cession of pairs and the side on which the correct member of the pair appeared.

Subjects sat at a table facing the experimenter, who was a Kpelle college student. The subjects were told: "Each time I will show you two things. Every time I do this, you must tell me which one I am thinking of. If you are correct, I will say 'yes.' If you are incorrect, I will say 'no.' Try to be correct every time."

Each subject was run until he had made fourteen correct responses in a row (a rather stringent criterion, but one which seemed necessary, because two independent discriminations were to be learned); in most cases this criterion reduces to seven in a row correct on each of the two discriminations. After subjects had successfully demonstrated acquisition of the two discriminations, they were randomly assigned to either a pseudoreversal-shift or a pseudononreversal-shift condition. The reversal condition was defined by our shifting reinforcement contingencies on *both* of the discriminations. The nonreversal condition was defined by our shifting reinforcement contingencies on only *one* of the discriminations. Subjects were run to criterion of ten in a row on the shift condition.

Four groups of thirty-two subjects each were employed. These were six to eight year olds who had not attended school, six- to eight-year-old first graders, nine to twelve year olds who had not attended school, and nine- to twelve-year-old third graders.

RESULTS

In view of the results of the earlier experiment with color, form, and number solutions, where many of the children failed to learn a form discrimination and learning was generally slow regardless of the dimension, it is of some interest that learning for this problem was extremely rapid. The younger nonliterate subjects learned in an average of six trials for the two subproblems combined, indicating an average of only three trials per subproblem. The older children learned slightly, but not significantly, more rapidly. This result is one further bit of evidence that there is nothing inherently difficult about form classifications per se, but leaves open the question of when they are difficult and when they are not.

The basic question of interest in this study is, "are subjects treating the two discriminations independently, or are they in some way interdependent?" Regardless of whether the subject was in the reversal or non-

reversal condition, we looked at his first response after no reinforcement as evidence relating to the question of independence.

Two possibilities exist. If the subject was treating the problems independently, his response to one pair would remain unaffected by his experiences with the other. In the case of a reversal shift (where the reinforcement contingencies are changed on both pairs), the subject should make an error on his first encounter with the second pair (since he is preserving his old response to that pair—which is now wrong). In the case of a nonreversal, the subject should respond correctly to the second pair, because the reinforcement contingencies on that pair are unchanged. This situation would produce a small, but consistent difference in favor of the nonreversal shift.

A second possibility, however, is that the subject has treated the two discriminations in nonindependent terms. He may see information gained from experience with one stimulus pair as being relevant to his performance on the other pair. In this case nonreinforcement on one pair would produce a "spontaneous reversal" on the other. This would lead to an error in the nonreversal condition, where the second pair has not changed, and a correct response in the reversal situation, where both pairs have been changed. In this case reversal would be easier than nonreversal learning.

Data pertinent to this analysis are shown in Table 5–1. Statistical analysis on the data in Table 5–1 (using the chi-square test) revealed the following:

TABLE 5-1

Percentage of Subjects Who Spontaneously Shift

AGE	EDUCATIONAL STATUS: SCHOOL	EDUCATIONAL STATUS: NONLITERATE
Six to eight years old	33	28
Nine to twelve years old	57	25

1. Older children tended to make more spontaneous shifts than younger children, and the schoolchildren made more spontaneous shifts than those who had not been to school.
2. Older schoolchildren did better than their nonliterate age mates, to a greater extent than did younger schoolchildren.

The pattern of results from this study strongly suggests that younger children, and children who had not attended school, tended to treat the individual instances in simple discrimination problems as if there were no relation between instances. Older children, especially if they had been to school, treated the individual subproblems as instances of some more general problem.

Looking back to the complex transfer problem that began this section, we can speculate that one of the difficulties that the subjects were experiencing (recall that they were quite young and had not attended school) was that they were not sensitive to the relation among separate pairs of instances. But before settling on that conclusion, we need to consider another simple discrimination-learning problem where common dimensions do, potentially, unite instances.

Standard Two-Dimensional Discrimination-Transfer Studies

When we first began our research using the discrimination-transfer experiment, we did not distinguish the response- and dimension-learning aspects of subjects' performances. Basing our work on extant theory (particularly that of Kendler and Kendler, 1962), we began by using the more or less standard discrimination-transfer design upon which the phylogenetic and ontogenetic sequence we outlined earlier rested. Our first experiment (described in more detail in Gay and Cole, 1967, pp. 84ff.) included sixty-four nonliterate Kpelle children between the ages of six and eight years. The stimuli were four 1″ x 1½″ wooden blocks that varied in height and color. Two of the blocks were 5″ high (T-tall), the other two were 2½″ high (S-short). One of each size was painted green (G) and the other white (W).

The children were tested individually by a Kpelle-speaking college student who was drilled in the proper techniques. All work was done in Kpelle. The experimenter and the child sat opposite each other at a table or on the ground. The experimenter then read the following instructions (in Kpelle): "I will show you two blocks of wood. Each time I show you these blocks, I want you to tell me which one I am thinking of. You must give me the block I am thinking of. If you are correct, I will say, 'yes.' If you are wrong, I will say, 'no.' You must try to be correct as often as possible."

The experimenter presented the pairs of stimulus objects in a predetermined order which he read from a mimeographed score sheet. Each

cue appeared an equal number of times on both sides. No stimulus pair appeared together on more than two consecutive trials. The criterion of learning was nine out of ten successive correct responses.

During training, the subjects were presented with SG-TW or SW-TG pairs, as shown in Figure 5–2. For half the subjects height was relevant; for the other half, color. Each value of the two dimensions was relevant for half of the appropriate subgroup.

The discrimination-transfer phase of the experiment was begun as soon as the training criterion was reached without interruptions or change in instructions. The four subgroups from the training phase (as defined by the positive dimension and attribute) were split, with a randomly selected half of each subgroup given a nonreversal shift while the other half was given a reversal shift.

In view of our later experience, one detail of the procedure used during the shift phase of the experiment must be described. Following acquisition, the pairings of the blocks were changed so that only a single dimension varied at a time. Thus, if the acquisition pairs were SW-TG and SG-TW, and if during the shift phase the correct response was "green," the shift pairs were TG-TW and SG-SW. This procedure, which was adopted to make the results as comparable as possible with those obtained by Kendler and Kendler (1959), precluded responses during the shift phase that were based on acquisition-phase *pairs,* since the acquisition pairs never occurred together.

RESULTS

The children learned the initial discrimination in approximately six trials, which is comparable to the speed of learning reported in American experiments using stimuli of this type and children in this age range. The only difference among groups was a strong learning-rate bias in favor of the size dimension (3.1 trials to criterion) over the color dimension (9.5). A similar bias was found by Kendler and Kendler (1959). In view of our earlier results showing a preference for color classification, this result serves to remind us once again of the situation-bound nature of dimensional preference among the Kpelle.

Performance on the transfer discrimination averaged 7.8 trials to criterion for both the reversal and nonreversal groups. This lack of differential transfer, when we first encountered it, appeared to be confirmation of the Kendler and Kendler findings that there is a transition point at about seven years of age at which the two kinds of transfer tasks are learned with equal ease. Also in line with their results was the fact that an analysis which separates the performance of fast and slow learners on the initial problem reveals the fast learners excel at the reversal shift, while the slow learners perform better on the nonreversal shift. As we reported in our earlier monograph (Gay and Cole, 1967, p. 87), we found that fast learners did, in fact, learn the reversal shift more quickly while slow learners learned the nonreversal shift more quickly. Unfortunately, subsequent analysis indicated that the fast learner–slow learner dichotomy was confounded with the rates of learning on the different dimensions, so that all that we now want to conclude is that nonliterate Kpelle children in the six to eight year range learn reversal and nonreversal shifts with equal ease for this set of stimuli.

If the Kendlers' analysis were correct, however, it would still be possible to show a developmental trend in response to the various kinds of transfer tasks by studying older and younger children. Consequently, we embarked upon such an enterprise, and for good measure, we included comparisons of nonliterate with school-attending children of the same ages.

The upshot of several studies using groups from four to fourteen years of age and zero to six years of schooling was that in virtually every case, reversal and nonreversal shifts were learned with approximately equal ease. The only regularities that stood out from this series of studies were a strong preference for the size dimension and a tendency for the older children to learn *more slowly* than the younger children. Neither of these findings could be considered hopeful bases upon which to build a developmental explanation of Kpelle problem-solving processes.

At approximately the same time as this initial study began (using the four blocks and nonliterate six to eight year olds), we undertook a similar study using considerably more complex materials with adults and young teen-agers (Cole, Gay, and Glick, 1968). The materials used were copied from a study by Kendler and Mayzner (1956) in which the authors were interested in studying discrimination transfer in American college students. The task required subjects to match each of sixteen response cards to one of two stimulus cards. There were several possible principles for matching—one of which the experimenters had arbitrarily chosen to reward. Once criterion had been reached on the initial discrimination, the basis of solution was switched in either a reversal or nonreversal fashion.

In this case we found that: (1) nonliterate adults showed positive transfer (learned more quickly) when presented a reversal shift and negative transfer when presented a nonreversal shift. This finding is similar to that obtained by Kendler and Mayzner (1956) for their college students. (2) Schoolchildren showed the same pattern as the adults. (3) Nonliterate children learned the reversal shift at the same rate as the initial problem and a nonreversal shift slower than the initial problem. Clearly, there are conditions under which the gross pattern of Kpelle discrimination-transfer processes is very similar to that of educated American adults. But such was not the case in our initial studies, and we are left with the problem of identifying the processes at work in the simple four-stimulus situation with which we began this investigation.

Returning to the outcome of the pseudoreversal experiment, it will be recalled that our analysis of that experiment considered each training pair as a separate problem and determined empirically the degree to which learning of one pair influenced learning of the other. The procedure adopted in our study of the four-stimulus, two-dimension problem did not permit us to follow learning of the individual pairs during reversal because we had carefully rearranged the pairs in order to preclude pair-specific transfer.

In the last two experiments in this series, we returned to the straightforward procedure of using the same stimulus pairings in the shift phase that were used in the training phase; assignments of correct stimuli within each pair were simply changed in accordance with the shift procedure desired. In all other respects the procedure was the same as that employed in the previous experiment (pp. 160–161) with which we introduced the four-block, dimensional experiment.

The subjects in the first of these experiments were 128 illiterate Kpelle children, half of whom were six to eight years old, half of whom were ten to fourteen years old. Within each of these age groups, subjects were assigned to various subgroups on the basis of availability (reversal or nonreversal shift, color or height correct, and so forth). For the major comparisons (age and type of shift), this arrangement meant that there were thirty-two subjects within each group.

The initial discrimination was learned in an overall average of 10.9 trials with the older children learning somewhat faster than the younger ones. The transfer phase was learned in 10.6 trials on the average. In this case reversal learning (9.2) was slightly, but not reliably, more rapid than nonreversal learning (12.1). Thus in its gross features this experiment produced results that are similar to those of our initial four-block problem, although the procedures were slightly different during the shift phase.

Because the stimulus pairings were not changed between initial learning and transfer, it was possible in this case to trace learning for each of the pairs separately. Consider once again a concrete example. Suppose that in initial learning, a subject is presented pairs consisting of tall-white versus short-green and short-white versus tall-green and the white blocks are correct. If a reversal shift follows, the correct block for each pair becomes incorrect; both pairs involve a change in the choice of blocks for solution. If a shift to choice of the tall blocks follows (nonreversal shift), solution of the tall-white versus short-green pair remains unchanged, but choice on the remaining short-white versus tall-green pair must be reversed.

If our analysis of the pseudoreversal learning problem is applicable (at least in part) to an analysis of this dimensional problem, we ought to expect different patterns of learning on the changed and unchanged pairs; the changed pair should suffer greatly during transfer, the unchanged not at all. Predictions concerning reversal learning are not so clear except that initial performance ought to be poor on both pairs. As a basis for discussion of the pair-by-pair learning that occurred during the transfer phase of the experiment, we have plotted the proportion of correct responses for the changed and unchanged pairs of the nonreversal condition and the two pairs for the reversal condition in Figure 5–3. This comparison is carried out only for the ten trials of the transfer phase because our practice of using a criterion of nine out of ten correct responses, combined with rapid learning on the part of many subjects, insured complete representation of all the subjects only through nine trials and almost complete representation with ten trials. With pairs interspersed, this arrangement meant that the first five trials for each pair were represented in the analysis. Since there were no important age differences, the two age groups were averaged together for this analysis.

From Figure 5–3 it is clear that for the nonreversal condition, performance on the unchanged pair remained at a very high level, although it was by no means perfect. Learning of the changed pair began at zero (there was no way for a subject to know that the basis of solution has changed for this pair until he had experienced it once during the shift phase) and increased rather slowly so that by the end of five trials with the changed pair (ten trials overall), performance was equivalent on the two pairs.

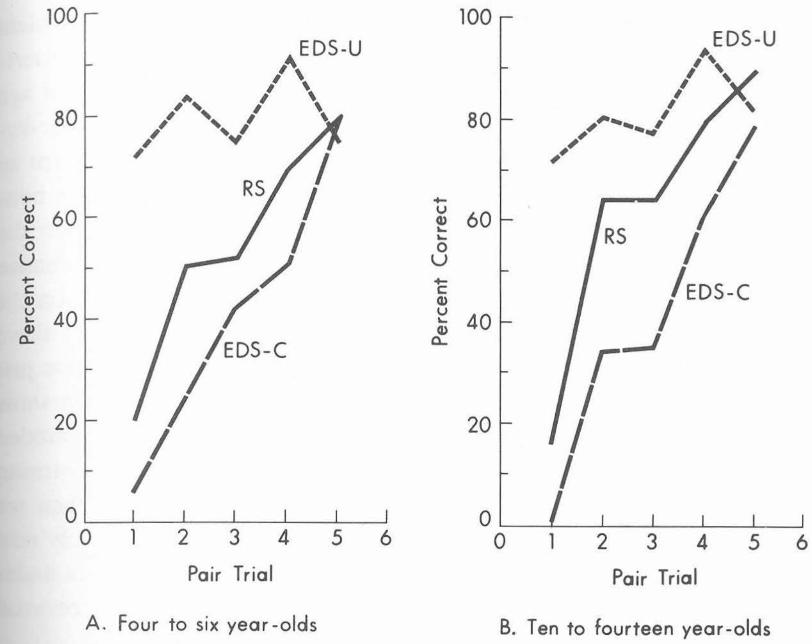

FIGURE 5–3 Trial-by-Trial Learning of the Discrimination-Shift Problem: Kpelle Nonliterate Children

The separate analysis of the two pairs suggests that they *were* being learned relatively independently. However, this result raises a puzzling problem: if changed pairs are learned so slowly, why don't we observe extensive negative transfer for the reversal group? After all, in this condition *both* pairs are changed. The answer provided by Figure 5–3 is that the learning rate for the two changed pairs of the reversal problem was greater than that of the single changed pair of the nonreversal problem. Moreover, a comparison of the initial trials with each of the pairs provided solid evidence of the *nonindependence* of the pairs. For the first pair presented, there were no corrected responses; this trial was simply a continuation of initial training from the subject's point of view until *after* he had been told he was wrong. For the second pair presented, 34 percent of the subjects responded correctly, although on their previous experience with that pair, the opposite block was correct. Thus, it appears that we have witnessed another manifestation of "spontaneous shifting," which clearly indicates that at least in terms of response-learning strategies, the two pairs were in some way connected.

To complete the picture we have obtained comparable data from two groups of middle-class American children tested on the same problem with very similar procedures (courtesy of T. Tighe). The older American group average ten years of age, the younger about four years of age (the data are from Tighe and Tighe, 1967). The results of our pair-by-pair analysis is shown separately for each of the American groups in Figure 5–4. Looking first at the right-hand panel, we see that the nonreversal performance of the younger American subjects looks like the nonreversal performance of both of our African groups; performance on the unchanged pair remained quite good, while performance on the changed pair dropped to zero and then recovered. However, for these young American subjects performance on the reversal problem was just like that for the changed pair in nonreversal; the subjects did not show the intermediate rate of learning for the two changed pairs that puzzled us in the Kpelle performance. As a consequence, nonreversal learning as a whole proceeded more rapidly than reversal learning. When we look at the results from the older American subjects, a completely new pattern of performance appears. Here performance on both pairs under both shift conditions suffered, and recovery was faster in the reversal case where both pairs had been changed.

Several points about the relation between Kpelle and American performances are intriguing. First of all, the Americans showed much more clearly than the Kpelle a distinction between independent learning of pairs (the younger children) and nonindependent learning where pairs were learned as "examples" of a more general problem (the older children). The Kpelle seemed to show both tendencies in some measure, as if they could treat the problem either way, depending on the circumstances. Moreover, there was no age-related trend among the Kpelle; both age groups showed the same pattern; as a consequence the younger children seemed precocious, the older children, retarded. Unfortunately we have no educated children run under these conditions, although results of the pseudoreversal study indicate that educational experience may affect the pattern of performance.

Further, these discrimination-transfer problems bear a direct relation to a question of major concern to us—under what conditions will learning one problem speed learning of a later problem? These data and our analysis of them suggest that only under special conditions are we going to find Kpelle children learning simple classification problems faster because they have learned a similar problem previously. More rapid learning occurred only when the relevant stimulus dimension exerted control over learning (in the Cole, Gay, and Glick 1968 study with six-

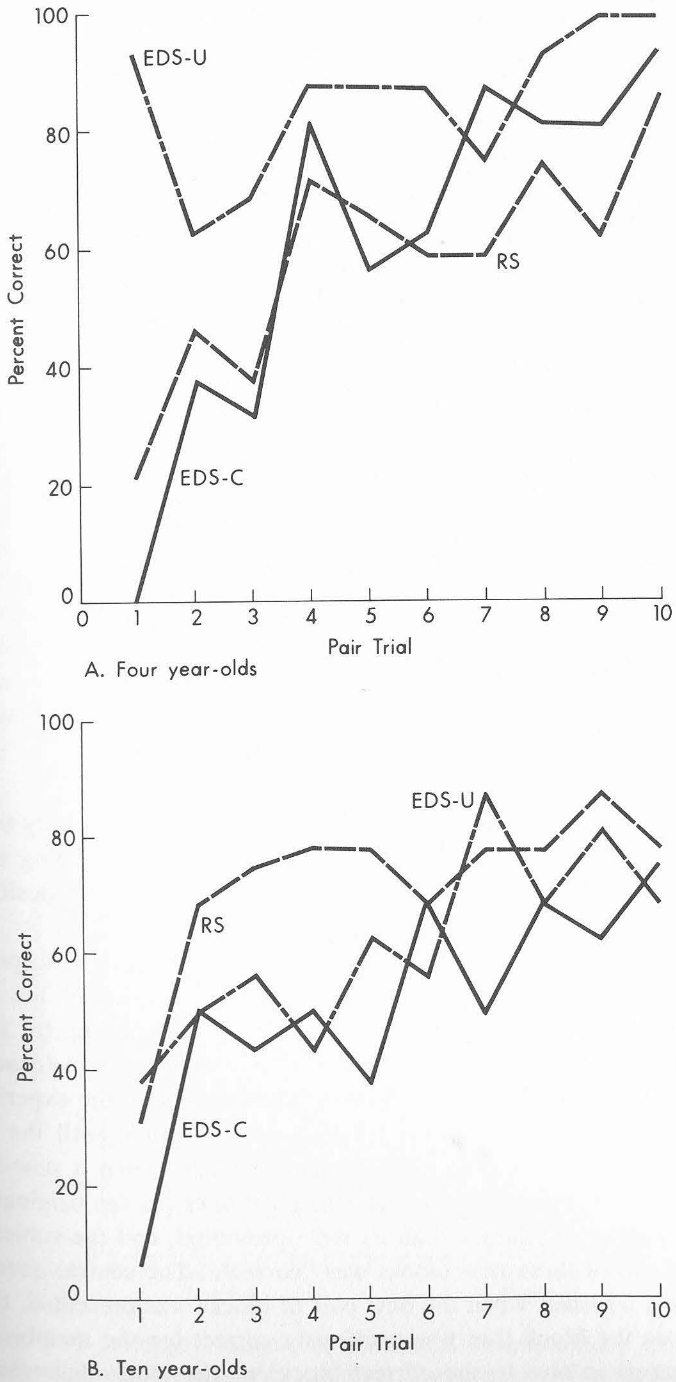

FIGURE 5–4 Trial-by-Trial Learning of the Discrimination-Shift Problem: American Schoolchildren

teen response cards), but we have found this generally not to be the case. In the absence of dimensional control (when subjects treat subproblems separately), the new problem, even if the same dimension is involved, is in effect a *new* problem. Thus, questions of subproblem learning and dimensional control seem to underlie the more general problem of learning to learn. We also have to reject the idea that we are dealing with learning mechanisms (linguistic mediation, abstraction, and so forth) that are not universal among the Kpelle. We know that under some conditions learning will occur under generalized dimensional control. For example, such a process is implied by the results of the Cole, Gay, and Glick (1968) experiment described briefly on pp. 162–163 where twelve- to fourteen-year-old nonliterates learned a reversal shift faster than a nonreversal shift. Still lacking, however, is any specification of when learning will occur in the instance-specific manner implied by the independence of the subproblems in our simple discrimination studies and when it will occur under general dimensional control.

Transposition

One classic situation used by American psychologists to study both the question of stimulus-specific versus dimension-based learning and the role of linguistic mediating processes is the so-called transposition experiment.

As first used by us among the Kpelle, the procedure was to present a subject with two blocks, varying in size. On each trial the subject guessed which of the two blocks was "correct." Assuming for the moment that the larger of the two blocks was always correct (exactly the same logic applies to the choice of the smaller block), the experimenter continued to reinforce the choice of the larger block until the subject identified it as correct on nine successive trials. Then a new pair of blocks was presented in which two larger blocks (or the originally correct block and one larger than it) were presented, and the subject indicated which of these new blocks was "correct." The central question of interest is whether, when the new pair of blocks was presented, the subject chose the block that was previously correct (or the member of the pair nearest in size to the correct block) or the block that was larger than its mate. In other words, does the subject base his discrimination

on the choice of a particular block, or does he base it on the relation of the two blocks along the dimension of size?

Regardless of what kind of test pair was presented and regardless of whether the initially correct block was larger or smaller than its mate, the subjects responded *relationally* (see top curve in Figure 5–5 and see Cole, Gay, Glick, and Sharp, 1969, for details of the experiment).

This experiment was repeated exactly using a color continuum. For one condition the training cards were two shades of gray, with the darker of the two always being correct. For a second training condition, three shades of gray were presented, with the middle shade always correct. Subjects run under these conditions (six- to eight-year-old or twelve- to fourteen-year-old nonliterate Kpelle children) gave the results in the lower two curves in Figure 5–5 (there were no substantial differences among age groups, so the curves are an average of all subjects who were presented a particular problem). Consider first the curve indicating transposition of the darker-than relation. From Figure 5–5 it is obvious that in general there was less relational responding than we had observed in the case of size transposition (the average amount of transposition for comparable age groups on the size transposition was about 90 percent). Moreover, when dealing with color, the particular test pair

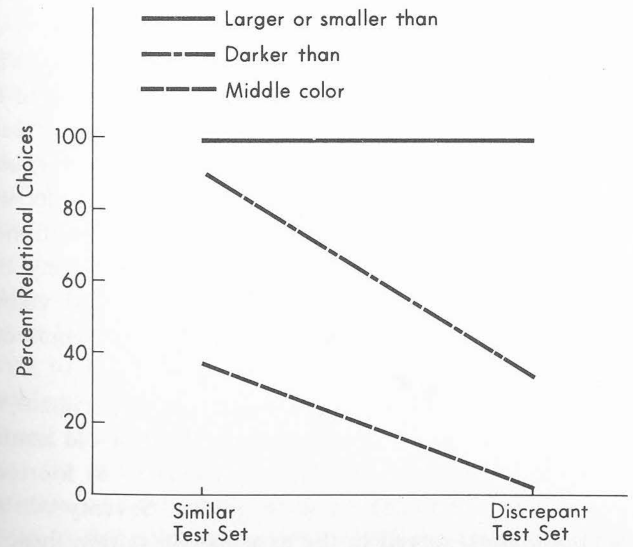

FIGURE 5–5 Average Number of Relational (transposition) Choices as a Function of Discrepancy between Training and Testing Blocks and the Nature of the Rule

made a difference; the pair which overlapped with the training pair was responded to as if the subject were choosing relationally, while the card nearest in color to the correct card during training was chosen most often if the test pair was discrepant from the training pair.

When we consider transposition of the "middle color" which is represented by the curve, relational responding was even less likely, but the effect of testing with a similar or disparate test set was about the same.

We do not propose to explain these results. We present them because they dramatically illustrate the fact that our Kpelle subjects can, for problems which seem very similar to us, respond in widely different manners that bespeak very different *ways* of learning.

Dimension Preferences, Concept Learning, and Learning to Learn

As a finale for this series, we will describe an experiment that unites several features of the disparate studies included in this chapter (a detailed report of this experiment is contained in Sharp, 1971). To begin this study, Sharp conducted the dimensional-preference study described on pp. 147–149, in which subjects were presented with pairs of cards differing from each other in terms of the color, number, and form of the figures printed on them. It will be recalled that when asked to describe these stimuli so that the experimenter could pick the correct card, subjects described the cards almost exclusively in terms of color, and when asked to sort these same cards, essentially the same results were obtained. Thus, in terms of two quite different measures of dimensional preference, it was found that color was a much more likely basis for choice than either number or form (the dimensions and values were color—red, blue, black; form—triangle, circle, square; number—two, three, four).

Then Sharp conducted a discrimination-learning experiment with the very same stimuli. His subjects were six- to eight-year-old nonliterates, twelve- to fourteen-year-old nonliterates, and twelve- to fourteen-year-old schoolchildren in the fourth to sixth grades. Seventy-two subjects from each subpopulation served in the experiment; within these groups, subgroups of twelve subjects each were run in specific experimental conditions.

Unlike our earlier experiment involving the learning of successive

discriminations with multidimensional stimuli, Sharp arranged things so that the correct dimension remained from one problem to the next. However, the particular set of cards changed from problem to problem. For example, a subject trained on color might have to discriminate between red and blue on the first problem, blue and black on the second problem, and red and black on the third problem (the correct attribute never remained the same for two successive problems).

In addition to studying learning of each of the dimensions, Sharp created three degrees of variability with each problem. In some cases only the relevant dimension differed between the two stimulus cards (for example, when number was the solution, two red triangles versus three red triangles). Sometimes one of the irrelevant dimensions varied (two red triangles versus three green triangles), and sometimes both irrelevant dimensions varied (two red triangles versus three green circles). The purpose of this manipulation was to assess the possibility that the children in our initial discrimination study with these relatively complex stimuli were hindered in their learning by the complexity of the varying, irrelevant stimulus dimensions.

The major result of this experiment is shown in Figure 5–6 where learning curves for each of the groups are shown separately for each dimension. Considering first the performance of the six to eight year olds, we see that regardless of the dimension of solution, there was relatively little improvement across problems. The twelve- to fourteen-year-old nonliterates showed improvement for form and number, while the twelve- to fourteen-year-old schoolchildren showed marked improvement on all dimensions. In general, the number of varying irrelevant dimensions did not affect the results graphed in Figure 5–6. Hence we can conclude that any difficulties experienced by our subjects in learning this kind of problem cannot be accounted for by the variability of alternative dimensions. On the other hand, the older children were learning to learn this problem fairly effectively, and in this case schooling seems to have increased the rate at which improvement occurred over problems.

A strong clue as to the reason for the lack of improvement across problems for the six to eight year olds and the improvement for the other groups was provided by an analysis of the performance of these groups up to the point where they reach the criterion of ten successive correct responses. Figure 5–7 shows a backward-learning curve for the third form problem for each of the groups. The right-hand end of the curves represents the median trial of the last error prior to criterion for

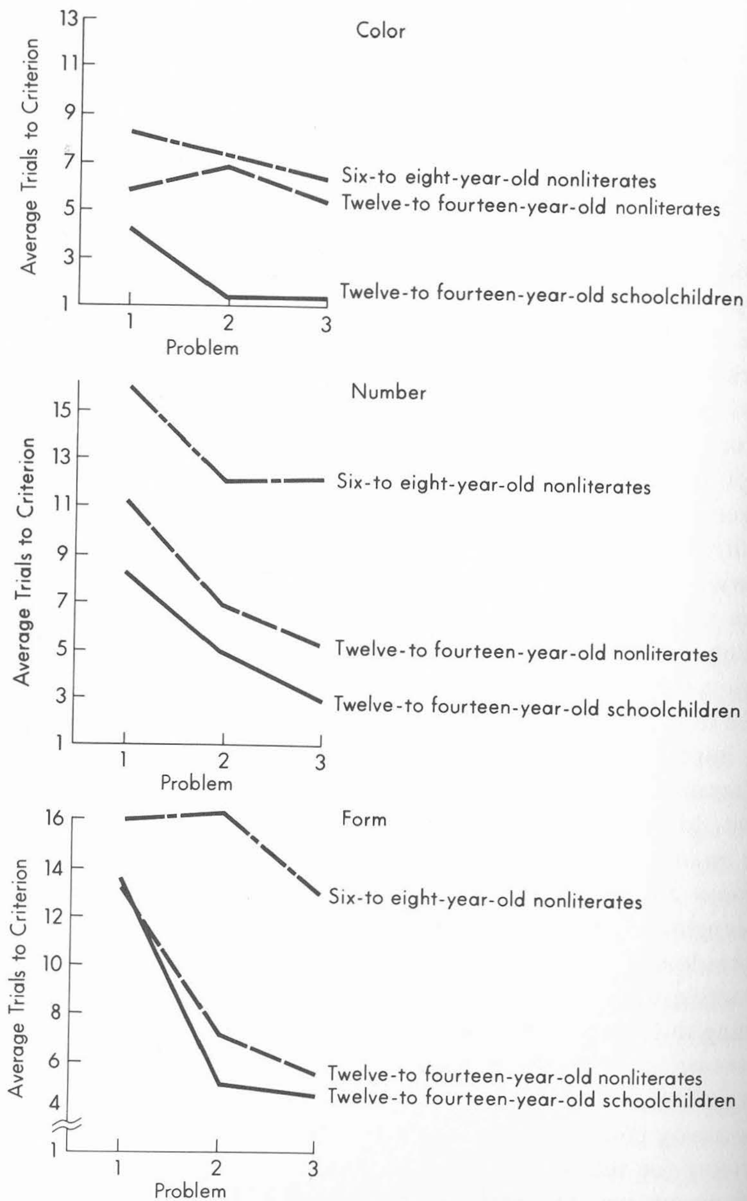

FIGURE 5–6 Learning-to-Learn as a Function of Dimension of Training for Each Group

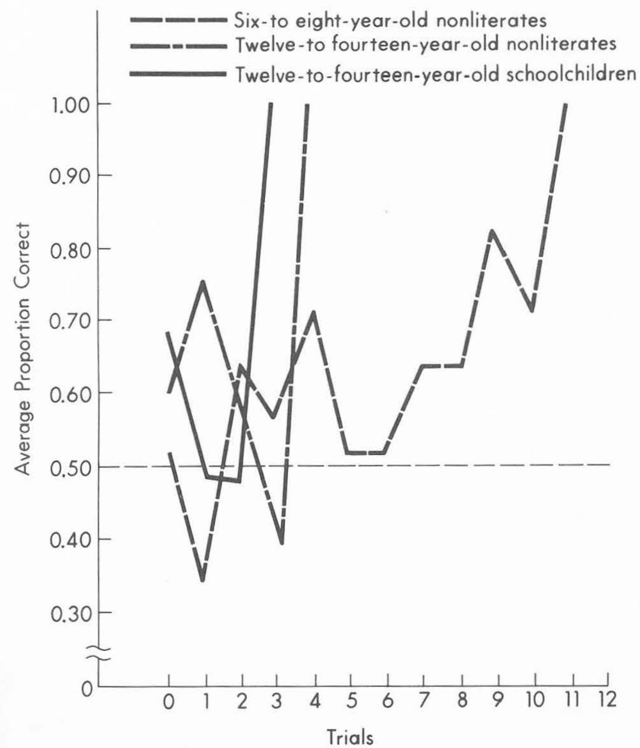

FIGURE 5–7 Performance Prior to the Last Error for a Form Problem. (The terminal point to the right of each curve presents the median trial of the last error for the designated group.)

the group in question (the technique for plotting the data is borrowed from Zeaman and House, 1963). The trials then extend backward from the criterion run to the beginning of the learning trials. As can be seen from Figure 5–7, not only did the six- to eight-year-old nonliterates require more trials to reach criterion, they showed a gradual improvement over the course of the precriterion learning period; the two older groups, on the other hand, showed no improvement prior to solution and chance performance on the trial just prior to beginning their criterion run.

In the light of recent analyses of concept and paired-associate learning (see, for example, Atkinson, Bower, and Crothers, 1964; Cole, Glick, Kessen, and Sharp, 1968) these data are consistent with the hypothesis that we are observing all-or-none concept learning in the older groups, and paired-associate learning in the younger group. Our reasoning runs as follows: the discrete jump from chance performance to 100 percent correct responding follows from the assumption that subjects learn the problem by considering various attributes until they find the correct one at which point the problem is solved in one trial; differences in rate of learning (such as the difference between color and form problems) reflect differences in the number of trials that it takes the subjects to hit upon the relevant attribute in the more difficult problem. Once the relevant attribute has been discovered, learning is virtually instantaneous in all problems. This all-or-none account describes the pattern of learning for the older educated children and to a large extent the behavior of the older noneducated children.

The younger children (and to a slight extent the older noneducated children) showed gradual improvement prior to the time they attained a criterion of 100 percent correct performance. We would expect this pattern of results if, instead of identifying relevant dimensions, these children were learning specific correct answers ("the three blue circles are correct"). When performance prior to criterion performance is measured, as in Figure 5–7, the improvement over the 50 percent level is interpreted as the learning of individual items; as the number of learned items increases, average performance improves. A very similar pattern of results has been observed by Suppes and Ginsburg (1963) and by Cole, Glick, Kessen, and Sharp (1968) in a verbal-discrimination learning context; in both cases a "mixed model" allowing for both item-based and concept-based learning has been proposed.

The most important fact about this analysis is that it provides a plausible explanation for the failure of young children to learn faster and faster with repeated exposure to the same kind of problem. We can expect to observe such learning to learn only when the basis for learning is conceptual, that is, when it is based on dimensions of the problem that go beyond specific instances. But our analysis of the learning pattern of the young children showed that just the opposite was true—they were learning specific correct answers. For them each new problem was just that—a new problem. For the older children, if the same dimension served as the basis of solution, the problem was not entirely new. It was "a problem like the last one" even though the specific correct answers were different. Learning occurred faster with each successive problem because the subjects continued to attend to the same dimension; so long as it was relevant, the "precriterion search" period was shortened and the problem was solved more quickly.

Additional groups in Sharp's experiment document the dimension-

specific nature of the improvement from problem to problem for the older children. In groups for whom the correct dimension changed between problems (for example, a subject learned color-form-number or number-color-form), there was no improvement across problems for the twelve- to fourteen-year-old groups.

These results replicate our earlier findings, graphed in Figure 5–1, where there was no improvement from problem to problem if the dimensional basis of solution was changed. However, we can now identify with some confidence the learning mechanisms that underlie those earlier results. The improvement associated with a series of problems having a single principle of solution occurs only if subjects learn in what we have called a dimension-based manner. This dimension-based (concept-based would be an acceptable alternative term) learning, in turn, requires that the subject respond to subproblems as instances of a general problem, rather than learning each subproblem in isolation. These two ways of learning often occur together, but as our work with the pseudoreversal shift has shown, they need not, since subjects who show the concept-based learning pattern will do so even in the absence of a dimension common to all subproblems.

In identifying a pattern of learning that treats each subproblem as an isolated unit, we seem to have stumbled upon an example of what is ordinarily termed rote learning, although the context in this case is the domain of concept learning rather than memory.

Finally, the entire series of studies described in this chapter underlines the fact that it is very difficult to discuss "cognitive skills' in a context-free manner. In some of our experiments six to eight year olds were rote learners; in others they responded in terms of stimulus relations. Sometimes our twelve- to fourteen-year-old children responded differently from the younger children. But on other occasions, increases in age led to changes in the *way* in which learning occurred only if the child had attended school. We have identified patterns that we can call rote and concept-based learning, but we do not know the laws determining which situations will evoke which kind of learning. As was the case with our memory experiments from Chapter 4, we seem to be locating cultural differences in the occasion upon which a particular psychological process will be brought to bear on a problem, rather than in the existence or absence of the process itself.

SIX : Culture, Logic, and Thinking

> It begins to look as though formal logic, as we know it, is an attribute of the group of Indo-European languages with certain grammatical features.
>
> P. W. BRIDGMAN, 1958, p. 88

> The chief problem is ignorance of language on the part of all concerned.
>
> W. LABOV, 1970, p. 187

No aspect of the relation between culture and cognition has a longer history or has produced more controversy than the question of whether the logical processes of preliterate peoples differ from the logic of Western thought. It was primarily the controversy over logical processes that has served as a focus for arguments over "primitive thinking" discussed in Chapter 1. Typical of the views that "primitives think differently than we do" are the following two quotes, the first from an explorer, the second from a highly respected, early anthropologist:

> The African Negro, or Bantu, does not think, reflect, or reason if he can help it. He has a wonderful memory, has great powers of observation and imitation, . . . and very many good qualities . . . but the reasoning and inventive faculties remain dormant. He readily grasps the present circumstances, adapts himself to them and provides for them; but a careful, thought out plan or a clever piece of induction is beyond him. [Bentley, p. 26]

> . . . between our clearness of separation of what is in the mind from what is out of it, and the mental confusion of the lowest savage of our own day, there is a vast interval. [Tylor, 1965, p. 125]

As we pointed out in Chapter 1, to a very large extent such statements rest on two assumptions, both of which we rejected. First, it is assumed that we can directly infer individual thought processes from a society's belief systems. We found in Chapter 1 that Franz Boas

(1911) in particular had demonstrated the errors to which such an assumption leads. Second, it is assumed that individual thought processes must reflect the model of logic put forth by Aristotle and his successors.

The problem of concluding nonlogical thinking from a lack of a *formalized* Aristotelian logic in a particular language is clearly illustrated in the following discussion by A. F. C. Wallace (1962):

> There is, however, no real evidence that any primitive people characteristically and conventionally employs what Western logicians would define as a logical fallacy. And to suppose that the primitive is *unable* to think rationally, for instance, would lead to the expectation that the primitive hunter would perform the following feat of cerebration with suicidal consequences:
>
> A rabbit has four legs
> That animal has four legs
> Therefore, the animal is a rabbit
> [Wallace, 1962, p. 355]

Wallace's example is interesting for reasons he probably did not intend. In shifting to the use of the word *rationally,* he exposes a confusion in the use of the term *logic* as applied to cognitive processes. What he is really arguing is that to adapt, man must be "rational," but no inferences about the role of logic in cognition seem warranted.

Consider the following example which we touched on briefly in Chapter 1 (taken from Morgan, 1891): a man sees black clouds on the horizon and says it's going to rain. Did he make an inference, or did he simply remember the association, black clouds-rain? Complicate the example. Suppose that a man uses instruments to measure wind velocity and barometric pressure. A certain combination of wind velocity and barometric pressure is observed and he says it is going to rain. Did he make an inference? It would seem more likely than in the first case, but it is still possible that he simply remembered this case from an earlier experience. In fact, it is impossible to determine, without specific kinds of prior knowledge about the person and circumstances involved, whether a particular conclusion is a remembered instance from the past, or an example of inference based on present circumstances. Hence, evidence about the logic of the "inference" obtained from anecdotes or naturally occurring instances is always open to alternative interpretation.

This ambiguity is the target of the many contemporary definitions of thinking as a *new* combination of previously learned elements. As a consequence of this line of argument, problem-solving situations have come to be closely associated with the study of thinking. Another feature of contemporary thinking about thinking is that the notion of logic is not a part of the *definition*. Problems can be solved in ways that do not fit any known logical models. Whether or not the course of problem solving (thinking) is consistent with a particular logical model or not is a matter to be determined in the course of the experiment.

Chapter 2 provides ample justification for belief in the *rationality* of behavior in Kpelle society. However, we have rejected the idea that we can use group data to make inference about individual processes.

In this section we provide two examples where individual behavior seems to require analysis in terms of rational thought processes. These examples are instructive both because they seem to *require* the inference of rationality and higher thought processes and because they demonstrate the difficulties of making such inferences in a clear-cut, convincing manner.

Law Courts: A Sample Case

The use of judicial procedures to settle disputes is very widespread among the Kpelle. Because it is public, explicit, and relatively formal, and because debating is valued by the Kpelle, the law case offers one promising natural setting in which to observe individuals as they construct arguments and draw conclusions from data.

As an example of the kinds of arguments that are used in such cases, we will present in some detail an unpublished case collected by Professor Gibbs and graciously made available for analysis. The case was heard before Paramount Chief Wua of the Panta Chiefdom in Bong County, Liberia, on December 9, 1965. The entire case was recorded by Gibbs, transcribed by a Kpelle-speaking informant, and then translated by Gibbs and the informant.

There are four principals in the case, the paramount chief (PC); Tuang, the woman who is bringing suit for divorce; Baawei, her mother who received the bride price when she was married; and Baa, Tuang's husband. We will present a series of important excerpts from this case, with a summary of the intervening action.

The case opens with Tuang's request that she be granted a divorce from her husband, Baa. The paramount chief turns to the wife's mother, Baawei, whose responsibility it will be to return the bride wealth she received from the husband when the marriage was contracted. The mother

agrees that she had arranged the marriage of the daughter, Tuang, to her father's sister's son, Baa. She does not want her daughter to leave the man, even though she agrees that she has the money available to refund the bride wealth. The mother then asks her daughter through the paramount chief why she is leaving her husband. This is an edited version of Gibbs' transcript, with comments by the editor in parentheses.

PC: (to Tuang): The old lady is questioning you. She said: "Are you leaving the man because of his ways?" That is an important question she is giving you. Don't think that she is playing.

UNIDENTIFIED VOICE: She does not want him. She does not want him. (There are also other voices speaking at the same time that are indistinguishable.)

PC: (to Tuang): Witchcraft cannot remain on "I don't know." (A proverb meaning that a witchcraft accusation cannot be sustained by saying "I don't know" when one is pushed for justifying evidence.)

TUANG: I said that I don't want him because of his ways.

PC: (to Tuang): You don't want him because of his ways. Isn't that so?

TUANG: Yes.

PC: (to Baawei): It reaches you. She said that she doesn't want your son-in-law anymore.

BAAWEI: (to Tuang): You should tell me: "I have left him because of his ways."

PC: (to Baawei): Yes, she said that. She said that she doesn't want him because of his ways. (He asks if Baawei can't accept her daughter's point unless she says "I have left him"? Isn't "I don't want him" the mother of "I am leaving him"? I don't want him!)

The paramount chief is irked at the excessive literalness of the mother and the obdurate "I don't want him" repeated regularly by the wife. He calls the husband and, in order to have him agree for the charges to be brought publicly before the court, asks if he will contest the divorce. The husband agrees to contest the case, whereupon the wife tells a *selective* tale of woe, although this selectivity is not apparent. She complains that her husband would not work for her or build her a farm, despite her help for him when he was sick, and despite the fact that she had had to visit her home when relatives died. She finally asserts that a child she bore when she was visiting her family died because of the enmity of her husband's family. In these assertions, she presents a picture of herself as meeting social obligations and of her husband as both socially irresponsible and possibly malevolent. The exchange continues:

TUANG: This person they gave me to—when I have a child, his mother eats it. (This is a witchcraft accusation).

PC: Who is that who eats human beings?

TUANG: (She points to her husband, Baa.) This person's mother. This is one of his mothers sitting here. When they are doing like that to you in a home, can you stay there?

PC: (to Tuang): Are you through?

TUANG: There (referring to what she has said) is why I say: "I don't want him." Because I took him from death and he overlooks me. He is just behaving like that to me.

PC: (to Baa): My brother-in-law, it reaches you. That is what the woman has said.

BAA: (to PC): Chief, I say, what really has she been saying?

PC: You heard what she was saying. If you want to question her, just question her.

BAA: (to Tuang): Are you saying that you are leaving the home because of the child's death? A palaver is just its head. (A proverb meaning that a dispute always has a single core.) I hear what you are telling me about the work. I say are you leaving because of the child's death?

TUANG: I am not leaving because of the child's death. But it is my keep that you are not taking care of properly. That is what hurt me enough to make me leave you. You are behaving like that to me.

BAA: (to PC): Oh, Chief! What for me. I am able to give a small explanation for what she has said.

PC: All right.

BAA: This is my wife standing so. This is my mother. It was my uncles who gave her to me.

PC: They didn't ask you about that. She said that you don't make a farm for her. (Several voices murmur approval.)

BAA: (to Tuang): You said that I have never made a farm for you ever since they gave you to me?

TUANG: When we were at Zowa you used to make farm for me.

BAA: Since we crossed the river?

TUANG: You have not made any farm for me.

BAA: Recently I made a farm for you. I can explain it.

PC: *Mama,* did you say this person has not made any farms for you?

TUANG: I said that he used to make farms for me. But since we crossed the river, he has not made farms for me nor built a house for me.

PC: And since you two came here?

TUANG: It was just recently that they told him that if he didn't come back across the river, his woman will no longer be his. This is why he came here.

PC: Since he came here, has he made any farm for you?

TUANG: I told you that I was at our home.

PC: Go and sit down. That is just what they said about you (implying that she is evasive).

CLERK: (to Tuang): The question self the old man (chief) gave you, you never talk it self (spoken in English).

At this point, the husband Baa is allowed to speak. He makes a long speech on his wife's sexual prowess and infidelity. In particular, she took many lovers when she went to her home in Guinea. And yet he denies ever insisting that her lovers pay adultery damages. He says he never beat her, but that she persisted in sleeping around, and that finally she disappeared, making it impossible for him to make a farm for her.

After this, standard procedure allows Tuang to cross-examine her husband. She does so ineffectually, to such an extent that the paramount chief feels forced to intervene. He says:

PC: Come now and do it. (Several voices groan.) Make (whatever) explanation you two are able to (the implication of the Kpelle is that neither one of them is able to explain well).

TUANG: I said that my father is not living. My father died in Zootaa. That was the reason why I went there.

PC: Ask him the question! (Several voices murmur approval.) How long has it been since you left your father's home? How many days?

TUANG: It has been a year and a half. (People murmur.)

PC: A year and a half?

TUANG: Yes. My father died and I went to greet the people. Not one of them (Baa's people) stopped there.

PC: Is that why you spent a year and a half there?

TUANG: Not one of them came and said that she and I were to go (back). (People murmur because she has evaded the question.)

PC: We are talking a palaver. (There is a dead silence and a pause.) Have you spent a year and a half there?

TUANG: Yes. Not one of them came to say that she and I were to go.

PC: Did you come from there to start (this) suit?

TUANG: Yes.

PC: (to Tuang): Woman, it is *you* who are wrong. This is what made your part (in it) wrong! You are a legally married woman. This is your husband. You said that you sued him because of his ways. But I didn't see any of the things you described here. As for him, bad ways or not, I didn't see him do it here today. It was only through our questioning and your (Tuang's) making it known to us that we saw one of the points that he tried to make. (It) was that you left this man and went to your home for a year and a half. If a woman spends a year and a half (away), can the man stay there and start a farm for her? Who will scratch it? And, in addition to that, who will he make the farm for? Now that farming season has come, just suppose you had remained with the man as a woman in her house who asks her husband for a farm. (If such a woman) says he (the husband) didn't make a farm for her, she has a power to sue her husband, saying, "I am with that man and he is not feeding me." But (when) you have left the man and gone to your father's home for two years, how can he feed you? You spent the two years with your father and you just left there to come and sue your husband. That's the thing that made your part (in it) wrong.

This presentation demonstrates both the strengths and weaknesses of using naturally occurring events as data about psychological processes.

The paramount chief's obvious disdain for the debating skill of Tuang and Baa indicates that this case is not a prime example of Kpelle argumentation. Even so, we can easily understand the lines of argument that developed. One important point is an analysis of how the wife selected the information she presented. The basis for her divorce action is a story of unmet social obligations combined with malevolence. What she seems to leave out of her account is her own socially unacceptable behavior.

Tuang was away from her husband for more than a year. Her justification for the long absence is that Kpelle custom requires that when a member of her family dies, a wife should go home until her husband sends for her. Judging from the behavior of the paramount chief and the spectators, the year and a half absence exceeded the "statute of limitations" on the custom Tuang had evoked. His summary emphasizes the *illogicality* of her argument (how can a man make a farm for a woman who is absent since her contribution is critical to "making a farm"?).

On the surface it seems that we have specific evidence of the way in which Tuang selects and uses information to further her argument. But this example contains many ambiguities. Gibbs notes that in the overwhelming majority of divorce cases, men are the victors. Perhaps Tuang is not selecting information, but the paramount chief is doing the selecting in order to justify a predetermined outcome. The existence of selectivity in either case would be interesting from our point of view, but we are left uncertain of who, if anyone, is doing the selecting and what is deliberately being left out.

In the light of data to be presented later, the explicit use of a hypothetical argument and juxtaposition of contradictory instances by the paramount chief should not be overlooked.

Malaŋ Game

Another context for the study of naturally occurring instances of problem solving is the malaŋ game, familiar under a variety of names in Africa and Southeast Asia. The game is played on a board with six holes on each of two sides. Initially, there are four seeds in each hole. Each player commands the seeds on his side of the board and must move on his turn all the seeds in any one hole. The object of the game

is to capture all the seeds. A player moves seeds counterclockwise, dropping one seed in each successive hole or he can collect the seeds in his hand. He captures seeds by placing his last seed in a hole on his opponent's side that had either one or two seeds in it.

We studied this game closely by holding a tournament for sixteen players for the town of Sinyee. We recorded thirty sample games, which we then analyzed in detail in order to discover the strategy of successful play.

It became clear immediately that some persons played well and others played badly. Those who played well used a clear and consistent set of strategies. Those who lost games on the first round displayed no such care and precision and appeared to have no long-range strategies. Their style of play appeared inconsistent and careless and seemed to show no thought for future consequences of their moves. Not only can we isolate no patterned behavior from the games of these players, but also they lost their games decisively and quickly. First-round games in the tournament tended to be short and one-sided, whereas later games were progressively longer and were won by narrower margins. Moreover, the winning player in these later games often did not gain his initial advantage until after 150 to 200 moves, which can be characterized as probing combined with self-protection.

Our analysis of the malaŋ game showed that victory for good players eventually came because of careful counting of seeds and setting up of captures, controlled by a strategy. Hypothetical rules (if I play the seeds from this hole, and if he responds by playing the seeds from that hole, then I can play the seeds from that other hole on the next move and win five seeds) underlie all such captures.

The first strategy that appeared was waiting until the opponent had made the first capturing move. It is possible to avoid capturing by collecting seeds in one's hand. However, after the first capture this option is no longer open. In twenty-three out of thirty games, the person who captured first lost the game, although this was not inevitable. Even though it is not necessarily the theoretically best strategy, good Kpelle players attempted to outwait their opponents.

The second strategy is redistribution of forces. When a player was collecting seeds in his hand, hoping for the other player to move first and then to force a big victory, he sometimes found that he had not calculated correctly or that the opponent had outwitted him. In this case he redistributed his seeds and started again. In every game where two good players were matched, there were many such redistributions. As a result, games tended to be very long, one game having a total of nine redistributions and more than 300 moves.

A third common strategy is for a player to tempt the opponent to make a capture, which will prove in the long run unprofitable. He offers what seems a careless weak spot, but has projected his strategy into the future where he can take advantage of this weakness. In the games we recorded there were at least thirty such temptations offered and accepted, to the ultimate disadvantage of the immediate beneficiary.

A fourth strategy is for the player to keep large numbers of seeds in certain holes in the middle of his side of the board. This makes long strings of capture impossible and, in turn, poses a threat to the opponent. In every game such accumulations of seeds were made by the winning players. Such accumulations are part of a good defense. In the games we recorded, we noted thirty-one cases of poor defensive strategy by losing players, but only four cases by winning players.

In summary, victory in a malaŋ game depends on a set of strategies. The winning player makes sure he has solid defenses, that he catalogues the possibilities of every move, that he reserves time to himself, that he lures the opponent into making premature captures, that he moves for decisive rather than piecemeal victories, and that he is flexible in redistributing his forces in preparation for new assaults.

These two examples of traditional Kpelle problem-solving situations, the court case and the malaŋ game, are both analyzable in terms of psychological processes such as "selectivity in the use of information" and "strategies." However, the question remains: are these terms descriptions of the processes used by the participants, or descriptions of the outcomes imposed by us?

Attempting to overcome the ambiguities inherent in such naturalistic observations, we turn to the experimental method, cautioned by these observations not to accept evidence of mental confusion too quickly.

Verbal Logical Problems

In this section we describe our efforts to take a more direct approach to logical rules by posing logical problems in verbal form. The subject was asked to draw his own conclusion or to judge a conclusion we have suggested to him. By varying the structure and content of the logical

problem, we obtained evidence on the relations between formal logical rules and logic-behavior.

The only research that we know of into the responses of preliterate people to verbal syllogisms was conducted more than thirty years ago by A. R. Luria (personal communication). Working in Central Asia with peasants who had not been incorporated into the large collective farms then being organized in the Soviet Union, as well as "progressive" peasants who had been collectivized, Luria found striking differences in the way these two populations responded to simple verbal syllogisms. For example, one noncollectivized (and presumably more traditional) peasant was posed the following problem:

> In a certain town in Siberia all bears are white. Your neighbor went to that town and he saw a bear. What color was that bear?

The peasant responded that there was no way for him to know what color that bear was, since he had not been to the town. Why didn't Professor Luria go to his neighbor and ask him what color the bear was? Such responses were typical and seemed to be more or less independent of the particular content of the problem. More sophisticated subjects (those who had been living on a collective farm for some time and had been exposed to new farm practices and new cultural traditions) responded very much as we might respond. That is, they simply said something like, "Of course the bear must be white since you said only white bears live in that town."

Although anthropologists have occasionally reported anecdotes resembling Professor Luria's observations, his are the only data we know of that suggest some of the variables that might affect responses to such verbal problems. One such variable is degree of Westernization and another is literacy or education.

Group Discussions

As part of our general inquiry into Kpelle learning processes, particularly as they relate to logic, we began pilot work on the question of Kpelle responses to various logical problems and syllogisms. Our initial observations were made in the small town of Gbansu. Gbansu is a relatively isolated and traditional Kpelle town, approximately a five-hour walk from the nearest motor road. Although many of the young people in the town migrate to the road to join the wage economy, many traditional elders retain ties with the town. It was with these important individuals in the town that the pilot work was conducted. A number of village elders were gathered at one time to discuss the truth or falsity of several statements. The entire interview was tape-recorded and then transcribed. Presented below is a summary of the problems and typical responses.

Problem 1: Everybody who has a house must pay a house tax. I have a house. Therefore, I must pay the house tax.

Answer: It was unanimously agreed that the statement was true because it had been decreed by the government that we have house tax.

Problem 2: Some of the animals in the bush are black deer. I have seen an animal in the bush. Therefore, I saw a black deer.

Answer: No, you have to see that what you saw was a black deer because there are many other animals in the bush such as red deer and bush hogs.

Problem 3: Everyone in the town eats rice. The chief is in the town. Therefore, the chief eats rice.

Answer: Yes, it is true because it is already said that *everyone* in the town eats rice. The chief is included in that number.

Problem 4: Every Kpelle man makes rice farms. Some of the *kwii* people make rice farms. Therefore, some of the *kwii* people are Kpelle.

Answer: Some informants said: Yes, we know that all Kpelle men make rice farms. If anybody makes rice farms he will be included in the group. Some informants said: No, it is true that all Kpelle men make rice farms, but there are some *kwii* people who make rice farms and are not Kpelle men. Therefore, the statement is not true. Even this white man (John Gay) can make a rice farm, but he is not a Kpelle man.

It may be seen from these examples that in general, when engaged in group discussion, there was no difficulty in responding to such oral syllogisms. However, certain features of the responses ought to be noted. In Problem 1 the information that the government has passed a law making everyone pay a house tax is clearly extraneous. Problem 3 is interesting because it includes an explicit response to the relation stated in the premise. Problem 4 contains an example of an incorrect response which seems to occur because the respondents broadened the definition of "Kpelle" presented in the problem itself.

The group-discussion technique showed that verbal syllogisms were understandable and could be responded to appropriately. However, we also wanted to try to distinguish the conditions under which adequate and inadequate responses to such verbal problems were given.

Individual Testing

Our initial experiment used verbal problems, which were designed to parallel the problems presented above to groups. The logical relation depended upon the conjunction of statements, disjunction of statements, and the implication of one statement for another. The particular content of the problems was also varied. Some problems concerned animal folk characters, others concerned people, other cases involved institutions. The subjects were studied individually rather than in a group, and the problems were stated in a somewhat different fashion than in the pilot work just discussed. Instead of providing an entire syllogism and asking for the truth or falsity of the conclusion, the subject was asked to draw a conclusion from the premises. A few examples of these problems and typical responses to them will give an indication of the kinds of responses that were typical of traditional adults.

Problem 1

EXPERIMENTER: At one time spider went to a feast. He was told to answer this question before he could eat any of the food. The question is: Spider and black deer always eat together. Spider is eating. Is black deer eating?
SUBJECT: Were they in the bush?
EXPERIMENTER: Yes.
SUBJECT: They were eating together?
EXPERIMENTER: Spider and black deer always eat together. Spider is eating. Is black deer eating?
SUBJECT: But I was not there. How can I answer such a question?
EXPERIMENTER: Can't you answer it? Even if you were not there you can answer it.
SUBJECT: Ask the question again for me to hear.
EXPERIMENTER: (repeats the question)
SUBJECT: Oh, oh black deer was eating.
EXPERIMENTER: Black deer was eating?
SUBJECT: Yes.
EXPERIMENTER: What is your reason for saying that black deer was eating?
SUBJECT: The reason is that black deer always walks about all day eating green leaves in the bush. When it rests for a while it gets up again and goes to eat.

Problem 2

EXPERIMENTER: Flumo and Yakpalo always drink cane juice [rum] together. Flumo is drinking cane juice. Is Yakpalo drinking cane juice?
SUBJECT: Flumo and Yakpalo drink cane juice together, but the time Flumo was drinking the first one Yakpalo was not there on that day.

EXPERIMENTER: But I told you that Flumo and Yakpalo always drink cane juice together. One day Flumo was drinking cane juice. Was Yakpalo drinking cane juice that day?
SUBJECT: The day Flumo was drinking the cane juice Yakpalo was not there on that day.
EXPERIMENTER: What is the reason?
SUBJECT: The reason is that Yakpalo went to his farm on that day and Flumo remained in town on that day.

Each of these problems gives a good demonstration of the kind of result obtained by Luria in Central Asia many years ago. The subjects were not responding to the logical relations contained in the verbal problem. Rather they were (or seem to have been) responding to conventional situations in which their past experience dictated the answer. This is particularly clear in the last problem where the subject seemed to be thinking of a particular Flumo and Yakpalo. We have encountered other examples in which the subjects, when presented a problem such as the last, said something like "Yakpalo isn't here at the moment, why don't you go and ask him about the matter"? In short, it appears that the particular verbal context and content dictate the response rather than the arbitrarily imposed relations among the elements in the problem.

It seems reasonable that subjects have difficulty with problems in this second experiment, whereas problems in the initial experiment were considerably less difficult, because in the first experiment subjects were not asked to reach a conclusion, but had to evaluate the conclusion suggested by the experimenter. In the second set of problems and in the problems posed by Luria, subjects had to reach conclusions for themselves. Nevertheless, it was somewhat startling that our subjects had so much difficulty with problems that to us seemed so easy. Although we can understand how the nature of the task might be misperceived by the subject, our own intuition suggested that we would immediately respond to the formal structure of the problem. Hence we set out to investigate the conditions under which we would find Kpelle people responding in the manner just described and those under which people would respond to the logical relations within the problem itself.

In this third study we contrasted two groups who on a priori grounds might be expected to respond very differently to such problems. The first group consisted of nonliterate adults such as those who participated in the first two experiments. The second group consisted of high-school students from two high schools in the interior, the Lutheran Training

Institute and the Zorzor Training Institute. There were thirty subjects in each group. Each subject was asked to draw conclusions concerning three logical problems. The problems differed according to the logical connective that combined its separate elements and the particular content of the problem. Examples of the *structure* of the three different rules involved are the following:

Conjunction: Spider and black deer are in their house together. Spider is in the house. Where is black deer?

Disjunction: Flumo or Yakpalo is in the house. Flumo is not in the house. Where is Yakpalo?

Implication: If the superintendent is in the court, then the clerk is in the court. The superintendent is in the court. Where is the clerk?

Differences in the *content* of the problems can be understood from the following three examples (using conjunctive problems):

Story: Spider and black deer are in their house together. Spider is in the house. Where is black deer?

Story and example: Flumo (show a cola nut to the subject) and Yakpalo (show a palm kernel) are in their house together (point to an overturned cup in front of the subject). Flumo (cola nut) is in the house (point to the overturned cup). Where is Yakpalo (palm kernel)?

Example: A cola nut (show) and palm kernel (show) are in the cup (point to the overturned cup). The cola nut (show) is in the cup. Where is the palm kernel?

These three levels we conceived of as a traditional form of question (story), a traditional form in which the traditional elements were symbolized by a concrete object (story and example), and a nontraditional form involving concrete objects (example). We hypothesized that if subjects were being systematically ruled by the particular content of the logical problem, then these three levels ought to represent successive approximations to the ideal situation in which the content would play an important role and thus verbal deception would not occur. Hence, we thought that, in general, errors would be greater on the story problem than on the other two problems.

Unfortunately, there were absolutely no differences associated with the form of the problem. Nor were there any great differences associated with the rule involved except for a slight tendency for conjunctive problems to be more difficult than disjunctive or implicative problems. The number of correct responses for the nonliterate adult and high-school populations is shown for each of the rules in Table 6–1. It is obvious from Table 6–1 that although differences among the rules

TABLE 6-1

Percentage Correct Solutions for Logical Problems Differing in Rule Structure–Study 3

RULE	NONLITERATE ADULTS	HIGH SCHOOL
Conjunction	27	73
Disjunction	37	100
Implication	40	97

(Based on *N* of 30)

were negligible, there was a very large and systematic difference among populations. The high-school students were correct in the overwhelming majority of cases, and the illiterate adults were incorrect in a majority of cases. These results confirmed our expectations that Westernized, literate Kpelle people would respond more or less like educated Americans to such verbal problems.

We were still interested in evidence of differential difficulty among conceptual rules in line with research on conjunctive and disjunctive problems to be presented later. Because these results suggested that the conjunctive rule is slightly more difficult than disjunction, we set out to replicate this third experiment with yet another experiment on verbal logical problems in which the primary interest was on differences among logical rules.

The use of nonliterate and high-school groups was maintained because, on the basis of some pilot work, we expected the particular logical relations embodied in the problem to affect nonliterate and educated subjects differently. This fourth experiment is so similar to the previous ones that only a few highlights of the procedure need to be reported. The general form of the problem was the folk story. Rather than three problems, each subject was now asked to respond to six different problems, presented (we thought) in a random fashion. The primary result of this experiment is presented in Table 6–2 for the two logical relations of primary interest, conjunction and disjunction.

From Table 6–2 it can be seen that the nonliterate subjects found the conjunctive and disjunctive verbal problems equally difficult and responded correctly only on about half of the problems. For the high-school subjects, there was a very large and significant difference between conjunctive and disjunctive problems, with response on the conjunctive problems being essentially perfect and response to the dis-

TABLE 6-2

Percentage Correct Solutions for Logical Problems Differing in Rule Structure–Study 4

RULE	NONLITERATE ADULTS	HIGH SCHOOL
Conjunction	61	100
Disjunction	50	17

junctive problems being very poor indeed. Since the problems resembled closely certain of the problems in the previous experiment, at first we were unable to explain the difference in results.

However, an examination of the particular examples we used suggests an interesting interpretation. In this fourth experiment (as mentioned before) all of the examples were of the folk-story variety. By an oversight on the part of the experimenter setting up this problem, it turned out that all sequences of problems began with a conjunctive example followed by a disjunctive example. The juxtaposition of these two problems in this order created a complex situation exemplified by these two problems:

Problem 1: Spider and black deer always eat together. Spider is eating. What is black deer doing? (the proper answer is an affirmative answer—black deer is also eating.)

Problem 2: Flumo or Yakpalo is drinking cane juice. Flumo is not drinking cane juice. What is Yakpalo drinking? (The answer to this problem is also affirmative—Yakpalo is drinking cane juice.)

However, subjects in the high-school group overwhelmingly chose a negative answer to this problem. The most reasonable explanation seems to be that they were fooled by the contrast between the affirmative and negative wording of the two problems. Such an effect would be completely consistent with results obtained in a study of verbal syllogisms in the United States (Woodworth and Sells, 1935) where it has been found that American college students are susceptible to just such context effects. The interesting point is that the context in this case was not social, but has to do with logical relations in two successive problems.

If our analysis is correct, then high-school subjects not only responded to the verbal relations within a given problem, but also were sensitive to the relations between verbal relations on successive problems, which is indeed a sophisticated performance. However, this interpretation means that we cannot use these data to draw any strong conclusions concerning the relative difficulty of conjunctive and disjunctive problems. We can conclude only that high-school subjects responded strongly on the basis of the verbal relations in the problem, whereas nonliterate adults responded only weakly to verbal relations and were not correct much more than half of the time on any of the experiments.

This finding naturally raises the question of what degree of education is necessary in order to produce the level of sophistication displayed by the high-school students. In order to answer this question, we undertook a fifth study in this series. The only difference in form between the questions in this and the previous experiments was that now the question asked of the subject could be answered yes or no. For instance, a problem might be, "Spider and black deer always eat together. Spider is eating. Is black deer eating"? Once the subject had responded "yes" or "no," he was asked to give his reason for so responding and both his response and his reason for choosing that response were recorded. Thirty-six subjects participated in this experiment, nine subjects each from the following populations: nonliterate twenty-three- to forty-three-year-old adults, nonliterate ten- to twelve-year-old children, eleven- to fourteen-year-old second and third graders, and eleven- to fourteen-year-old sixth graders. Each subject was given nine problems, three problems for each of the logical rules conjunction, disjunction, and implication. The results of this fifth experiment are shown in Tables 6–3 and 6–4. Looking first at Table 6–3, we see that performance for the two nonliterate groups is only slightly above chance. The two school groups performed reliably better than the nonliterate groups, but the two school groups did not differ from each other. Turning to an analysis of difference in

TABLE 6-3

Proportion Correct Responses to Logical Problems

Adults	.65
Ten- to fourteen-year-old nonliterates	.64
Ten- to fourteen-year-old second and third graders	.82
Ten- to fourteen-year-old fourth to sixth graders	.89
Conjunction	.75
Disjunction	.61
Implication	.81

TABLE 6-4

Proportion Correct Verbalizations to Logical Problems

	CONJUNCTION	DISJUNCTION	IMPLICATION
Nonliterate adults	.58	.24	.29
Ten- to fourteen-year old nonliterates	.39	.36	.22
Ten- to fourteen-year-old second and third graders	.58	.17	.44
Ten- to fourteen-year-old fourth to sixth graders	.92	.60	.74

difficulty among concept types, we see that the disjunctive problem was the most difficult of all and that the conjunctive and implication problems were of roughly equal difficulty. All four populations showed the same differences among logical connectives.

Group differences did appear in the ability of subjects to explain their answer once they had given it. These data are presented in Table 6–4. The probability that a subject correctly verbalized the basis of a correct answer varied considerably among groups. Once again we find that the nonliterate groups were poorer in their performance than the educated groups. In this case, however, only the fourth to sixth graders showed any real proficiency in explaining their solutions.

We also find a sizable difference among concept types in the difficulty of verbalization. In this case conjunction was clearly the easiest kind of problem about which to talk for all except the younger nonliterate subjects. This latter finding is interesting in view of a continuing inquiry into the relative difficulty of conjunctive and disjunctive problem solving which we shall take up in the next section.

Looking back over the series of logical problems, we find that the ability of Kpelle people to make verbal logical judgments depends upon the subjects' education and on the way in which the problem is posed. For nonliterate people, to pass judgment on the conclusions reached by someone else presents no great difficulties. However, to reach a conclusion for oneself based upon premises handed down by others leads nonliterate Kpelle subjects to depend on the particular content of the problem in forming an answer. However, education shifts dramatically the mode of response to such verbal problems, so that the particular content no longer determines the answer. Rather, subjects begin to respond on the basis of the logical relations contained in the problems themselves. Under some circumstances there are differences between problems on the basis of the logical relation involved, but in general the problem type makes little difference.

The fact that content is of such great importance in the answers of the nonliterate subjects raises a further question. Is it possible to pose problems in such a way that the nonliterate subject will be led to respond appropriately to the conditions of the problem?

In a pilot study on this question each of several nonliterate adults was given three problems, in each of which he was to choose between two alternatives presented in the following story.

Flumo and Yakpalo set out one day to find beautiful girls to marry. They came to a man's house and found that he had a beautiful daughter. Each had brought gifts for the marriage, and in order to ensure that the man would give away his daughter, they told him they would kill him if he did not accept the gifts of one of them and marry his daughter to him in return. The point of the story was that the two men brought gifts which were slightly different, on the basis of which the householder could make up his mind. Each man presented his gift in one of the following three forms: "You must take ________ *or* ________"; "you must take ________ *and* ________"; "*if* you take ________, you must take ________."

On a given problem each of the two men used a different form to present his gift. There were three different combinations of money, sickness; money, a good name; a bad name, sickness. On a particular problem the two men had the same gifts, but different forms of presentation, and the subject had to decide which man presented a more advantageous package.

Each subject had one problem of each presentation form, and one problem for each pair of gifts. These were counterbalanced so that all combinations appeared an equal number of times in each position.

The results were helpful in understanding how the content influences the ability to solve the problem. When the gifts were money and sickness, there is a large distance between them as to their desirability. It proved relatively easy for the subjects to answer the questions in these cases, with eight persons answering correctly, two incorrectly. However, when both gifts were bad, namely, a bad name and sickness or when both gifts were good, namely money and a good name, subjects found the problem more difficult.

Some of the answers that skirt the question are of interest. In five of the cases, when both alternatives were bad, the person was willing to die rather than force such unpleasantness on his family. In a few cases, the subject referred the solution to his daughter, saying that she must make up her own mind. In one case, when both alternatives were bad, the subject accepted sickness since it is better than a bad name. Another more pragmatic subject accepted a bad name, since he said that he could still work and make a living.

These results suggest that it is possible to pose problems in a way that lead to responses in terms of the relations in the problem. What the set of these "ways" is, is a matter for future study.

Riddles

As we have mentioned before, a favorite Kpelle sport is for one person to pose a riddle for a group of people, who then debate the proper response. Our earlier observations (Gay and Cole, 1967) seemed to indicate that the way to win an argument concerning a riddle was to invoke a cultural rule. However, it is difficult to say by merely observing such debates what part of this is guided by some implicit tradition concerning the proper answer for the riddle. Consequently, we decided to separate these two aspects of responding to the riddles by posing an artificially constructed riddle with its own explicit rule for solution. Unfortunately, we were only able to conduct pilot work on this problem, but one or two of the results seemed reliable enough to warrant reporting. This investigation was carried out with nonliterate adults and with schoolchildren in first, third, fifth, and eighth grades by David Lancy. Three different riddles were investigated:

Problem 1

A. Any time a rice farmer sees something in the bush it is his to keep.

B. Sumo, the trapper, Flumo, the rice farmer, and Goma Togba, the hunter, are walking together in the bush behind Kayata. They have been walking for three hours and since the sun is very hot they are tired. As they pass a clearing, Flumo spots a very large leopard. Sumo quickly makes a trap and with it catches the leopard. But the leopard is very angry and dangerous still, so Goma Togba must take his gun and kill it.

C. Now, to which of these three people does the leopard belong?

Problem 2

A. A match and a cigarette packet always go together.

B. Do you see this matchbox and this cigarette packet? (The experimenter places these two objects on the table in front of the subject.) I can open this matchbox and take out a match. (As the experimenter does this, he lays the match on the table next to the matchbox.) I can also open this cigarette packet and take out a cigarette. (The experimenter lays the cigarette next to the cigarette packet on the table.) I will light the cigarette with the match. (The experimenter does this, then lays the match and cigarette down on the table between the packet and the box.)

C. Which of these three things (he points to the cigarette, the matchbox, and the packet) does the match go with?

Problem 3

A. A match and a cigarette packet always go together.

B. I could have a matchbox and a packet of cigarettes. I could take the matchbox, open it, and take out one match. I could then take the cigarette packet, open it, and take out one cigarette. After doing this, I could strike the match on the side of the box, put the cigarette in my mouth and light it with the match.

C. Which of the three things I mentioned, the matchbox, the packet, and the cigarette, does the match go with?"

Each of these riddles has three parts, A, B, and C. Parts B and C are standard parts of the riddle, namely the riddle itself (Part B) and question at the end (Part C). Part A was introduced for purposes of this experiment. It contains the rule according to which the solution to the riddle can be found. Riddles 2 and 3 cannot be properly called Kpelle riddles. Rather they are artificial riddles each with its own purpose. Riddle 2 concretely exemplifies the relations contained in the riddle. Riddle 3 is the same as Riddle 2 except that it is purely verbal. Both Riddles 2 and 3 involve materials that are quite alien in terms of the material ordinarily contained in Kpelle riddles.

We computed the average percentage of correct responses to these riddles and found that only 10 percent of the nonliterate adult answers were correct, 50 percent of the third graders were correct, and 100 percent of the eighth graders were correct. Riddle 1 produced the largest proportion of correct responses (67 percent); Riddle 2 was next (25 percent), and Riddle 3 the least (17 percent).

Subjects were also rated for the degree to which their reason for responding corresponded to the rule given in Part A of each problem. Almost never did the nonliterate adults base their responses on the rule given in Part A, but all of the eighth graders responded in this way. The subjects in the lower grades responded in terms of the rule approximately half of the time.

The overall picture produced by this pilot study is that nonliterate adults, particularly when responding to the traditional riddle, base their

responses on the content of the problem and their past experience with responding to riddles of this type. Their responses tend to be quite long and elaborate, and they tend to agree that the hunter in Riddle 1 should be the one to get the leopard. By contrast, the eighth graders always responded by saying something like, "You said that any time a rice farmer sees something, it's his to keep, therefore, Flumo, the rice farmer, should get to keep the leopard." Unfortunately, we do not have systematic enough data with respect to the responses of the nonliterate and educated subjects on the other two problems to allow us to make statements about how they rationalize their answers.

In the riddles experiment just as in the verbal logical-problems experiment, nonliterate subjects depended on the particular content of the problem, and responses were much more likely to be based on this content than on the particular logical relations inherent in the problem itself. We also found consistently that subjects at the junior high school or higher level responded on the basis of relations within the problem, a tendency that increases systematically with education.

A second issue raised by these experiments is the nature of the relation between problem structure (conjunction, exclusive disjunction, negation, and implication) and the adequacy of the subject's response. Both of these issues were the basis of further experiments.

Linguistic Connectives and Conceptual Rules: Conjunction and Disjunction

In our earlier work among the Kpelle (Cole, Gay, and Glick, 1968, pp. 176–178), we explored the ways in which various logical relations among phrase elements might help explain differences in problem-solving difficulty associated with the different logical relations. In some pilot studies we obtained evidence that the relation between natural-language rules for connecting elements of a sentence and the effect of these rules in concept-learning tasks was different for Kpelle and American subjects.

In particular, our early evidence indicated that Kpelle subjects found equally easy concept-learning problems based on conjunctive (red *and* triangle) and disjunctive (red *or* triangle) classifications. This is essentially the same finding that we have just reported for the verbal logical problems in the previous section, although in the case of the verbal problems, there was occasional evidence that conjunctions might be easier in some respects than disjunctions.

This result is curious because our own data collected with American subjects, as well as a vast array of other studies (Bruner, Goodnow, and Austin, 1956; King, 1966; and so forth), have shown conjunctive problems to be uniformly easier than disjunctive. Originally, we thought the difference in relative difficulty could be explained by a greater precision in the Kpelle language with respect to disjunction. Our initial linguistic analysis had suggested that the Kpelle distinguish clearly between inclusive disjunction (where "or" implies "red or triangle" or both "red and triangle") and exclusive disjunction ("red or triangle," but not "red and triangle together"). Unfortunately, later analysis has indicated that although Kpelle has two terms for disjunction, both are of the *exclusive* variety. This would imply a superiority for the Kpelle only in the sense of a lack of the disjunctive ambiguity found in English, but not in the sense of flexible linguistic usage.

Although there is some evidence that repeated practice can reduce the difference in difficulty between conjunctive and disjunctive problems for American adults, the pervasiveness of the difference has led to a great deal of speculation about universal conceptual tendencies. For example, J. S. Bruner, J. Goodnow, and G. A. Austin (1956) speak of an "abhorrence of disjunctiveness" and maintain that in English there is a tendency for disjunctive definitions to be modified over time into easily grasped conjunctive forms (p. 160). C. E. Snow and M. S. Rabinovitch (1969) offer a variety of explanations for the differences they observed in favor of conjunctive concepts, ranging from greater familiarity to the speculation that the brain works conjunctively (!).

All of this speculation, combined with the lack of difference between conjunction and disjunction in most of our previous work among the Kpelle (Gay and Cole, 1967, Chapter 10 and pp. 189–193 of this volume), led us to explore further the question of conceptual rules and learning.

We borrowed and adapted a special procedure from the work of L. E. Bourne (Haygood and Bourne, 1965; Bourne, 1967). The basic idea was to consider the usual concept-learning experiment as composed of two subprocesses: one process is the learning of the attributes relevant to solution; the second is the learning of the rule by which the attributes are joined. In a rather extensive series of studies (see Appendix I for details), we sought to simplify the usual concept-learning situation so

that there would be a minimum of attribute learning and a maximum of rule learning.

The logic of our approach seemed quite straightforward—reduce the amount to be learned to include just the relevant aspect of the problem and thereby neutralize extraneous learning factors. The outcome was just the opposite of what we intended. Something about our "simplified procedure" made the problem difficult to solve. We are not at all sure what this "something" is, and can only make some possibly relevant observations.

Our pervasive impression while conducting our pilot work was that our subjects were involved in some "game" other than the one we had in mind. Often a subject who had difficulty with the problem (there are only four instances, a trivial task if one is simply observing the experimenter's behavior and remembering the instances identified as "correct") seemed to pay an extraordinary amount of attention to the experimenter's hands, as if their placement held the answer. Even if he solved one problem, the subject would persist in his attention to irrelevant details, apparently satisfied that he had "hit" upon the system last time and would be able to do so again.

When we questioned the Kpelle college students who acted as experimenters about this problem, they suggested that we might be inadvertently suggesting a game familiar to the Kpelle in which one member of a group is asked to leave. When he comes back, he must guess on the basis of observational clues which member of the group is holding a stone in his hand. These difficulties and the interaction between unknown aspects of the culture and experimental procedure serve as yet another reminder of the extreme caution required to infer the presence or absence of cognitive processes from cross-cultural data.

We had to admit failure in our attempt to study learning by specially devised techniques. We thus turned to a more standard psychological procedure which was slightly modified for our purposes.

Conjunction and Disjunction: Replicating American Procedures

This series of experiments (described in detail in Ciborowski, 1971) studied concepts built out of combinations of physical attributes. The stimuli were printed on cards and presented to the subject one at a time. The cards had pictures combining the following dimensions and values:

number (one, two, or three figures); size (small, medium, or large); color (red, white, or black); and form (circle, triangle, or square). Examples of conjunctive concepts might be *two red figures, black triangles,* and *small circles.* Examples of disjunctive concepts using these same attributes and values might be *two figures or red figures* and *small figures or triangles.*

Six problems involving six different concepts were presented to each subject. Half of the subjects learned conjunctive problems and the other half learned disjunctive problems. The six problems represented different combinations of relevant attributes so that each attribute was paired with each other attribute some time during the subject's six problems.

The decks of cards that made up each problem were constructed specifically for our purposes. For example, if the concept was green squares, there were nine cards with green squares, nine cards with green triangles or circles, nine cards with squares that were white or black, and nine cards with neither squares nor green figures on them. We did this in order to balance the type of instances to which the subject was exposed. We found later that this design had important consequences for our analysis of the relation between logical rules and concept learning.

To begin the experiment, the subject was shown the first and last cards of the deck, which had been previously randomized. One of these cards was placed on the subject's left, the other on his right. After he had a chance to examine them, the cards were placed back in the deck. Then the subject was told that the experimenter was thinking about certain cards in the deck. Each time a card was held up, the subject was asked whether the card was one of those that the experimenter was thinking about. All the "correct" cards were placed on the subject's right, all the "incorrect" cards were placed on his left.

This somewhat circuitous procedure, which in effect gets the subject to classify the cards into two groups, was arrived at after a great deal of pilot work. Of all the possibilities we tested, this procedure proved to be the easiest to administer.

Subjects were run to a criterion of ten successive correct responses on each problem or until they had gone twice through the deck of thirty-six cards. After a problem had been completed, the subject was asked to explain why he placed the cards as he did.

In addition to the comparison between conjunctive and disjunctive concepts, Ciborowski investigated the effects of age (twelve- to fourteen-year-old versus eighteen- to twenty-one-year-old subjects) and education (noneducated versus educated groups at each age level) on problem-solving performance, yielding a design with eight groups. The entire experiment was replicated three times with six subjects participating in each of the eight groups in each replication.

The subjects found the problems very difficult. About 40 percent of them were not solved, although even in these cases there seemed to be some learning. In order to study the process more closely, Ciborowski used as his measure the number of errors committed on each problem. It was assumed for purposes of analysis that a subject who had reached criterion committed no errors thereafter, even though the problem was terminated.

Although there were no large differences between groups, two differences were statistically reliable:

1. Conjunctive problems (14.1 errors per problem) were slightly easier than disjunctive problems (15.8).
2. Education enhanced the performance of the younger subjects (12.4 errors for the educated group, 17.4 errors for the nonliterate group) but there was no reliable difference between the older educated (14.6) and nonliterate (17.4) groups.

Overall, there was no significant variation attributable to age. Also important in view of the discussion in Chapter 5 was the fact that learning was more rapid on later problems than earlier ones, the error rate dropping from approximately nineteen per problem on the first problem to thirteen per problem on the last problem.

It appears that we have replicated the basic results of earlier experimenters (for example, King, 1966) in finding a difference, even though small, in favor of conjunction that is more or less constant across groups. We clearly did not replicate our own earlier finding of equal difficulty for conjunctive and disjunctive problems.

However, there are at least two puzzling features of these results. First, the difference between conjunction and disjunction was very small —much smaller than has usually been reported. Second, why should a difference between educated and nonliterate groups exist only at the lower age and education levels? Our previous experience had taught us to anticipate the opposite result.

While puzzling over these results, we noticed that our procedure had allowed correct responding on an unintended basis. In constructing our decks of cards we had inadvertently biased the number of times that a given card was placed on the subject's left or right side. Given an equal number of each kind of instance (for example, green and triangle or green but not triangle), nine cards were placed on one side of the table and twenty-seven on the other side in the course of running through any deck a single time. If a subject noted only this fact, and always responded to the more frequently correct *side,* he would be correct 75 percent of the time. This corresponds to only eighteen errors. Since our subjects averaged about fifteen errors a problem, they were doing little better than this pure position response.

Looking at the data from individual subjects, we found that pure position responding was very rare. However, we also found strong evidence that subjects were, to some extent, basing their responses on position information rather than stimulus information. In particular, we found that the probability of responding to the *side* correct on the previous trial was far higher than would have been the case if subjects had made their positional responses randomly.

In order to evaluate the relative degrees of sensitivity to positional information and sensitivity to the relevant stimulus information as factors controlling subjects' responses, Ciborowski constructed a simple mathematical model, which assumed that errors occurred only if the subject did not know the relevant stimulus information, in which case he responded to positional information and guessed incorrectly. In this model, correct responses occur either because the subject knew the response appropriate to the stimulus presented or because he guessed correctly on the basis of positional information. Although certainly an oversimplification of the underlying response process, this model yielded two very interesting results.

1. In terms of the stimulus-learning factor, conjunction (.35) was learned more rapidly than disjunction (.23). The ratio in this case is much larger than obtained for the error data. But in terms of positional responding, the disjunctive problems (.65) were more biased than the conjunctive problems (.52).
2. Younger educated children did better than their nonliterate counterparts solely because of increased *positional* responding. No difference in stimulus learning was obtained for these groups.

We were initially quite dismayed when we realized that subjects might be learning to solve the problem (in the sense of improving their performance) for reasons unrelated to logical rules and concept learning. However, the resultant pattern of behavior enriches our understanding of the way in which our subjects dealt with the problem. It appears that the conjunctive problem was considerably easier than the disjunctive problem in terms of stimulus learning, but that subjects compensated for the difficulty of the disjunctive problem by depending on position information, thus reducing the apparent differences between problems. The fact that the younger schoolchildren perform better by using positional information fits quite nicely with our earlier observations (Gay and Cole, 1967, Ch. 4) that there is a stronger dependence in the classroom on the teacher's concrete behavior rather than on the logic of the material being discussed.

At the time that these experiments were being conducted, we had not analyzed the data in terms of stimulus and positional information. We were concerned only to explain the slow learning that we had observed and the relatively small difference between groups. For example, we expected a much larger effect of education on the rate subjects learned this problem.

In an attempt to discover the subjects' difficulty, Ciborowski conducted a modified form of the experiment. In this case, when a card had been responded to, it was left out in view of the subject instead of being placed back in the deck. The major consequence of this procedure was to provide the subject with a continuously available memory aid during concept learning.

This memory-aid procedure made a major difference in learning for all groups. All but 4 percent of the problems were solved, and overall the average number of errors per problem was only 5.6. Conjunctive problems (4.2) were learned faster than disjunctive ones (6.9), but there were no reliable differences as a function of age or educational experience.

Ciborowski's results suggest some important points. First, he succeeded in identifying position cues as a mode of learning used by the subjects, a procedure we noted in other contexts, for example, the free-recall experiment. That position cues aided memory suggests one source of the overall difficulty of these problems, a difficulty that related directly back to our studies of attribute learning. Subjects did not make efficient use of information from past trials to arrive at a solution to the problem. Although the improvement over trials and the levels of performance indicate that there was cumulative learning, there was apparently less trial-to-trial comparison than efficient learning demands.

Second, Ciborowski showed that at least under some conditions conjunctive and disjunctive rules differ in difficulty for Kpelle people. The differences in rule difficulty are in the same direction as those found in similar studies in the United States, but are less in amount.