested as a group in their public school classes.

After the children had drawn their pictures, they were shown (continually, for 4 minutes) the array shown in figure 1 and asked to draw a copy of it.

TABLE 7

RESULTS OF CONCEPTUALIZATION AND COPYING EXPERIMENTS

Grade	N	Percent Patterned Arrays (Categories 5–9) Drawn: From Verbal Description	While Seeing the Array
Kindergarten..........	30	53	83
First................	38	68	92
Second...............	30	87	97

The results (table 7) indicate that older children are both more able to *conceptualize* and more able to *copy* the patterned array.

There arise, accordingly, several explanations of the data from Groups A, B, and C of our first study. The first and most obvious explanation is that the content of memory changed over the months. Perhaps there was an automatic recoding of the stored information over time, which reorganized a detailed, complicated (and for purposes of reproducing the patterned array, clumsy) image of the array into a simpler one. If there were such a recoding, it would not be too surprising if the resulting image were more patterned and ordered than the original. This recoding hypothesis can easily account for the Group C data, where drawings of a disorganized array became more ordered over time.

This "content" explanation assumes that the information processing (and sensory-motor) systems which turned a stored image into a drawing remained constant—and isomorphically faithful—over time. The data can also be explained through a different assumption, namely, that the content of memory did not change but that the central processes did become, in the ensuing months, more able (or more prone) to conceptualize arrays as patterned arrays. That is, the child's stored image of the array may not have changed over time (besides, perhaps, becoming less vivid as a whole); but the sense he made of the memory may have changed: from a "bunch of sticks" (which are subsequently reproduced as such) to an ordered array. The development may be considered analogous to the difference between mimicking and speaking words from a foreign language. One uninitiated in the language's phonemes will make many mistakes in imitation, although he hears the same sounds the accomplished speaker can flawlessly repeat, even with unfamiliar words. In our case, the children may have learned something of the language of patterned arrays on their own over the intervening months. Such an array is not unlike the way children line up according to height when marching around in school, for example. And indeed, the data presented in table 7 indicate that children *do* become better able to conceptualize such a patterned array as they grow older.

Both the "content" and the "process" explanations can account for the data in our study. Both explain why some subjects' reproductions of the patterned array improved over time. Each can find reasons (in differential development rates, for example) why some did not. Each can live comfortably with the well-established fact that performance on most memory tasks deteriorates over time. Each can find reasons why the Group C subjects drew more patterned arrays at the final session, although the central processes explanation may have to labor a bit more here. Each is, in its own way, plausible. And each could be right; the two are not necessarily exclusive.

More likely, time will show neither is right, certainly not in the simple forms outlined above. Research on these matters is presently underway.

REFERENCE

Piaget, Jean. Lecture on memory presented at University of Minnesota on September 28, 1967. Sponsored by Department of Special Education, Institute of Child Development and Department of Psychology, University of Minnesota.